The importance of including time as a criterion in the assessment and selection of suppliers

J. van Dijk

Faculty of Economics and Business, University of Groningen,
Groningen, the Netherlands

Abstract

Purpose – The study aims to research how including the element of time in supplier assessment and selection can lead to an increase in performance of the focal organization.
This will be pursued by analyzing how suppliers are chosen currently. Besides this, the trade-off between time and cost within supply chain management, especially regarding supplier assessment and selection is studied. Finally, studying how the element of time can be included in the assessment and selection of suppliers is used to reach the purpose.

Design – The study has been a multiple case study, two organizations have been analyzed. Data regarding historical selections of suppliers has been used to study the trade-off between time and cost. Logically, time and cost have been the studied parameters. Furthermore, semi-structured interviews have been conducted with several involved people. Information gained from these interviews has been used to analyze current decision making, and differences and similarities between the organizations. Furthermore, the information has been used to find an optimal supplier selection method with time included as a selection criterion.

Findings – First of all, it has been studied in which way suppliers are selected. It can be concluded that optimal methods for selection are described in procedures. However, because of multiple reasons, this optimal method is executed only sporadic and not all stakeholders are involved. Price and quality are seen as the most important selection criteria, with reliability as a third.

Secondly, the trade-off between time and cost of material as present in project management is analyzed. After several statistical tests it can be concluded that this trade-off is not recognized in the relationship with suppliers.

In addition, the best way to include the element of time in supplier assessment and selection has been analyzed. The element of time can be included in several stages of the selection process after some prerequisites are met: procedure need to be in place to structure the selection process, and the selection should be based on multiple criteria. Performance can be improved by means of the following steps: realizing the power of time; securing financial support; using cost calculation with other criteria for selection; securing agreements in contracts and, decreasing time and cost were possible.

Paper type – Master thesis

Keywords – Quick Response Manufacturing, element of time, supplier selection, MTO/ETO, trade-off time and cost, multiple case-study.

Master Thesis Operations and Supply Chains
<u>Author:</u> Jurian van Dijk
<u>Student number:</u> s2050706
<u>Date:</u> 23 August 2012
<u>Supervisors:</u> J. Riezebos and J. A. C. Bokhorst

1. Introduction

Quick Response Manufacturing (QRM) has proven to be an effective approach in decreasing lead times within an organization (Suri, 1999; 2010). Furthermore, lead time has been mentioned as an important performance criterion for supplier assessment and selection (Ohdar and Ray, 2004; Chen, 2011; Lee et al., 2001; Cormican and Cunningham, 2007; Ho et al., 2010). Although both aspects are considered in previous literature, a clear link between these aspects has not been made before.

In addition, Handfield et al. (2002) found out that suppliers are becoming increasingly critical with regard to the performance of the organization. According to Wang et al. (2009) the possibility of reaching a competitive advantage nowadays heavily relies on the performance of suppliers. Because of the growing importance of suppliers, including the principles of QRM in supplier assessment and selection might lead to a decrease of lead times and, therefore, an increase in overall performance.

Numerous methods and criteria for choosing and measuring suppliers' performance have been described (Muralidharan et al., 2002; Ho et al. 2010; Chen, 2011; Talluri and Sarkis, 2002). Furthermore, the importance of supplier selection has been identified. Muralidharan et al. (2002) refer to Mohanty (1990) by stating that most of the managers describe the selection of suppliers as the most important decision problem for their organization.

Several methods and criteria for selecting and evaluating suppliers are discussed in the existing literature. According to Talluri and Sarkis (2002), price has been considered as the most important factor in relationships with suppliers for a long time. However, the authors describe that nowadays emphasis is necessary on criteria as quality, delivery and flexibility as well. The need for evaluating time has been identified by more authors (Ohdar and Ray, 2004; Lee et al., 2001; Chen, 2011; Cormican and Cunningham, 2007; Ho et al., 2010; Muralidharan et al., 2002).

According to Suri (2010), QRM is a "companywide strategy to reduce lead times". Implementing this strategy and decreasing lead times have shown that not only response time is improved, quality is improved and costs are decreased as well. According to the philosophy of QRM two types of variability exist. Strategic variability is necessary to remain competitive. However, dysfunctional variability leads to all kinds of problematic situations as, for example, rework. Therefore, QRM focuses on decreasing this dysfunctional variability.

As can be concluded from previous sections, multiple authors emphasize the importance of suppliers for organizational performance. Furthermore, the importance of the element of time is recognized by several authors as well. QRM might be helpful in improving performance regarding the element of time in the supply chain. Current literature discusses delivery performance as an important criterion in supplier selection. However, the importance of the element of time is not completely described in this criterion. Increasing the importance of time in selection of suppliers might lead to increased performance.

Wu and Barnes (2011) identified the need for further research on selection of partners. The authors describe the need for more attention towards decision-making regarding this selection. Furthermore, in project management related literature the trade-off between time and cost is discussed thoroughly (Feng et al., 2000). However, this trade-off is not discussed in relation supply chain management.

This research aims to discover and analyze the trade-off between time and cost within supply chain management, especially regarding supplier assessment and selection. Furthermore, it will be studied how the element of time, by means of the principles of QRM, can be included in the assessment and selection of suppliers. By means of the research clarity will be provided on the effects of including the element of time in supplier assessment and selection. First of all, it will be studied whether including this element will be beneficial. Next, the results of the first step will be used to find out how the element of time can be included in tools for supplier assessment and selection. Therefore, the following research question is used to guide this research: *"How can including the element of time to supplier assessment and selection lead to an increase in performance for the focal organization?"*

Two organizations are looked at. Insights retrieved from these organizations are used to create general applicable guidelines with regard to including the element of time in assessment and selection of suppliers. Both organizations are familiar with QRM and operate in make-to-order environments characterized by high variety and low volume. Because of the high variety of products that are made-to-order in these organizations, there is no possibility to keep all parts on stock. Parts of the products need to be ordered at suppliers. Therefore, time is one of the essential order winning factors for these types of organizations (Kingsman et al., 1996; Li and Womer, 2012). As a result, using the element of time within supplier assessment and selection might be beneficial

This paper is composed as follows. First of all, the existing literature on relevant subjects will be discussed in the second chapter. The third chapter discusses the method of the study and describes the operational definitions. In the fourth chapter, the results of the study are described. The fifth chapter includes the analysis and discussion of the described results. Finally, the study is concluded in chapter six.

2. Literature review

2.1. Principles of QRM

This research aims to study the effects of including the principles of QRM, especially the element of time, to supplier assessment and selection. In order to make clear what is meant with the principles of QRM, this paragraph is used to describe the main aspects of QRM.

Including the principles of QRM to supplier assessment and selection will put emphasis on the trade-off between time and cost. By means of this section, the principles of QRM are explained and discussed. The trade-off will be discussed in section 2.4.

QRM is based on four main principles. Realizing the power of time, rethinking organizational structure, understanding and exploiting system dynamics, and implementing a unified strategy enterprise wide (Suri, 2010). These principles will only be discussed shortly to give an idea of the QRM strategy.

First, the power of time should be realized. Most organizations are aware of the fact that time is important and is related to costs. However, it is often not known what the impact is of long lead-time and how much time is wasted within the organization. When the impact of time is recognized, the total lead-time should be measured and reduced where possible (Suri, 2010).

Next, rethinking the organizational structure is necessary. Attention should be paid to

creating cross-trained QRM cells. Instead of efficiency, lead-time reduction is the main goal for all of these cells (Suri, 2010).

Third, understanding and exploiting system dynamics is important. The strategy of QRM focuses on dealing with variability. Suri (2010) states that capacity planning decisions need to include lead-time targets and variability measures as well. Spare capacity is necessary to cope with variability.

Finally, QRM does not only focus on the work floor, the approach is useful for all operations of an organization. According to Suri (2010), QRM is beneficial for supply management as well. The focus on lead-time reduction is useful in supplier development and using QRM will affect sourcing decisions as well. However, how organizations should use the approach to create the benefits is not discussed.

2.2. Elements of supplier selection
In this second section of the literature review, the elements of supplier selection are described.

According to de Boer et al. (2001), there are four areas within supplier selection: problem definition, choosing criteria, pre-qualification and final selection. The problem definition can be defined as the goal that needs to be achieved, for example maximization of revenues (Hong et al., 2005). The problem for this situation is defined by means of discussions with both organizations and the gap in literature. Secondly, criteria will be chosen by means of literature and information gathered at the studied organizations. According to Hong et al. (2005), pre-qualification can be defined as 'the process of reducing the set of "all" suppliers to a smaller set of acceptable suppliers'. In addition, final selection is the definitive step to choose the best supplier out of the reduced set created by means of the pre-qualification. Both of these steps can be executed when proper criteria are described.

2.3. The role of time as criterion in supplier selection
The philosophy of QRM stresses the importance of time at organizational activities. By means of this section, it will be studied whether time is seen as important for supplier selection in current literature.

Multiple authors discuss supplier selection and corresponding assessment. Furthermore, several criteria for the assessment are described. First of all, Ohdar and Ray (2004), and Chen (2011) refer to Dickson (1966). He describes multiple criteria and according to that, Ohdar and Ray (2004) concluded that cost, quality and delivery performance are the most important criteria. However, according to Chen (2011), quality, delivery and performance history are the most important criteria. Lee et al. (2001) describe delivery reliability as a main criterion as well; the reliability is ranked third according to these authors. In addition, Cormican and Cunningham (2007) also mention these criteria. However, the authors ranked the importance of criteria in a different manner. According to them, the sequence should be on time delivery, quality and total cost. Kannan and Tan (2002) conclude that cost is the primary criterion. Among other aspects, delivery is identified as well. Ho et al. (2010) did their own research regarding criteria for evaluation, and found fourteen main criteria. According to these authors, quality is the most important, followed by delivery reliability. Muralidharan et al. (2002) agree to this; however, the authors place cost between quality and delivery reliability. The study by Ho et al. (2010) and the article by Muralidharan

4

et al. (2002) revealed flexibility as an important criterion as well.

There are more authors who discuss delivery reliability as a criterion for performance evaluation and supplier selection. However, these authors did not rank the different criteria. Ohdar and Ray (2004) mention delivery reliability among seven other important criteria. In addition, Chen (2011) reviewed multiple articles and concluded that the relative importance of the main criteria as price, quality and delivery is comparable. Within delivery, lead time, on-time delivery rate and delivery flexibility are recognized.

It can be concluded that delivery performance is identified as a criterion by all discussed authors. However, there is no consensus regarding the importance of the criterion. Multiple authors see delivery as a main criterion, while other authors describe it as one of many criteria. Furthermore, flexibility is discussed as a separate criterion; this can be related to the delivery as this flexibility is important to deliver on time. Three important remarks can be made. There is only one article, the article by Cormican and Cunningham (2007), among all articles discussed which describes on time delivery as the most important criterion. Next, quality is identified as the main criterion by multiple authors. However, this might be expected as quality is a qualifying factor in the selection process.

In contrast to other mentioned authors, Handfield and Pannesi (1995) described the importance of time. The authors focus especially on make-to-order environments. According to the authors, long lead times might have an unfavorable effect on customer loyalty and market share. This is found particularly true for make-to-order products, because quick delivery is an order-winning factor for these products.

Author	*Discussed criteria*
Ohdar and Ray (2004)	Cost, quality and delivery performance
Chen (2011)	Quality, delivery and performance history
Lee et al. (2001)	Delivery reliability
Cunningham (2007)	On time delivery, quality and total cost
Kannan and Tan (2002)	Cost and delivery
Ho et al. (2010)	Quality, delivery reliability, flexibility
Muralidharan et al. (2002)	Quality, cost, delivery reliability, flexibility

Table 1: Overview criteria supplier selection

Although on time delivery is described as important in literature discussing supplier assessment and selection, attention for the total element of time is missing. On time delivery cannot be seen as the same aspect as the element of time; both aspects are related to different performance objectives. On time delivery can be described as the performance objective dependability. On the other hand, the element of time is more about the performance objective speed (Slack and Lewis, 2008).

2.4. Trade-off time and cost

By means of this section, the trade-off between time and cost as described in project literature is discussed. This time/cost trade-off is discussed extensively in literature regarding project management. On the other hand, the trade-off between time and costs of materials is not

discussed in literature regarding supply chain management, and supplier assessment and selection. However, analyzing the trade-off in the area of supplier selection could be insightful as well. According to Feng et al. (2000) analyzing the time/cost trade-off is one of the most important aspects of project planning and control. For each activity of a project, there is a trade-off between time and cost. In addition, the authors state that in project management the relationship can be explained by stating that the less expensive resources are used, the longer it takes to complete an activity. However, as Feng et al. (2000) state as well, not all activities are critical. Some activities can be executed more slowly without having an impact on the total duration of the project. These activities can, therefore, be performed with less cost as well.

In supplier assessment and selection, cost is seen as more important than time by some organizations. However, when the statement by Feng et al. (2000) applies to supplier assessment and selection as well, it can be stated that the lower the costs, the longer it will take before delivery takes place. Logically, this is especially relevant for the critical or near critical items. According to the philosophy of QRM, an increase in time will lead to an increase in cost. This increase might neutralize the initial lower costs.

According to Chen and Tsai (2011), and Błaszczyk and Nowak (2009), it might happen in projects that the required completion date is earlier than the date that can be achieved by means of following the fastest path. The authors state that in such a situation one or more activities need to be speeded in order to meet the required completion date. This situation can be compared to a delivery from a supplier that is required as soon as possible or up- or downscaling in demand. Chen and Tsai (2011) state that speeding activities can be achieved by increasing the resources and, therefore, cost as well. This trade-off can be related to supplier selection as well. A decision needs to be made between cost and time related to delivery by each supplier. Increasing material cost does, however, not necessarily mean that the total cost of ownership will increase as well.

In conclusion, choosing for the supplier with the lowest material cost might lead to an increase in time and its related costs. Furthermore, the opposing can be stated as well. Increasing initial investments might decrease total costs because time and its related costs are decreased. Making organizations aware of the effects of this trade-off related to supplier selection is necessary in order to achieve benefits of including the element of time in supplier assessment and selection. QRM showed that both a decrease in time and cost is possible (Suri, 2010). This seems to be contradictory to the trade-off described by Feng et al. (2000). By means of this study this conflict will be researched and analyzed.

2.5. Costs related to time

According to Suri (2010), there are a number of hidden costs related to time. First of all, additional costs are encountered in "repairing" late orders. Costs will increase because of air freight and time needed by staff and management. Secondly, meetings to update priorities and change targets will have an influence as well. Moreover, overtime might be needed to speed up late orders. Work in process and inventory will lead to holding costs and a need for additional space. Resources will be needed to store and retrieve parts during the long lead-time. This increases the risk for damage as well. As inventory is larger, the risk of obsolescence increases. Furthermore, quality problems might be detected late, leading to

higher amounts of scrap. In addition, the more time it takes to finish a product, the more time a customer has to make changes to its order. Time needed to handle these requests will add to the costs as well. Another increasing factor regarding costs is the time spend by all departments to plan and update the amount of produced parts. Finally, all time spend on speeding orders, changing orders and explaining delays to customers, decreases the time that could have been spent on obtaining new sales.

Besides all costs mentioned by Suri (2010), sourcing products outside the country the organization is located in will lead to additional costs. Platts and Song (2010) mention several of these. Mainly costs will be encountered in transport and inventory. According to the rule of thumb, total costs for keeping inventory are estimated on 20% to 25% of the product's value. Although this percentage is commonly known, scientific evidence is missing. Furthermore, inventory will cover up problems within the organization and increase time to market. Activities as travel costs, additional inspections, and all sorts of fees will increase the total cost (Platts and Song, 2010). In addition, other aspects will increase the effectiveness of the relationship with the supplier. Platts and Song (2010) mention cultural and language differences, inadequate quality, skills, technology and equipment, and a worse reliability as problems related to sourcing in other countries.

2.6. Existing methods for supplier assessment and selection
QRM has been described as a method to decrease lead times and, therewith, increasing quality and decreasing costs as well. By means of describing elements of supplier selection, the influence of time and the related costs have been reviewed. However, before including new insights will be beneficial for an organization, the optimal method to enclose all these insights needs to be chosen.

Several methods for supplier selection are discussed in literature. Therefore, the optimal solution for the studied characteristics needs to be defined. This section will identify the main methods mentioned in literature. The information gained will be compared to the situations at the studied organizations, and the most suitable method for these types of organizations will be determined. Main elements of these methods are described in this section. Furthermore, usefulness and problems of these methods are discussed. Finally, it will be discussed how information from suppliers should be captured.

According to Lee et al. (2003) several methods for supplier selection can be identified: the cost-based method, weight-oriented method, analytic hierarchy process method, and the mathematical optimization method. These methods are identified by Hong et al. (2005) and Wu et al. (2009) as well.

Within the cost-based method, all costs associated to a supplier are calculated and the least expensive supplier is chosen. With the weight-oriented method organizations can choose their own criteria. When the criteria are known, each one of these will get a weight assigned. Suppliers can be compared on the criteria itself and on a final score. The analytic hierarchy process method (AHP) first creates a hierarchy, and the criteria are determined. Next, the criteria are compared to determine their weights and a final score is created. AHP can be useful for analyzing subjective criteria as well. By means of mathematical optimization a goal of the organization is maximized or minimized. For example the goal to minimize the total cost.

Although numerous methods are available and numerous criteria can be identified, it might be difficult to capture the right data from potential suppliers. Actual performances that differ from promised performances might be a problem arising after a supplier is chosen. According to Purdy and Safayeni (2000) information necessary for supplier assessment can be acquired by means of different modes. The overview created by the authors is shown in figure 1. Making use of the right mode might prevent surprises regarding performance of the chosen supplier.

Information Acquisition Mode	Information Domain	
	Process	Product
Indirect	Supplier provides customer with information about manufacturing and / or management processes.	Supplier provides customer with performance information (e.g., cost, quality, delivery).
Direct	Customer goes to supplier and examines manufacturing and management processes.	Customer tests outputs or collects its own performance data.

Figure 1: Acquisition mode by Purdy and Safayeni (2000)

The indirect modes might lead to problematic situations as data is provided by suppliers. Direct acquisition of information is important in assessing and selection suppliers. However, the focal organization should be clear in its expectations, as only in this case the right data can be acquired from suppliers.

3. Method

3.1. Research method

Although assessment and selection of suppliers has been studied thoroughly, the importance of the element of time has not been described extensively. It is not clear whether the trade-off between time and cost exists in supply chain management, and especially supplier selection as well. Furthermore, it does not seem to be completely clear how the final decision for selecting a partner takes place. The importance of including the element of time will be studied in this research. The philosophy of QRM will be kept in mind when the element of time is applied to supplier assessment and selection.

A multiple case study is executed for multiple reasons. First of all, this type of research is described as useful for theory development (Aaboen et al., 2012). A gap in literature is identified, and, therefore, development of literature is the major goal of this research. Furthermore, a multiple case study is useful to identify variety and similarities between specific cases (Aaboen et al., 2012). For that reason, the multiple case study will be useful in studying and comparing the current state of supplier assessment and selection at the organizations.

As the multiple case study is chosen, a guideline for conducting this type of research is helpful. Moe et al. (2012) use a five step process for executing a multiple case study based on Yin (2003). These steps are used for this research as well. First, the case study needs to be designed. The research questions are described in this method and a planning is created.

Secondly, the data collection is prepared. Procedures for this data collection are defined; a topic list is created to structure the interviews. An overview of the topic list is shown in appendix 2. Thirdly, evidence is collected. This step is conducted by means of executing the interviews and the direct observation. Fourthly, the collected data is analyzed. The literature review and the typology by Treacy and Wiersema (19997) are used to explain the results that are found. Finally, all analyzed data is brought together in a report.

Information from two organizations is used to create a multiple case study. The organizations are both familiar with QRM and have already started to apply the principles within the organization. Both organizations are manufacturers and mainly work on engineer- and make-to-order basis. Besides these similarities that fit the study, strategies of the organizations are different. These different strategic choices are used to structure the analysis of the current decision making. Figure 2 shows the three strategic options in the used method by Treacy and Wiersema (1997).
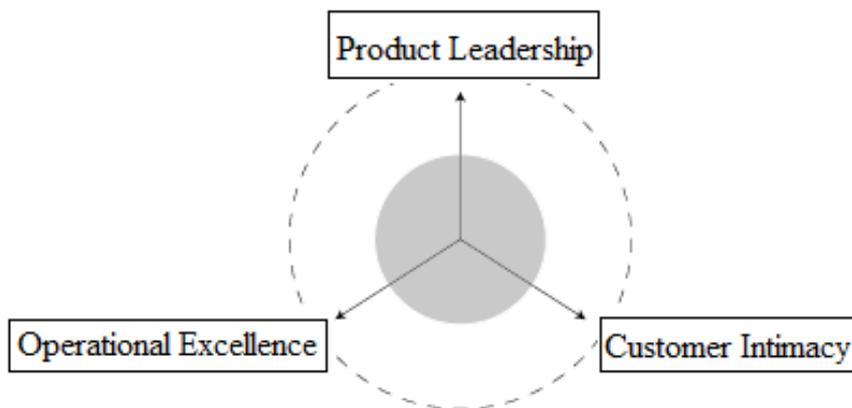
Figure 2: Strategies by Treacy and Wiersema (1997)

First of all, both organizations have a moderate level of customer intimacy. Organization one pays most attention to operational excellence. Organization two, on the other hand, focuses mainly on product leadership.

To sum up, the organizations are chosen because of the knowledge of QRM. Additionally, the different strategies that are pursued are used for the study as well. These different approaches are used to explain possible differences in supplier assessment and selection.

First of all, it is identified how decisions regarding supplier selection are currently made. Information received from the organizations is used for this step. Information from the organizations is captured by means of semi-structured interviews with people responsible for the assessment and selection of suppliers on the strategic, tactical and operational level. Furthermore, datasets regarding the assessment and selection of suppliers are used, where possible, as well. The returning structure used for the interviews will create consistency in the data collection. Furthermore, feedback regarding the formulation of given answers will increase the reliability of data. The current situation at organizations will be analyzed by means of the information gathered from the interviews. The criteria used at organizations are analyzed, and possibilities to include the element of time are identified. Direct observation

will be used to support the findings from the interviews. Documentation with regard to the RFI, audit, and supplier assessment will be studied. This part of the study will be guided by means of sub question one: *"What does the current assessment and selection procedure look like and is including the element of time acceptable?"*

Next, it will be analyzed whether including the principles of QRM will be beneficial, and it will be analyzed how the element of time can be included in the assessment and selection of suppliers. Again, interviews with the employees responsible for the strategic and tactical level of supplier assessment and selection are used to gather this data. Furthermore, the responsible employee for the strategic and tactical level of the operations within the organizations, and employees at the operational level of purchasing are interviewed as well. To sum up, interviews are conducted with purchasers, purchasing directors and logistic managers. Analyzing the trade-off between time and cost is an important aspect for finding out whether QRM in assessment and selection can be beneficial in the first place. The trade-off will be analyzed by means of data regarding previous supplier selections. SPSS is used to analyze all data. Subquestions two and three structure this part of the study: *"To what extent is the trade-off between time and cost also recognized in supply chain management, and especially supplier assessment and selection?"* and *"How can the element of time be included in supplier assessment and selection?"*

3.2. Operational definitions
A number of definitions with regard to the research are operationalized to prevent ambiguity and to describe the boundaries of the definitions for this study. The operational definitions are shown in table 2.

Concept	Used definition
Supplier assessment	Analyzing performance of suppliers by means of selected criteria
Supplier selection	The selection process of the best suppliers out of a pool of potential suppliers.
Time/cost trade-off	The decision that organizations need to make regarding the interaction of fastest delivery and lowest costs of material.
Quick Response Manufacturing (QRM)	A strategy focused on the goal of reducing internal and external lead-times of an organization.
Element of time	The time that elapsed between creating an order and receiving the order. This element of time is important in standard situations; however, the importance will increase in a situation with large variation.

Table 2: Operational definitions

4. Results
4.1. Current methods for assessment and selection
Both organizations are assessed on their methods regarding supplier assessment and selection. In this way it is analyzed how suppliers are selected with the current working method. By means of this section, the current state of these methods is described. Furthermore, success

areas and areas for improvement are discussed in order to find the most effective manner of assessment and selection. Finally, including the element of time in the assessment and selection is discussed and it is studied in which way the element of time can be used to increase performance of the focal organization.

4.1.1. Procedures for selection of suppliers
Both organizations have created methods for supplier assessment and selection. At organization one, specific requirements regarding quality, speed and flexibility are necessary for all parts. These requirements already minimize the number of suppliers which are able to deliver. At the second organization minimum requirements are important as well. For example, a supplier needs to be able to deliver all facilities. Specific requirements regarding products are asked for as well, a minimum level of quality is necessary.

At organization one, further information regarding production and delivery of the parts is to a certain extent delivered by the supplier. The other part is gathered by means of an audit, this audit is only executed at new suppliers. Important suppliers (based on level of money spent) are assessed by a large audit; less important suppliers are assessed by means of a lighter version of the audit. All gathered information is reviewed each two years. Although this data is gathered, an overview of capabilities for each supplier is not available. Placing a sample order is usual to test the supplier and product. Organization two has different steps for supplier selection described in procedures. When searching for a completely new supplier, desk research is the first step in the optimal situation. Next, a RFI is sent to all interesting suppliers, and a long list is created. This RFI is filled in by the supplier. Furthermore, the best suppliers are chosen based on the results of the RFI. Each aspect in the RFI has a weighting, this weighting is decided up front and differs per commodity. A supplier needs to obtain a minimum score in order to make it to the short list. All suppliers on the short list are audited on process and quality, the best supplier is chosen. The decision is based on a discussion with all stakeholders. Price has been and still is one of the most important criteria.

However, the optimal process is not used very often. Approximately in ten percent of all cases this optimal method is used. First of all, this is because new suppliers are only chosen rarely; maximally one supplier for each commodity a year. In addition, partnerships are desirable for strategic products. Moreover, when a change is made to a supplier which is already known, the optimal process is seen as less important. In this case an RFI and an audit are not asked for because the organization is not new. The second organization has a large supplier base, and a lot of other suppliers are known informally. Additionally, because of time issues, the process is often shortened. In this case, other stakeholders are not involved and steps are skipped. Besides these reasons, the organization prefers to decrease risks. Improving operational processes at a current supplier is more important than choosing a new supplier. In addition, a supplier delivering faster for a higher price is seen as an organization doing something "special"; paying a current supplier more to do the same is preferred.

Furthermore, choosing completely new suppliers does not happen often at the first organization. Firstly, this is the case because suppliers are chosen as partners. Improving a current supplier has a higher priority than choosing a new supplier. Secondly, the organization has set the goal to reduce the total supplier base. Therefore, when a change is made, changing to a supplier which is already known has the preference. Furthermore, a lack of time might

also lead to a less thorough process. However, this might create the situation that not the most optimal supplier is chosen. Agreements with suppliers are made regarding a minimum level of money spent per year. This increases the difficulty to change. When a new supplier is chosen, the organization first looks at current suppliers delivering their location. Next, suppliers in the total concern are reviewed. Each location has different suppliers and is responsible for its own supplier base. As a final step, completely new suppliers can be approached when the first two steps do not lead to the required result. Another reason for the minimal number of new suppliers is the internal supplier in India. The decision to outsource products is taken some time ago and the decision for these products is not reconsidered. Finally, product life cycles for produced products are long, up to 30 years. Therefore, changes in requirements and, therefore, the need for new suppliers are not experienced often.

It can be stated that both organizations have an optimal method for supplier assessment and selection based on similar aspects. However, these methods are used only sporadically.

4.1.2. Criteria for selection
Selection of suppliers is based mainly on quality, logistics and price at organization one. Quality is necessary, a certain level is expected. Without meeting these standards, a supplier does not have any chance of being chosen. Next, price is a criterion for selection. Especially when selecting a completely new supplier, price is the main focus. After price, R&D and logistics are used as criteria. Time is currently only included in delivery time compared to other suppliers. As can be concluded, suppliers are assessed on multiple criteria. However, these criteria are not always in line with performance objectives communicated to customers of the focal organization. Another problem is the lack of conformity in agreements with customers and agreements with suppliers. An example is the return policy discussed with the customer. This is usually not similar as agreements with the supplier.

At organization two focus lays on price; aspects as quality and reliability are encountered afterwards. In this case, the policy is based on improving the supplier; the department involved in educating suppliers would like to prevent problems leading to this need. However, the time spent on educating actually increased. Furthermore, spending lots of money on education does not prevent a changeover to a new supplier. Different triggers for supplier selection exist. First of all, suppliers are selected because of problems with quality or delivery with the current supplier. In addition, reduction of the supplier base is also a trigger. The organization strives for one supplier which delivers all facilities. Furthermore, price is definitely a trigger as well; changes are made based on product price.

At this moment, people at organization two realize that the lowest price not always leads to the lowest total cost. This is one of the reasons that not always the supplier with the lowest price is chosen. TCO is seen as important. In one of the discussions it came forward, that the additional costs occur in transport and the hours spent by R&D and quality to solve problems. Others state that the costs of inventory are not calculated in the internal TCO approach. TCO is calculated in a selection process, at least when the optimal process is executed. However, at this moment there is not enough attention for quality and logistics. The responsible departments are not involved directly in the selection process. Furthermore, suppliers in, for example, Asia lead to a lot of problems. Throughput time is very long and

quality is too low and cannot be guaranteed. Costs related to this problems are not calculated either. The organization identifies the need for including the element of time in selection of suppliers. Aspects as flexibility and scaling can be included in contracts. However, currently only one or two percent of all cases include these aspects. Sometimes contracts are not even created.

Criteria described as important in literature are seen as important in the organizations as well. In all cases cost, quality and reliability seem to be the most essential.

4.1.3. Different focus

The first organization has divided its products in several commodities and each commodity has a different focus. For example, logistic aspects as time and flexibility can differ per commodity. The weighting for each criterion can differ per selection process as well. Furthermore, a second source is chosen in some cases as well. In other situations, a second supplier can be chosen from the existing supplier base when necessary.

For the second organization, requirements are different for each commodity as well. For each commodity, and subsequently for each supplier, a profile and strategy is created. Each product gets its own specific profile as well, aspects as scaling and downscaling are possibly discussed. The purchaser creates the profiles and is responsible, although it is validated by a superior. Each commodity has one responsible purchaser, who can be responsible for multiple commodities. The purchaser takes care of purchasing for all facilities within the international organization.

4.1.4. Supplier assessment

Each active supplier is assessed on a number of criteria at organization one. This assessment is recently renewed. Every three months, delivery reliability is assessed. Furthermore, each year a full assessment based on delivery, quality and the relationship is conducted. Ideally, this is conducted every month, however, as the assessment is recently renewed, spending time on improving the method is preferred. Continuous improvement is seen as a key aspect as well. Therefore, feedback is given to suppliers regarding their performance. However, there is no succession connected to this feedback.

Organization two works on supplier assessment as well. Suppliers are assessed on two main areas: reliability and quality. The assessment is partly automated, and partly based on questions which need to be answered manually every time. All suppliers are reviewed every month; however, only the largest suppliers are discussed every month. Possible corrective actions take time, and, therefore, six months are taken into account as time to improve. Results are sent to the supplier and when a supplier scores below the requirements an action plan is necessary. This process is standard and described in procedures; succession is guaranteed as well. The largest suppliers based on money spent are discussed on their performance monthly. Suppliers which perform below standards are discussed as well.

Both organizations mention the importance of assessment. However, the second organization seems to make more use of the abilities of the assessment.

4.1.5. Improvements

Although the whole organization is involved in the selection process of a new supplier,

improvements are desired at organization one. Currently, the involvement is arranged informally. An internal formal checklist for the internal organization will prevent possible problems.

At organization two, people stated that including a subjective assessment regarding the relationship and communication might be interesting. Furthermore, a combined method for assessment and selection which is used in all facilities is wished for, at this moment every location sticks to its own methods. Currently, problems arise because of the lack of understanding, communication and standard working methods. Furthermore, including employees responsible for quality and logistics in the selection process is preferred. Advice by employees instead of meeting requirements in the RFI needs to get a heavier weighting. This change will also increase commitment from other departments.

To conclude, both organizations state that formal procedures and a standardized working method might help in involving all stakeholders and improving the selection process.

4.2. Trade-off time and cost

According to literature, a trade-off between time and cost exists in project management. When this trade-off exists in supply chain management as well, there is a contrast with the ideas of QRM. The possibly existing trade-off should be broken through before QRM in the supply chain can be effective. This section will describe the results of analyzing a dataset regarding deliveries with different prices and delivery times. The comparison related to price is only based on the price paid for the part. Additional costs as transport, etcetera are not included in this amount.

The used dataset consists of 40 articles which are ordered at suppliers. Currently the parts are sourced from Poland. Besides this supplier, different suppliers are capable of delivery as well. First of all, products can be bought in Hungary. Secondly, another supplier in Poland is able to deliver as well. Finally, parts can be produced in India. Lead time from India is on average 88 days and from Eastern Europe on average 53 days.

First of all, changes are compared to the current situation. Poland and India are cheaper than the current supplier, respectively 52.6 percent and 54.4 percent. On the other hand, Hungary is more expensive: 13 percent. An overview is given in table 3. Only for India the lead time changes: an increase of 66 percent.

Supplier	Poland (new)	Hungary	India
Change in price (%)	-52.6%	13.0%	-54.4%
Lead time (days)	53	53	88
Change in lead time (%)	0.0%	0.0%	66.0%

Table 3: Changes in price and lead time compared to current situation

Although these figures do already give an overview, another comparison is necessary to create an optimal figure. In this case, all new suppliers are compared. Both for the new suppliers in Poland and the supplier in India, all parts can be bought cheaper than at the current supplier. In Hungary only 23.1% of all parts can be bought cheaper. On average this choice is 13.0% more expensive.

Population 1	Population 2	Difference in price	Difference in lead time
Poland	Hungary	59.0%	0.0%
India	Hungary	49.6%	-66.0%
India	Poland	-18.7%	-66.0%

Table 4: Mutual comparison new suppliers

As can be derived from a comparison between all new suppliers, Poland and India are on average cheaper than Hungary. Poland is 59 percent cheaper and India 49.6 percent. Furthermore, all parts are more expensive in Hungary than in Poland and India. Next, Poland is on average less expensive than India, the difference is 18.7 percent. India is more expensive for 57.5 percent of all parts; on average Poland is 44.8 percent cheaper in these cases. In the other 42.5 percent of the parts, India is less expensive than Poland. On average India is 16.5 percent cheaper for these parts.

However, all used descriptive statistics do not say everything. Therefore, a more in depth statistical test is used to check whether the different countries significantly differ in offered price. The right test is chosen by means of a number of criteria. First of all, the test should be suitable for interval/ratio data. Secondly, it should fit a measure of central location in a non-normal distribution. Finally, data is gathered in matched pairs. Because of all these criteria, The Wilcoxon Signed Rank Sum Test fits the situation.
By means of the Wilcoxon Signed Rank Sum Test the following hypotheses have been tested:

H0: The two population locations are the same.
H1: The location of population one is different from the location of population two.

The test is executed for all different situations. First of all, all possible new suppliers are compared to the current supplier. Next, all three new suppliers are compared mutually. Results of the comparison with the current situation are shown in table 5. Results from the comparison between all new suppliers are shown in table 6.

A confidence level of 95 percent is used for all calculations. The rejection region for a 95 percent confidence interval is $z > z_{.025}$. $Z_{.025}$ leads to a value of 1.96. Or $z < -z_{.025}$. This leads to a value of -1.96. Consequently, the rejection regions are $z > 1.96$ and $z < -1.96$.

Population 1	Population 2	Z-value	P-value (2-tailed)
Current	Hungary	-1.363	0.173
Current	Poland	-4.458	0.000
Current	India	-4.458	0.000

Table 5: Results Wilcoxon Signed Rank Sum Test #1

From the results it can be stated that the population locations of the current supplier and a new supplier in Hungary are the same. In addition, both the population locations of the new suppliers in Poland and India are different from the location of the current supplier.

Population 1	Population 2	Z-value	P-value (2-tailed)
Poland	Hungary	-4.458	0.000
India	Hungary	-4.458	0.000
India	Poland	-2.326	0.020

Table 6: Results Wilcoxon Rank Sum Test #2

As the rejection region is similar to the one used for the first comparison, it can be stated that all population locations of the new suppliers differ. There are significant differences between Poland and Hungary, India and Hungary, and India and Poland.

5. Discussion

5.1. Contradiction trade-off and QRM

First of all, the trade-off between time and cost mentioned in literature regarding project management will be discussed. As stated in the literature review, the trade-off does contradict the statements made by the philosophy of QRM. In case this trade-off exists in supply chain management as well, a break-through is necessary before QRM can be applied effectively. The existence of the trade-off is studied and analyzed by means of descriptive statistics and non-parametric statistical hypothesis tests. The descriptive statistics already reveal the trade-off possibly does not exist in supply chain management. However, additional statistics are necessary to support this statement. The Wilcoxon Signed Rank Sum Test created this support. The analysis lead to the figures as discussed in tables five and six. These figures give a clear overview of the situation. The differences in the population locations are already mentioned; however, an interpretation of the figures will increase the detail of the analysis.

Corder and Foreman (2009) used a section of their book to describe the interpretation related to the figures found by means of the Wilcoxon Signed Rank Sum Test. According to the authors the results can be further interpreted by means of the sum of the difference ranks created by SPSS. A higher sum for the positive ranks demonstrates a positive effect; a higher sum for the negative ranks demonstrates a negative effect.

When the comparison with the current situation is analyzed, both Poland and India are significantly different. As Poland is cheaper for all parts, the sum of the negative ranks is, logically, higher. It can be stated that there is a negative effect on price for this change. The same goes for India. Again all parts are cheaper and again a negative effect on price is encountered.

Next, all new suppliers are compared to each other. Poland and India are cheaper for all parts compared to Hungary. Therefore, the sum of the negative ranks is higher. The negative effect on price is found here as well. Finally, the most important comparison is made. Both Poland and India are significantly cheaper than the current situation. However, only for India a change in lead time is found. The sum of the negative ranks is 237 and the sum of the positive ranks is 583. Therefore, when India is compared to Poland, a positive effect on price is found. This means that India is more expensive than Poland.

To sum up, Poland is the cheapest option for sourcing this group of products. Because there is no change in lead time the trade-off between time and cost is not found. In addition, sourcing in India leads to an increase in lead time. However, this increase does not lead to the

lowest price, as might be expected when the trade-off is present. To conclude, the trade-off between time and cost is not recognized in supply chain management, especially supplier assessment and selection. Therefore, it does not necessarily mean that a lower, respectively higher, price of materials leads to a longer, respectively shorter, lead time. Additionally, as it is trade-off, the other way around is valid as well. A longer, respectively shorter, lead time does not necessarily lead to a lower, respectively higher, price of materials.

5.2. Influence of strategy on supplier selection

Differences in the supplier selection at both organizations is analyzed by means of the different strategies defined by means of the model by Treacy and Wiersema (1997). Both organizations rate customer intimacy with moderate importance. Their preference for partnerships leads to this importance. However, customers are not the central point in the organization. Therefore, the importance is only moderate (Treacy and Wiersema, 1997).

Additionally, the first organization is typified as an organization pursuing operational excellence. Products have a long life cycle and, this leads to an efficient production process and the lowest possible production costs. Focus is expected on the lowest total price for their products. Organization two is pursuing product leadership. Innovation is real important, new products are developed regularly by the large internal R&D department. In this case focus is expected on producing the best products (Treacy and Wiersema, 1997).

Some results can be related to the described expectations and can be explained. First of all, organization one developed a calculation model for the total cost already including some parts of the element of time. In contrast, organization two does not always calculate the total cost and, even then only a part of the total cost are calculated. This result can be explained by the choice for operation excellence at the first organization.

Although the selection process is more developed at organization one, the assessment of supplier performances is better organized at the second organization. This can be explained by the importance of quality. With a strategy for operational excellence quality and, therewith, quality improvement, is less important than with product leadership.

The preceding two differences can be explained by means of the chosen strategies; however, another difference is hard to explain. For organization two, focus is expected on quality. Nevertheless, the quality department and quality as a criterion are only sporadically involved in decision making with regard to the supplier selection. On the other hand, quality is seen as a necessary criterion at the first organization. Logically, quality needs to meet certain standards. However, the higher importance for quality at organization one compared to organization two does not seem to be in line with the strategic choices that are made.

5.3. Optimal method

For both organizations, purchasing is of major importance for running their business. First of all 53 (organization one) and 70 percent (organization two) of parts are bought from suppliers. In addition, to source these parts, the organizations have supplier bases of respectively 165 and 150 active suppliers. With these figures in mind, it can be stated that supplier selection and the management of supplier relationships is necessary to optimize operations at the organization. Kannan and Tan (2002) underpin this statement by stressing the importance of supplier assessment and selection for buying organizations. González et al. (2004) add to this

by stating that supplier decisions are important aspects that need to be included in strategic processes because of the increasing importance of purchasing. Therefore, organizations also become more dependent on their suppliers. Because of this dependency, consequences of poor decision making become critical.

In the literature review, the information acquisition mode has been discussed. Both organizations revealed the usage of a mix between direct and indirect acquisition. In an optimal method, most information will be retrieved by means of direct acquisition. Indirect information should be treated with care because of possible dissembling by the supplier.

Additionally, four methods for supplier selection have been discussed: the cost-based method, weight-oriented method, analytic hierarchy process method, and the mathematical optimization method.

The cost-based method is, as its name reveals, only focused on costs. Therefore, this method is too limited to analyze potential suppliers. The same goes for the mathematical optimization. Each goal needs its own optimization process and subjective measures are not possible. AHP is useful for measuring objective and subjective aspects of a supplier, and multiple criteria are assessed. However, this method takes more time and is more complicated compared to the other methods. Finally, the weight-oriented method is not difficult to use, different criteria can be assessed and weights can be assigned by the organization itself.

A minor literature review has been executed to find out the most important methods for supplier selection. As the objective of this study is based on including the element of time and not studying all different methods, the analysis for choosing one of the methods is not more detailed. Furthermore, both organizations already use a weight-oriented method and continuing this path will make it easier to include the element of time. Additionally, both organizations seem to have difficulty in creating time for working with the optimal selection process. Therefore, focusing on an easier method will have more effect.

According to González et al. (2004), an optimal selection process is based on trade-offs between quality, cost and delivery performance. Both organizations revealed that logistic aspects as delivery reliability and quality need to be included in an optimal method. Looking at the philosophy of QRM, time needs to be included as well. Both organizations accept the importance of time and would like to add this aspect to the process. Additional aspects as costs and flexibility came forward from the literature review and are recognized within both organizations as well.

5.4. Creating support for using the element of time
After the previous two sections, the most important (general) elements of supplier assessment and selection are known and, in addition, it can be stated that the trade-off between time and cost is not present in this area of business. However, QRM stresses the importance of realizing the influence of time in organizational activities. By means of this section it will be identified what needs to be done before the element of time can be included effectively.

Different elements of the selection process are meaningful to look at with regard to including the element of time. Four stages are identified in the literature review: problem definition, choosing criteria, pre-qualification, and final selection. First of all, time can be used for the pre-qualification of suppliers. Secondly, the element of time can be included in the RFI and the audit. Finally, including the element of time in the calculation regarding the

total cost of ownership is possible. To define all these elements, aspects related to the element of time need to be included in contracts.

Within the pre-qualification, RFI and audit specific aspects related to time, for example additional hours needed to arrange deliveries, cannot be discussed. These elements of the selection process should focus on flexibility and speed of delivery by the supplier as aspects related to time.

Although the element of time can be included in several stages of the selection process, an improved performance is not necessarily achieved. Generally, two possibilities for improving performance are available: increasing turnover and decreasing cost. It can be stated that decreasing cost with a certain amount has a larger effect than increasing turnover with the same amount.

As can be concluded, decreasing cost has a larger effect on performance than increasing turnover. The total cost of ownership can only be decreased when all costs are considered in the selection process. Both organizations mentioned the need for financial support when changes in the selection method are made. Without this factual justification, management of the organizations will not accept using the element of time for selection of suppliers. Section 2.5 discussed the costs related to time. Costs are related to longer transport and higher risks. Additional costs occur because of repairing and speeding late orders. Besides, inventory will increase and time needed working on customer requests will increase as well.

These costs need to be included in the calculation regarding the total cost of ownership to get an optimal overview of the lowest total cost. Table 7 gives a simplified example of the calculation of the total cost including the element of time. The example is based on information received from the organizations. The influence of time on the total cost is shown by means of this example.

	Location		
	Netherlands	*Eastern-Europe*	*Asia*
Monthly demand (units)	2000	2000	2000
Cost per unit	€3.00	€2.70	€2.40
Average inventory (units)	325	2,100	6,300
Carrying cost (unit)	€0.01	€0.05	€0.14
Transport cost (unit)	€0.15	€0.41	€0.36
Other time related cost (unit)	€0.20	€0.40	€1.39
Total cost per unit	€3.36	€3.56	€4.29

Table 7: Sample calculation total cost of ownership

The cost per unit is the price that needs to be paid to the suppliers. The average inventory depends on the safety stock and order quantity. Safety stock will be higher when the lead time increases. Normally, the order quantity is higher when products are sourced in Eastern-Europe or Asia as then the lowest price can be agreed. Carrying costs are related to the inventory as these include cost covering storage, obsolescence and risks. Transport costs are only related to the base cost of transport. Costs because of air freight are found in the time related costs. In addition, travel and inspection cost, and all additional hours spend on the

order until delivery to customer takes place are mentioned as other time related cost. Only the cost per unit decreases when products are sourced from abroad; all other costs increase with the lead time necessary to deliver a product. Although a large negative difference in initial price exists, the total costs are the lowest for production in the Netherlands in this example.

To conclude, the element of time can be included in all stages of the selection process. Nevertheless, specific aspects are limited to the calculation of the total cost of ownership. Besides the, for the organizations necessary, financial support, creating support for changes in general is one of the most important aspects of the change process. However, as this change management does not fall within the boundaries of this study, a detailed guideline is not given. Lots of authors described the subject; Hayes (2010), and Oakland and Tanner (2007) are recommended for this subject. Furthermore, J. P. Kotter has written several books with regard to dealing with change.

5.5. Limitations
A number of limitations are connected to this study. First of all, a limited data set is used to analyze the trade-off between time and cost. A larger data set might lead to different results. However, the data set has been large enough to get reliable results with the used statistical tests.

Furthermore, the trade-off between time and cost is analyzed based on a number of parts. A difference has not been made between these products. Section 4.1.4. revealed the importance of different strategies at both organizations. A specific analysis based on the four types of products proposed by Kraljic (1983) might give other insights. As identifying the trade-off has only been a preceding element of the final goal, a more extensive analysis was not necessary.

In addition, only two organizations have been studied because of time limitations. A study with more organizations would have been more reliable. At these organizations only a limited number of people have been interviewed. Although the number of discussants is limited, the people interviewed represent the total organization. Furthermore, all discussants came up with similar situations and problems. Therefore, the discussed results are verified with multiple sources.

6. Conclusion
Before this study will be concluded by answering the research question; the results of all three sub questions will be recalled. Studying the first sub question revealed how decisions regarding supplier selection are currently made. Both organizations have an optimal procedure for selection, including an RFI and, an audit. The final selection is made based on the results of the audit. Differences in the selection process are explained by means of the strategic options by Treacy and Wiersema (1997). The choices for operational excellence and product leadership on the other hand have an influence on the process of supplier selection.

Two explainable results are found. Price calculations are more important with operational excellence. Supplier assessment and improvements are more developed at organizations pursuing product leadership. However, a third result seems to be odd. Quality is expected to be more important at the product leadership strategy. Nonetheless, the comparison between both organizations revealed that quality was more important at the organization that

chose for operational excellence.

Secondly, the trade-off between time and cost is analyzed and it can be concluded that the trade-off is not necessarily present in supply chain management.

The third sub question focused on including the element of time in supplier assessment and selection. The element can be included in several stages of the selection procedure. Including the element of time to calculation of the total cost of ownership will be the most effective. Requirements of suppliers regarding speed and flexibility can be defined in contracts; however, this will only be a first step. Making comparisons based on the total cost, including the element of time, will make an increase in performance possible.

This study revealed that including the element of time can lead to an increase in performance for the focal organization by means of decreasing cost. Before time can be included, two important prerequisites need to be met.

First of all, a right execution of the assessment and selection procedure seems to be problematic and happens only sporadic. Accurate routines and procedures need to be in place and need to be followed before time can be included, otherwise effectiveness cannot be guaranteed. Only in this case all stakeholders can be included.

Additionally, the selection process needs to be based on multiple criteria. Currently the organizations do not always include all important criteria. Only when this is secured, including the element of time will be interesting. Otherwise this criterion will never be included in practice.

After meeting these prerequisites, the element of time can be included. A number of general guidelines are created to help organizations with achieving an increase in performance by means of including the element of time.

First of all, the power of time needs to be realized. This study is executed to make the first step in this realization. Next, the financial support needs to be secured. This support can be created by analyzing all cost related to the order and calculating the total cost of ownership. The overview needs to be used in combination with the other criteria to select the best supplier.

Furthermore, all agreements with the supplier need to be recorded in contracts. Only this will make sure all agreements are known and can be pointed out to the supplier. These agreements are necessary for the following step as well: decreasing time and, therewith, costs were possible. Both improving current suppliers as selecting new suppliers should be a possibility.

Now that is discussed how including the element of time can lead to an increase in performance, this study can be rounded by returning to the tile and, therewith, stressing the importance of including the element of time in supplier assessment and selection for the final time.

As a final part of this study, the need for further research is identified. First of all, this study has been conducted in organizations already working on QRM in a make-to-order and engineer-to-order environment. These types of organizations are especially suitable for using QRM because of the importance of speed in deliveries. However, including organizations operating in different environments need to be studied as well.

Furthermore, the study has been rather limited in the number of organizations, number of discussants, and the data set. A larger study is important to verify the results and proposed

guidelines from this study.

In addition, a number of improvements have been discussed with regard to including the element of time in supplier selection. However, these changes have not been tested in practice. An extensive test in practice is necessary to identify the effects of all proposed changes.

Appendices

1. Case studies
By means of this section both studied organizations are described.

1.1. Organization 1: SPX
The first organization that is used for the case study is a manufacturer of all kinds of centrifugal pumps. This organization has its facility located in the northeast of the Netherlands. Again, the organization is part of an international group with its headquarters in the United States. The facility in the Netherlands is part of this group since 2006. By means of facilities in over 35 countries and 17,000 employees products are mainly sold in Europe, the Middle East and Africa. The products are mainly used in markets as food, dairy, beverage, biotechnology and pharmaceutics. On average 70 percent of the final product is bought. The facility in the Netherlands employs approximately 90 people and produces 5,000 pumps a year.

Currently, the organization has a supplier base of multiple hundreds of organizations. Parts are regularly ordered at 150 of these organizations. These suppliers are subdivided in tens of commodities. On average these organizations need three to six weeks to deliver. The group has created its own in-house supplier in India. This facility delivers a large amount of parts to all other facilities as outsourced activities are executed at this facility.

Quick Response Manufacturing is a familiar topic within the organization. However, it is only applied to the office environment. The products manufactured at the organization can also be defined as high variety and low volume. Certain parts require a substantial delivery lead time from the suppliers. Collaboration with these suppliers and decreasing this lead time can lead to advantages and an increased position on the market for the organization.

Currently, the aspects quality and price are important in general. However, because of differences between commodities, performance objectives have different levels of importance for each commodity. A standard level of quality is required at all times. Sometimes products need to be delivered within a day, so flexibility and time are important. In some cases price is more important and the cheapest suppliers are chosen. Attention is paid to multiple aspects; however, quality and logistic aspects are not used on the required level. A clear reasoning for choosing the cheapest parts is not difficult. Nevertheless, the reasoning for choosing suppliers with a higher price is more difficult, even though these might have the lowest total costs, is much harder and needs more attention.

1.2. Organization 2: Neopost Technologies
The second organization studied is a producer of machines for handling incoming and outgoing mail. All machines are focused on automating the mail process within all types of organizations. Machines for sorting, folding, and stamping are produced. For the production of a machine 1,500 to 6,000 parts are needed. The organization is located in the northwest of the Netherlands and is part of a worldwide organization which is market leader within Europe. Besides producing the different machines, additional activities are executed. Machines are developed and engineered, software solutions are delivered, and supporting services like consultancy and maintenance are part of the organization as well. Products and services are

delivered to more than 800,000 customers in 90 different countries. Main markets are the United States, England, France and Germany.

The organization in the Netherlands was founded in 1924 and has been a member of the worldwide group since 1992. The international group employs approximately 4,700 people; the organization in the Netherlands employs around 350 of them. At this location, parts are produced and final products are assembled. Facilities are located in England, France, the Netherlands and Hong Kong.

The different products that are made can be described as low volume and high variety. Orders are rather small and lots of different products can be delivered. In addition, multiple parts of the final products are bought from other organizations; approximately 53 percent of the final product is bought. The establishment of the organization in the Netherlands has a regular used supplier base of approximately 165 suppliers. Suppliers are based in Europe and Asia. All products and suppliers are subdivided in twenty commodities; each commodity is handled by a different purchaser. This purchaser can be stationed at one of the four facilities.

Up to this moment the main area of interest at the assessment and selection of suppliers is the price of the products. However, the organization identified that the lowest price does not always lead to the lowest costs. Currently, more and more attention is paid to Total Cost of Ownership. The final goal should be the lowest overall costs. Therefore, it is necessary to base the assessment and selection of suppliers on the combination of price, quality and flexibility. Support for decisions to be made is important within the organization.

2. Structure interviews

Number	Topic	Subtopic
1.	Personal details	• Who are you?
2.	Position at organization	• Job description • Responsibilities
3.	Introduction	• Short overview thesis
4.	Experiences	• Supplier assessment • Supplier selection
5.	Current situation	• Used methods and procedures • Measured aspects • By means of which parameters? • How is data retrieved from suppliers? • How and to what extent are results used for selection? • What does the decision making look like? (short term/partnerships) • What is going well/successes? • What can be improved?
6.	Needed elements of selection	• Which aspects are important? • By means of which parameters? • Can time be included or is current method perfect? • How should it be included? • Which support is necessary?
7.	Trade-off time and cost	• Explanation • Recognizable? • Describe case (what are the boundaries?) • Available information for analysis
8.	Desires/demand	• Additional demands • Points of interest
9.	Additional comments	• Anything to add?

References

Aaboen, L., Dubois, A. and Lind, F. (2012). Capturing processes in longitudinal multiple case studies. *Industrial Marketing Management*, Vol. 41:2, pp. 235-246.

Błaszczyk, T. and Nowak, M. (2009). The time-cost trade-off analysis in construction project using computer simulation and interactive procedure. *Technological and Economic Development of Economy*, Vol. 15:4, pp. 523-539.

de Boer, L., Labro, E. and Morlacchi, P. (2001). A review of methods supporting supplier selection. *European Journal of Purchasing and Supply Management*, Vol. 7:2, pp. 75-89.

Chen, S. P. and Tsai, M. J. (2011). Time–cost trade-off analysis of project networks in fuzzy environments. *European Journal of Operational Research*, Vol. 212:2, pp. 386-397.

Chen, Y. (2011). Structured methodology for supplier selection and evaluation in a supply Chain. *Information Sciences*, Vol. 181:9, pp. 1651-1670.

Corder, G. W. and Foreman, D. I. (2009). *Nonparametric Statistics for Non-Statisticians: A Step-by-Step Approach (1st ed.).* Hoboken: John Wiley and Sons Limited.

Cormican, K. and Cunningham, M. (2007). Supplier performance evaluation: lessons from a large multinational organisation. *Journal of Manufacturing Technology Management*, Vol. 18:4, pp. 352-366.

Feng, C., Liu, L. and Burns, S. A. (2000). Stochastic Construction Time-Cost Trade-Off Analysis. *Journal of Computing in Civil Engineering*, Vol. 14:2, pp. 117-126.

González, M. E., Quesada, G. and Mora Monge, C. A. (2004). Determining the importance of the supplier selection process in manufacturing: a case study. *International Journal of Physical Distribution & Logistics Management*, Vol. 34:6, pp. 492-504.

Handfield, R. B. and Pannesi, R. T. (1995). Antecedents of lead-time competitiveness in make-to-order manufacturing firms. *International Journal of Production Research*, Vol. 33:2, pp. 511-537.

Handfield, R., Walton, S. V., Sroufe, R. and Melnyk, S. A. (2002). Applying environmental criteria to supplier assessment: A study in the application of the Analytical Hierarchy Process. *European Journal of Operational Research*, Vol. 141:1, pp. 70-87.

Hayes, J. (2010). *The Theory and Practice of Change Management (3rd ed.)*. Basingstoke: Palgrave Macmillan Ltd.

Ho, W., Xu, X. and Dey, P. K. (2010). Multi-criteria decision making approaches for supplier evaluation and selection: A literature review. *European Journal of Operational Research*, Vol. 202:1, pp. 16-24.

Hong, G. H., Park, S. C., Jang, D. S. and Rho, H. M. (2005). An effective supplier selection method for constructing a competitive supply-relationship. *Expert Systems with Applications*, Vol. 28:4, pp. 629-639.

Kannan, V. R. and Tan, K. C. (2002). Supplier Selection and Assessment: Their Impact on Business Performance. *The Journal of Supply Chain Management: A Global Review of Purchasing and Supply*, Vol. 38:4, pp. 11-21.

Kingsman, B., Hendry, L., Mercer, A. and de Souza, A. (1996). Responding to customer enquiries in make-to-order companies: Problems and solutions. *International Journal of Production Economics*, Vol. 46-47, pp. 219-231.

Kraljic, P. (1983). Purchasing must become supply management. *Harvard Business Review*, Vol. 61:5, pp. 109-117.

Lee, E., Ha, S. and Kim, S. (2001). Supplier selection and management system considering relationships in supply chain management. *IEEE Transactions on Engineering Management*, Vol. 48:3, pp. 307-18.

Lee, M., Lee, Y. and Jeong, C. (2003). A high-quality-supplier selection model for supply chain management and ISO 9001 system. *Production Planning & Control,* Vol. 14:3, pp. 225-232.

Li, H. and Womer, K. (2012). Optimizing the supply chain configuration for make-to-order manufacturing. *European Journal of Operational Research*, Vol. 221:1, pp. 118-128.

Moe, N. B., Aurum, A. and Dybå, T. (2012). Challenges of shared decision-making: A multiple case study of agile software development. *Information and Software Technology,* Vol. 54:8, pp. 853-865.

Muralidharan, C., Anantharaman, N. and Deshmukh, S. G. (2002). A Multi-Criteria Group Decisionmaking Model for Supplier Rating. *The Journal of Supply Chain Management: A Global Review of Purchasing and Supply*, Vol. 38:4, pp. 22-33.

Oakland, J. S. and Tanner, S. (2007). Successful Change Management. *Total Quality Management*, Vol. 18:1-2, pp. 1-19.

Ohdar, R. and Ray, P. K. (2004). Performance measurement and evaluation of suppliers in supply chain: an evolutionary fuzzy-based approach. *Journal of Manufacturing Technology Management*, Vol. 15:8, pp. 723-734

Platts, K. W. and Song, N. (2010). Overseas sourcing decision – the total cost of sourcing from China. *Supply Chain Management: An International Journal,* Vol. 15:4, pp. 320-331.

Purdy, L. and Safayeni, F. (2000). Strategies for Supplier Evaluation: A Framework for Potential Advantages and Limitations. *IEEE Transactions On Engineering Management,* Vol. 47:4, pp. 435-443.

Slack N. and Lewis M. (2008). *Operations Strategy (2nd ed.)*. Harlow: Pearson Education Limited.

Suri, R., (1999). How Quick Response Manufacturing Takes the Wait Out. *Journal for Quality & Participation*, Vol. 22:3, pp. 46-49.

Suri, R. (2010). Going Beyond Lean: Focusing on time, not cost, can save your company a bundle. *Industrial Engineer*, April 2010, pp. 30-35.

Talluri, S. and Sarkis, J. (2002). A model for performance monitoring of suppliers. *International Journal of Production Research*, Vol. 40:16, pp. 4257-4269.

Treacy, M. and Wiersema, F. (1997). *The discipline of market leaders: Choose your customers, narrow your focus, dominate your market (2nd ed.).* New York: The Perseus Books Group.

Vanteddu, G., Chinnam, R. B. and Gushikin, O. (2011). Supply chain focus dependent supplier selection problem. *International Journal of Production Economics*, Vol. 129:1, pp. 204-216.

Wang, S., Chang, S. and Wang, R. (2009). Assessment of supplier performance based on product-development strategy by applying multi-granularity linguistic term sets. *Omega,* Vol. 37:1, pp. 215-226.

Wu, C., Barnes, D., Rosenberg, D. and Luo, X. (2009). An analytic network process-mixed integer multi-objective programming model for partner selection in agile supply chains. *Production Planning & Control,* Vol. 20:3, pp. 254-275.

Wu, C. and Barnes, D. (2011). A literature review of decision-making models and approaches for partner selection in agile supply chains. *Journal of Purchasing & Supply Management*, Vol. 17:4, pp. 256-274.

Yin, R. K. (2003). *Case Study Research: Design and Methods (3rd ed.).* London: SAGE Publications Inc.