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MASTER'S THESIS

Linking Supplier Development Programmes with Conformance Quality

- A Survey of Scania CV AB Suppliers

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Linking Supplier Development Programmes with Conformance Quality
A Survey of Scania CV AB Suppliers

A Master of Science Thesis within the area of Quality Management presented to the Department of Business Administration and Social Sciences at Luleå University of Technology, Luleå, Sweden and Scania CV AB, Södertälje, Sweden.

by
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The company in which you will improve most will be least expensive to you

- George Washington

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Anders Ekholm Sebastian K Pashaei

ABSTRACT

Title	Linking Supplier Development Programmes with Conformance Quality – A Survey of Scania CV AB Suppliers
Grant sponsor	Scania CV AB, Södertälje Sweden
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Purpose	The purpose of this Master's thesis is to contribute to previous research on supplier development and to gain further knowledge on how initiatives for supplier development affect conformance quality and the business of Original Equipment Manufacturers in the automotive industry.
Methodology	The study was conducted at the heavy truck and bus manufacturer Scania CV AB. Two primary methods where used during the research. Quantitative data was collected through a survey targeted to 161 first-tier automotive suppliers and qualitative data was obtained by interviews with representatives of high- and low-performing suppliers. Using structural equation modelling, three hypothesized models of the expected effects of Supplier Development Programmes were tested. After analysis of the collected data, significant contributors to supplier development were derived from the findings.
Conclusions	The main findings indicate that initiatives for Continuous Improvement have a significant and positive effect on conformance quality. Moreover, initiatives for Joint Action and Process Mapping are found to be significant contributors to supplier performance. Additionally, Scania is suggested to use a weighted Key Performance Indicator for supplier assessment, in addition to their current practice of assessing their suppliers based on the total number of quality reports.

SAMMANFATTNING

Titel
Linking Supplier Development Programmes with Conformance Quality – A Survey of Scania CV AB Suppliers

Uppdragsgivare
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Syfte
Syftet med detta examensarbete är att bidra till tidigare forskning inom leverantörsutveckling samt öka kunskapen om hur initiativ för leverantörsutveckling påverkar kvalitetsutfallet för originaldelstillverkare inom fordonsindustrin.

Metod
Examensarbetet gjordes vid lastbil- och busstillverkaren Scania CV AB. Två primära forskningsmetoder användes under arbetets gång. Kvantitativ data inhämtades genom en enkät som skickades till 161 av Scanias leverantörer. Vidare inhämtades kvalitativ data genom intervjuer med representanter för leverantörer som klassificerades som låg- respektive högpresterande. Genom strukturella ekvationsmodeller testades tre hypotetiska modeller över initiativ för leverantörsutveckling och de förväntade effekterna. Efter analys av insamlad data kunde signifikanta bidrag för leverantörsutveckling identifieras.

Slutsats
De huvudsakliga resultaten från detta examensarbete indikerar att initiativ för ständiga förbättringar har en signifikant och positiv effekt på kvalitetsutfallet. Vidare visade sig initiativ för samarbete och processkartläggning vara en signifikant bidragsgivare till leverantörens prestanda. Utöver detta, föreslås Scania att använda sig av viktade nyckeltal vid leverantörsbedömning som ett komplement till deras nuvarande metod som är baserad på det totala antalet kvalitetsrapporter.

ACRONYMS AND GLOSSARY

APQP	Advanced Product Quality Planning
AMOS 7	Statistical software package for structural equation modeling
CFA	Confirmatory Factor Analysis
EFA	Exploratory Factor Analysis
First-tier supplier	A supplier that invoices the customer for goods and services delivered
FMEA	Failure Mode and Effect Analysis
Fordism	Manufacturing philosophy that aims to achieve higher productivity by standardizing the output
KPI	Key Performance Indicator
OEM	Original Equipment Manufacturer
Pull production	Manufacturing system in which production is based on actual daily demand and where information flows from market to management
Push production	Manufacturing system in which production is based on a projected production plan and where information flow from management to the market
PPAP	Production Part Approval Process
RPA	Rapid Plant Assessment
SEM	Structural Equation Modeling
SDP	Supplier Development Programme
SPS	Scania Production System
SPSS 15.0	Statistical software package for the social sciences
SQA	Supplier Quality Assurance
eQuality report	eQuality reports are used at Scania to report and communicate supplier deviations

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1 Introduction

As the business environment becomes more competitive, supply chain management is recognized by top managers as key business drivers (Van Weele, 2006), and can be seen as a strategic tool for improvement of overall customer satisfaction, competitiveness and profitability according to Giunipero & Brand (1996).

Performance of suppliers is a crucial factor in the supply chain and directly affects the profitability and the ability of Original Equipment Manufacturers (OEMs) to satisfy the customers (Foster, 2001). As a response to this, and in combination with increasing competition, OEMs are forced to improve their relationships with their suppliers and initiate Supplier Development Programmes to improve supply chain performance and capabilities (Carr et al, 2008). The aim of these initiatives is to achieve higher product quality and lower total costs (Larsson, 1994).

According to Carr *et al.* (2008) there are several tools that buying organizations can use to improve their suppliers. As examples of these tools, Carr *et al.* (2008) mentions initiatives ranging from performance feedback, audits, sharing information and training, to changing the suppliers' operations. One initiative widely used by OEMs in the automotive industry is the use of the Production Part Approval Process (PPAP), which defines generic requirements for suppliers to fulfil in addition to quality standard QS9000 (now replaced with ISO/TS 16949). The purpose of the PPAP is to secure that all customer engineering records and specifications are understood by the supplier organizations and that the manufacturing process produces products within specification. (PPAP, 2006)

Like many other companies within the automotive industry, Scania CV AB (from now on referred to as Scania), one of the leading manufacturers of heavy trucks and buses, continuously works to improve their suppliers' production facilities as well as their own. To do so, Scania has a zero-defects vision and in addition to certificate standards such as ISO/TS 16949 and the requirement of PPAP, Scania uses a system for handling supplier deviations called the eQuality system. If a supplier receives an eQuality report from Scania, they are required to generate a short term action within 24 hours, securing all incoming goods to Scania. A long term action, guaranteeing that the specific deviation will not re-appear, is required within ten days. Thus, the eQuality system is used as an information and feedback system, as well as a system for identifying trends of increasing deviations. Urban Eriksson, Quality Assurance Manager at Scania, explains that increasing trends may lead to more frequent site visits at the supplier's premises, an increased number of supplier audits, direct involvement such as supplier training or, if options are limited, commercial decisions (i.e. switch supplier) to secure the quality of incoming goods.

After introduction of the eQuality system and PPAP in year 2001 and 2002 respectively, supplier deviations have greatly decreased according to Urban Eriksson. However, the use of eQuality reports as the basic source for evaluation of whether or not to execute Supplier Development Programmes leads to a re-active rather than a pro-active approach.

1.1 Problem definition

Foster (2001) states that for any company, suppliers are a key in satisfying the customer and Sánchez-Rodriguez *et al.* (2005) conclude that quality management and Supplier Development Programmes (SDPs) are fundamental factors for customer satisfaction. At Scania, about six years after the introduction of PPAP and the eQuality system, the quality improvement of products produced by their suppliers has stagnated, and as a response to this, a more pro-active method of supplier assessment and development is sought after.

Among other problems caused by the suppliers that may affect the business for OEMs on a daily basis, Wagner (2006) approaches the problem of poor quality with three possible actions:

1. Switch supplier
2. Integrate the needed product through in-house production
3. Deploy SDPs

Scania's zero-defects policy continuously challenges Scania and it's suppliers to increase productivity and reduce deviations. Consequently, actions that aim to enhance supplier performance and buyer-supplier relationships over time are of particular interest to reach the goal of zero defects. Thus, this Master's thesis aims to engage the OEM's point of view when actions 1 and 2 are not possible or wanted, and determine how different SDPs affect the business performance of OEMs.

1.2 Purpose

The purpose of this research is:

1. To contribute to prior research on the effects of Supplier Development Programmes initiated by OEMs
2. To describe how Supplier Development Programmes affect conformance quality as perceived by OEMs

1.3 Research delimitations

The delimitations of the research are as followed:

- The research is conducted at Scania and is consequently limited to Scania's first-tier suppliers
- To reduce inconsistency and make comparison between suppliers possible, only suppliers of direct material are considered in this research. Suppliers of indirect material, such as services, are not included
- To reduce cultural differences within the population used in this study, while at the same time reaching a large enough sample of suppliers, suppliers participating in this research are limited to suppliers active within the European region.

2 Scania overview

This chapter presents a brief introduction to Scania as an organization, and as a manufacturer of heavy trucks and buses. The study presented in this Master's thesis was conducted at Scania, and thus, the purpose of the following overview is to familiarize the reader with the company that has supported and facilitated the research of this Master's thesis.

2.1 Corporate profile

Scania was founded 1891 and has since then delivered more than one million trucks and buses globally. Today Scania is a manufacturer of heavy trucks, buses and industrial and marine engines. Moreover, Scania provides a wide range of service related products and financial services. Scania is present in over 100 countries and has around 35 000 employees. Manufacturing facilities are located in Europe and Latin America, and assembly plants are present in Africa, Asia and Europe. (Scania Web, 2008)

Scanias competitive strength is mainly based on the modular product system that allows the company to offer optimized vehicles to the customers. The idea with the modular system is to provide a carefully balanced number of main components with a standard interface. This results in greater flexibility and benefits for Scania's cross-functional product development and global production. The modular system enables Scania to have longer production runs and improve parts management while at the same time increasing customer satisfaction. Additionally, Scania is using standardized working methods to ensure high uniform quality. The company continuously improves the standardized working methods through discovering deviations, understanding them and finding long term solutions. (Scania Production System, 2007)

The modular product system and the standardized working methods are the basic principles of the Scania Production System. Heavily influenced by the success of Japanese manufacturing practices and the Toyota Production System in particular, the Scania Production System makes certain that philosophies, principles and priorities that govern Scania's working methods are the same, regardless of where production takes place. (Scania Web, 2008)

Lately Scania has been working continuously to integrate key suppliers into the operations of the organization. These suppliers are involved with the development of production processes in an earlier stage and are progressively integrated in the Scania Production System the same way as Scania's own units. (Scania Web, 2008)

3 Theoretical frame of reference

This chapter introduces the theoretical frame of reference that serves as a foundation for the research presented in this thesis report. The literature review carried out prior to the primary study presented in Chapter 4, focused predominantly on recent research papers on supplier development and best practice in the automotive industry since these topics are well explored. Examples of key words used in the search for relevant literature are "supplier development", "supplier performance", "plant performance", "best practice", "supplier evaluation", and "buyer-supplier relationship". Different keywords have also been used in combinations to create more accurate search strings. Search engines used during the literature review were Emerald Insight, Business Source Elite (Ebsco), Elsevier Science Direct and Google Scholar. Lastly, this chapter presents hypotheses drawn from the theory. The hypotheses are analyzed in chapter 0 and will be further discussed in chapters 7 and 8.

3.1 Lean production

In the middle of the 1980's, researchers at Massachusetts Institute of Technology (MIT) concluded that the auto industry in North America and Europe were still relying on techniques based on Henry Ford's mass-production system while loosing competitive advantage and market shares to the Japanese companies with their new set of ideas. To identify these ideas and techniques, a 5-year 5-million USD study was set up at the International Motor Vehicle Program at MIT. (Womack *et al.,* 1990)

The outcome of the study, today known as *Lean production,* is based on the Toyota Production System which was developed by Toyota as a response to that mass production, as practiced by Henry Ford, would never work in 1950's Japan (Womack *et al.* 1990). Contradictory to the western countries, Japan did not have any guest workers who could work for low wages. At the same time, the domestic market in Japan was tiny but demanded a wide range of vehicles to satisfy the consumers. Fordism was clearly not compatible with Japanese needs (ibid).

Womack & Jones (1996) argue that Lean production is a way to consistently do more with less. The intention is less human effort, less equipment, less time and less space, while coming closer to providing customers with what they want, when they want it (ibid). A similar description of Lean production is given by Sánchez & Pérez (2001) who explain the objectives as to increase productivity and shorten lead times while reducing costs and improving quality.

3.1.1 Lean thinking – the philosophy of Lean production

Womack & Jones (1996) describe lean thinking as the way to achieve a leaner organisation and a leaner production process. They summarise lean thinking in five principles: specify the *value of a product*, identify the *value stream* for each product, make *value flow* without interruptions, let customers *pull* the value from the producer and pursue *perfection*. Below follows a summary of the five principles:

Principle 1 - Specify the value of a product

Product value can only be determined by the customer. In consequence, a product is only meaningful when customer needs are satisfied at the right time and to the right price as specified by the customer. Lean thinking should therefore start with a precise definition of product value. Existing assets and technologies should be ignored and the focal point should be on customer value and strong product teams which can realize the required product. (Womack & Jones, 1996)

Principle 2 - Identify the value stream for each product

The value stream is defined as "all specific actions required for bringing a specific product to the hand of the customer". When identifying the value stream of a product an enormous amount of waste will be exposed. Value stream analysis will often identify that some actions unambiguously create value, that some actions do not create any value but is unavoidable with current technologies and production assets, and lastly, that some non value-adding actives can be completely avoided. The goal of this principle is to dredge away all waste throughout the value chain. (Womack & Jones, 1996)

Principle 3 - Make value flow without interruption

When all waste has been exposed and eliminated, the next step is to make value flow. Here, a shift from organizational categories, such as departments and functions, to value-creating processes, is crucial for letting value flow efficiently. This requires not just the creation of lean enterprises for each product, but also changes within the traditional firm's functions and careers, so that they can make a positive contribution to value creation. (Womack & Jones, 1996)

Principle 4 - Let customers pull the value from the producer

The first visible effect from turning from departments and batches to product teams and flow, is the ability to design, plan, schedule and produce on customer demand. In addition to developing new products in accordance to customer needs, Lean production allows adaptation of current products to shifting markets. All things considered, this means that production can now be customer based and products can be produced based on customer need. This is the idea of pull production. Contrary to the more traditional push production (e.g. Fordism), pull production leads to small batch sizes and high customer focus. (Womack & Jones, 1996)

Principle 5 - Pursue perfection

When all actions described above have been successfully implemented, the next step is to understand that there is no end to the process of reducing waste and offering customer value. The pursuit of perfection is Kaizen; Kaizen is the Japanese word for continuous improvement and firms that have this mindset can typically double productivity within three years and halve errors, inventory and lead times during the same period. (Womack & Jones, 1996)

3.2 Supplier assessment tools

The following sections present two different tools used by international OEMs to assess potential and current suppliers. The first tool, the Rapid Plant Assessment, mainly concerns assessment of plant leanness, whereas the second tool presented, Production Part Approval Process, takes on a more formalized approach with focus on documentation and process mapping.

3.2.1 Lean evaluation -The Rapid Plant Assessment process

The Rapid Plant Assessment (RPA) process developed by R. Eugene Goodson at Michigan Business School, is a tool which evaluates a plant's strengths and weaknesses. According to

Goodson (2002) the RPA process has been used by several companies, such as Lockheed Martin and Seagate Technologies, in their lean transformation journey. The RPA process is based on 11 categories which evaluate the leanness of the plant. These categories are:

- Customer satisfaction
- Safety, Environment and Order
- Visual Management System
- Scheduling System
- Use of Space, Movement of Materials and Product Line Flow
- Levels of Inventory and Work in Process
- Teamwork and Motivation
- Condition and Maintenance of Equipment and Tools
- Management of Complexity and Variability
- Supply Chain Integration
- Commitment to Quality

In addition to the general categories above, which are evaluated on a six-point scale, the RPA includes a questionnaire with 20 supplementary questions. The rating of these eleven categories and the score from the questionnaire will give a fairly accurate assessment on the plant's efficiency and leanness according to Goodson (2002). To view the full RPA Rating Sheet and the RPA Questionnaire readers are advised to view Goodson (2002).

3.2.2 The Production Part Approval Process

The Production Part Approval Process (PPAP) is developed by Auto Industry Action Group with the purpose of determining if all customer engineering design records and specification requirements are properly understood by the supplier. Furthermore, PPAP aims to secure that the manufacturing process has the potential to produce products consistently meeting these requirements at an actual production run at a quoted production rate. (PPAP, 2006)

PPAP Requirements

Suppliers should meet the specified requirements and results outside specifications will normally not be accepted for delivery to the customer. If any part specifications cannot be met, the supplier should document how they intend to solve the problem and contact the customer for approval. The supplier should have records as listed below for each part or family of parts: (PPAP, 2006)

1. Design Records
2. Authorized Engineering Change documents
3. Customer Engineering Approval
4. Design Failure Mode and Effects Aanalysis (Design FMEA)
5. Process Flow Diagrams
6. Process Failure Mode and Effects Analysis (Process FMEA)
7. Control Plan
8. Measurement System Analysis Studies
9. Dimensional Results
10. Records of Material/Performance Test Results
11. Initial Process Studies (i.e. capability study)
12. Qualified Laboratory Documentation

13. Appearance Approval Report
14. Sample Production Parts
15. Master Sample
16. Checking Aids
17. Customer-Specific Requirements
18. Part Submissions Warrant

Thus, the PPAP-procedure is highly standardized and focused on documentation (e.g Design records, Engineering Change documents, dimensional results etc.), the development of process charts that describe the manufacturing process and reduce the elements of risk (e.g. Design FMEA, Process Flow Diagram, Process FMEA and Control Plan) and techniques to reduce variability of process output (e.g. capability study and Measurement System Analysis). The PPAP requires all applicable documents to be available at any given time (PPAP, 2006), resulting in a comprehensive set of material that can be used for supplier assessment.

3.3 Supplier Development Programmes

Inspection, visits and evaluation of current or prospective suppliers are common procedures among buying firms. When these activities focus on training and improving the supplier, they are usually termed Supplier Development Programmes (SDPs) (Foster, 2001). There is considerable theoretical support for the connection between supplier development and enhancement of the buying firm's performance. Recent literature suggest a relationship between *supplier involvement* (Carr *et al.,* 2008; Li *et al.,* 2007; Krause *et al.,* 2007) as well as *supplier training* (Carr et al., 2008; Krause et al., 1997) and the supplier's operational performance. These findings suggest that direct involvement strategies of OEMs seem to be working as intended.

However, findings also suggest that high-performing plants practice *process management* to a greater extent than low-performing plants (Park *et al.,* 2001; Laugen *et al.,* 2005). Parallel to Lean thinking, as explained by Womack & Jones (1996), Park *et al.* (2001) explains process management as a way of reducing cycle time and continuously improving processes. Similarly, Laugen *et al.* (2005) mentions streamlining of processes and implementation of pull production as vehicles for process improvement.

Although there have been several studies on SDPs and their effect on quality and plant performance, different definitions of dependent variables and measures of SDPs make it difficult to draw any general conclusions. Table 1 gives an overview of selected literature and development programmes with a significant effect on supplier performance. The studies presented in Table 1 was selected as reference material in this Master's thesis based on the relevance of the used dependent variable (e.g. quality, plant performance, supplier performance etc.).

Table 1 Selection of literature and development programs with a positive impact on quality and/or plant performance

Development programs with a significant and positive impact on quality/performance*	Mapes *et al.* (2000)	Li *et al.* (2007)	Park *et al.* (2001)	Carr *et al.* (2008)	Laugen *et al.* (2005)	Krause *et al.* (2007)	Krause *et al.* (2000)	Krause & Ellram (1997)
Throughput time	x							
Process focus**	x		x		x			
Joint action/Supplier involvement**		x		x		x	x	x
Trust		x						
Employee satisfaction			x					
Supplier training**				x				x
Supplier-buyer communication				x				
Shared values						x		
Equipment productivity					x			
Environmental compatibility					x			
Supplier assessment/evaluation/feedback**							x	x
Supplier Incentives							x	
Supplier certification programmes								x
Recognition of achievements								x
Investment in supplier's operation								x

* Because of similar practices are named differently by different researchers, some names have been altered to give the reader a better overview
**Program mentioned by two or more authors

To further elaborate on previous findings (presented in Table 1), initiatives that were mentioned by two or more authors were chosen for further exploration. The following chapters will focus on initiatives that from now on are referred to as Process Focus, Communication and Feedback, Joint Action and Supplier Training.

3.4 Hypothesis development

This section of the report intends to further explain the four frequently mentioned concepts of SDPs identified in section 3.3. The concepts of *Process Focus*, *Communication and Feedback*, *Joint Action* and *Supplier Training* will be elaborated and subsequently, three competing models are presented that aim to explain quality conformance as affected by SDPs.

3.4.1 Process Focus

Process Focus is commonly mentioned in the literature as a catalyst for performance and quality. Park *et al.* (2001) state that high performing suppliers have greater emphasis on process management than low performing suppliers. In their study, Process Management is indicated by "use of statistical techniques", "reduction of cycle time", "process performance charts" and "continuous improvement". Mapes *et al.* (2000) conclude that high performing plants have lower levels of variability in process output and process time, as well as shorter throughput times. Moreover, the research of Mapes *et al.* (2000) also show significant evidence to support the hypothesis that high-performing plants operate with less stock of raw materials than low-performing plants. Laugen *et al.* (2005) provide further support for process focus as a method for performance and quality improvement, reporting Process Focus[1] and pull production as best practice.

Process Focus is also an integrated part of the PPAP procedure applied by Scania and other automotive manufacturers. The intention is to secure the manufacturing processes of their suppliers. Requirements such as Failure Mode and Effect Analysis (FMEA), Process Flow Diagrams and Control Plans are intended to map out, identify risks, and set up control points and action plans to reduce or eliminate potential failure in the manufacturing process (PPAP 2006). Goodson (2002) takes on a different and less formalized approach to process focus with the RPA process designed to rapidly evaluate supplier plant performance. The RPA focuses on plant leanness by assessment of visual management, product line flow and work in progress, among other things.

Since the concept of Process Focus is rather abstract, a common ground for different recommendations for assessment and development programs can be difficult to find. To allow for a more in-depth analysis, previous research together with the PPAP and the RPA can be categorized roughly into three separate factors:

Plant Leanness
Literature shows that high-performing plants are set apart from low-performers by lower levels of stock, streamlining of manufacturing processes and pull production (Laugen *et al.,* 2005; Mapes *et al.,* 2000). Focus on plant leanness to increase capability is also supported by several aspects of Goodson's RPA (e.g focus on work in progress, pull production etc.).

Continuous Improvement
Statistical techniques to reduce variance and efforts to reduce cycle time and increase manufacturing capacity are significant factors among high performing plants (Mapes *et al.,* 2000; Park *et al.,* 2001).

Process Mapping
Visual process performance charts are used by high performing suppliers according to Park *et al.* (2001) In addition, process mapping through process flow diagrams and Failure Mode and Effect Analysis is a substantial parts of the PPAP procedure used by automotive firms to asses existing and potential suppliers.

3.4.2 Communication and Feedback

Inter-firm communication is an important prerequisite for supplier development (Krause, 1999) and research suggest that successfully implemented SDPs include supplier assessment and certification, along with performance feedback (Krause & Ellram, 1997).

Prahinski & Benton (2004) address the issue of supplier evaluation and its effect on supplier performance in their study of 139 first-tier North American automotive suppliers. Even though no statistically significant correlation between inter-firm communication and supplier performance is found, the research shows strong evidence for the connection between formality, evaluation and feedback, and buyer-supplier relationships. Alike Prahinski &

[1] Process focus is defined by Laugen *et. al* (2005) as "restructuring the company's manufacturing processes and layout to obtain process focus and streamlining".

Benton (2004), Krause *et al*. (2000) found no direct linkage between feedback and supplier performance. However, a mediated impact model is suggested by Krause *et al*. (2000) where feedback via the buying firm's direct involvement (e.g. site visits and training of supplier's personnel) positively influences supplier performance. Nevertheless, Krause *et al*. (2000) argues that assessment and feedback are vital enablers of SDPs and suggest that assessment allows the supplier to trace its performance over time, thus providing the supplier with direction for process improvement.

3.4.3 Joint Action

Joint Action can be seen as cooperation between buyer and supplier. The shared goal is improvement of performance for both parties. Through Joint Action, a closer relationship between buyer and supplier is created (Li *et al.,* 2007) and when the supplier is involved in product development they acquire knowledge which can be utilized for increasing capabilities and reducing waste (Carr *et al.,* 2008). As a result, Joint Action has been shown to increase the overall operational performance (Li *et al.*, 2007; Carr *et al.*, 2008).

Additional initiatives that can be categorized as Joint Action are site visits and collaboration in reducing non-value adding activities. As part of a direct involvement strategy, site visits of the buying firm to the supplier's premises can lead to significant process improvement (Krause *et al.,* 2000; Krause *et al.*, 2007). Moreover, Li *et al.* (2007) argues that the success of Japanese manufacturers in producing products with high quality and low cost, to a large extent is an outcome of a successful linkage between product development and manufacturing. Joint action can be seen as an effort to establish this important link.

3.4.4 Supplier Training

The purpose of supplier training is to improve the supplier's performance and ensure that requirements of the buying firm are met. Much like Joint Action, Supplier Training gives the buyer and the supplier the opportunity to interact with each other. It is proposed by Li *et al.* (2007) that increased experience in working together may lead to a closer feedback loop and also reduce the risk of misinterpreted blue prints or other information communicated by the parties. In this report, Joint Action and Supplier Training are differentiated by that Supplier Training has the specific intention of training or educating the supplier.

Empirical research (Krause *et al.,* 2007; Carr *et al.,* 2008; Krause & Ellram, 1997) imply that training programs work as intended, and put forward that Supplier Training has a significant and positive impact on supplier performance (e.g. product quality, delivery time and reduction of cost). While Krause *et al.* (2007) and Carr *et al.* (2008) put emphasis on training in process improvement, Krause & Ellram (1997) also put forward the importance of more product-oriented education. Their study implicates that firms that report successfully implemented SDPs, also demonstrate a greater willingness to cooperate with their suppliers. One of the cooperative initiatives that set the successful group of firms apart from the less successful firms, is the extent to which they use site visits with the intent of educating their suppliers in how their specific product is used.

Apart from the knowledge explicitly intended to be transferred by Supplier Training initiatives, supplier training should also lead to increased buyer-supplier interaction with, as argued by Li *et al*. (2007), a closer feedback loop as a result. In conclusion, initiatives for Supplier Training seem to have several positives effects on the business of OEMs.

3.4.5 Direct Impact Model

Given the arguments presented above, a direct impact model is assumed to explain how different SDPs affect the outcome of quality conformance. No hierarchy of the initiatives is expected and each initiative is hypothesized to have a direct and positive impact on conformance quality. See Fig. 1 for a schematic view of the Direct Impact model.

The following hypotheses are suggested:

Hypothesis 1: Initiatives to improve Plant Leanness have a direct and positive impact on conformance quality
Hypothesis 2: Initiatives for Continuous Improvement have a direct and positive impact on conformance quality
Hypothesis 3: Process Mapping has a direct and positive impact on conformance quality
Hypothesis 4: Communication and Feedback have a direct and positive impact on conformance quality
Hypothesis 5: Initiatives for Joint Action have a direct and positive impact on conformance quality
Hypothesis 6: Initiatives for Supplier Training have a direct and positive impact on conformance quality

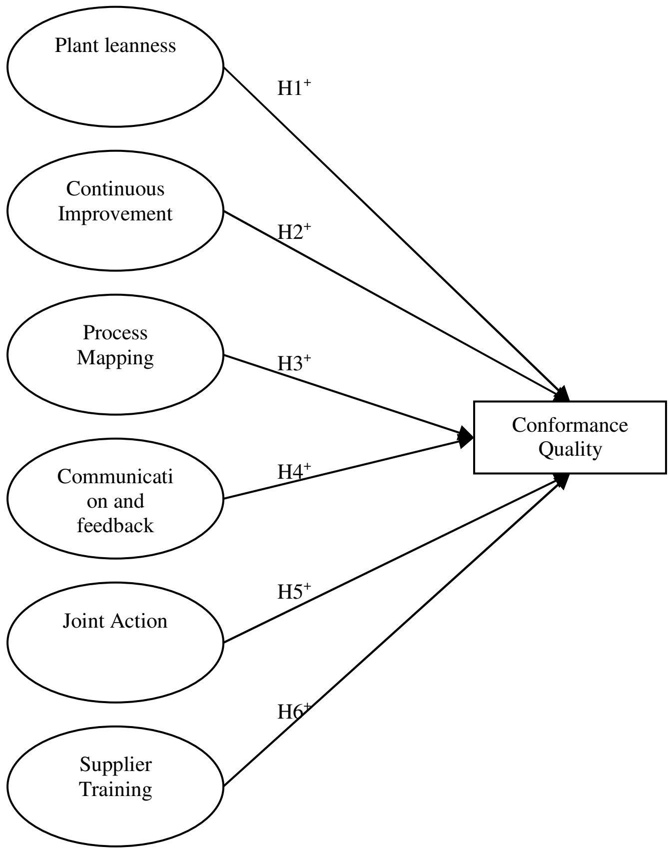

Fig. 1 Direct Impact Model

3.4.6 Mediated Impact Model A

In a study of effectiveness of strategies to improve supplier performance, Krause et al. (2000) propose a mediated model were only "Direct Involvement" (indicated by site visits and training of supplier's personnel) has a direct impact on supplier performance. Other factors studied by Krause et al. (2000), (e.g. "Supplier Incentives", "Competitive Pressure" and "Supplier Assessment") are found to have no direct impact on supplier performance. Instead, the impacts of these factors are found to be mediated by "Direct Involvement". With regards to this previous study, a mediated impact model (Fig. 2) is proposed were only initiatives managed by the supplier *at the supplier's* site have a direct impact on conformance quality. Other initiatives are assumed only to have an impact mediated by these "on-site initiatives".

The following hypotheses are suggested:
Hypothesis 7: Initiatives to improve Plant Leanness have a direct and positive impact on conformance quality
Hypothesis 8: Process Mapping has a direct and positive impact on conformance quality
Hypothesis 9: Initiatives for Continuous Improvement have a direct and positive impact on conformance quality
Hypothesis 10a: Communication and Feedback have a direct and positive impact on plant leanness
Hypothesis 10b: Communication and Feedback have a direct and positive impact on Process Mapping
Hypothesis 10c: Communication and Feedback have a direct and positive impact on Continuous Improvement
Hypothesis 11a: Initiatives for Joint Action have a direct and positive impact on Plant Leanness
Hypothesis 11b: Initiatives for Joint Action have a direct and positive impact on Continuous Improvement
Hypothesis 11c: Initiatives for Joint Action have a direct and positive impact on Process Mapping
Hypothesis 12a: Initiatives for Supplier Training have a direct and positive impact on Plant Leanness
Hypothesis 12b: Initiatives for Supplier Training have a direct and positive impact on Process Mapping
Hypothesis 12c: Initiatives for Supplier Training have a direct and positive impact on Continuous Improvement

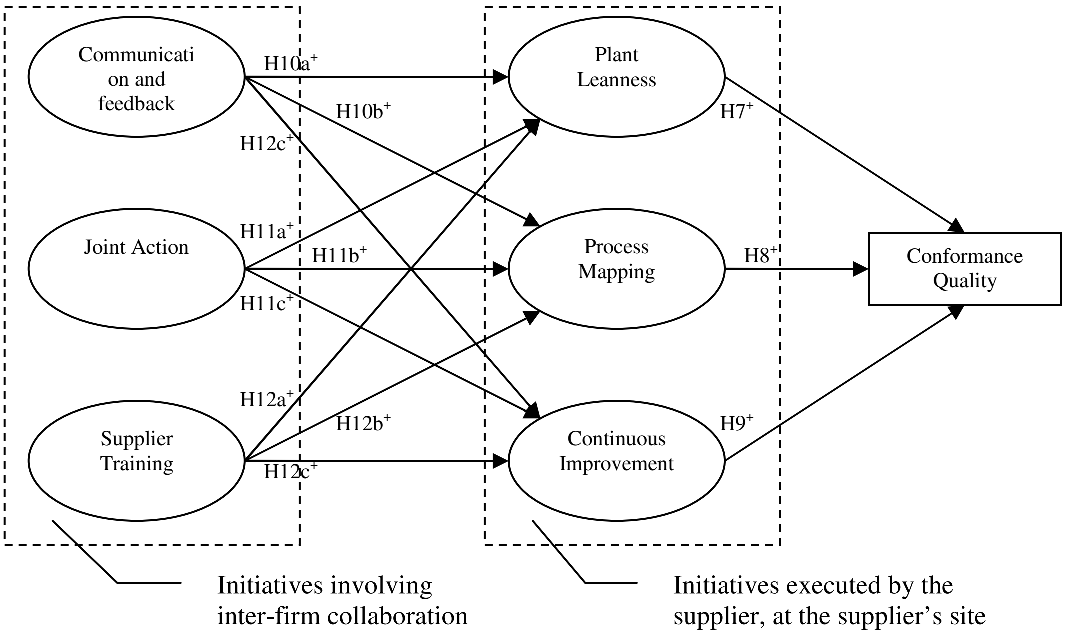

Fig. 2 Mediated Impact Model A

3.4.7 Mediated Impact Model B

Manufacturing processes are expected to be updated and improved continuously (APQP, 1995) and consequently documents requested by PPAP, such as Flow Diagrams, FMEAs, Control Plans and work instructions are to be considered as living documents. Particularly, the Control Plan should reflect the strategy of continuous improvement (APQP, 1995), and does so by incorporating a detailed plan over the manufacturing process with specified measurement techniques for critical characteristics and reaction plans that are executed if deviations occur. Subsequently, it can be expected that systematic Process Mapping may lead to improvement of plant efficiency and leanness as well as a greater emphasis on structured work for Continuous Improvement in general. The following hypothesized model (Fig. 3) proposes no direct effect of Process Mapping on Conformance Quality. However, it is suggested that Process Mapping has a positive influence on Plant Leanness and Continuous Improvement.

Hypothesis 13a: Process Mapping has a direct and positive impact on Plant Leanness
Hypothesis 13b: Process Mapping has a direct and positive effect on Continuous Improvement

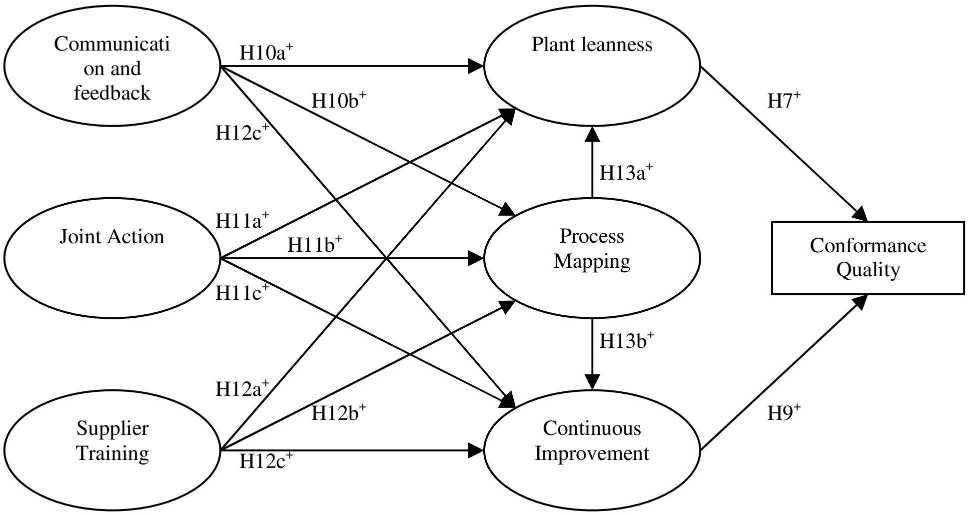

Fig. 3 Mediated Impact Model B

3.5 A brief introduction to Structural Equation Modeling

Statistical techniques are classified into univariate techniques and multivariate techniques. Univariate techniques refer to analysis with only one variable. Although several variables may be analysed using univariate techniques, each variable has to be analysed in isolation. In contrast, multivariate techniques allow the researcher to investigate relationships between two or more variables simultaneously (Malhotra, 2007). This section will give the reader an overview of multivariate techniques in general and give a brief, and non-mathematical, introduction to the special case of Structural Equation Modelling (SEM) in particular.

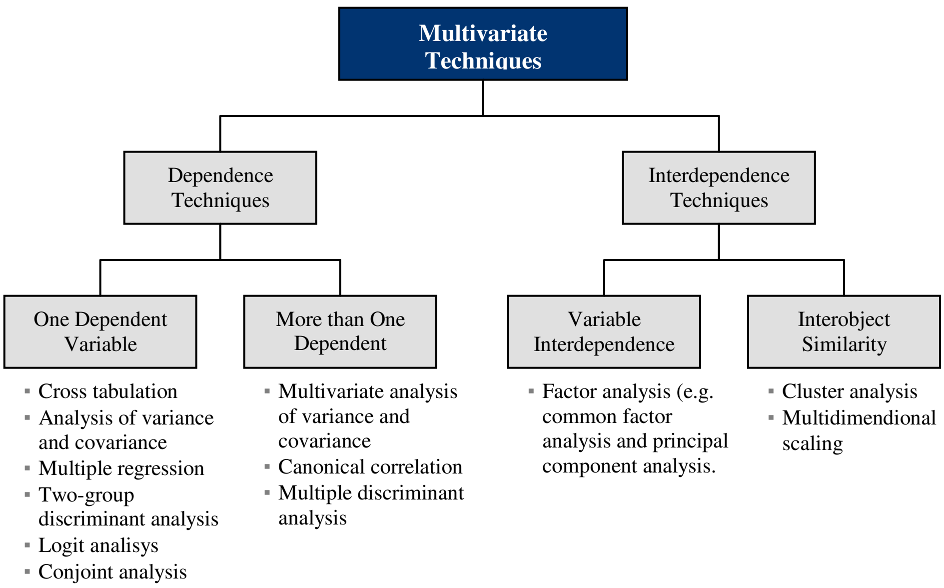

Fig. 4 Classification of Multivariate Techniques adapted from Malhotra (2007)

As seen in Fig. 4, multivariate statistical techniques can be classified into two major groups, dependence techniques and interdependence techniques. Dependence techniques are suitable when a single or multiple dependent variables can be identified. Interdependent techniques on the other hand, allow the researcher to investigate a whole set of relationships between variables without them being classified as dependent or independent. (Malhotra, 2007)

SEM is a technique that integrates both dependence techniques and interdependence techniques and take on a confirmatory rather than exploratory approach. This approach makes it particularly suitable for hypothesis testing. The hypothesized model is expressed mathematically or diagrammatically and is typically based on related theory and empirical research of the examined phenomena. The primary task of SEM is to impose a model on the sample data to test the plausibility of the hypothesis (Byrne, 2001). The model rarely fits the sample data perfectly, and hence, assessment of model fit is essential. Byrne (2001) explains the model-fitting process as,

Data = Model + Residual,

where Data is the observed sample data, Model is the model hypothesized by the researcher that aims to explain the sample data, and Residual is the discrepancy between observed data and hypothesized model.

Often researchers are interested in studying theoretical constructs and their relationships. A construct is an abstract phenomena that cannot be observed directly. Commonly, they are referred to as latent (unobserved) variables or factors. Given the nature of latent variables, they cannot be measured directly, and thus, the researcher must rely on observed variables that are thought to represent the underlying latent variable. The latent variable is accordingly thought to be the *cause* of the observed variables (also called indicators in SEM vocabulary). A frequently used method for investigating these types of relationships is Factor Analysis which is incorporated in the measurement model of the SEM approach. (Byrne, 2001)

In Fig. 5 a schematic representation of a general SEM-model can be seen. The path diagram represents a mathematical assumption of a set of equations that relates the dependent variables with their explanatory variables (Byrne, 2001). By convention, four different shapes are used when depicting SEM path diagrams. Elipses (or circles) represent latent variables (factors), rectangles represent observed variables, single-headed arrows represent impact of one variable on another variable, and double-headed arrows (not seen in Fig. 5) represent correlation or covariance between two variables. These four shapes are used by researchers to create four different basic configurations within a model. As described by Byrne (2001) these are: **(1)** "*Path coefficient for regression of an observed variable onto an unobserved latent variable (factor)"*, **(2)** *"Path coefficient for regression of one factor onto another factor"*, **(3)** "*Measurement error associated with an observed variable"* and **(4)** *"Residual error in the prediction of an unobserved factor"*. As noted by viewing these four basic configurations, structural equation models can be described as a series of regression equations representing the influence on one or several variables. As such, the SEM-model in Fig. 5 could also be described as six linear dependencies (Byrne, 2001):

MATH = MSC + residual
MSCIND1 = MSC + e1
MSCIND2 = MSC + e2
MSCIND3 = MSC + e3
MATHIND1 = MATH + e4
MATHIND2 = MATH + e5

Readers that are interested in further reading on SEM are advised to view Byrne (2001) and Kelloway (1998).

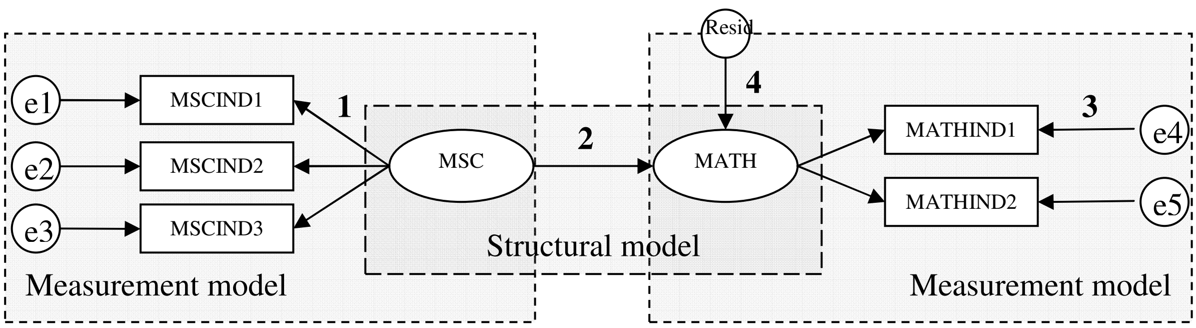

Fig. 5 General Structural Equation Model (figure adapted from Byrne 2001). **Circles** in the model represent measurement error **(e)** or residuals **(Resid.)**, **rectangles** indicate observed variables **ellipses** represent latent variables and **arrows** represent impact between variables

4 Methodology

The following chapter aims to introduce the reader to the research methodology of this report. The chapter starts with a general introduction to the research purpose and strategy approach of the study. After the introduction, two studies are presented: The survey and the interviews.

4.1 Introduction

Two research questions have been presented as the purpose of this Master's thesis:

1. To contribute to prior research on the effects of Supplier Development Programmes initiated by OEMs
2. To describe how Supplier Development Programmes affect conformance quality as perceived by OEMs

To answer the research questions as presented above, two primary methods where used. Quantitative data was collected through a survey targeted to 161 first tier automotive suppliers across Europe, and qualitative data was obtained by interviews with representatives of high- and low-performing suppliers in Sweden. To test the hypothesized models, SEM was applied to the collected data using SPSS 15.0 and AMOS 7. As suggested by Malhotra (2007), the qualitative study was conducted with the purpose to clarify and elaborate the quantitative findings.

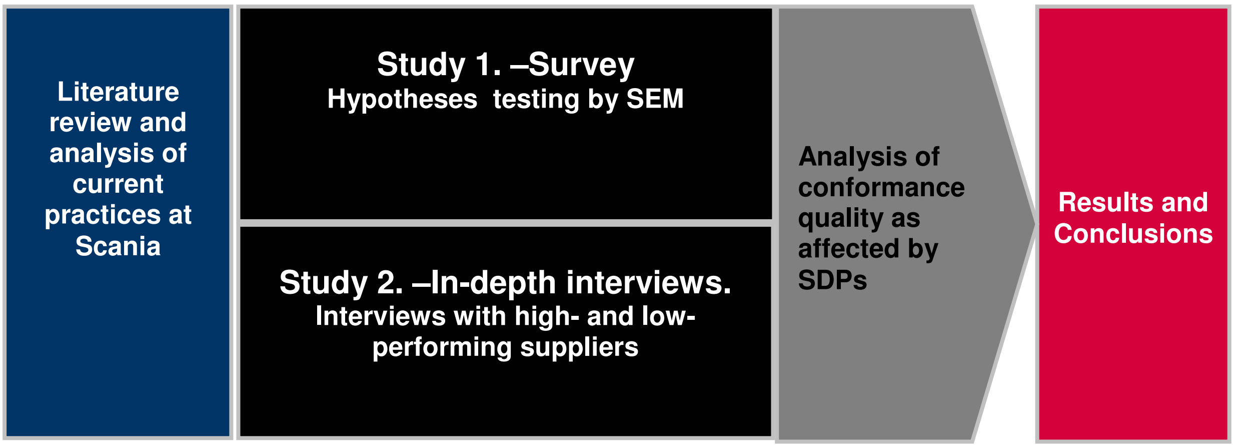

Fig. 6 Overview of research methodology

4.1.1 Research purpose

Zikmund (2000) claims that it is helpful to categorize research types into categories because of the existents of a variety research activities. Activities can be categorized based on their purposes by determining if the nature of the problem is exploratory, descriptive or explanatory. Marshall & Rossman (2006) describe the connection between research purpose and the categories as presented in Table 2.

Table 2 Categorization of research purposes, adapted from Marshall and Rossman (2006)

Exploratory	Explanatory	Descriptive
To investigate little-understood phenomena	To explain the patterns related to the phenomenon of study	To document and describe the phenomenon of interest
To identify or discover important categories of meaning	To identify plausible relationships shaping the phenomenon	
To generate hypotheses for further research		

According to Marshall & Rossman (2006), descriptive and exploratory studies describe complex circumstances which are not previously explored in the literature, for example many qualitative studies are descriptive or exploratory. On the other hand, Marshall & Rossman describe explanatory studies as having the purpose to study relationships between events and the meaning of the relationships. Zikmund (2000) argues that explanatory research is done when the researcher has prior knowledge about the research subject and the problem is narrowly defined.

This study aims to *explain* factors that have been identified by previous research as significant contributors to supplier performance. Moreover, the study aims to *explain* factors with a significant impact on conformance quality. Lastly, the research aims to *identify* plausible relationships among the factors and *describe* the outcome of initiatives for supplier development. This study can consequently be categorized as explanatory with descriptive elements.

4.1.2 Research approach

According to Neuman (2003) researchers can approach theories from two directions; deductive or inductive. A deductive approach begins with an abstract, logic relationship among concepts and tests it towards concrete empirical evidence, i.e. a specific case is explained by theory. In contrast, an inductive approach begins with detailed observations and move toward more abstract generalizations and ideas, that is, theory is constructed from empirical data. There is also a third approach according to Alvesson & Sköldberg (2008), who argue that by an abductive approach, it is possible to study empirical data prior to, or combined with, the study of theory.

The research approach of the thesis was split into two directions. To create the online-survey, which also served as an interview guide for the conducted interviews, literature and previous research were studied to gain knowledge and understanding on how SDPs affect supplier performance. Thus, theory was applied to empirical data and the approach was consequently deductive. Next, theory and empirical data where analyzed iteratively while applying Factor Analysis and Structural Equation Modeling to the data. Accordingly, the analysis can be regarded as abductive. In summary, the research approach can be classified as abductive with an initial deductive approach.

4.1.3 Research strategy

According to Denscombe (2003), approaches for research strategies are selected on the basis of the appropriateness for investigating a specific problem. Denscombe (2003) identifies five primary research strategies; survey, case study, experiment, action research and internet research. The choice of research strategies are discussed below.

For both the quantitative study (Study 1) and the qualitative study (Study 2) conducted during this Master's thesis, the survey strategy was selected. Denscombe (2003) argues that the survey approach has three characteristics:

- It gives a wide coverage
- It describes a specific point in time
- It often serves as starting point when conducting empirical research

Denscombe (2003) identifies several types of surveys; questionnaires, face-to-face interviews, telephone interviews, documents and observations, and argues that the benefit of questionnaire surveys is that researchers can cover wide geographic areas and reach a large-scale of respondents. Denscombe (2003) also put forward that online questionnaires enable the authors to contact the respondents for a low cost and receive the questionnaires in short time.

The quantitative survey (Study 1) conducted during this Master's thesis intended to reach 161 suppliers across Europe and the time-frame and the financial resources were limited. In view of that, the description made by Denscombe (2003) of online questionnaires matches the intentions of Study 1 well. Consequently an online questionnaire was chosen for Study 1.

The qualitative study (Study 2) was conducted as face-to-face interviews. According to Denscombe (2003) face-to-face interviews is as a way to receive more detailed data and validate other sources of data. Moreover, Denscombe (2003) argues that interviews allow the researcher to carefully select their potential respondents to fill necessary quotas. Prior to conducting the interviews of Study 2, the authors chose to select the interviewees based on the number of eQuality reports issued, giving the authors the possibility validate the results of Study 1 while bringing a more in-depth knowledge of SDPs to the study.

4.2 Study 1 –the survey

As the primary method for collecting data to test the hypothesized models (depicted in Fig. 1, 2 & 3), an online survey was conducted. The questionnaire was developed through literature review of existing research as a way of achieving content validity. Reviewed material dealt with the topic of supplier development and "best practice" of manufacturing firms. To further aid in the development of the survey, manuals for supplier assessment were used as a way of creating new, and prior to this study, untested constructs. The concept of constructs is further elaborated in chapter 4.2.1.

Apart from the initial literature review, further validation of content was achieved through frequent consultation of Supplier Quality Assurance Engineers at Scania. The questionnaire was also reviewed by our tutor Björn Kvarnström, and Sara Thorgren, PhD, students at Luleå University of Technology. The final questionnaire consisted out of 25 questions and can be seen in full in Appendix 1.

Prior to sending out the questionnaire to the targeted group, a pilot study was conducted with four respondents. The respondents included an industrial engineer and a group manager at Scania Foundry, and two project engineers at Scania Production Engineering Consulting. The respondents were asked to answer the questions while thinking out loud. During the pilot, suggestions for wording modifications as well as for reducing ambiguity in the questionnaire were collected. Minor language alterations were made after the pilot study.

To guarantee anonymity for the respondents towards Scania employees, Resolvia AB, a company specializing in conducting on-line surveys, was contracted to distribute the questionnaire. Together with the questionnaire, a cover letter (attached in Appendix 2), giving a brief introduction of the research and an explanation of how the respondents could benefit from the study, was sent to all respondents.

4.2.1 Variables

This section presents the different variables examined in the report. Conformance quality is presented as the observed dependent variable and the independent variables, as hypothesized in section 3.4, is presented as constructs indicated by several observed variables.

The dependent variable

Quality is a multifaceted word. As summarized by Montgomery (2005), the quality of a product can be described by eight different dimensions: performance, reliability, durability, serviceability, aesthetics, features, perceived quality, and conformance to standards. This research however, focuses on conformance to standards (in this report referred to as conformance quality) as a measurement of the suppliers' ability to produce a product according to the agreed specification. Furthermore, the focal point of the research is conformance quality as perceived by the customer, and hence, the number of quality reports issued towards the supplier by the customer is used as a measurement of conformance quality.

To adjust for the quantity delivered by each supplier and thus allow for comparison of supplier performance, Defects Per Million Opportunities (DPMO) is a frequently used KPI.

DPMO is calculated as

$$DPMO = \frac{1000.000 \times Number\ Of\ \ Defects}{Total\ Number\ Of\ \ Opportunities}. \tag{1}$$

However, at Scania quality deviations are handled not by the number of actual defective products, but by the number of eQuality reports issued towards the supplier. The eQuality reports does not consider the amount of defective products but the number of occasions that defective parts are found. That is, one eQuality report is issued for *every type of defect* revealed at a *given time*.

With regards to the current practices at Scania, an adjusted measurement based on the number of eQuality reports was used in this study: eQuality reports Per Million Opportunities, from now on referred to as eQPMO.

eQPMO was calculated as,

$$eQPMO = \frac{1000.000 \times eQ}{Quantity\ Delivered}, \qquad (2)$$

were eQ was the number of eQuality reports issued during a period of twelve months (November 2007 to October 2008) and quantity delivered was the quantity of products delivered during the same period.

Independent variables

The independent variables examined in the study comprise Plant Leanness, Continuous Improvement, Process Mapping, Joint Action, Supplier Training and Communication and Feedback. These variables are latent, meaning they cannot be assessed or measured directly, and as such, variables of this kind are often called constructs (DeVellis, 2003). In means of measuring constructs, scale items are used which are intended to reflect the underlying construct. Accordingly, the latent variable is presumed to be the *cause* of the item scores (ibid).

All items used in the questionnaire were presented as statements and the respondents were asked to respond to each statement on a five-point Likert scale. Seeing that a wide scale of possible responses is difficult to handle for the respondents because of the complexity of differentiating the response categories, Malhotra (2007) recommends a number of scale categories between five and nine. An odd numbered Likert scale for the questionnaire was chosen since a neutral position is assumed to be a possible response by some of the respondents. The choice of five response categories on the Likert scale, instead of seven or nine, was motivated since several items where combined to produce total scores for the respondents. As argued by Malhotra (2007), the approach of combining items into total scores makes five a sufficient number of categories.

Items of the individual variables were adapted from previous research studying SDPs and/or plant performance. In some cases, items were adopted from standards or manuals for supplier assessment. In Table 3, variables are presented with the indicators representing each construct.

Table 3 Constructs and their indicators

Construct		Indicator	Indicator adapted from
Plant Leanness	PLL1	Materials in our plant are moved short distances and only once, to following operation*	Goodson (2002)
	PLL2	Production materials are stored at line side rather than separate storages*	Goodson (2002)
	PLL3	Our inventory levels are always sized with respect to production rate*	Goodson (2002) & Mapes *et al*. (2000)
	PLL4	All tools and equipment at our plant are kept in their own unique place*	Goodson (2002)
	PLL5	Our plant uses pull production systems rather than push production*	Laugen *et al.*(2005)
Continuous Improvement	CON1	Reducing cycle time/increasing manufacturing capacity is a priority for all our processes*	Park *et al.* (2001)
	CON2	All factory workers at our plant participate in continuous improvement of our products/processes*	Goodson (2002))
	CON3	We make extensive use of statistical techniques to reduce variance in quality (e.g. Statistical Process Control, capability studies, Measurement System Analysis etc.)*	Park *et al.* (2001)
	CON4	Preventative maintenance is scheduled and performed regularly for all checking aids used in our plant*	Goodson (2002)
Process Mapping	PRM1	Updated Process Flow Diagram is available for all processes*	PPAP (2006) and Goodson (2002)
	PRM2	Updated Failure Mode and Effects Analysis is available for all processes*	PPAP (2006)
	PRM3	Updated Control Plan is available for all processes*	PPAP (2006) and Goodson (2002)
	PRM4	All work areas in our plant have updated and visible work instructions on the shop floor*	Goodson (2002)
Communication and Feedback	CON1	We are frequently informed by our customers of our performance (quality, delivery, cost, etc)*	Krause et al. (2000), Krause et al. (1999) and Prahinski & Benton (2004)
	CON2	We frequently inform our customers of our performance (quality, delivery, cost etc)*	Krause (1999)
	CON3	We keep a record of, and frequently follow up, customer satisfaction*	Goodson (2002)
	CON4	Our firm can easily approach our customers for discussion regarding ideas for process performance*	Prahinski & Benton (2004) and Krause (1999)
Joint Action	JNT1	Our plant is visited by our customers**	Krause *et al.* (2007), and Krause (1999)
	JNT2	We are involved with our customers in new product design**	Li *et al.* (2007), and Park *et al.* (2001)
	JNT3	We are involved with our customers in development of existing products**	Li *et al.* (2007)
	JNT4	We collaborate with our customers to eliminate non-value adding activities**	Li *et al.* (2007)
Supplier Training	TRN1	Employees at our production line participate in training by our customers**	Krause *et al.* (2007), Park *et al.* (2001) and Krause (1999)
	TRN2	Managers in our company participate in training by our customers**	Krause *et al.* (2007), Park *et al.* (2001) and Krause (1999)
	TRN3	Employees in our organization receive training to increase productivity in our plant (e.g. Lean Production, Six Sigma, TQM etc.)**	Krause *et al.* (2007) and Park *et al.* (2001)
	TRN4	Personnel at our plant are invited to our customers' sites to increase awareness of how our products are used**	Krause & Ellram (1997)

*Measured by strength of agreement: 1 = *Strongly disagree*, 2 = *Disagree*, 3 = *Neither agree nor disagree*, 4 = *Agree*, 5 = *Strongly agree*
**Measured by level of involvement: 1 = *Never*, 2 = *Seldom*, 3 = *Sometimes*, 4 = *Often*, 5 = *Very often*

4.2.2 Sample

The survey was sent to 161 of Scania's first tier suppliers. To make comparison between different suppliers possible, all participants in the survey where hand-picked by Quality Assurance Engineers at Scania. Thus, the sample can be categorized as a subjective sample. Choosing a subjective sample is an alternative when the researcher has prior knowledge of the researched phenomena, allowing the researcher to choose the respondents he or she believes will provide the most information (Denscombe, 2000).

Suppliers from three different commodities where selected: Sheet Metal, Machining and Casting and Forging. Suppliers within these commodities can be regarded as relatively comparable in the sense that there is no, or very light, assembling involved, electronics is not included and the complexity of manufacturing is relatively low. The targeted group was further limited to exclude Casting and Forging suppliers delivering raw material. That is, the targeted group does not include suppliers delivering casting goods that has not been machined prior to delivery to Scania. This exemption was made seeing as a lot of defects caused by the casting procedure are found during machining. Consequently, allowing these suppliers to participate in the study would most likely distort the data.

To increase reliability the survey was targeted mainly to quality engineers and quality managers. In some cases, no such contact could be found, and the survey was sent to account managers or sales managers. However, all targeted respondents are contact persons to Scania's Quality Assurance Engineers, meaning they are involved in the PPAP-procedure and should have knowledge of manufacturing processes and methods for quality assurance.

Out of the total 161 questionnaires, 77 usable questionnaires were returned, leading to an effective response rate of 47, 8 %.

4.2.3 Method of analysis

Analysis was performed by computer software SPSS 15.0 and AMOS 7. To test and evaluate the proposed direct and indirect models, SEM was applied to the collected data.

Prior to conducting SEM an initial Exploratory Factor Analysis (EFA) of the 77 returned questionnaires was performed in order to assess the validity of the constructs presented in section 4.2.1. The aim of the EFA was to purify the measurement model and make sure that each item in the questionnaire loaded properly on the hypothesized latent variable (i.e. factor loadings are the correlation between items and latent variables). An iterative approach was used to determine which items to exclude. As suggested by Costello and Osborne (2005), items were excluded based on low factor loadings (cut-off for minimal loading set to 0.5) and cross-loadings (loads at 0,32 or higher on two or more factors). Since the conducted EFA was not exploratory in its purest form (the constructs had already been put together and the intent was indeed confirmatory), theoretical determination, as suggested by Anderson & Gerbing (1988), was also considered.

A crucial part of SEM is the evaluation of how well a hypothesized model describes the empirical data (Byrne, 2001). There is no single statistical significance test that can identify a correct model, and hence, evaluation of goodness of fit should be based on several criteria that assess the model in different perspectives (ibid). A large variety of goodness-of-fit indices are available for this purpose. However, different indices may indicate different levels of model fit, which can lead to conflicting conclusions, resulting in a problematic issue regarding the choice of what indices to report. Schermelleh-Engel *et al.* (2003) take on the issue of goodness-of-fit indices and presents an adequate selection of recommended fit indices. Recommendations are based on robustness to non-normality and sample size, as well as sensitivity towards model misspecification. Below follows short descriptions of the indices used during this study as recommended by Schermelleh-Engel *et al.* (2003). Interested readers are recommended to view the full paper by Schermelleh-Engel *et al.* (2003) for full definitions and further explanation of the respective indices.

Chi-square

The Chi-square test statistic is used for evaluation of overall model fit. The test is constructed to evaluate whether the population covariance matrix Σ (indicated by the *sample* covariance matrix S since the population matrix Σ is unknown to the researcher) is equal to the covariance matrix Σ(θ) implied by the model.

The null-hypothesis is consequently:

$$H0: \Sigma - \Sigma(\theta) = 0 \qquad (3)$$

The Chi-square statistic is highly sensitive to sample size. As sample size increases, all other things being equal, the statistic grows. This leads to the possibility of rejection of a plausible model due to a significant Chi-square even though the discrepancy between model-implied covariance matrix and the sample is very low. Likewise, as sample size decreases the chi-square statistic decreases. The researcher might consequently be deceived into accepting a model even though there is considerable discrepancy between the model-implied covariance matrix and the sample. To adjust for sensitivity to sample size, Chi-square/df (Chi-square divided by the degrees of freedom) is proposed to be used as an additional index. The number of degrees of freedom is calculated as

$$df = s - t, \qquad (4)$$

where s is the number of nonredundant elements in S, and t is the number of parameters estimated.

No absolute standards exist for this index, but a rule of thumb is that Chi-square/df should have a maximum ratio of between 2 to 3. (Schermelleh-Engel *et al.,* 2003)

Root Mean Square Error of Approximation (RMSEA)

Due to the limitations of the Chi-square statistic (as described above), RMSEA has been developed to replace the exact-fit criteria of chi-square, with a null-hypothesis of “close fit”. RMSEA is considered relatively independent of sample size and is a measure of approximate fit. (Schermelleh-Engel *et al.,* 2003)

Root Mean Square (RMR) and Standardized Root Mean Square Residual (SRMR)

The Root Mean Square Residual (RMR) is based on the residuals between S and Σ(θ) (i.e. S - Σ(θ)). Since these residuals are scale dependent, the scales of the variables has to be taken into account when RMR is evaluated. To overcome this problem SRMR is based on a standardized residual matrix, i.e. the residuals are divided by the standard deviation of the manifest variables (the elements of the empirical covariance matrix S) to allow for easier interpretation. When SRMR signalises poor fit, the matrix of absolute residual values (provided by the SEM software) can be helpful to find the source of misfit. Generally absolute values of residuals greater than 1.96 or 2.58 are said to indicate poor fit. (Schermelleh-Engel *et al.,* 2003)

Nonnormed Fit Index (NNFI)
NNFI (reported as Tucker-Lewis Index, TLI, by AMOS 7) is a comparison index by which the model of interest is compared to a baseline model. Usually, the independence model (i.e. a model where all variables are assumed to be measured without error, variables are uncorrelated and factor loadings are set to one) is used as baseline model. Fit-indices for baseline models typically indicate poor fit and they serve only as comparison to see whether or not the hypothesized model is an improvement. (Schermelleh-Engel *et al.,* 2003)

NNFI is based on the Normed Fit Index (NFI) which compares the Chi-square index of the model of interest with the Chi-square index of the independence model. NFI ranges from zero to one, where zero indicates same Chi-square for both models, and one indicates perfect fit of the hypothesized model. Analogous to Chi-square, NFI is very sensitive to sample size and as a consequence to this, NNFI has been developed to compensate for this inadequacy. By taking the degrees of freedom in consideration, NNFI is less sensitive to sample size and will also reward parsimonious models by increase of fit index. Seeing that NNFI is not normed, the index may sometimes leave the normal range between zero and one. (Schermelleh-Engel *et al.,* 2003)

Comparative Fit Index (CFI)
CFI is yet another index based on the Chi-square statistic and, alike NNFI, CFI is also a comparison index. The index ranges from zero to one and is less affected by sample size than NNFI. (Schermelleh-Engel *et al.,* 2003)

Table 4 Table adapted from Schermelleh-Engel *et al* (2003)

Fit measure	Criterion*
Level of significance of Chi-square (p-value)	≥0.05
Chi-square/df	≤3
RMSEA	<0.8
SRMR	<0.1
NNFI	≥0.9
CFI	≥0.9

* Criterion for p-value as reported by Li *et al.* (2007), Carr *et al.*(2008) and Schermelleh-Engel *et al.* (2003), criterion for Chi-square/df and CFI as reported by Prahinski & Benton (2004), Li *et al.* (2007), Krause *et al.* (2000) and Carr *et al.*(2008), criterion for RMSEA as reported by Prahinski & Benton (2004), Li *et al.* (2007), and Carr *et al.*(2008), criterion for SRMR as reported by Schermelleh-Engel *et al.* (2003), criterion for NNFI as reported by Prahinski & Benton (2004), Li *et al.* (2007) and Carr *et al.*(2008)

4.2.4 Reliability and validity of the survey instrument

Here, *reliability* refers to the degree of consistent results produced by a scale (i.e. the items indicating each factor) intended to measure an underlying construct. A strong relationship between items and their latent variable imply a strong correlation between the individual items of a specific construct (DeVellis, 2003). Chong (2001) mentions three different tests by which reliability can be evaluated; Cronbach's Alpha, Kuder Richardson's Formula and Split-

Half Reliability Coefficient. Calculation of Cronbach's Alpha is recommended by Chong (2001) because of two distinct reasons:

1. In contrast to Kuder Richardson's Formula, Chronbach's Alpha can be used for binary data as well as large scale data. Kuder Richardson's Formula is intended for binary data only.
2. Split-Half requires one test to be treated as two tests. The resulting coefficient is the correlation between the two subsets and may consequently differ depending on how the initial test is divided.

In agreement with Chong (2001), Malhotra (2007) proposes Cronbach's Alpha as a way of overcoming the problematic approach of Split-Half. Cronbach's Alpha is a measure of squared correlation between scale items and is the average of all possible Split-Half Coefficients. The coefficient can vary from 0 to 1. A high value indicates strong correlation, and generally, a value below 0.6 indicates unsatisfactory reliability. (Malhotra, 2007)

As suggested by Chong (2001) and Malhotra (2007), Cronbach's Alpha was calculated during the research as a measurement of reliability of the measurement scales.

Whereas reliability concerns consistency among items, *validity* concerns the intended interpretation of the items; do the items really measure what they purport to measure? To take on this issue, Supplier Quality Engineers at Scania were consulted during the development of the questionnaire and each item incorporated in the questionnaire was included on the basis of previous research and/or supplier assessment tools. The intention of this procedure was to find previously tested constructs and adapt them to suit the purpose of this report. Additionally and as previously mentioned, an initial EFA was also conducted to assure that all indicators loaded properly on the intended factors.

4.3 Study 2 –the interviews

The secondary method of collecting data was performed through interviews. According to Yin (2003) interviews are one of the most important sources of gathering information and Denscombe (2003) argues that interviews are appropriate when the researcher wants a more in-depth insight to the topic. In addition, Denscombe (2003) claim that interviews is a way to supplement quantitative data by adding detail and depth and argues that interviews are appropriate to prepare for a questionnaire, follow-up a questionnaire or for triangulation with other methods.

The authors of the thesis decided to perform two interviews to complement the quantitative survey and gain an in-depth knowledge of supplier development and "best practice" of manufacturing firms. The interviews were done to follow-up the questionnaire, which by Denscombe, is described as a suitable approach when a questionnaire have thrown up some interesting lines. By conducting interviews the researchers can pursue these new lines in greater detail and depth. The interviews were consequently conducted using the questionnaire as an interview guide.

4.3.1 Selecting the suppliers

The respondents were picked from Scania's first tier suppliers within the Sheet Metal commodity with respect to the number of eQuality reports issued during a 12 months period

(Nov. 2007 – Oct. 2008). With the assistance of Supplier Quality Assurance Engineers at Scania, two respondents representing low-performing suppliers and two suppliers representing high-performing suppliers were initially picked out for interviews. However, a setback occurred because of temporary problems, partially due to the current financial crisis that has negatively affected large parts of the automotive industry, resulting in the cancellation of two of the interviews. Consequently one interview was conducted with a low-performing supplier and one interview was conducted with a high-performing supplier.

4.3.2 Conducting the interviews

The selected suppliers were contacted 3-4 weeks prior the interviews were the authors explained the aim of the thesis and the context of the planned interviews. Both suppliers recalled our study because of the questionnaire and cover letter which had been sent out prior to the interviews and were willing to take part in our study.

The interviews were conducted at the suppliers' location in a semi-structured way. According to Denscombe (2003) there are several interview methods, such as structured, semi-structured, unstructured, one-to-one, focus and group interviews. Denscombe describe semi-structured interviews as having a clear list of questions to be answered, but at the same time, the interviewer is prepared to be flexible and let the interviewee develop ideas and speak more widely on the issue raised by the researcher.

The authors decided to conduct the two interviews with Quality Managers because of their knowledge and familiarity of the research topic. However, in both cases the interviewees received some additional help from other employees who had deeper knowledge of some specific areas. The interviews were recorded to increase the accuracy of the data and was consequently summarized and analyzed in a later stage.

By conducting face-to-face interviews the authors also had the opportunity to make direct observations which is useful for providing additional information on the research topic (Yin 2003).

4.3.3 Reliability and validity of the interviews

To evaluate the quality of the research design, Denscombe (2003) argues that there are two tests which can be made, reliability and validity. According to Denscombe reliability means that the research instrument produces the same data time after time on each occasion it is used, and that any variation in the results obtained by the instrument is due entirely to chance. Furthermore, he explains validity as whether or not the data and methods reflect the truth, reality and cover crucial matters.

To increase the reliability, the authors recorded the interviews and listened to them several times and discussed the contents to eliminate misunderstandings and personal values. In addition, direct observations and other impressions were discussed and handled directly after the interviews to limit that any information got lost or was distorted.

To increase validity, the targeted interviewees were quality managers with knowledge of quality assurance and lean production. Moreover, the questionnaire, which served as an interview, guide was developed and tested internally at Scania several times to decrease any ambiguous and irrelevant questions. Additionally, the suppliers were promised anonymity to increase the truth in their answers which also should increase validity.

5 Study 1 – The Survey

This chapter presents the empirical data and analysis of the survey that was conducted to explore the effects of Supplier Development Programmes. First, Exploratory Factor Analysis (EFA) with principal components and varimax rotation was done on the survey data. Eight indicators were dropped as a result of poor factor loadings. Next, Confirmatory Factor Analysis was performed to validate the EFA results and the three competing models (presented in chapter 3.4) were assessed using Structural Equation Modeling (SEM). Lastly, the best fitting model was used to test the hypotheses presented earlier in this report. The analysis presented in this chapter was performed using SPSS 15.0 and AMOS 7.

5.1.1 Empirical data

In Table 5, the descriptive statistics of the empirical data can be viewed. To view the full correlation matrix of the collected data readers are advised to Appendix 3.

Table 5 Descriptive statistics of empirical data

	Mean	Std. Deviation	N
PLL1	3,4416	,97998	77
PLL2	3,1558	1,03955	77
PLL3	3,8701	,73181	77
PLL4	4,1558	,70831	77
PLL5	3,5065	,78846	77
CON1	4,1299	,67572	77
CON2	3,8571	,73832	77
CON3	3,9610	,75117	77
CON4	4,1299	,74957	77
PRM1	4,1169	,84252	77
PRM2	4,0130	,73437	77
PRM3	4,2857	,64598	77
PRM4	4,1579	,80088	76
COM1	3,8442	,88948	77
COM2	3,3636	1,02481	77
COM3	4,1039	,64040	77
COM4	3,9091	,89121	77
JNT1	3,6234	,74408	77
JNT2	3,5844	,97806	77
JNT3	3,5844	,87885	77
JNT4	3,4026	,84697	77
TRN1	1,9221	,70274	77
TRN2	2,2727	,64147	77
TRN3	3,1169	,88814	77
TRN4	2,8052	,84354	77

5.2 Evaluating the measurement model

The measurement model specifies the connection between latent variables and the observed indicators that were measured with the survey instrument. To examine the proposed indicators and their latent variables Exploratory Factor Analysis (EFA) was used to assess the appropriateness of the constructs. The purpose was to exclude or, if necessary, respecify indicators with cross-loadings, low factor loadings or poor theoretical relevance. After EFA, the reliability of each measurement scale (i.e. the indicators used to measure the underlying latent variables) was assessed, and finally, Confirmatory Factor Analysis (CFA) of the proposed measurement model was conducted.

5.2.1 Exploratory Factor Analysis

Purification of the measurement model was done with EFA to make sure that all indicators loaded properly on their respective latent variable. In accordance with the recommendations of Costello & Osborne (2005), items were excluded based on low factor loadings, cross loadings and theoretical relevance. Out of the 25 suggested items used in the questionnaire, 8 items were eliminated during three separate runs of EFA. During the first run, items CON1, PRM4, PLL4 and CON4 loaded on factors with poor theoretical relevance and were consequently removed. While performing the second run of EFA, items PLL3 and PLL5 were noted as problematic and were excluded on the basis of theoretical relevance and multiple cross-loadings. During the third run TRN3 was removed due to low factor loadings in combination with cross-loadings. In addition, COM2 was removed as a result of cross-loadings and theoretical relevance. The final rotated component matrix can bee seen in Table 6. To view the full process of the EFA readers are advised to Appendix 4.

Table 6 The final rotated component matrix as computed by SPSS 15.0. The matrix illustrates factor loadings, that is, how much each factor taps into each individual item. Factor loadings smaller than 0,32 (minimum criteria for cross-loading according to Costello & Osborne 2005) have been suppressed in this matrix to allow for easier interpretation

Rotated Component Matrix[a]

	Component					
	1	2	3	4	5	6
JNT3	,897					
JNT2	,729					
JNT4	,696					
JNT1	,596					
PRM2		,837				
PRM1		,775				
PRM3		,725				
TRN2			,841			
TRN1			,824			
TRN4	,404		,541			
COM4				,749		
COM3				,708		
COM1	,400			,688		
PLL2					,825	
PLL1					,800	
CON2						,785
CON3						,755

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 8 iterations.

After four consecutive runs of Factor Analysis, six factors were extracted. All factor loadings were above the 0,5 cut-off limit and only two cross-loadings could be found. COM1 ("We are frequently informed by our customers of our performance (quality, delivery, cost, etc)") and TRN4 ("Personnel at our plant are invited to our customers' sites to increase awareness of how our products are used") both had cross-loadings on Factor 1 (JNT1, JNT2, JNT3 and JNT4). However, increased participation in Joint Action (as described by JNT1, JNT2, JNT3 and JNT4) may very well result in increased communication of supplier performance. Likewise, Joint Action can be expected to result in an increased amount of invitations to the buying firm's site.

5.2.2 Reliability of measurement scales

Calculation by SPSS 15.0 of Cronbach's Alpha for all six scales confirmed all coefficients >0.6 (as recommended by Malhotra 2007) except for Continuous Improvement ($\alpha = 0.588$). However, if the complete construct of Continuous Improvement was to be excluded, significant information was expected to be lost. As a result of the expected information loss, in combination with an Alpha relatively close to the cut-off, the construct was decided to be kept.

Alpha-if-item-deleted (change of Cronbach's Alpha if an item is excluded) was also calculated for all constructs. Calculation showed an increase in Alpha (from 0.726 to 0.835) of Supplier Training if TRN4 was excluded. TRN4 was initially kept not to loose any significant information, however, this decision was later revised due to poor model fit.

Table 7 Cronbach's Alpha for each construct used in the study

Construct - Cronbach's Alpha (α)	Survey question	Joint Action	Process Mapping	Supplier Training	Comunication and Feedback	Plant Leanness	Continuous Improvement
Joint Action $\alpha = 0.809$	JNT3	,897					
	JNT2	,729					
	JNT4	,696					
	JNT1	,596					
Process Mapping $\alpha = 0.736$	PRM2		,837				
	PRM1		,775				
	PRM3		,725				
Supplier Training $\alpha = 0.726$	TRN2			,841			
	TRN1			,824			
	TRN4 (D)	,404		,541			
Comunication and Feedback $\alpha = 0.609$	COM4				,749		
	COM3				,708		
	COM1	,400			,688		
Plant Leanness $\alpha = 0.606$	PLL2					,825	
	PLL1					,800	
Continuous Improvement $\alpha = 0.588$	CON2						,785
	CON3						,755

D = Dropped as a consequence of initial poor model-fit and better Alpha (i.e. reliability) when deleted

5.2.3 Assessment of the final measurement model

Subsequent to EFA and calculation of Cronbach's Alpha, the proposed constructs where revised as seen in Table 8, and Confirmative Factor Analysis (CFA) was used to assess the measurement model.

Table 8 Revised constructs

Construct		Indicator	Indicator adapted from
Plant Leanness	PLL1	Materials in our plant are moved short distances and only once, to following operation*	Goodson (2002)
	PLL2	Production materials are stored at line side rather than separate storages*	Goodson (2002)
Continuous Improvement	CON2	All factory workers at our plant participate in continuous improvement of our products/processes*	Goodson (2002)
	CON3	We make extensive use of statistical techniques to reduce variance in quality (e.g. Statistical Process Control, capability studies, Measurement System Analysis etc.)*	Park *et al.* (2001)
Process Mapping	PRM1	Updated Process Flow Diagram is available for all processes*	PPAP (2006) and Goodson (2002)
	PRM2	Updated Failure Mode and Effects Analysis is available for all processes*	PPAP (2006)
	PRM3	Updated Control Plan is available for all processes*	PPAP (2006) and Goodson (2002)
Communication and Feedback	CON1	We are frequently informed by our customers of our performance (quality, delivery, cost, etc)*	Krause *et al.* (2000), Krause et al. (1999) and Prahinski & Benton (2004)
	CON3	We keep a record of, and frequently follow up, customer satisfaction*	Park *et al.* (2001)
	CON4	Our firm can easily approach our customers for discussion regarding ideas for process performance*	Prahinski & Benton (2004) and Krause (1999)
Joint Action	JNT1	Our plant is visited by our customers**	Krause *et al.* (2007), and Krause (1999)
	JNT2	We are involved with our customers in new product design**	Li *et al.* (2007), and Park *et al.* (2001)
	JNT3	We are involved with our customers in development of existing products**	Li *et al.* (2007)
	JNT4	We collaborate with our customers to eliminate non-value adding activities**	Li *et al.* (2007)
Supplier Training	TRN1	Employees at our production line participate in training by our customers**	Krause *et al.* (2007), Park *et al.* (2001) and Krause (1999)
	TRN2	Managers in our company participate in training by our customers**	Krause *et al.* (2007), Park *et al.* (2001) and Krause (1999)

*Measured by strength of agreement: 1 = *Strongly disagree*, 2 = *Disagree*, 3 = *Neither agree nor disagree*, 4 = *Agree*, 5 = *Strongly agree*
**Measured by level of involvement: 1 = *Never*, 2 = *Seldom*, 3 = *Sometimes*, 4 = *Often*, 5 = *Very often*

Basic descriptive statistics of all items included in the measurement model can be viewed in Table 9**.** The table presents the number of returned responses of each indicator (e.g. the 77 returned questionnaires), the minimum and maximum level of agreement/involvement as reported by the respondents, the mean of all responses and the standard deviation.

Table 9 Basic descriptive statistics of sample data

Indicator	N	Minimum	Maximum	Mean	Std. Deviation
JNT1	77	2,00	5,00	3,6234	,74408
JNT2	77	1,00	5,00	3,5844	,97806
JNT3	77	2,00	5,00	3,5844	,87885
JNT4	77	1,00	5,00	3,4026	,84697
PRM1	77	1,00	5,00	4,1169	,84252
PRM2	77	2,00	5,00	4,0130	,73437
PRM3	77	3,00	5,00	4,2857	,64598
TRN1	77	1,00	3,00	1,9221	,70274
TRN2	77	1,00	3,00	2,2727	,64147
COM3	77	2,00	5,00	4,1039	,64040
COM4	77	1,00	5,00	3,9091	,89121
COM1	77	2,00	5,00	3,8442	,88948
PLL1	77	2,00	5,00	3,4416	,97998
PLL2	77	1,00	5,00	3,1558	1,03955
CON2	77	2,00	5,00	3,8571	,73832
CON3	77	2,00	5,00	3,9610	,75117
Valid N (listwise)	77				

In Fig. 7, the CFA is depicted as performed in AMOS 7. In comparison to the EFA previously conducted, the CFA allows each indicator to load on one factor and one factor only. Thus, the CFA is a strictly confirmatory evaluation of the measurement model. Nevertheless, and as depicted by the double-headed arrows, the factors are allowed to correlate. Resulting indices of model fit are presented in Table 10. It is noted that all fit indices fall within the recommended range, and thus, the measurement model was accepted.

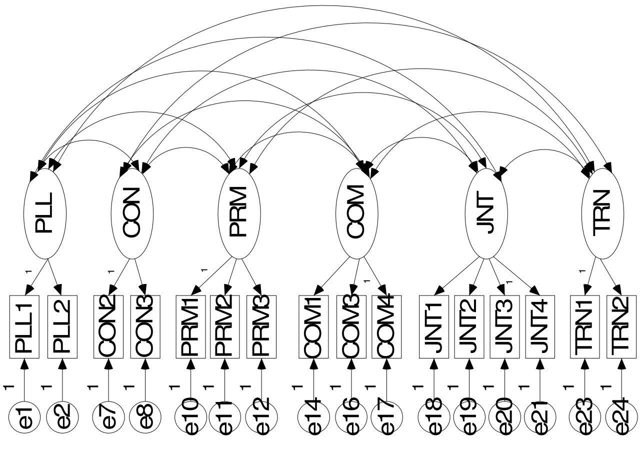

Fig. 7 Measurement model. **PLL:** Plant Leanness. **CON:** Continuous Improvement. **PRM:** Process Mapping. **COM**: Communication and Feedback. **JNT:** Joint Action **TRN:** Supplier Training. **Circles** represent measurement error, **rectangles** indicate observed variables **ellipses** represent latent variables, **arrows** represent impact between variables and **double-headed arrows** indicate correlation

Table 10 Model-fit of the measurement model

Fit measure	Criterion*	Measurement model
Level of significance of Chi-square (p-value)	≥0.05	0.553
Chi-square/df	≤3	0.973
RMSEA	<0.8	0.000
SRMR	<0.1	0.0606
NNFI	≥0.9	1.011
CFI	≥0.9	1.000

5.3 Exploring the constructs – an ad-hoc analysis

Prior to hypothesis testing, as seen in Chapter 5.4, an initial ad-hoc analysis was carried out to explore the constructs and the sample of the 77 returned questionnaires. The sample was divided into two groups where the 38 suppliers with the lowest reported eQPMO was assigned to group 1, and the 39 suppliers with the highest eQPMO was assigned to group 2. The mean of all indicators assigned to a specific construct was calculated to create an un-weighted composite score for each constructs. Comparison of the two groups was performed by t-test in SPSS 15.0. To test the assumption of normality, Shapiro Wilk's test of normality was performed (Appendix 5). It should be noted that several of the samples tested failed to meet the criterion of normal distribution. However, the t-test could be viewed upon as an initial test that gives a first indication of differences in the analysed data. Table 11 lists the mean response of each construct for the two groups. Asterisked constructs indicate statistically significant difference in response between the two groups.

Table 11 A comparison of means of the composite scores. Percentile group 1 consists of "higher-performing suppliers" and percentile group 2 consists of "lower-performers"

	Percentile Group of eQPM	N	Mean	Std. Deviation
MeanJNT	1	38	3,5461	,69227
	2	39	3,5513	,69816
MeanPRM*	1	38	4,2719	,55807
	2	39	4,0085	,62355
MeanTRN	1	38	2,3158	,60996
	2	39	2,3504	,57709
MeanCOM	1	38	3,9912	,54518
	2	39	3,9145	,67416
MeanPLL	1	38	3,3158	,85757
	2	39	3,2821	,86447
MeanCON**	1	38	4,0526	,62374
	2	39	3,7692	,60531

MeanJNT = Mean Joint Action, **MeanPRM** = Mean Process Mapping, **MeanTRN** = Mean Supplier Training, **MeanCOM** = Mean Communication and Feedback, **MeanPLL** = Mean Plant Leanness, **MeanCON** = Mean Continuous Improvement
* $p<0,1$
** $p<0.05$

As seen in Table 11, two composite scores differ statistically between the two groups (Process Mapping, p = 0.055 and Continuous Improvement, p = 0.047). Thus, the t-test indicates that Process Mapping and Continuous Improvement is used to a greater extent among the 38 suppliers with the lowest reported eQPMO than the 39 suppliers with a higher reported eQPMO.

5.4 Hypothesis testing

The three competing models were assessed using AMOS 7 and all parameters were estimated using Maximum Likelihood (ML). ML is the most widely used fitting function for SEM and is used to create estimates to maximize the likelihood that the model-implied covariance matrix is valid for the empirical data (Schermelleh-Engel *et al.*, 2003). Weighted Least Square (WLS) is another frequently used method and also available by AMOS 7. WLS requires minimal assumptions about the distribution of the observed variables, however, simulation has shown that ML outperforms WLS with or without correction of nonnormality and should therefore be preferred (Schermelleh-Engel *et al.*, 2003). Moreover, Schermelleh-Engel *et al.* (2003) declare that ML should generally be used with small samples. With respect to sample size and the nonnormality of the observed variables as produced by the five point Likert scales (see Table 9), ML was used for parameter estimation. Grave nonnormality of the dependent variable (eQPMO) was noted and the data was consequently logarithmized (as seen in Fig. 8) to better fulfil the normal assumption.

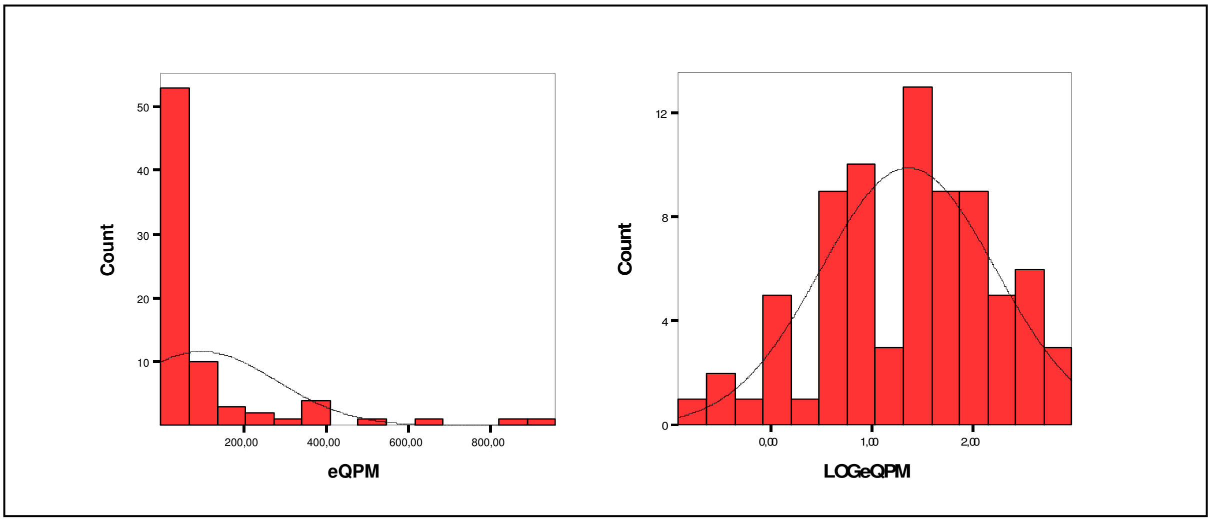

Fig. 8 eQPMO (left) and Logarithmized eQPMO (right) for the sample during the twelve moths period of November 2007 to October 2008

By running the Direct Impact Model and Mediated Impact Model A and B with logarithmized eQPMO as the dependent variable, fit indices for each model was extracted and evaluated. Models as depicted in AMOS 7 can be seen in Fig. 9 and a comparison between the fit indices of the competing models is shown in Table 12.

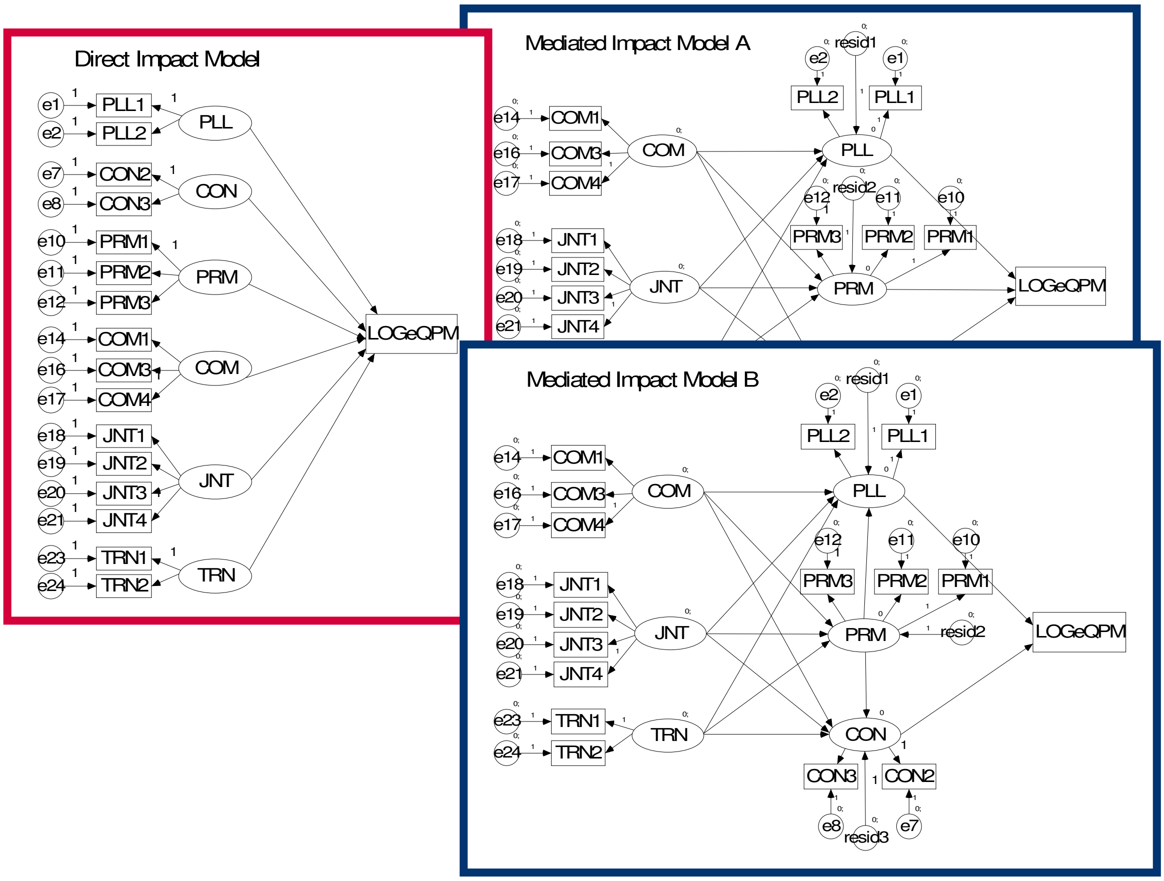

Fig. 9 The three competing models as seen in AMOS 7

Table 12 A comparison of model-fit

Fit measure	Criterion*	Direct Impact Model	Mediated Impact Model A	Mediated Impact Model B
Level of significance of Chi-square (p-value)	≥0.05	0.002	0.003	0.007
Chi-square/df	≤3	1.429	1.417	1.364
RMSEA	<0.8	0.075	0.074	0.069
SRMR	<0.1	0.163	0.146	0.135
NNFI	≥0.9	0.803	0.809	0.833
CFI	≥0.9	0.834	0.847	0.868

* Criterion for p-value as reported by Li *et al.* (2007), Carr *et al.*(2008) and Schermelleh-Engel et al. (2003) criterion for Chi-square/df and CFI as reported by Prahinski & Benton (2004), Li *et al.* (2007), Krause *et al.* (2000) and Carr *et al.*(2008), criterion for RMSEA as reported by Prahinski & Benton (2004), Li *et al.* (2007), and Carr *et al.*(2008), criterion for SRMR as reported by Schermelleh-Engel et al. (2003), criterion for NNFI as reported by Prahinski & Benton (2004), Li *et al.* (2007) and Carr *et al.*(2008)

It can be noted that with the exemption of Chi-square/df and RMSEA none of the recommended fit indices indicate good fit for any of the models. It was concluded that none of the proposed models could be accepted and accordingly hypothesis testing could not be performed with any of the models as originally specified. However, Mediated Impact Model B shows better statistics and can be regarded as the better model. Consequently, Mediated Impact Model B was chosen for respecification.

5.4.1 Respecification of Mediated Impact Model B

As mentioned by Anderson & Gerbing (1988), respecification is an often necessary procedure in SEM. Anderson & Gerbing (1988) however, stress the fact that respecification must be done with consideration to theory and content. To rely solely on statistics may lead to that the researcher modifies the model to attain good fit by capitalizing on chance (i.e. sampling error), and thus, theory must be taken account for.

Considering the recommendation of Anderson & Gerbing (1998), respecification was done based on statistical considerations as well as theory. Statistical considerations were taken into account by evaluating modification indices (provided by AMOS 7) that estimate change in discrepancy between model and population when parameters are freed (e.g. when covariances or regressions are added to the model). Changes suggested by AMOS 7 can be seen in Table 13.

Table 13 Changes for better model-fit according to AMOS 7

Covariances			Regressions		
COM	<-->	JNT	TRN2	<---	COM
TRN	<-->	JNT	JNT4	<---	COM
e24	<-->	COM	COM1	<---	JNT
e20	<-->	e24			
e21	<-->	COM			
e21	<-->	e24			
e14	<-->	JNT			
e10	<-->	e24			
e8	<-->	e7			
e2	<-->	e1			

As noted in Table 13, AMOS suggests linkage between Communication and Feedback and Joint Action as well as Joint Action and Supplier Training. The relationships between Joint Action and Supplier Training could very well be seen as expected since both are strategies of direct involvement and consequently, one strategy may very well include the other. As argued by Li *et al.* (2007), interaction leads to improved communication, and thus, a relationship between direct involvement strategies and Communication and Feedback is also likely. Mediated Impact Model B is consequently respecified to include covariances as described above (i.e., between Joint Action and Supplier Training and between Joint Action and Communication and Feedback). Furthermore, a linkage between Supplier Training and Communication and Feedback is proposed as a result of the argument of linkage between interaction and communication. Other suggestions for model improvement proposed by AMOS 7 are disregarded since the changes cannot be justified by theory.

5.4.2 Results after respecification of Mediated Impact Model B

After respecification, all model fit indices indicate acceptable overall fit for Mediated Impact Model B (Table 14) and thus, it can be considered to be a plausible theoretical model. In Fig. 10, the respecified model is presented with standardized estimates of impact. To evaluate the hypotheses presented in Chapter 3.4, statistical significance of the estimates were assessed at the p<0.1 and the p<0.05 level. Significant relationships implied by the model can be viewed in Table 15.

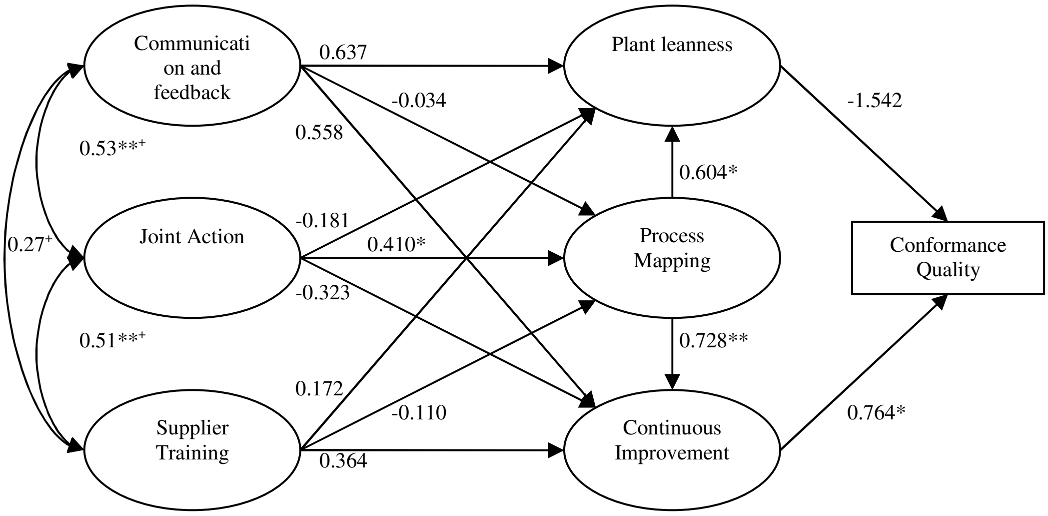

Fig. 10 Respecified model. Signs of the estimates of Conformance Quality as affected by Continuous Improvement and Plant Leanness have been reversed since Conformance Quality is defined as number of eQuality-reports per million delivered products.

*Significant at p>0.1
**Significant at p>0.05

Table 14 Model-fit of the respecified Mediated Impact Model B

Fit measure	Criterion*	Mediated Impact Model B (respecified)
Level of significance of Chi-square (p-value)	≥0.05	0.105
Chi-square/df	≤3	1.176
RMSEA	<0.8	0.516
SRMR	<0.1	0.0752
NNFI	≥0.9	0.919
CFI	≥0.9	0.938

Table 15 Significant relationships

Relationship			Influence	p
Continuous Improvement	→	Conformance Quality	+	0.057
Joint Action	→	Process Mapping	+	0.087
Process Mapping	→	Plant Leanness	+	0.092
Process Mapping	→	Continuous Improvement	+	0.014
Communication and Feedback	↔	Joint Action	+	0.008
Joint Action	↔	Supplier Training	+	0.001

By analyzing the suggested model, the following hypotheses can be supported:
Hypothesis 9: Initiatives for Continuous Improvement have a direct and positive impact on Conformance Quality
Hypothesis 11c: Initiatives for Joint Action have a direct and positive impact on process mapping
Hypothesis 13a: Process Mapping has a direct and positive impact on Plant Leanness
Hypothesis 13b: Process Mapping has a direct and positive effect on Continuous Improvement

It should be noted that the model shows five negative estimates among the relationships examined. Although not significant, negative findings are unexpected and deserve extra attention. Particularly the estimates for Conformance Quality as affected by Plant Leanness (-1.542) and Continuous Improvement as affected by Joint Action (-0.323) are of interest because of their relative size. A possible explanation of the negative relationship indicated between Joint Action and Continuous Improvement could be that incentives for site visits and related initiatives increase when dealing with suppliers that have a less integrated view of Continuous Improvement (e.g. less formalised participation in continuous improvement and less utilization of statistical techniques). At Scania, activities such as site visits and audits generally increase as a result of quality deviations and consequently, investigation of the true effect of these initiatives is far from unproblematic when using historical data. Scania's reactive approach to SDPs could consequently be the explanation of the unexpected negative relationship between Joint Action and Continuous Improvement. The negative effect of Plant Leanness on Quality performance is also somewhat surprising. Even though the effect does not significantly differ from zero, one would expect that the estimate would point in the other direction. Theoretically, and as argued by Womack *et al.* (1990), a lean flow should lead to increased quality. Nevertheless, it is possible that some of the practices underpinning this factor may require organisational and physical restructuring which might have a, temporarily and initially, negative effect on quality.

6 Study 2. – The interviews

This chapter presents the summary of the two interviews conducted during the research. Interviews were held with Quality Managers at two different companies (from now on referred to as Company X and Company Y) within the Sheet Metal segment. Company X has had many eQuality reports assigned to them during the last year and is considered to have more problems than the average supplier, while Company Y belongs to the opposite end of the spectra of suppliers. The purpose of these interviews is to gain further insight to supplier development initiatives and initiatives for process improvement as perceived by the supplier and, if possible, to clarify the quantitative study.

6.1.1 Company X

Company X is a privately owned firm with around 250 employees and had a turnover of approximately 600 million Swedish crowns (SEK) in 2008. The company has a long tradition as a manufacturer with a history of over 50 years as a first tier supplier to the car industry. The last years Company X has been focusing on the heavy/medium truck and bus industry. Investments in modern production and process technologies have been made, and principles of lean production are used where possible. Quality is seen as an important part of Company X and they are ISO/TS 16949 certified.

Process focus
According to the Quality Manager at Company X their factory has an old layout, and as a consequence, a satisfying product flow is sometimes difficult to achieve. However, efforts are made for a leaner flow, but these efforts are mainly concentrated to areas that are considered appropriate for this type of restructuring (with respect to the old layout of the factory) and areas that produce high volume parts. The majority of the production planning is done by forecasting, and in certain parts of the production, in-house logistics are supported by a Kanban-like system. Company X has not implemented lean production principles everywhere, but is working towards a leaner organisation and has received help from Scania with an introduction to the Scania Production System (SPS). The system is however not fully implemented, but improvements in quality, work environment and the general tidiness of the factory have been noted since the introduction to SPS.

According to Company X they map their processes well. Flowcharts, FMEAs and Control Plans are available for all product families. The flowchart is developed by technicians, while the FMEA and the Control Plan are developed in cross-functional groups. Work instructions are always available on the shop-floor but detailed instructions are often left out since the management wants to put trust in their employees and therefore not be over explicit.

Continuous Improvement
In the ongoing process of improving quality and flow, Company X has implemented groups that work with continues improvements of the production processes. In some departments independent SPS-groups have been formed and have been given the responsibility for quality and process improvements and cleaning of their specific work stations. These SPS-groups are allowed to make improvements and small investments without asking upper management, but most departments however, work with continuous improvements through meetings, where members are voluntarily active and have less formalized roles and less authorization than within the SPS-groups.

According to Company X, they have no use of statistical techniques for process control; instead, deviations are followed up through weekly reports. In addition, deviations are handled by 8D-reports that are sent to the production manager and the responsible quality assurance personnel. Maintenance of tools and machinery is scheduled in a maintenance system. However, Company X states that a lot of the maintenance of tools is performed when the operator deems it to be appropriate. To better keep track of maintenance, Company X plans to introduce a new material handling system that incorporates a maintenance module

Communication and Feedback
As with all Scania suppliers, communication between Company X and Scania is mainly held through a supplier portal. The portal supports the eQuality-system and performance feedback is usually communicated to Company X through eQuality reports. The Quality Manager at Company X says that other types of communication channels are rarely used for feedback, and that when suggestions for improvement are presented to Scania for approval, it is often difficult to get a response. To get an overview of customer satisfaction, meetings are held twice a year with the marketing department. However, no formal evaluations or surveys are conducted to measure customer satisfaction. Instead, the company relies on the overall "sense" of satisfaction experienced by marketing and sales personnel during the year. In general, efforts for feedback of process/product improvement are often perceived as one-way communication.

Joint Action
Even if the opinion is that communication with Scania could be better, Company X is generally satisfied with the cooperation. Employees from Scania regularly, almost weekly, visit Company X's production site. The Quality Manager believes that this, to a large extent, is a result of the close proximity between the two companies. Company X has also had the opportunity to send employees to Scania's site, and the manager believes that this mutual exchange is positive and beneficial for both parties. Another result of Joint Action between Scania and Company X is that Company X now has a designer located at Scania's premises to guard their interests. To date, Company X has a large influence on new product development and improvement of internal processes. However, the Quality Manager ads, improvements of existing products are almost impossible when design changes are needed.

Although collaboration and mutual exchange between the two companies is perceived as satisfactory, one thing put forward is that Scania could send assembly personnel to Company X's production site. This type of initiative would hopefully lead to a better awareness and understanding of products and processes, as well as an improved collaboration that goes beyond management level.

Supplier Training
Training of employees is mainly held internally, and when necessary, external resources are contracted. To follow up the progress of the workforce, each team leader is responsible for the formal assessment of the team for which he or she is responsible for. By assessing the individual team members on a scale from A to C on specific areas of interest, the team leader gets an overview of each member's know-how and a chance to lay out an education plan together with the assessed team member.

Except site visits and the presentation of SPS, employees at Company X have not received any form of formal training from Scania The attitude is that training of management or factory workers held by OEMs is unnecessary, because - "What would they be able to help us with?".

6.1.2 Company Y

Company Y is privately owned and located in the southwest of Sweden. The company has around 50 employees, had a turnover of approximately 100 million SEK in 2008, and is a manufacturer of sheet metal products to the heavy truck segment of the automotive industry. Recently, large investments have been made in new automatic hydraulic press cells and automatic welding cells. Lean principles have been implemented by Company Y where considered possible, preventing errors and focusing on continuous improvements. Quality is an important aspect of the daily work and Company Y is consequently ISOS/TS 16949 and ISO 9001 certified. The company's major customer is Scania who stands for approximately 90 % of the sales.

Process focus

Company Y has during the last years implemented a more efficient flow of goods and materials within the factory. However, there is a small number of parts which, as of today, is still in need of flow improvement. According to the Quality Manager at Company Y, the poor flow of certain parts is a result of the old layout of the plant. Despite the challenges of the layout, Company Y actively works with shortening the transportation distance of goods and materials in all areas of the factory. The majority of the production planning is done with a MPS system connected to actual customer demand and a Kanban system that has been implemented to pull production from their one dominant customer. During the last 5 to 6 years, flowcharts, Control Plans and FEMAs have been developed for all parts manufactured at Company Y. To increase involvement and motivation, process charts are put together in cross-functional teams of employees from the shop floor as well as employees in upper management positions.

The company has come a long way in their work with lean manufacturing principles and has been influenced by Scania's SPS in their daily work. They put heavy emphasis on visualising information, continuous improvements and the teaching of basic Lean principles to employees as individuals, and as team members.

Continuous Improvement

Continuous improvement is an important part of Company Y's process of improving in terms of quality and profit. Teams at the shop floor are continuously educated to become better and take more responsibility for their own work tasks. Company Y uses planned maintenance for their tools, and the operators are responsible for keeping their own tools in good condition. As explained by the Quality Manager, Company Y's aim is to have competent personnel with a good knowledge of the manufacturing process rather than having detailed instructions at every work station. The argument is that trust and responsibility lead to employees who are motivated to learn and achieve better results. In addition, work instructions are available, but mainly focused on complex procedures as well as cleaning and maintenance of tools and equipment.

Company Y has put a lot of time and effort into introducing formal teams to work with continuous improvement. Training materials for these groups focus mainly on safety and cleaning routines, the importance of organised tools, finding and solving deviations and continuously improving the manufacturing process. The training is carried out in three steps, from basic to advanced training, and after the completion of each step, the team is awarded with a certification. Thus, the focal point is on team work and not the accomplishment of single individuals. The Quailty Manager, who is also the initiator of this project, says that the initiative has been successful and that members of the groups take pride in their work and strives to achieve the next certification. Furthermore, teams with the highest certification serve as role models to other groups and thus enable knowledge and competence transfer between teams. The initiative has also led to that team members have a better knowledge of the existing know-how of the group, as well as a greater commitment to the team and to the company.

Company Y has a widespread training and mentoring program and recognizes training as a fundamental part of the improvement and growth of the organisation. For example, when new personnel are hired, they receive training in measurement technique to make sure that all parts are measured correctly. Parts that have been measured by newly hired personnel will then be double checked by a more experienced colleague. The new recruit will also receive training in the production process and an experienced mentor will be assigned to assist the employee during the first few weeks. The importance and the formality of the mentorship are highlighted by a written contract which is signed by the mentor and the protégé.

Communication and Feedback

The majority of communication between Company Y and Scania is held through the supplier portal where eQuality reports and delivery information are shared. Company Y shares information of the production and delivery status daily with their customers and if any problems that could affect the customers occur, they will be contacted within 3 days. According to the quality manager, quarterly meetings used to be held with Scania where information and feedback were shared. These meetings had a positive effect on daily work and the overall relationship with Scania and Scania employees, and in the end, the quality outcome of Company Y's products. Currently however, these meetings occur less frequently and visits are now usually only a consequence of something being wrong.

To follow up customer satisfaction Company Y has sent out questionnaires to their customers. As a result of poor response rate, this initiative was stopped and Company Y now has to rely on feedback from personal meetings and eQuality reports.

Joint Action and Supplier Training

The relationship between Company Y and Scania is perceived as good and Joint Action generally takes form of site visits and cooperation in new product development. Site visits commonly take place a few times per year, but during the development phase of a new product, the frequency of site visits and personal meetings increase. The Quality Manager at Company Y says that Scania usually lets Company Y get involved in new product development and that ideas and opinions for improvement are welcome during this phase. However, ideas for improvement of existing products are often difficult to get through.

In terms of Supplier Training, no such cooperation is currently in progress. Scania has been involved in reducing lead time and waste at Company Y, but activities such as these are unusual. Workers and management at Company Y has also had the opportunity to visit Scania and see the production of trucks in Södertälje. The Quality Manager describes this experience as much appreciated. It gave the workers motivation and the chance to see that they are actually part of producing trucks and not just small metal parts. The Quality Manager continues to say that sometimes when a Scania truck is seen outside of the plant, workers study the truck with pride to see if they can find parts that have been manufactured by Company Y.

Regardless of the lack of formal Supplier Training, visits to Scania have been used to benchmark training material and the information boards used at Company Y. As in the production facilities at Scania, information boards displaying process performance and downtime can be seen at Company Y's shop floor and these have partially been developed from information boards seen at Scania, as explained by the Quality Manager.

6.1.3 Comparison of Company X and Company Y

The process towards a leaner flow of materials and goods within the plant is implemented by both companies, and as of today, both companies have some areas in the plant with satisfying flow and some areas that are problematic in terms of lean flow. The common issue is the original layout of the factories, which makes Lean production challenging to put into action. Both companies also report the issue of low volume spare parts that further complicate the aim for lean flow. Company X and Company Y have been influenced by the Scania SPS in their work for implementing Lean principles in their organisations. It appears as if Company X has noticed the importance of Lean thinking and are in the start-up phase, while Company Y has come a step further, with a more widespread Lean thinking that is supported by formalized mentoring and certification programs.

Both companies work actively with continuous improvements and give the employees responsibility for their own work stations in terms of keeping their tools in good shape and keeping the work space clean and tidy. At Company X, the improvement teams have the possibility make small purchases to implement improvements without upper management permission. Company Y on the other hand, have formalized training and certification programs to support their improvement teams. The purpose is to spread knowledge throughout the organisation by actively involving individuals as well as teams in improving working methods and productivity. Common for both companies is that they have seen improvements in quality and productivity and that both have a mindset of continuously becoming better.

Neither of the companies uses statistical techniques, except when required by PPAP. Maintenance of tools is performed similarly at the two companies, through a combination of planned maintenance and routine inspection performed by the operators. Process Mapping, such as Control Plans and FMEAs, are developed in cross-functional teams at both companies, and both companies argue that it is important to involve all functions within the company in these activities. However, the emphasis on cross-functional groups seems to be greater at Company Y in terms of involving upper management. Another similarity between the companies is the somewhat hesitant approach to detailed work instructions. Both companies have work instructions available, but hesitate to include the amount of details often promoted by Scania. The argument is that they want to put trust in their employees and that it is important that workers have the right competence to handle their duties. Consequently, fully detailed work instructions seem to be viewed upon as over explicit and of no use.

The majority of the communication between the companies and Scania is held through the supplier portal where information about quality and logistics is shared. Company X has regular visits from Scania mainly as a result of the close proximity, and sees these visits as having a positive effect on both parties. In the case of Company Y, what used to be quarterly meetings now occur less frequently, and as of today, most contact is held through the supplier portal. However, to create a deeper understanding and a stronger relationship between Scania and the two companies, employees of Company X and Company Y have made site visits to Scania. These initiatives are reported as successful, as it gives the employees the opportunity to put their work into a larger context and motivates the employees to perform better.

Although Company X and Company Y state that they participate in new product development and that they usually have the opportunity to present ideas for product and process improvement, they also report shortcomings in feedback; suggestions that include design changes are often left to linger without any response from Scania.

Neither of the companies report formalized methods to follow up customer satisfaction. At Company X, marketing and sales personnel help to evaluate customer satisfaction at internal meetings where they report their overall experience with the customers, and at Company Y, personal meetings with the customer are used of to acquire information regarding customer satisfaction and performance.

Training and assessment of the employees at both Company X and Company Y are important tools for increasing competence within the two companies. Both companies have training programmes and evaluate the competences of the employees in different levels. The main difference seems to be that Company Y puts heavier focus on formalised training and the improvement of teams instead of individuals. The attitude towards receiving training from their customers is split; Company Y welcomes it, and Company X thinks that their customers probably can not teach them in anything.

In conclusion, Company Y has come a step further with their Lean development compared to Company X. With a more widespread implementation throughout the organisation, supported by formalized mentoring and training programmes, Company Y have been able to switch focus from individualism to a team based organisation.

7 Summary of results

Presented in this chapter, is a summary of results from the hypothesis testing and the two interviews conducted during this Master's thesis project. The results are discussed with the quantitative findings as starting-point, and are further elaborated with the findings derived from the in-depth interviews.

Our study tested three competing models, and the Mediated Impact Model B (Fig. 11) was selected on the basis of better statistics. After respecification, the overall fit of the model could be regarded as satisfactory and four of the thirteen hypotheses as proposed by Mediated Model B were concluded to be supported and statistically significant.

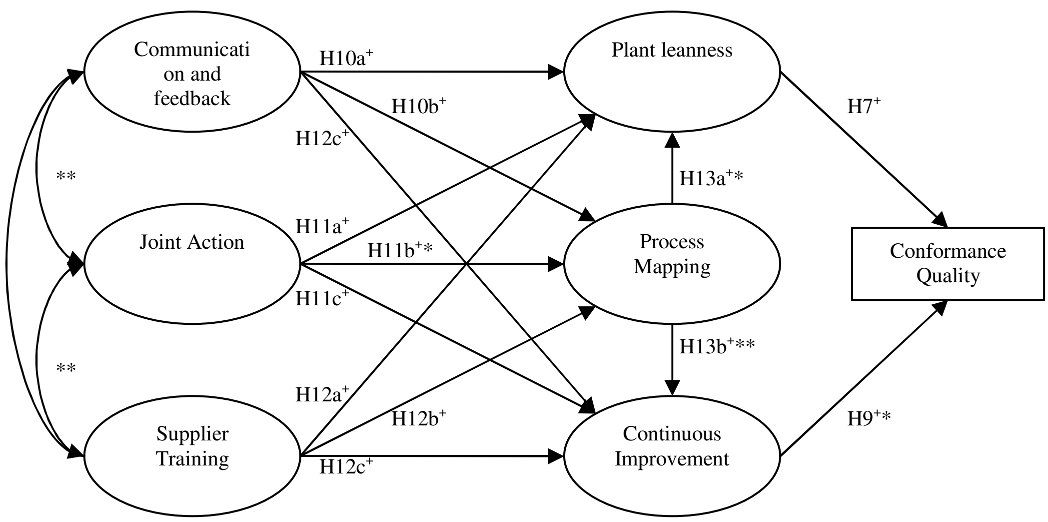

Fig. 11 Mediated Impact Model B (respecified) *Path significant at p<0.1. **Path significant at p<0.05

The following hypothesises could be supported:

- **Hypothesis 9:** Initiatives for Continuous Improvement have a direct and positive impact on conformance quality
- **Hypothesis 11c:** Initiatives for Joint Action have a direct and positive impact on Process Mapping
- **Hypothesis 13a:** Process Mapping has a direct and positive impact on Plant Leanness
- **Hypothesis 13b:** Process Mapping has a direct and positive effect on Continuous Improvement

By viewing the supported hypotheses presented above, a tendency for a logical route could be identified. Initiatives for Joint Action result in a positive impact on Process Mapping, Process Mapping in turn, positively affects Plant Leanness and Continues Improvement. Lastly, Continues Improvement seems to have a general, and direct, effect on conformance quality.

This being said, the indirect and positive effect of Process Mapping or Joint Action on conformance quality is unclear but could be seen as a logical extension of the argument. In addition, the initial analysis of the survey reveals that Process Mapping and Continuous Improvement is used to a greater extent among the 38 suppliers with the lowest reported eQPMO compared to the 39 suppliers with a higher reported eQPMO, which supports the assumption of an indirect effect of Process Mapping on conformance quality.

The interviews with the Quality Managers of Company X (low performer) and Company Y (high performer) indicate that Company Y seems to put more emphasis on cross-functional groups when mapping their processes. Although both companies state that they use cross-functional groups to receive better input for Process Mapping, Company Y seems to involve more people in different levels of the organisation than Company X. It should be noted that Company Y (approximately 50 employees and 100 million SEK turnover) is clearly a smaller company than Company X (approximately 250 employees and 600 million SEK turnover), and thus, the involvement of upper management is probably less problematic for Company Y than for Company X. Nevertheless, the involvement of upper management in tasks such as flow charting and the development of FMEAs suggest a well integrated method for Process Mapping, which in turn, may lead to a smoother process of implementing improvements or reducing risks that are found during the work.

Consistent to the qualitative findings, Company Y also has a well developed culture for Continuous Improvement. Both Company X and Company Y has established teams with the purpose to maintain and improve their processes. However, Company Y has executed formalized certification programmes and mentoring programmes to improve productivity and working methods by supporting teams as well as individuals. The formalized methods may consequently be part of the explanation to Company Y's high performance.

As argued above, the interviews support the positive effects of Process Mapping and Continuous Improvement identified by structural equation modelling. However, Company X (low performer) seems to have a better developed collaboration in Joint Action with Scania in terms of frequent site visits and the designer that they have located at Scania's facility. But it should be noted that Company Y has taken the opportunity at hand to benchmark their working methods with Scania and shows a more open attitude towards mutual exchange between buyer and supplier. It should also be noted that both suppliers state that they participate in improvement of processes as well as product design. However, both companies also express the occasional lack of feedback when ideas for improvement have been sent to Scania. As reported by Krause (1999), inter-firm communication is an important prerequisite to supplier development efforts. Perhaps, increased feedback could help Scania and other OEMs to gain even more positive effects from their efforts for supplier development, and thus, to experience an even stronger connection between efforts for Joint Action and conformance quality.

In summary, initiatives for Joint Action, Process Mapping and Continuous Improvement seem to have positive effects for OEMs. Formalized training programmes for Continuous Improvement, the involvement of cross-functional groups in Process Mapping and a well developed and open attitude for mutual exchange and Joint Action could very well be part of a recipe for successful supplier development.

8 Conclusions and discussion

The analysis conducted in this Master's thesis, suggests that it is possible to use eQPMO (number of issued eQuality reports per million parts delivered) as an indicator of supplier performance. Even though not all of the hypotheses of eQPMO, as affected by SDPs, could be supported, an overall plausible model was developed and all significant relationships in the model acted as expected. Thus, eQPMO could be a possible indicator of supplier performance in addition to the current practice of measuring the number of eQuality reports. Since eQPMO takes the number of parts delivered into account, the index could be useful in situations where products are moved from a current supplier to another and when suppliers need to be compared to find the supplier that is least likely to cause future deviations. It should be recognized that factors such as the supplier's know-how and technology could force the buyer to source from a supplier with an eQPMO indicating poor performance. Under those conditions, eQPMO could serve as an indicator of future possible change in the number deviations, allowing the buyer to set up SDPs proactively. The use of eQPMO as a supplementary KPI could consequently lead to a more proactive approach to SDPs and provide additional information when similar suppliers are assessed and compared.

While eQPMO could serve as an additional KPI to the number of eQuality-reports, the conducted research shows support for positive effects of several SDPs. As previously reported, initiatives for Joint Action, Process Mapping and Continuous Improvement seem to have positive effects on supplier performance. In our study, the construct of Joint Action included plant visits, involvement in new product design, involvement in the design of existing products and collaboration to eliminate non-value adding activities, Process Mapping included the use of flow diagrams, FMEAs and control plans, and Continuous Improvement was indicated by workers' participation in continuous improvement and the use of statistical techniques. Based on these findings, and the additional information that was collected through interviews and by the literature review that was conducted during the research, Table 16 presents a summary of issues to consider when assessing suppliers and executing Supplier Development Programmes. It should be noted that the Table 16 does not aspire to give a complete overview of SDPs or KPIs for supplier assessment; Table 16 is merely a summary of the results, and as such, it could be viewed upon as a supplementary checklist of topics to consider when executing SDPs to improve supplier performance.

Table 16 Suggestions for KPIs that can be used for supplier assessment along with focus areas for initiatives within Supplier Development Programmes and their expected outcome

<table>
<tr><th>KPI</th><th>What</th><th>When</th><th>Why</th></tr>
<tr><td>eQ *(current practice)*</td><td>No. of eQuality-reports</td><td>Continuously</td><td>To find and reduce current risk factors</td></tr>
<tr><td>$eQPMO$</td><td>$eQPMO = \frac{1000.000 \times eQ}{QuantityDelivered}$</td><td>For commercial decisions and comparison of suppliers etc.</td><td>To evaluate potential risk factors</td></tr>
<tr><th colspan="4">Supplier Development Programmes</th></tr>
<tr><th colspan="4">Joint Action</th></tr>
<tr><td colspan="4">▪ Establish contact by visiting the supplier’s site
▪ Give the opportunity for the supplier to benchmark Scania’s site
▪ If possible, include the supplier in new product development
▪ Encourage the supplier to present suggestions for design/process improvement
▪ Give feedback on suggestions for improvement</td></tr>
<tr><th colspan="2">Process Mapping</th><th colspan="2">Continuous Improvement</th></tr>
<tr><td colspan="2">▪ Coach and encourage the supplier to use cross-functional groups when developing process charts (e.g. flow charts, FMEAs control plans etc.)
▪ Give examples on how to use visible performance charts at the supplier’s work shop
▪ If the supplier is new to PPAP, coach the supplier in how to create well developed process charts</td><td colspan="2">▪ If applicable, encourage the supplier to use statistical techniques for process control
▪ Make sure that the supplier have the necessary knowledge to correctly apply statistical techniques as required by PPAP (i.e. MSA and capability studies)
▪ Encourage the supplier to involve workers in activities for continuous improvement?
▪ Encourage formalized working methods to achieve continuous improvement (i.e. improvement teams and mentoring programs)
▪ Encourage the supplier to reward, and keep track of, suggestions and implemented improvements</td></tr>
<tr><th colspan="2">Expected outcome</th><th colspan="2">Expected outcome</th></tr>
<tr><td colspan="2">▪ Increased Plant Leanness
▪ Increased emphasis on Continuous Improvement</td><td colspan="2">▪ Lower levels of eQPMO</td></tr>
</table>

8.1 Theoretic contribution and generalizability

This Master's thesis identifies significant factors that contribute to the success of Supplier Development Programmes in the automotive industry. The factors that were identified as major contributors were Joint Action, Process Mapping and Continues Improvement. The sample of suppliers participating in this study was relatively small (i.e. 77 first-tier automotive suppliers) and the reliability and validity of the research could consequently be a matter of discussion. However, the results are not in anyway contradictory to previous research and moreover, the positive effects of Joint Action (Li *et al.*, 2007; Carr et al., 2008), Process Mapping (PPAP, 2006) and Continuous Improvement (Mapes *et al.* 2000; Park *et al.* 2001) are supported by several researchers and tools for supplier assessment. Additionally, all items included in the research were adapted from previous research and/or tools for supplier assessment and can be regarded as common activities within the automotive industry. The authors of this thesis are consequently led to believe that the generalizability of this research can be extended to the automotive industry in general.

8.2 Future research

The authors believe it would be valuable to conduct a similar study with a larger base of respondents to validate the conclusions. Moreover, supplier development within the automotive industry is a well explored topic and the authors of this research suggest that future research focus on the service industry to cover a broader base of supplier development initiatives. In addition, the constructs presented in this Master's thesis could be applied to non-manufacturing organisations to determine if they are still valid and of interest to the service industry as well.

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SPSS 15.0, (2006b). Help topics. Factor analysis rotation. SPSS inc. [computer software]

SPSS 15.0, (2006c). Tutorial. Factor analysis inverse of correlation matrix. SPSS inc. [computer software]

Appendix 1
QUESTIONNAIRE

What is your current profession?	
How many years have you been in your current position?	

Please indicate to what degree you agree with the following statements (check one box only):

Plant Leanness					
Please indicate to what degree you agree with the following statements (check one box only):	Strongly disagree (1)	Disagree (2)	Neither agree nor disagree (3)	Agree (4)	Strongly agree (5)
Materials in our plant are moved short distances and only once, to following operation					
Production materials are stored at line side rather than separate storages					
Our inventory levels are always sized with respect to production rate					
All tools and equipment at our plant are kept in their own unique place					
Our plant uses pull production systems rather than push production					

Continuous Improvement					
Please indicate to what degree you agree with the following statements (check one box only):	Strongly disagree (1)	Disagree (2)	Neither agree nor disagree (3)	Agree (4)	Strongly agree (5)
Reducing cycle time/increasing manufacturing capacity is a priority for all our processes					
All factory workers at our plant participate in continuous improvement of our products/processes					
We make extensive use of statistical techniques to reduce variance in quality (e.g. Statistical Process Control, capability studies, Measurement System Analysis etc.)					
Preventative maintenance is scheduled and performed regularly for all checking aids used in our plant.					

Process Mapping					
Please indicate to what degree you agree with the following statements (check one box only):	Strongly disagree (1)	Disagree (2)	Neither agree nor disagree (3)	Agree (4)	Strongly agree (5)
Updated Process Flow Diagram is available for all processes					
Updated Failure Mode and Effects Analysis is available for all processes					
Updated Control Plan is available for all processes					
All work areas in our plant have updated and visible work instructions on the shop floor					

Communication and Feedback					
Please indicate to what degree you agree with the following statements (check one box only):	Strongly disagree (1)	Disagree (2)	Neither agree nor disagree (3)	Agree (4)	Strongly agree (5)
We are frequently informed by our customers of our performance (quality, delivery, cost, etc)					
We frequently inform our customers of our performance (quality, delivery, cost etc)					
We keep a record of, and frequently follow up, customer satisfaction					
Our firm can easily approach our customers for discussion regarding ideas for process performance					

Please indicate the level of involvement in the following activities (check one box only):

Joint Action					
Please indicate the level of involvement in the following activities (check one box only):	Never (1)	Seldom (2)	Sometimes (3)	Often (4)	Very often (5)
Our plant is visited by our customers					
We are involved with our customers in new product design					
We are involved with our customers in development of existing products					
We collaborate with our customers to eliminate non-value adding activities					

Training					
Please indicate the level of involvement in the following activities (check one box only):	Never (1)	Seldom (2)	Sometimes (3)	Often (4)	Very often (5)
Employees at our production line participate in training by our customers					
Managers in our company participate in training by our customers					
Employees in our organization receive training to increase productivity in our plant (e.g. Lean Production, Six Sigma, TQM etc.)					
Personnel at our plant are invited to our customers' sites to increase awareness of how our products are used					

Appendix 2
COVER LETTER

Dear Sir/Madame

We are currently writing our Master's thesis for Luleå University of Technology at Scania CV AB. As part of our thesis on supplier development, we are conducting a survey to study differences in work procedures and process development initiatives among automotive suppliers.

We would appreciate it if you, as a representative of one of the companies in our target group, took the time to complete the questionnaire. The questionnaire consists of 25 questions and will take approximately 7 minutes to complete.

The survey is anonymous. Neither your name nor the name of the organization you are representing will be exposed in the thesis report. Your answers will not be able to be traced back to you by any Scania employee or any people outside the research group, consisting of us two students and our tutor at the university.

All participants in our study will receive a copy of the finished report. As a result, you will be able to see how work procedures and process development initiatives differ among Scania suppliers. This will give you an opportunity to benchmark your organization towards other organizations within your specific segment.

We hope to receive your completed questionnaire shortly.

Best regards

Anders Ekholm
Email: XXXX@student.ltu.se

Sebastian Pashaei
Email: XXXX@student.ltu.se

For questions regarding the survey questionnaire please contact Anders Ekholm or Sebastian Pashaei. For Technical issues please contact Resolvia AB by phone at +46 8 XXX XXX XX or by email at XXXX@XXXX.XXX.

Appendix 3
CORRELATION MATRIX

Pearson Correlation

	PLL1	PLL2	PLL3	PLL4	PLL5	CON1	CON2	CON3	CON4	PRM1	PRM2	PRM3	PRM4	COM1	COM2	COM3	COM4	JNT1	JNT2	JNT3
PLL1	1	,435(**)	0,191	0,108	,235(*)	0,131	0,107	0,167	,279(*)	0,064	0,010	0,089	0,112	0,140	,283(*)	,240(*)	0,122	-0,022	0,057	0,017
PLL2		1	0,200	0,127	,416(**)	,327(**)	0,132	0,143	,244(*)	0,204	0,049	0,090	0,068	0,112	0,008	0,094	0,158	0,162	0,090	0,057
PLL3			1	,293(**)	,412(**)	0,114	0,160	0,206	0,079	0,196	0,126	0,191	0,192	0,070	,309(**)	0,170	0,224	-0,139	-0,003	-0,003
PLL4				1	,304(**)	0,067	,244(*)	0,110	,333(**)	-0,075	0,072	,304(**)	,306(**)	0,102	,229(*)	,254(*)	,377(**)	0,063	0,076	0,105
PLL5					1	,319(**)	0,081	0,211	0,221	0,108	-0,080	0,100	,249(*)	0,020	0,095	-0,027	0,123	-0,007	0,089	0,213
CON1						1	0,170	,243(*)	0,148	,343(**)	,288(*)	,336(**)	0,035	,297(**)	,254(*)	0,060	,282(*)	0,151	0,222	,380(**)
CON2							1	,417(**)	,319(**)	0,154	,246(*)	,363(**)	,263(*)	0,106	,261(*)	0,143	0,180	,284(*)	0,190	0,151
CON3								1	0,079	,257(*)	,239(*)	,240(*)	,341(**)	0,070	,343(**)	0,009	0,073	0,138	,228(*)	0,155
CON4									1	-0,066	0,164	0,221	,296(**)	,248(*)	,246(*)	,355(**)	,353(**)	,278(*)	,326(**)	0,183
PRM1										1	,487(**)	,446(**)	0,208	0,042	0,103	0,172	0,014	0,008	0,156	0,209
PRM2											1	,547(**)	0,222	-0,037	-0,059	0,137	0,002	0,009	0,154	0,070
PRM3												1	,398(**)	0,124	0,099	0,150	0,137	0,145	,253(*)	,235(*)
PRM4													1	0,054	0,187	,226(*)	0,169	0,099	,254(*)	,243(*)
COM1														1	,510(**)	,306(**)	,397(**)	,308(**)	0,197	,303(**)
COM2															1	,262(*)	,267(*)	0,009	0,140	0,170
COM3																1	,340(**)	0,194	0,217	0,078
COM4																	1	0,186	,228(*)	0,119
JNT1																		1	,469(**)	,442(**)
JNT2																			1	,638(**)
JNT3																				1
JNT4																				
TRN1																				
TRN2																				
TRN3																				
TRN4																				

Appendix 3
CORRELATION MATRIX

Pearson Correlation

	JNT4	TRN1	TRN2	TRN3	TRN4
PLL1	0,163	0,127	,225(*)	0,212	0,137
PLL2	0,092	0,107	0,172	0,094	0,005
PLL3	0,107	0,210	,273(*)	0,084	0,001
PLL4	0,091	0,210	0,195	,243(*)	0,051
PLL5	0,045	0,215	0,218	,253(*)	0,071
CON1	,298(**)	0,077	0,160	,303(**)	0,022
CON2	0,198	0,207	0,167	,327(**)	,229(*)
CON3	0,066	0,019	-0,005	,322(**)	-0,095
CON4	0,207	0,094	0,199	0,214	,290(*)
PRM1	,284(*)	0,060	-0,084	0,140	-0,116
PRM2	0,182	0,002	0,048	,280(*)	-0,060
PRM3	,244(*)	0,137	0,127	,400(**)	0,103
PRM4	0,119	0,093	0,069	,328(**)	,262(*)
COM1	,381(**)	0,065	0,145	0,040	0,169
COM2	,269(*)	0,113	0,127	0,097	0,037
COM3	,310(**)	0,135	0,218	0,025	0,208
COM4	0,223	0,157	,274(*)	,246(*)	0,169
JNT1	,411(**)	,321(**)	,383(**)	,426(**)	,406(**)
JNT2	,491(**)	,354(**)	,330(**)	,435(**)	,331(**)
JNT3	,634(**)	,330(**)	,250(*)	,484(**)	,457(**)
JNT4	1	,319(**)	,425(**)	,304(**)	,314(**)
TRN1		1	,719(**)	,289(*)	,374(**)
TRN2			1	,359(**)	,391(**)
TRN3				1	,294(**)
TRN4					1

Exploratory Factor Analysis (EFA) using SPSS 15.0

The EFA was done with an iterative approach. Below follows a brief description of the repeated EFA-runs conducted to purify the measurement model.

Run 1

To test the suitability of factor analysis of the sample, Kaiser-Meyer-Olkin Measure of Sampling Adequacy and Bartlett's Test of Sphericity was analyzed prior to further analysis. A Kaiser-Meyer-Olkin-index close to 1 indicates that the proportion of common variance among the entered variables is high, and thus, may be caused by common underlying factors (e.g. latent variables). A value less than 0.5 indicate that that the results from Factor Analysis might not be useful (SPSS 15.0, 2006c). Bartlett's Test of Sphericity tests if the correlation matrix produced is in fact an identity matrix which would imply that all data is uncorrelated (ibid). Since Factor Analysis is based on correlation between variables, uncorrelated data would make the choice of analysis unsuitable. A small significance level (<0,05) indicates relationships between variables (ibid).

Table 1 Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO) and Bartlett's Test of Sphericity as reported by SPSS 15.0

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		,666
Bartlett's Test of Sphericity	Approx. Chi-Square	733,175
	df	300
	Sig.	,000

The extraction from SPSS 15.0 in Table 1 shows the calculated Kaiser-Meyer-Olkin Measure of Sampling Adequacy and Bartlett's Test of Sphericity. Both measures indicate correlation within the analyzed data, suggesting Factor Analysis as a possible method of analysis.

The rotated component matrix as computed by SPSS 15.0 is presented in Table 2. When, in accordance with the Kaiser criterion (Costello & Osborne, 2005), extracting all factors with eigenvalue greater than 1, nine different factors can be distinguished. It would be possible to extract as many factors as there are variables. However, by applying the Kaiser criterion it is made certain that only factors that that explain more variance than a single indicator are extracted (Brown, 2006). The component matrix illustrates factor loadings, that is, how much each factor taps into each individual item. Factor loadings below 0,2 have been suppressed to allow for easier interpretation.

Table 2 Component Matrix after Run 1

Rotated Component Matrix[a]

	Component								
	1	2	3	4	5	6	7	8	9
JNT3	,867							,219	
JNT2	,742								
JNT1	,637				,220	,213		-,348	
TRN4	,620				,279				-,343
JNT4	,593	,281		,414	,294				
TRN3	,518		,205			,437			
PRM2		,837							
PRM1		,786	-,247						
PRM3		,708	,283			,240			
PLL4			,721					,339	
COM4			,683	,341					,203
CON4	,282		,614				,404		
COM2				,810		,346			
COM1	,273		,249	,726					,208
COM3		,270	,362	,436			,267		-,375
TRN2	,276				,841				
TRN1	,303				,823				
CON3						,792		,216	
CON2			,243			,710			
PLL1							,785		
PLL2							,784		,311
PLL5							,331	,775	
PLL3	-,263	,213		,279	,402			,557	
CON1	,263	,348		,225					,639
PRM4	,312	,269	,264			,278		,394	-,513

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 22 iterations.

Further analysis of the extracted factors shows that factor 3 and 9 have weak theoretical relevance. In response to this, items for factor 9, "Reducing cycle time/increasing manufacturing capacity is a priority for all our processes" (CON1) and "All work areas in our plant have updated and visible work instructions on the shop floor " (PRM4) were excluded. Analysis of factor 3 shows that COM4 have cross-loadings (loads at 0,32 or higher on two or more factors (Costello & Osborne 2005)) on Factor 4 (COM1, COM2 and COM3). In addition, COM3 has cross-loadings on Factor 3. Items PLL4 and CON4 however, do not have strong connections with other factors that can be theoretically justified. With this in mind, PLL4 and CON4 are excluded and COM4 is kept for another extraction.

Run 2

After elimination of the first items, 7 factors are extracted using the method as described in Run 1.

Table 3 Component Matrix after Run 2

Rotated Component Matrix[a]

	Component						
	1	2	3	4	5	6	7
JNT3	,907						
JNT2	,712	,231					
JNT4	,663	,228	,369	,258			
JNT1	,540	,326			,262		-,423
TRN2		,838					
TRN1	,250	,779					,219
TRN4	,361	,559					-,233
COM1	,349		,748				
COM2			,681		,319		,423
COM3		,226	,673	,284			
COM4		,251	,576				
PRM2				,850			
PRM1	,233	-,213		,750			,223
PRM3				,709	,305		
CON3		-,215			,750		,254
CON2		,216		,219	,738		
TRN3	,437	,324			,519		
PLL2						,885	
PLL1			,274			,691	
PLL3		,267	,207	,200			,731
PLL5						,511	,595

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 10 iterations.

The rotated matrix shows that TRN3 loads on Factor 5 (together with CON2 and CON3) and has cross-loadings on Factor 1 (JNT1, JNT2, JNT3 and JNT4) and Factor 2 (TRN1, TRN2 and TRN4). However, the constructs of Joint Action and Supplier Training are closely related and some correlation is expected. Furthermore, the link between TRN3 ("Employees in our organization receive training to increase productivity in our plant (e.g. Lean Production, Six Sigma, TQM etc.)") and the construct Continuous Improvement (Factor 5) cannot be theoretically dismissed. Therefore, TRN3 is not excluded in this run.

Factor 7 (PLL3 and PLL5) taps into several items by cross-loadings with COM2 and JNT1 and is identified as a problematic factor. Theoretical justification of theses cross-loadings is difficult and by elimination of this factor we achieve a model similar to the proposed six-factor model consisting of Joint Action, Supplier Training, Communication and Feedback, process Mapping, Continuous Improvement and Plant Leanness. Thus, items PLL3 and PLL5 are excluded.

Run 3

The third extraction shows six factors similar to the hypothesized model. Several cross-loadings can be seen in the matrix.

Table 4 Component Matrix after Run 3

Rotated Component Matrix[a]

	Component					
	1	2	3	4	5	6
JNT3	,901					
JNT2	,726	,224				
JNT4	,678		,244	,346		
JNT1	,593	,379				
TRN2		,816				
TRN1	,237	,745				
TRN4	,401	,573				
PRM2			,848			
PRM1	,207	-,241	,749			,216
PRM3			,732		,279	
COM1	,340			,757		
COM2				,701	,399	
COM3		,245	,286	,656		
COM4		,292		,611		
CON3					,796	
CON2		,274	,233		,692	
TRN3	,435	,364	,223		,488	
PLL2						,840
PLL1				,214		,783

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 8 iterations.

TRN3 is a problematic item in terms of several high cross-loadings on three different factors. In addition, none of the factor loadings are above 0,5 which is commonly referred to as cut-off for smallest factor loading. Consequently, TRN3 is excluded from the material.

Furthermore, COM2 is excluded as a response to relatively high cross-loadings with poor theoretical support.

Run 4

After three consecutive runs of Factor Analysis, six factors are extracted. All loadings are above the 0,5 cut-off and few cross-loadings can be found. COM1 ("We are frequently informed by our customers of our performance (quality, delivery, cost, etc)") and TRN4 ("Personnel at our plant are invited to our customers' sites to increase awareness of how our products are used") both have cross-loadings on Factor 1 (JNT1, JNT2, JNT3 and JNT4). However, increased participation in Joint Action (as described by JNT1, JNT2, JNT3 and JNT4) may very well result in increased communication of supplier performance. Likewise, Joint Action can be expected to result in an increased amount of invitations to the buying firm's site.

Table 5 Component Matrix after Run 4

Rotated Component Matrix[a]

	Component					
	1	2	3	4	5	6
JNT3	,897					
JNT2	,729		,221			
JNT4	,696	,268	,217	,271		
JNT1	,596		,290			,304
PRM2		,837				
PRM1	,203	,775			,210	
PRM3		,725				,274
TRN2			,841			
TRN1	,236		,824			
TRN4	,404		,541			
COM4				,749		
COM3		,240		,708		
COM1	,400			,688		
PLL2					,825	
PLL1					,800	
CON2		,207	,234			,785
CON3					,225	,755

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 8 iterations.

Test of normality

To test the assumption of normal distribution necessary for the t-test performed in the ad-hoc analysis, Shapiro-Wilk's test of normality was carried out. The test was performed on composite scores from the 38 suppliers with the lowest reported eQPMO (group 1), and the 39 suppliers with the highest reported eQPMO (group 2) respectively. It was detected that several of the samples differed significantly from normal distribution, and hence, the initial t-test should only be viewed upon as a rough indicator of differences in the sample. Below follows extractions from SPSS 15.0.

Table 1 Test of normality for composite scores calculated from the 38 suppliers with the lowest reported eQPMO. Significance lower than 0.05 indicates that the data differs from normal distribution.

	Shapiro-Wilk		
	Statistic	df	Sig.
MeanJNTgroup1	,967	38	,316
MeanPRMgroup1	,866	38	,000
MeanTRNgroup1	,946	38	,068
MeanCOMgroup1	,932	38	,024
MeanPLLgroup1	,924	38	,013
MeanCONgroup1	,929	38	,019

Table 2 Test of normality for composite scores calculated from the 39 suppliers with the highest reported eQPMO. Significance lower than 0.05 indicates that the data differs from normal distribution.

	Shapiro-Wilk		
	Statistic	df	Sig.
MeanJNTgroup2	,951	39	,088
MeanPRMgroup2	,946	39	,061
MeanTRNgroup2	,947	39	,065
MeanCOMgroup2	,919	39	,008
MeanPLLgroup2	,961	39	,191
MeanCONgroup2	,915	39	,006

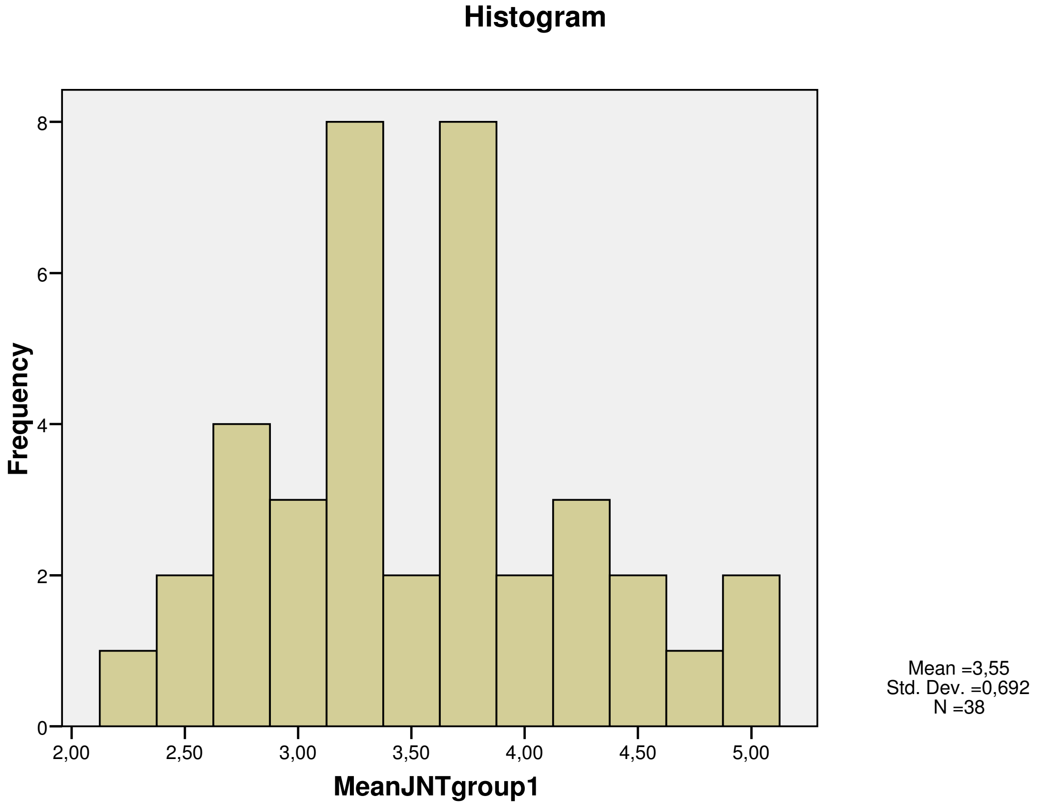

Fig. 1 Histogram of composite scores for Joint Action as reported by respondents in group 1

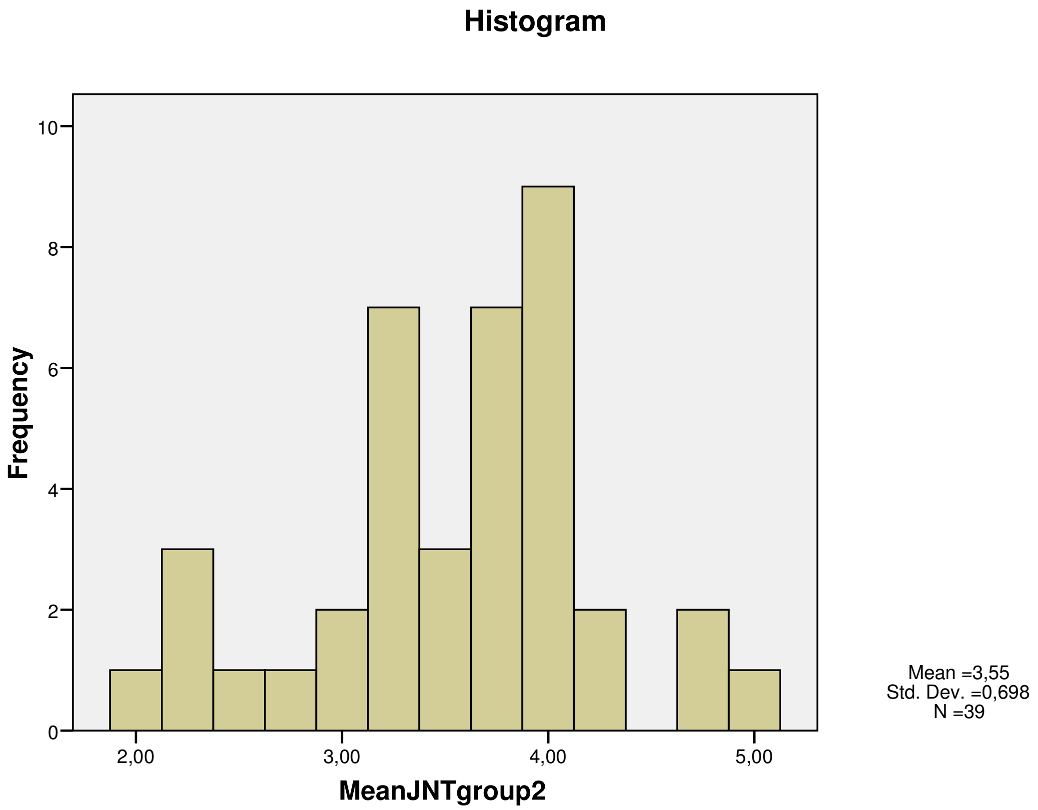

Fig. 2 Histogram of composite scores for Joint Action as reported by respondents in group 2

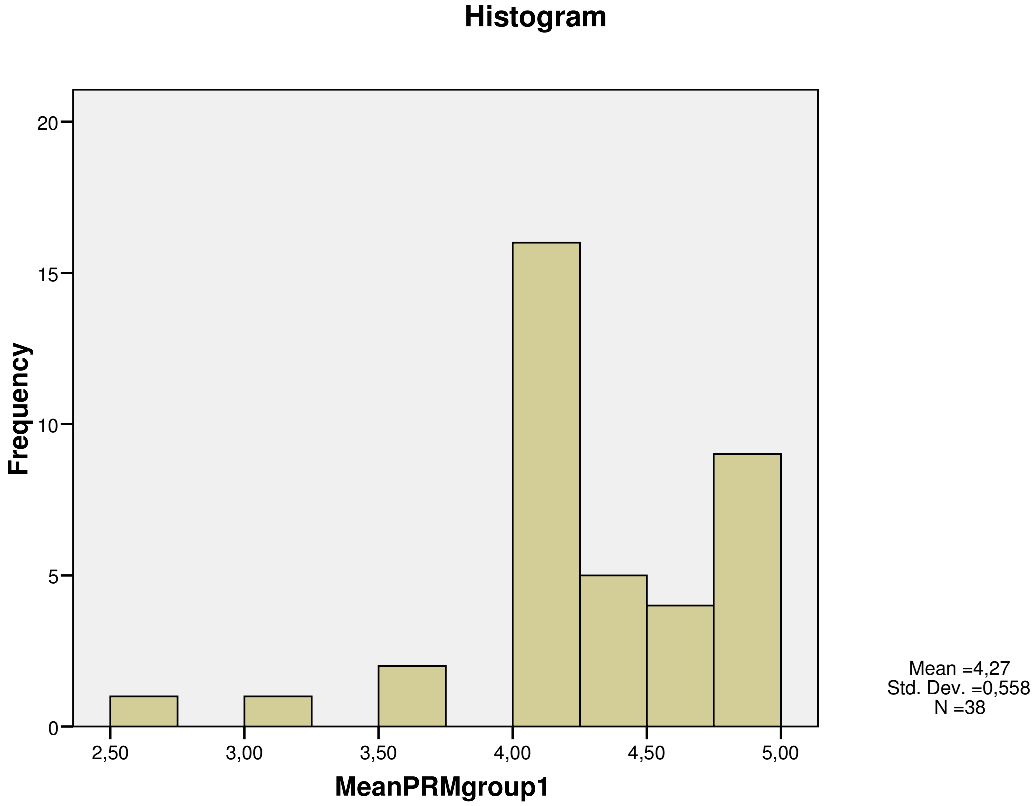

Fig. 3 Histogram of composite scores for Process Mapping as reported by respondents in group 1

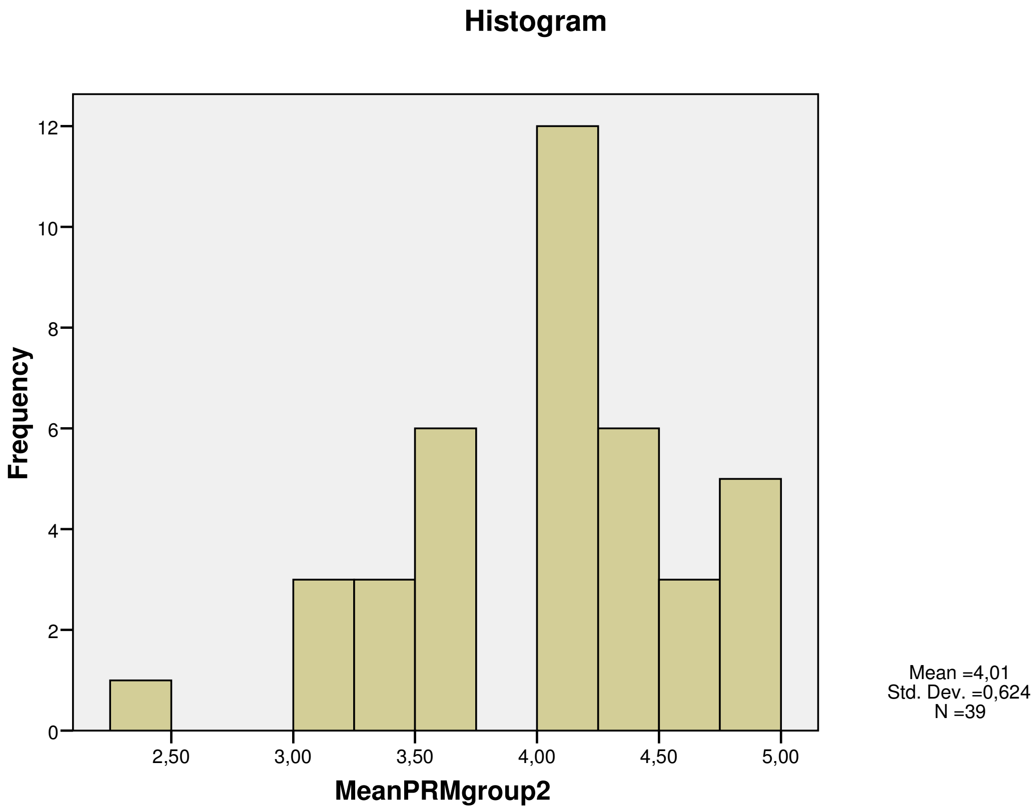

Fig. 4 Histogram of composite scores for Process Mapping as reported by respondents in group 2

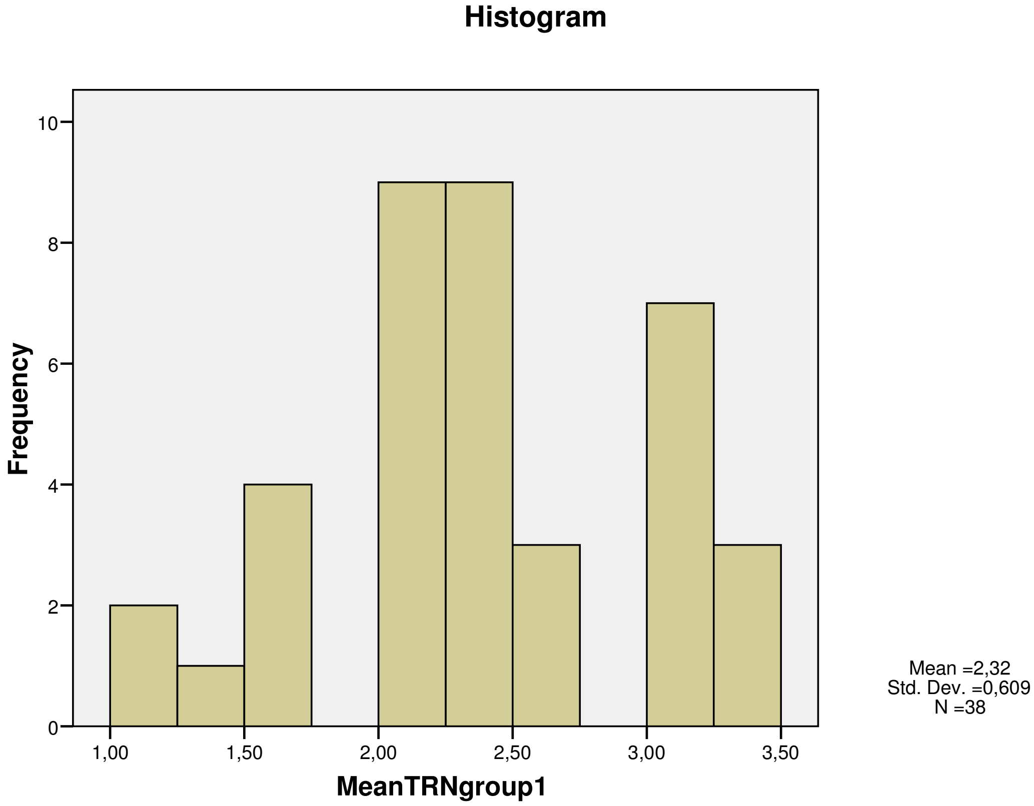

Fig. 5 Histogram of composite scores for Supplier Training as reported by respondents in group 1

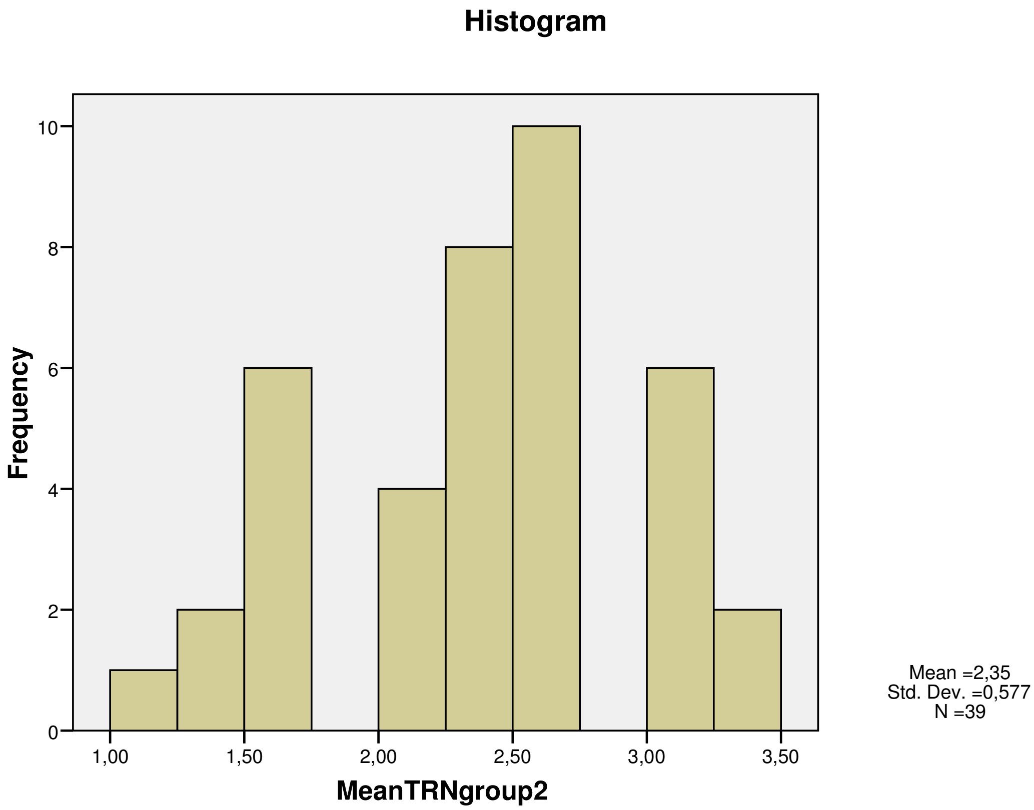

Fig. 6 Histogram of composite scores for Supplier Training as reported by respondents in group 2

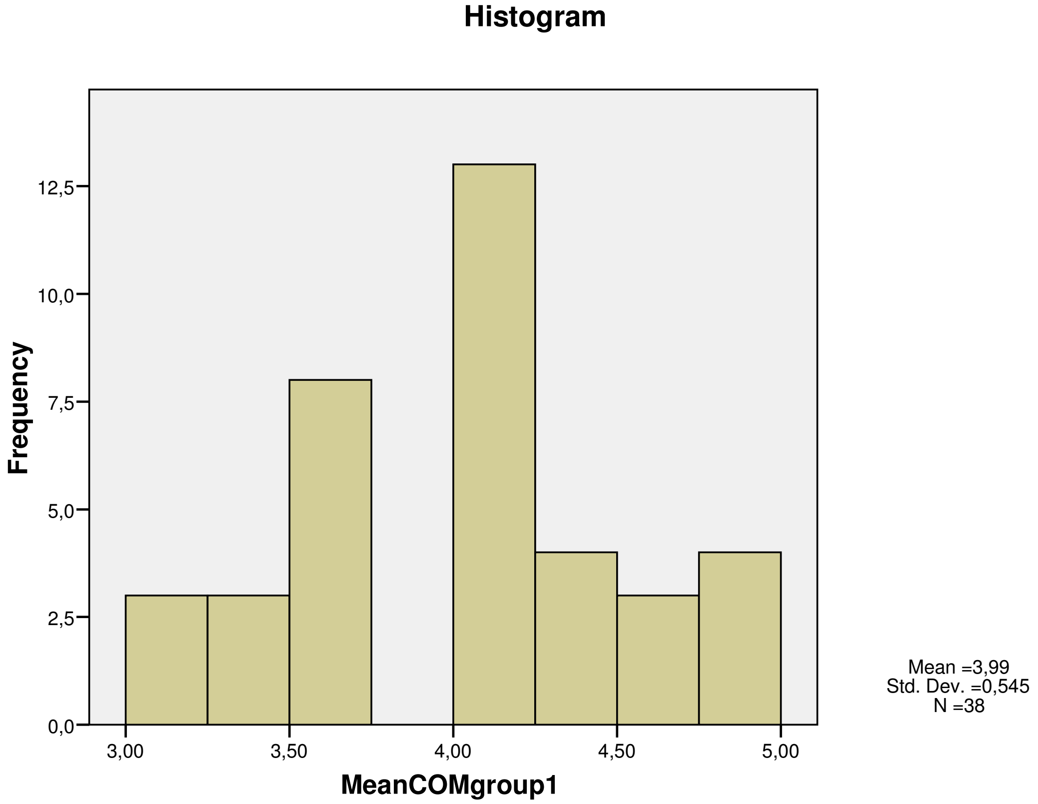

Fig. 7 Histogram of composite scores for Communication and Feedback as reported by respondents in group 1

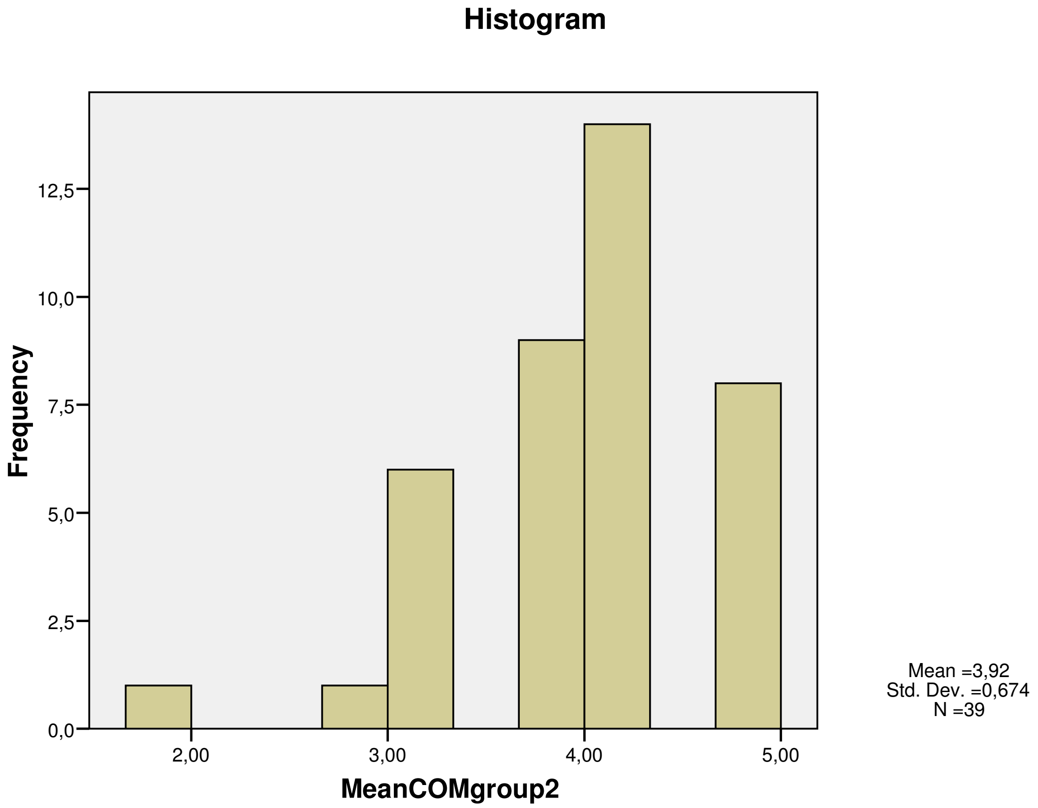

Fig. 8 Histogram of composite scores for Communication and Feedback as reported by respondents in group 2

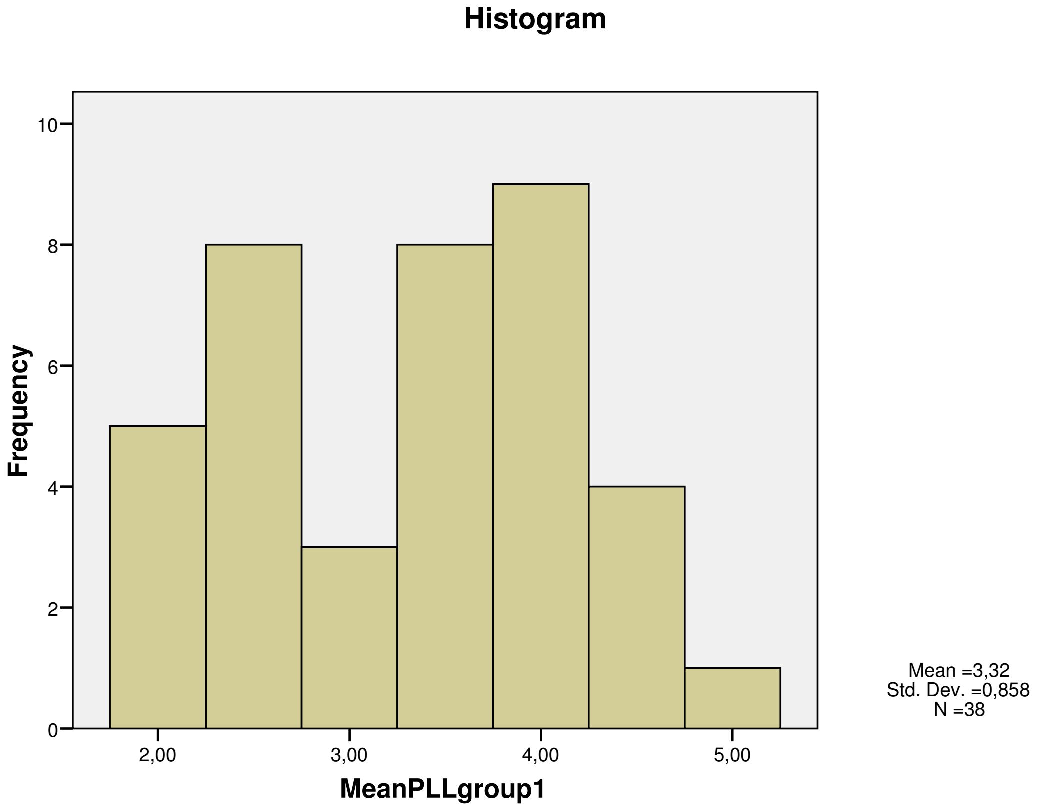

Fig. 9 Histogram of composite scores for Plant Leanness as reported by respondents in group 1

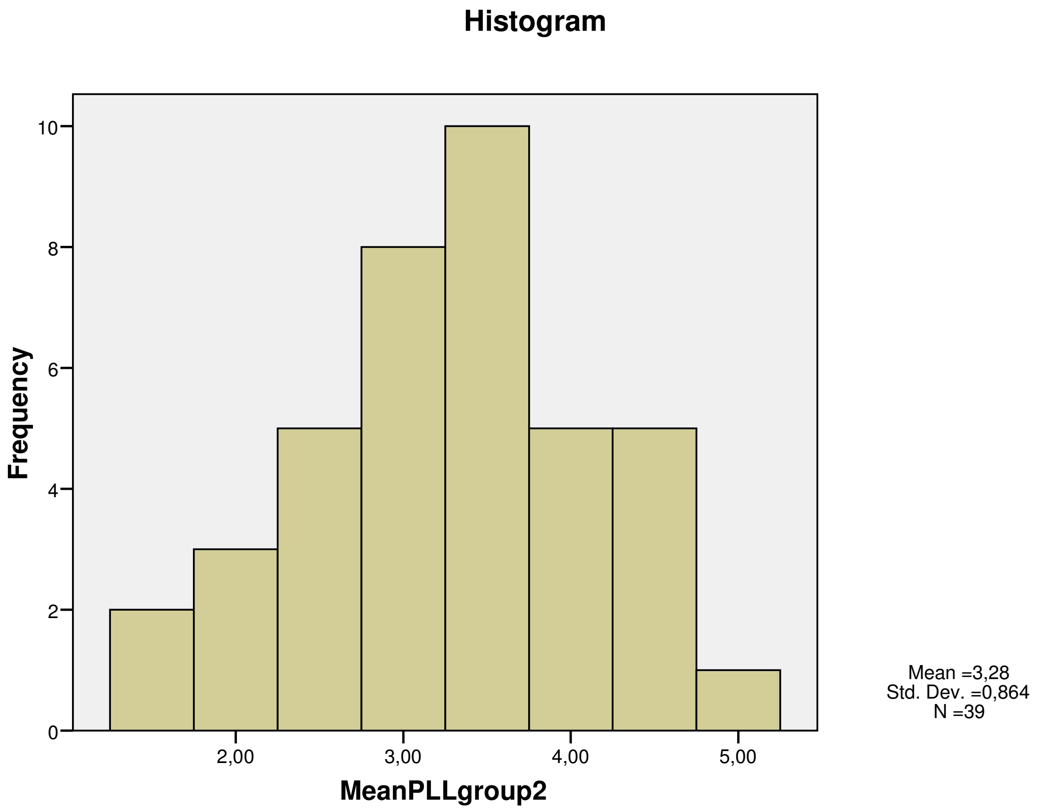

Fig. 10 Histogram of composite scores for Plant Leaness as reported by respondents in group 2

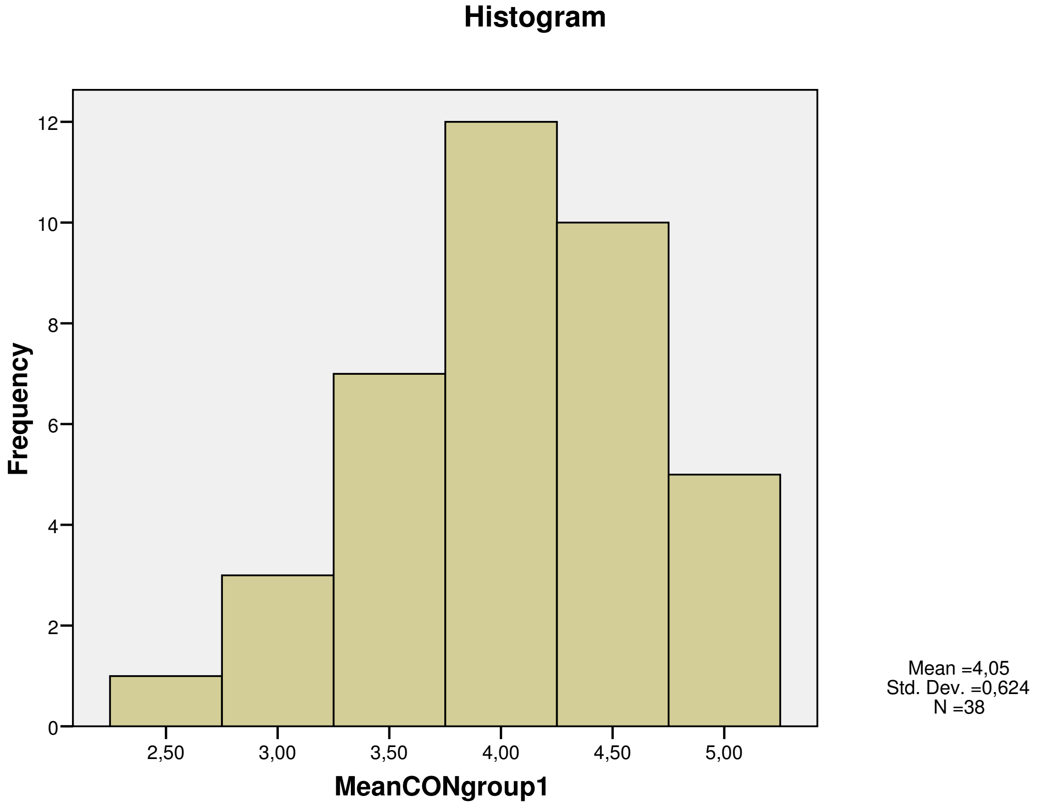

Fig. 11 Histogram of composite scores for Continuous Improvement as reported by respondents in group 1

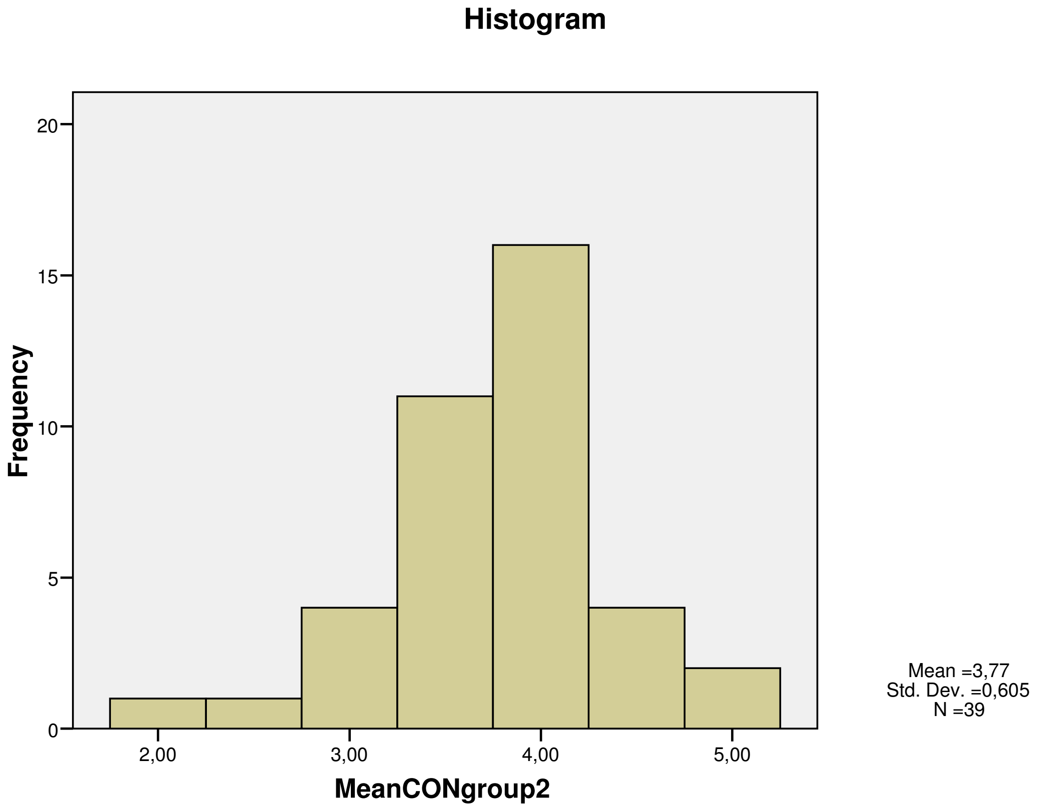

Fig. 12 Histogram of composite scores for Continuous Improvement as reported by respondents in group 2