Purchasing manages and optimises existing product variance

Abstract

Purpose - The purpose of this paper is the presentation of a new optimisation approach for product variance from the purchasing perspective.

Design/methodology/approach - The research is based on a case study of a collaboration with a global acting automotive Tier 1 supplier, who produces steering systems for cars and commercial vehicles. A total of 116 different variants of three components of a car automotive steering system were analysed and evaluated. The data was gathered from 13 sub suppliers for three different types of a steering system.

Findings - Unnecessary time, money, quality and technology can be saved through a greater understanding of such product variances. The results of the case study lead to a general method to optimise existing product variance and present cost improvements and a new key performance indicator to manage product variance out of the purchasing department.

Research limitations/implications - The research is based on a purchasing case study at a Tier 1 supplier of the automotive branch. The approach can be used for other company departments like e.g. logistics and for different industries than automotive.

Practical implications - A company can be successful and competitive when it meets the customer needs with a maximum on satisfaction without generating of waste. Unnecessary existing product variance is a kind of waste. The insights of this article support the operative user and the strategic company management to reduce and improve unnecessary variance in different sections.

Originality/value - The structured analysis of product variance from the purchasing perspective and the key performance indicator "variance share" are new to company management. The research focuses on the management of existing variance out of the purchasing department which is a segment that has received limited academic attention in research to date.

Keywords Variance- and complexity-management, lean management, strategic purchasing, product standardisation

Paper type Case study

1. Introduction

The growing importance of supply chain management has led to an increasing recognition of the strategic position of purchasing (Suarez-Barraza *et al.*, 2016; Paulraj *et al.*, 2006; Anderson and Rask, 2003; Bozarth *et al.*, 2009). The globalisation of the supply chain is the big future challenge for the supply chain management and the function of purchasing has tremendous impact to create value in the organisation (Thun and Hoenig, 2011; Pop Sitar, 2012). Therefore, the integration of purchasing, supply chain design and management will become more and more relevant in the strategic company planning.

1.1 Agility of purchasing regarding variance

Before, these areas were often an underestimated task in management levels (Rast, 2008; Slone *et. al.*, 2010) but today purchasing plays a key role in terms of adopting a cooperative approach to create innovation-oriented and cost-oriented products (Tracey and Neuhaus, 2013). The challenge here is that an enormous increase in product variance has a serious impact on the value creation processes throughout the supply chain and cause the company an enormous effort in terms of costs (Krumm and Schopf, 2014). In order to meet this challenge is an agile supply chain strategy necessary which is defined through flexibility by adapting quickly, effectively to rapidly changing customer needs (Krieg, 2004) and a cost optimisation approach across the procurement chain (Huang *et al.*, 2002; Christopher and Towill, 2000; Droege, 1999). One important approach of cost optimisation across the procurement chain is the elimination of waste in form of reduction of unnecessary product variants (Douglas *et al.*, 2015; Christopher, 2005; Droege, 1999; Liker, 2004, Wang *et al.,* 2011). In parallel, companies increasingly rely on externally supplied services and products, which often account for more than half of the company's spend (Schiele, 2007; Bals *et al.*, 2009; Cox *et al.*, 2005; Smeltzer and Ogden, 2002). The purchasing department has a very high impact on the costs of the product (Carr and Pearson, 2002) and the variance of these purchased parts. Ultimately, the purchasing department can be the control center for the reduction or optimisation of existing variance.

1.2 Research gap and questions

The state of the art is an approach which focuses on cost optimisation across the procurement chain through the elimination of product variance from the beginning of the product development process, abbreviated PDP (Douglas *et al.*, 2015; Christopher, 2005; Droege, 1999; Liker, 2004, Wang *et al.,* 2011). For Adobor and Mc Mullen (2014), Danilovic (2006), Sjoerdsma and van Weele (2015) and Wynstra et al. (1999) this problem could be covered within the supply chain by early supplier integration in the PDP.

Therefore, in this study we expect to extend this stream of research by focusing on one important gap in the literature: The focus on the reduction of existing internal product variance through the combination of methods and tools from complexity management, variance management and technical purchasing. This research pursues an optimisation approach through the methodical analysis and evaluation of existing internal product variance out of the purchasing perspective in contrast to an avoidance approach of product variance from the beginning of the PDP. One important question guides this research:

RQ. How is a systematic reduction of existing complexity in form of a huge amount of product variance out of section purchasing possible?

In this study has the research collaboration partner, an automotive Tier 1 supplier, a huge amount of existing product variance within the company. The product variance has arisen over several years due to fast technology leaps and further product development. The variance is often not visible due to a so called operation-blindness (Theilacker, 2015), a communication lack between R&D, purchasing and the supplier (Rosell *et al*, 2014) or simply due to the missing time to examine and if necessary to eliminate unnecessary variants. Unnecessary variance means the optimisation of the existing, which has no influence on customer satisfaction.

1.3 Paper design
The paper is structured as follows: first a theoretical framework is provided related to the subject of the importance of purchasing and the increasing complexity and variance within this area. Then, the methodology chosen for the study is presented. The paper proceeds with a presentation of the findings namely the variance cube of purchasing, followed by an analysis of the data and presentation of the results through the case study "pressure piece". Finally, there is a discussion and conclusion where managerial implications, limitations and suggestions for further research are presented.

2. Theoretical background
Procurement success has several dimensions: cost, quality, time and flexibility (Drake *et al*., 2013; Young and Varble, 1997; Scannel *et al*., 2000; González-Benito, 2007; Cirtita and Galser-Segura, 2012) which can be extended to common mindset to find the cost optimisation potentials across the procurement chain (Droege, 1999; Fisher, 1997). Fawcett et al. (2008) reinforce these insights with a survey through different channels regarding benefits, barriers and bridges of supply chain management. The core benefits are on the one side the customer focus through e.g. on-time deliveries and increased responsiveness; on the other side the company's focus through e.g. a reduction of purchasing and product costs. The involvement of purchasing and suppliers in product development is therefore very important to support a cooperative product development process approach and the main challenge for purchasing will be to find the balance between an innovation- and cost-oriented supply chain (Rosell *et al*., 2014; Tracey and Neuhaus, 2013; Wynstra *et al*., 1999). This is possible through the management of product complexity (Lucchetta *et al*., 2005; Novak and Eppinger, 2001).

2.1 Complexity management
The concept of complexity can be described concerning the characteristics of variety, connectivity and dynamics. The variety includes the number and the type of elements in a system. The term connectivity represents the number and the type of the relations between the individual system elements and the dynamics describes the indeterminacy and unpredictability of complex systems (Klabunde, 2003). Novak and Eppinger (2001) identify the following three elements of product complexity: number of components, component interactions and product novelty. An enormous increase in product complexity has a serious impact on the value creation processes throughout the supply chain and cause the company an enormous effort in terms of complexity costs (Schöneberg, 2014; Hirschsteiner, 2006). The supply chain design should depend on the complexity of the assembled or manufactured product (Inman and Blumenfeld, 2014).

The purchasing integrates more and more into the strategic corporate management (Hartmann, 2011; Krumm and Schopf, 2014) and strategic management means the control of complex systems, in which the complexity increases with the variety of distinguishable states within the system (Malik, 2008) with the goal of an end-to-end focus on integration of business processes throughout the value chain for the purpose of providing optimum value to the end-customer (Wisner, 2003; Green *et al.*, 2008). The degree of complexity depends on the number of system elements, the variety of the relations between these elements and the number of possible system states (Ulrich and Probst, 1995). Real systems can have infinitely many states and the complexity of a system can be quantified and measured with the help of the concept of variety. Variety is the number of distinguishable states of a system or the number of distinguishable elements of a set (Malik, 2008; Duarte Jr., 2016). Malik (2008) clarifies that a supposed simple system can have enormous variety and the complexity of a system can be kept under control only by an equally complex system. The British cybernetics, Ross Ashby (1956), has formulated this insight as follows: "Only variety can absorb variety". This means, a system is controlled, when it prevents the system moving into states to which it is capable in principle of which are not desirable. The insight of Ashby has evolved into Ashby's law and today is still quoted in different literature areas like Fleck (2009) - Business and political economics or Masak (2010) - IT architecture.

The operation blindness could be one consequence of a complex system. The more complex a system is, the harder it gets to capture all coherences. The insights of Simchi-Levi et al. (2014) support this statement. They have analysed the supply chain of the company Ford regarding risk management with the resulting picture that the supply chain is getting more complex, global and extensive. They have developed a risk management model for a supply chain. One insight of this model is also that the focus is mostly only on the important suppliers. But a small

supplier of an O-ring can also stop the whole production line if there is a problem. The complexity of a supply chain system can depend on the number of suppliers (Gerschberger *et al.*, 2012).

2.2 Internal and external complexity
Schuh (2005) divides the term complexity into internal and external complexity. External complexity occurs in the environment of a company through e.g. customer requirements and market changes, whereas internal complexity can occur through product- and process-diversity within the company. Today companies are daily exposed to internal and external complexity. The internal complexity especially must be identified and controlled and possible potentials need to be developed. For Marti (2007), the two dimensions of external and internal complexity obtain in the field of complexity management a special attention from theorists and practitioners.

These two dimensions of complexity are widely used in the literature of complexity management: Schuh (2005) emphasizes the effects of excessive customer orientation on internal complexity and complexity costs. Kaiser (1995) uses the terms external (exogenous) and operative (endogenous) complexity as well as external and internal complexity. External complexity like e.g. customer requirements, competitive forces, technological changes, etc. pushes companies to broaden their product portfolios and introduce product variety. This in turn increases the enterprise's internal complexity such as product complexity, organisational complexity, production complexity, etc. The avoidance of unnecessary variety is a key element for a company to be successful and competitive (Rapp, 2010; Fisher 1997). A company should not produce unnecessary variety, which is unnoticed on the market side. For a company, variety is considered wasteful without customer value. Within lean management, this is known as "Muda". "Muda" is a process or activity not adding value to a product for the customer (Liker, 2004).

These insights return to the second research question: How is a systematic reduction of existing complexity in form of a huge amount of product variance out of section purchasing possible? Malik (2008) answers this question partly with his statement that the complexity of a system can be quantified and measured with the help of the concept of variance management.

2.3 Variance management
The variance must also be differentiated in external and internal variance like the complexity. The external variance is useful for the customer in form of variety of product variants. The internal variance describes, in the context of order processing, the variety of products and processes that are necessary for the performance of the external variance (Franke *et al.*, 2002, ElMaraghy *et al.*, 2013). The misunderstanding of the customer orientation leads to exploding variants figures and strong economic problems for a company connected with a loss of competitiveness (Boutellier *et al.*, 1997).

Three general approaches of variance-optimisation are described in numerous publications by different authors: 1) The avoidance of variance, 2) the reduction of variance and 3) the control of variance (Bayer, 2010; Scheer *et al.*, 2006; Grotkamp and Franke, 2007). The second approach of variance-optimisation regarding the internal company complexity is the center of attention in the present study. The article describes a solution for the problem of the increasing complexity by variance and presents a solution by connecting the areas of purchasing, lean management and complexity- and variance-management.

2.4 Summary
The researchers are focussing on the avoidance of unnecessary purchasing and product costs through the early integration of the purchasing department of a company and the suppliers within the PDP. Unnecessary costs can result from unnecessary product variance and complexity. Variance and complexity are closely linked and can be subdivided into internal and external factors. However, the research question of this work cannot be fully answered on the basis of the latest findings. The subdivision of variance and complexity into internal and external factors, as well as the methods out of these two areas, are important pillars, which are nevertheless not yet fully sufficient to answer this question. It remains unclear which role purchasing can play and how these areas must be linked together in order to optimise existing, internal product variance. The following approach of this research will close this gap and fully answer the research question.

3. Methodology
3.1 Research design
This research aims to provide knowledge that helps to determine which method can be used in order to improve an existing situation (Verschuren and Doorewaard, 2010). It's a practice-oriented research which refers to the unstructured set of problems with which a practitioner is dealing (Dul and Hak, 2008). The practitioner in this case is a buyer of an automotive Tier 1 supplier. The Tier 1 supplier is a global acting company which delivers steering systems for cars and commercial vehicles to all famous Original Equipment Manufacturers (OEM's) worldwide. The empirical research work is supported by an explanatory single case study of research question, data collection, data analysis and deriving of research findings in form of a new method (Cousin, 2005; Yin, 2003). The research question have already been formulated in the section introduction. Pohl and Förstl (2011) have already been

successfully used a case study approach for analysing a purchasing-variance measurement system for the analysis of a general purchasing performance measurement system.

3.2 Data collection

The collected and evaluated data of the case study represent decades of automotive Tier 1 company history. The company produces three different types of car steering systems for different car sizes in Asia, Europe and Americas. The analysed data are taken from this global database. The assembled steering system consists of approximately 100 different single components. Each steering system is individually adapted for the respective customer. 116 different variants of one sub assembly of the steering system "the pressure piece", which exist of 3 single components, were analysed and evaluated regarding variance. The data was gathered from 13 sub suppliers for 80 customers and 3 different types of a car steering system. The case study thus involves and analyses a pressure piece purchasing volume of around 17 million euros.

3.3 Data analysis

The data were examined with the help of a cost- and variance driver analysis. This kind of analysis is structured in five phases and the form is derived by a tool for continuous improvement from quality management. Derived is the structured approach of the five phases of define, measure, analyse, improve and control (DMAIC), as a reactive method to find the root causes for the number of variants and the optimum solution (Alvarez, 2015; Mishra and Sharma, 2014). Additional helpful tools and methods, which are used in section 4.3, are the principal of Pareto (2005) and the software Metus from the company ID-Consult. The software Metus is a supporting tool to make complex systems and coherences visible and reasonable.

3.4 Research findings

The research findings are a new tool for the structured analysis of existing product variance from the view of the purchasing department, the so called variance cube of purchasing (VCP) and a new KPI "the variance share". The results of the case study have led in addition to a huge yearly cost saving for the automotive Tier 1 supplier which is presented in the following section results.

4. Results

4.1 Variance cube of purchasing (VCP)

Each year the goal is proclaimed that the OEM needs cost savings from the suppliers without loss of performance on quality and logistic. The pressure of the OEM runs throughout the complete supply chain. Due to these facts originate the findings, which have led to the development of the VCP, from an automotive Tier 1 supplier. It's a supplier of steering systems with a very high proportion of bought-in parts. The influence of the purchasing on the overall result of the company is therefore immense.

Derived by the approach of ElMaraghy et al. (2013), that the variance management considers the product, process and market views has the variance cube of purchasing also the 3 dimensions: product, supplier and process. The dimensions represent the workspaces of the purchasing department in a company. The core business in the purchasing department is to buy products from suppliers according to the defined company processes. From the view of purchasing, especially from a commodity group, there are three perspectives to explore: the process perspective, the product perspective and the supplier perspective. The product and the process perspective reflect the internal company's structure from the view of purchasing and the supplier perspective represents the environment e.g. of a commodity group (Schuh, 2005). The main interest of the company is to satisfy the customer's needs best. These needs, requirements and desires enter the company and they are virtually filtered, adapted or extended and distributed via the communication interface such as logistics, quality, purchasing, etc. to the supplier.

The automotive Tier 1 supplier has been producing steering systems for many years. In the last 15 years there was a technical change from a mechanical steering gear to an electrical steering gear. Currently both systems are running in parallel but the hydraulic business is decreasing and the electrical business is increasing. Some processes are based on the old system and some processes were implemented to support the new system. Some components could be used for both systems, but some are unique. Consequently the number of products, processes and suppliers is very large with the consequence of high internal existing variance and complexity.

According to the presented literature and the fact that purchasing occupies a key role, the requirements for the VCP could be recommended as:

- Efficient localisation of cost potentials in every dimension

- Easy and self-explaining tool and method

- Fast increase of cost savings for a company

- Definite localisation and optimisation of existing internal variance

- Fast development of lean processes

- Pragmatic guideline for the user to find potential cost savings

- Easy adaptability to other commodity groups, departments and industries as e.g. VCL – **V**ariance **C**ube of **L**ogistics

4.1.2 Product Dimension

In this work is the focus on a detailed analysis and explanation of the product dimension. The purchasing department of the automotive Tier 1 supplier is divided in different commodity groups like electrics, aluminum die casting components, turned parts or plastic parts. Due to the technical change from hydraulic to electrical steering gear, the portfolio on parts is very enormous. The dimension product of the VCP serves to ask critically if this range of different parts is necessary and will make some optimisation potentials visible. The detailed functionality of the dimension product is presented through a case study in the sections 4.2 and 4.3.
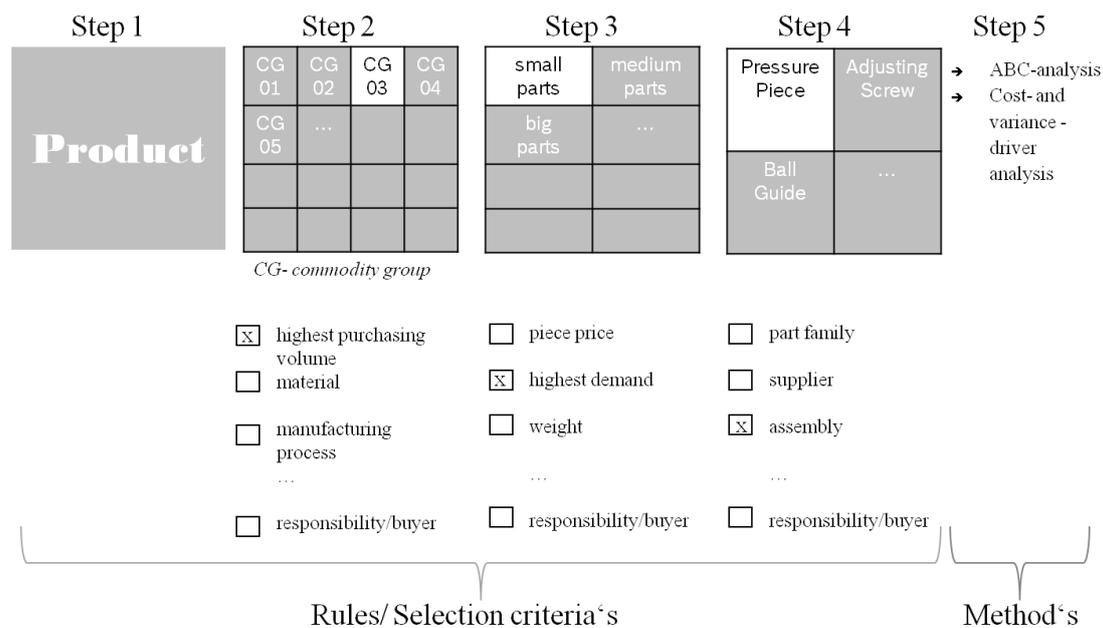

Figure 1: The 5 steps of the dimension product from VCP

4.2.2 Function of the VCP exemplary for the dimension product (see figure 1)

1st Step: The cube is a 3-D-tool and turnable. The user can select between the perspectives product, supplier and process. The product and process dimensions reflect the internal and the supplier dimension the external perspective (Pohl and Förstl, 2011).

2nd Step: The cube switches to a 2-D-matrix with different selection fields. In this case are the different selection fields the commodity groups (CG) like e.g. electrics, aluminum die casting components, turned or plastic parts. The user has three options: 1) The user will choose directly one CG because he knows exactly which area he wants to analyse. 2) The user has different selection criteria that will lead him through the cube/matrix. Example: The user can click on the criteria "purchasing volume" and choose "highest" and the CG with the highest purchasing volume will be automatically highlighted. 3) The user with a detailed responsibility regarding products or suppliers wants to analyse his area of operation. He can directly click on responsibility and choose his name. The cube leads him directly to his responsibility. This option exists also for step 2, 3 and 4. In this case, the user has selected the highest purchasing volume and the cube leads him to CG 03.

3rd Step: Every CG is divided into part families. The advantage of categorisation, which is an important part of purchasing, is integrated from step 2 till step 4 in the VCP (Jouni *et al.*, 2011). The user has the same three options as explained in step 2. The example of *figure 1* leads the user through the selection of the highest demand to the part family of the small parts.

4th Step: The fourth level is the level of components and the last selection step. The user has now the choice to select a special component for the variance analysis according to the three main options. Exemplary to *figure 1*, the user chooses the variance analysis of an assembly and the VCP leads to the component "pressure piece".

5th Step: The final step is different from the others in terms of the fact that switching from selection criteria and rules to methods. E.g. the ABC-analysis or the cost- and variance-driver analysis. The ABC-analysis is a useful tool in order to categorise e.g. the part family pressure piece according to purchasing volume. The VCP presents in the last step methods for variance visualisation and optimisation to the user.

The VCP is the proposed solution to the research question from the introduction. The VCP is a tool for structuring and organising complex systems (Malik, 2008) which visualises simple coherences and optimisation potentials to counteract the problem of operation blindness. The cube connects the strengths of purchasing such as the organisational system structure and the steering process in form of KPI's, targets and rules (Pohl and Förstl, 2011). A large amount of product variance that leads to an increase of complexity can be managed by the connection of the three areas of purchasing, variance- and complexity management and lean management.

4.2 Case study pressure piece

The case study is divided according to the five phases of DMAIC for the subassembly pressure piece, which is a part of the CG aluminum die casting. The pressure piece is an assembly of three parts: the pressure part, the insert foil and the O-ring, see figure 2. The automotive Tier 1 supplier is ordering the whole assembly from the Tier 2 supplier. The Tier 2 supplier is consequently a system supplier. The purchasing department negotiates a price for the whole assembly and has normally no direct contact to Tier 3 suppliers. Nevertheless are the design of every single product, the requirements and the specifications coming from the automotive Tier 1 supplier and will be submitted from the Tier 2 supplier to the Tier 3 supplier. The whole variance of the pressure piece is for the automotive Tier 1 supplier not visible. No one comes up with the idea to put the assembly to the test, because everything is working. The logic of the VCP is to examine everything and structure questioning.

4.2.1 Function of the pressure piece

The pressure piece is placed in a whole of the steering housing and fixed through the adjusting screw. The pressure piece has direct contact to the steering rack. The interface between the pressure piece and the steering rack is the insert foil. The pressure piece has the function to press the steering rack against the steering pinion. The lash between the pinion and the rack can be adjusted through the combination of the pressure piece and his screw.
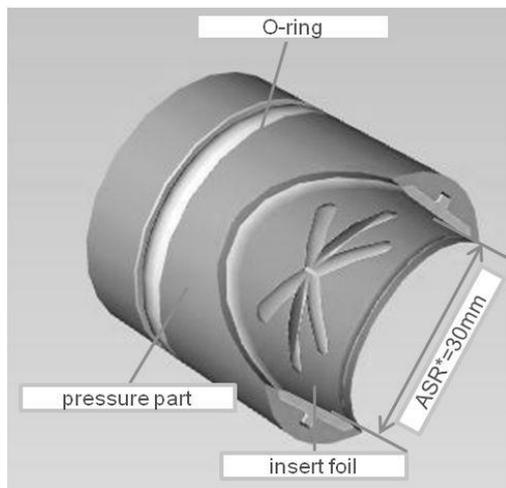

Figure 2: Pressure Piece

Facts/KPI's:

- demand: 25 Mio. pcs./ year
- turnover: 17 Mio.€
- number of pressure piece variants: 67
- number of insert foil variants: 40
- number of O-ring variants: 9
- number of suppliers: 5
- number of sub suppliers: 8

Is this amount of variance in form of O-rings, insert foils, pressure pieces, suppliers, sub suppliers etc. necessary?

4.3 Cost- and variance-driver analysis

The next 5 phases of the cost- and variance-driver analysis will answer this question.

4.3.1 Phase 1: Definition of variance and coherences

The first phase of the cost- and variance-driver analysis is the definition of all potential variance drivers for the pressure piece. Some tools and methods can be helpful for the visualisation of the variance sectors and the coherences. The variant tree mainly used for the visualisation of technical variance from products (Schuh, 2005), mind mapping (Buzan T. and Buzan B., 1996) or the software METUS, especially developed from the company ID-Consult to visualise and analyse complex systems and improve their variance. The software METUS is also used to visualise and analyse the product variance along the entire value chain and the product architecture, but it can be easily transferred to every sector like purchasing. In this study mind mapping and the software METUS are used for the localisation and visualisation of the variance sectors and their coherences.

Figure 3 shows the coherences of the different variance sectors. The software METUS is very easy to use and helpful to make complex systems and the interdependencies of its elements transparent. Figure 3 is only an extract and not to be evaluated regarding completeness. The path and the coherences of one combination (O-ring 34x4 mm) are marked in light grey. The O-ring 34x4 mm is manufactured in two different materials (NBR and HNBR) and is assembled within three different pressure pieces (0001, 0002 and 0006). The software METUS helps to create easily the whole net especially in this situation that one O-ring size is used with different O-ring materials for several pressure parts in combination with several insert foils for different steering racks,. All coherences and

effects can be visualised in one picture. This makes it easier to understand the system and to localise optimisation potentials.

Summary phase 1: All variance sectors of the pressure piece are defined, first focus is on the variance sector O-ring and the coherences of this variance sector are captured.

4.3.2 Phase 2: Measure of variance drivers

The O-ring has two variance drivers that are responsible for the number of variants: The material and the O-ring size. Currently, there are 7 different O-ring sizes and two materials that are presented in figure 3. The range of the O-ring size is between 30x2 mm and 36x4 mm. The cheapest one consists of the material NBR and costs 4.0€/100 pcs. and the dearest one consists of the material HNBR with a price of 10.0€/100pcs. The optimal case is that the company can satisfy all customer needs only with one O-ring size and one O-ring material for every pressure piece. This optimisation has positive impacts in form of cost savings within the purchasing department, an increase of the company profit, an increase of the competitiveness and an increase of flexibility within the supply chain and the production (Wei, 2008; Schiele, 2007). In this study the optimisation of the variance sector material is examined as first step.

Malik (2008) has defined the variety of a system with the following formula:

$$V=k^n$$

V=variety of the system; n=elements; k=conditions

This formula can be translated to the example of the different O-ring sizes:

n=elements=7 (O-ring sizes); k=conditions=2 (Material)

$$V=2^7= 128$$

A seemingly simple system turns out to be a system with a high variety.

What will happen if it's possible to reduce one element through e.g. the elimination of one material for a special size?

$$V=2^{7-1}= 64$$

The variety of the system will be halved but the core question is: Is it also a cost improvement? A variance driver is not automatically a cost driver.
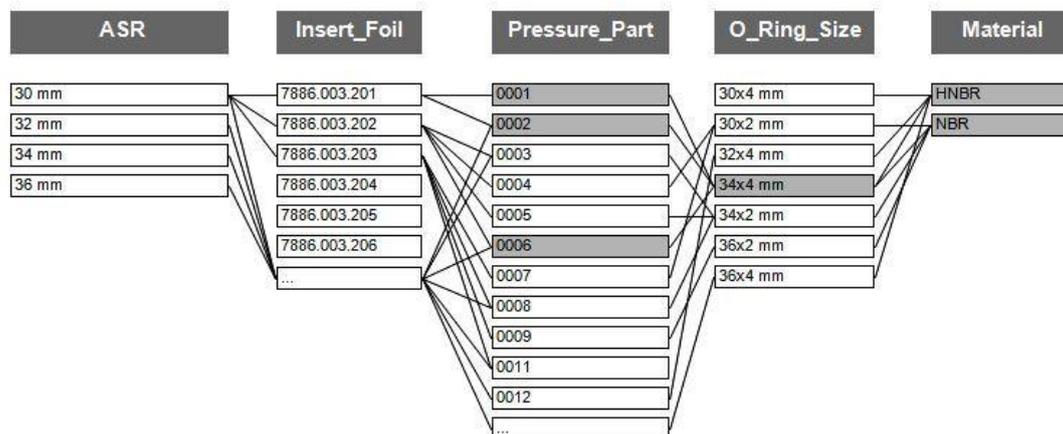

Figure 3: Net of pressure piece coherences; software METUS

Schuh (2005) describes the following: As the product portfolio grows and variants proliferate, complexity costs do not spread equally among all product variants. It is the target to find variance drivers that have the characteristic to be in parallel a cost driver. The case of the O-ring size 34x4mm, which is light grey marked in figure 3, shows that one O-ring size has two material variants, HNBR and NBR. The price of the O-ring 34x4 mm from the material HNBR is 10.0 €/100 pcs. and the price for same O-ring size from the material NBR is 5.0 €/100 pcs. The Consequence is that the variance driver material (especially HNBR) is in parallel a cost driver.

Summary phase 2: The variance drivers of the O-ring are defined (material and size), the first focus is on the material HNBR that is in parallel a cost driver.

4.3.3 Phase 3: Analysis of variance drivers and cost drivers

Phase 1 and 2 have shown that the O-ring material for the O-ring size of 34x4 mm represents a potential for optimisation due to the fact that it is both a cost driver and a variance driver. What happens if it's possible to reduce to one material variant for the O-ring size 34x4 mm?

To answer this question a detailed analysis of the part family pressure piece is necessary. Phase 3 shall now analyse which effects this insight could have on the whole assembly of the pressure piece and at the end for the company performance. The analysis phase contains the collection of data and the representation of the current situation (Yin, 2003). An excel table with all important data like demand, price, turnover etc. is summarised in figure 4. The clear target is to increase the efficiency of the company in form of reduction of waste (Liker, 2004). According to the principal of Pareto (2005) the first focus is on the pressure pieces with the highest purchasing volume assuming that there is the biggest effect in form of cost savings. Figure 4 shows the typical Pareto analysis. The different pressure piece variants are listed on the x-axis; on the left y-axis is the yearly demand in pcs. and on the right y-axis is the yearly turnover in € listed. The curve is traditionally divided into three categories:

- category A: 10% of the variants have a share on turnover and demand of 80%

- category B: 20% of the variants have a share on turnover and demand of 15%

- category C: 70% of the variants have a share on turnover and demand of 5% (Christopher, 2005).
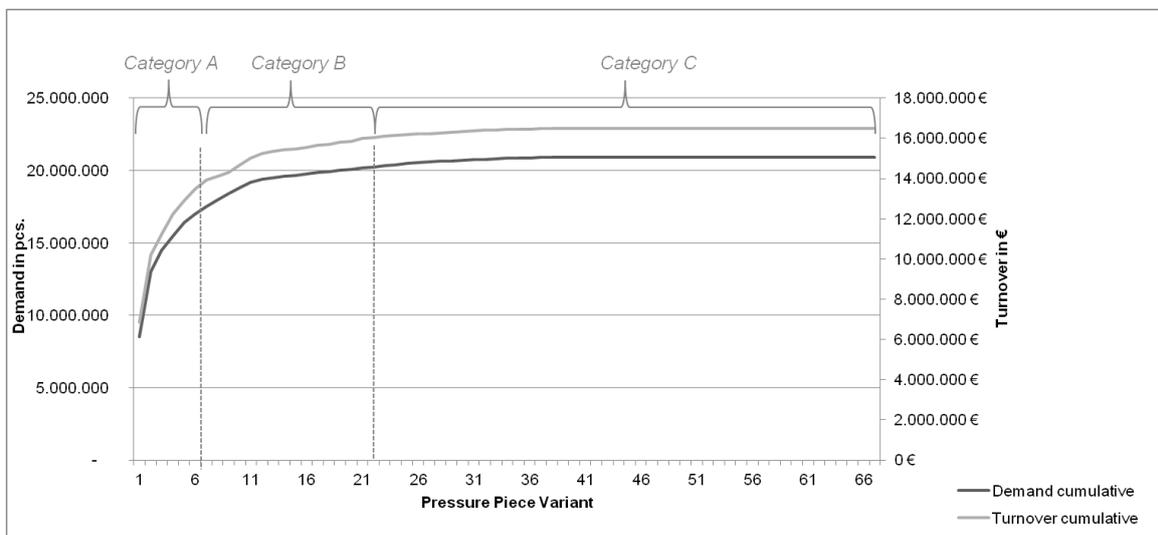

Figure 4: Pareto analysis of the pressure piece variants

The first focus is on category A due to the fact that 10% of the variants represent in parallel 80% of the purchasing volume and 80% of the demand. Table 1 shows the important data of the category A.

Table 1: Overview category A of pressure piece variants

Pressure Piece	Demand in Mio. pcs./year	O-Ring size in mm	O-Ring material	O-Ring price/100pcs.
0001	**8.5**	**34x4**	**HNBR**	**10.0€**
0002	**4.5**	**34x4**	**NBR**	**5.0€**
0003	1.5	32x4	HNBR	8.0€
0004	1.0	34x2	NBR	4.0€
0005	0.9	30x2	HNBR	7.5€
0006	0.6	36x2	NBR	6.0€

Table 1 represents the category A from the Pareto analysis of the pressure pieces. Category A comprises six pressure pieces which have a share on turnover and demand of 80%. The categories are also shown and separated in figure 4 by dashed lines. Table 1 illustrates that the pressure pieces 0001 and 0002 are the pieces with the highest demand and they have in parallel the same O-Ring size but a different material. This overview raises the question of whether two materials for the O-Ring size 34x4 mm are necessary.

Summary phase 3: All data are collected and summarised in an ABC-category-diagram. The first focus is on category A and especially on different O-Ring materials for the pressure pieces 0001 and 0002 due to the high potential leverage.

4.3.4 Phase 4: Improvement of the variance structure

After defining the variance driver O-Ring, analysing, making its relations visible and measuring its processes and cost drivers, a specific optimisation is possible, in this case in form of a material comparison. There is one difference between NBR and HNBR. The heat stability of HNBR is 20 degree higher than for NBR. The result, after a detailed analysis with the R&D department and some tests within the laboratory, is that the heat stability of HNBR is not necessary for the pressure piece 0001. The requirement of the high heat stability is a relic from the hydraulic steering system and the pressure piece 0001 has since some years only been used for electrical steering systems. The variance of the two O-ring materials is in the age of the electrical steering system not necessary and waste. One lean management tool is the 5-W-method. Ask five times "why" to find the root cause of the problem or in this case the root cause of the variant (Liker, 2004). This method was also very helpful to answer the question if a second O-ring material for the O-Ring size 34x4 mm is necessary. Such a material change is only in alignment and close cooperation with the R&D department possible. Purchasing has the possibility to make the variance visible, to display cost potentials and to ask critical. R&D aids towards the decision of whether such a change is required.

The following figure 5 shows the initial variance structure with two O-Ring materials compared to the optimised variance structure without the material HNBR.
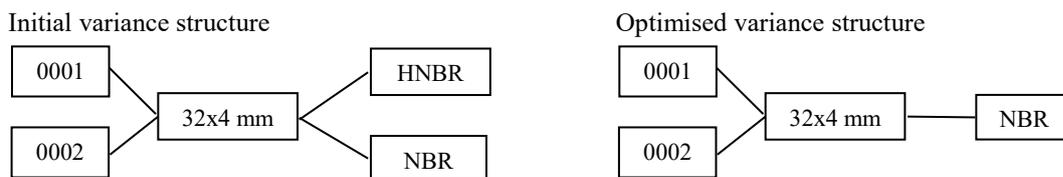
Initial variance structure

Optimised variance structure

Figure 5: Initial vs. optimised variance structure

The optimised variance structure leads to a yearly cost saving of

$$\left[\frac{5.0\euro}{100pcs.} - \frac{10.0\euro}{100pcs.}\right] \times \left[8,500,000 \; \frac{pcs.}{year}\right] = -450,000\euro/year.$$

These are hard yearly savings due to the fact the yearly price of the pressure piece is reduced compared to the price of the previous year (Nollet *et al.*, 2008). The purchasing volume of two pressure pieces, which have the highest share, could be reduced about -450 k€/year due to the harmonisation of the O-ring material.

Summary phase 4: Easy optimisation of the variance structure with immense cost effects. The potential was not visible for the company due to two facts; first, the pressure piece is an assembly which is purchased from the Tier 2 supplier as a complete system (pressure piece, O-ring and insert foil). The Tier 3 supplier management is a 100% task of the Tier 2 supplier. The automotive Tier 1 supplier has no direct contact to the Tier 3 supplier and the cost structure of components from Tier 3 suppliers is often not directly visible. One example is the O-ring of the assembly pressure piece. Second, the O-ring material was defined from the automotive Tier 1 supplier in the past for a hydraulic steering system. In parallel the steering system has changed from hydraulic to electric. Many components of the steering system made also a change due to different technical requirements between hydraulic and electric but the O-ring of the pressure piece was not in focus. Why? Nobody will scrutinise the sense if the assembly is working and also the price impact is not known. The HNBR O-ring fulfills both the requirements of a hydraulic steering system as well as an electric steering system. The heat stability of the HNBR O-ring overachieves the requirements of an electrical steering system and this is waste due to the fact that there is a price difference of -5€/100 pcs. between NBR and HNBR.

4.3.5 Phase 5: Controlling and monitoring

The philosophy of continuous improvement is a basic element of the Toyota Production System. Implemented measures and changes must be controlled at regular intervals and again adjusted if necessary (Liker, 2004). The difficulty in the fifth phase is not to rest but to question optimised things again and initiate appropriate changes.

A group of parts like the pressure pieces must be reviewed regarding variance constantly. The frequency depends on the market, the business and the life cycle of the products. It's an individual and product specific definition. In case of the pressure piece a time period of every 3-5 years is useful.

One helpful key performance indicator (KPI) to measure constantly the development of the variance is the KPI "Variance share":

$$Variance \; share \; = \frac{number \; of \; variants * 1 Mio. \euro/year}{Purchasing \; volume \; in \; Mio. \euro/year}$$

The variance share puts the number of variants and the purchasing volume (PVO) in proportion. In the case of the initial situation of 9 O-ring variants and a PVO of 17 Mio.€ is the variance share 0.53. The variance share has

two impact factors which are the increase or the decrease of the PVO and the number on variants. Table 2 shows the initial situation (before the optimisation), the first improvement (elimination of the material HNBR for the O-ring size 34x4 mm) and a potential second improvement (constant number on variants and an increase of the PVO).

Table 2: Monitoring of the variance share

Initial situation	1.Improvement	2.Improvement
PVO: 17 Mio.€/y.; 9 O-ring variants	PVO: 17 Mio.€/y.; 8 O-ring variants	PVO: 20 Mio.€/y.; 8 O-ring variants
Variance share = 9/17 = 0.53	Variance share = 8/17 =0.47	Variance share = 8/20 = 0.40

The first improvement has reduced or optimised the variance share from 0.53 to 0.47 through a reduction of the variants like the usage of the same O-Ring material. The second improvement shows a reduction to 0.40 through a growing PVO in combination of a constant level of variants. The KPI variance share is a helpful value for the management to control and report the development of variance for different variance sectors. The optimal variance share for a PVO of e.g. 20 Mio. €/year for the part family pressure piece is 0.05. That means one variant for the total pressure piece PVO. The major challenge of a company is to find the balance between the number of variants and the fulfillment of all customer needs. A company will be successful and competitive in the future if it meets with a minimum on variance all customer needs.

Summary phase 5: The improvements must be constantly reviewed. One supporting KPI is the variance share. This KPI is an optimal reporting and controlling element for the purchasing management. The management can easily track if the development of the variance share is according to the defined target for different components, assemblies or commodity groups. Countermeasures can be defined if the development is not according to the plan.

4.4 Summary of the case study pressure piece
The example of the optimisation of the O-ring material shows a small sequence of the big potential. The measure to change the material is at the end very easy but it's tricky to make it visible. The process to optimise the variance structure of the pressure piece is currently ongoing but with the help of the VCP two variance sectors could be optimised in short time. The result in form of a yearly cost saving is shown in table 3.

Table 3: Optimisation results for the variance sector "pressure piece"

Topic	Measure	Cost Saving
O-ring material	Change from two different materials to one material for the pressure pieces of the category A	-450k€/year
Anodisation	Change from four sub-suppliers to two sub-suppliers → Volume bundling	-250k€/year

It's now possible to fully answer the research question, how a systematic reduction of existing complexity in form of a huge amount of product variance out of section purchasing is possible. The answer is the VCP in combination with the cost- and variance-driver analysis. The VCP is the product of the combination of different methods from the areas of purchasing, lean management, variance and complexity management. It was possible to reduce the existing internal variance of the pressure piece with a result of immense cost savings for the automotive Tier 1 supplier.

5. Discussion
From our analysis we can conclude with confidence that the management of existing internal variance from the perspective of purchasing will support the competiveness of a company. We also believe that this study can supplement the literature on integration of strategic purchasing. In discussing this potential, we start with the theoretical approach of Bayer (2010), Scheer et al. (2006) and Grotkamp and Franke (2007) that the management of variance can be done through the avoidance, the optimisation and the control of variance. These three approaches of variance management build up the basis for different practical methods. Most of the practical approaches are focusing on the avoidance of variance from the beginning of the product development process (PDP). E.g. the insights of Adobor and Mc Mullen (2014), Danilovic (2006), Sjoerdsma and van Weele (2015) and Wynstra et al. (1999) cover on the avoidance approach through early supplier integration in the PDP. Our analysis focuses on the optimisation approach through the methodical analysis and evaluation of existing internal variance and complexity. The novelty of this research is the variance optimisation focus from the view of the purchasing department. The purchasing department functions as a filter system for existing internal variance and complexity.

The research develops

- a new structured guide for variance analysis (the VCP),

- insights from a new application field (purchasing) for a cost- and variance-driver analysis which is derived by the DMAIC method

- and a new KPI (the variance share).

The case study 'pressure piece' examines 116 different pressure piece variants. The variant sample quantity supports the data quality. Each drawing and the procurement structure of these variants is examined for the differences. The variants comprise a purchasing volume of around 17 Mio.€. A yearly cost of 700,000 € could be saved due to the structural variant analysis with the tool of the VCP and the method of the cost and variance driver analysis. The savings can be attributed to the elimination of variants in the area of the anodisation and the O-ring. The savings have already been implemented at the automotive Tier 1 supplier in the year 2016. The resulting new KPI 'Variance Share' of this case study is a controlling element for the automotive Tier 1 supplier to track the variance level of a single component. The effect of the work with the VCP and the cost and variance driver analysis is therefore immense. The yearly PVO for pressure pieces could be reduced about 4 % without any investment in machines or technology, only through the analysis of data regarding variance. The overall results of the case study 'pressure piece' can be positively evaluated due to the fact that an cost potential came to light which could be already implemented without any negative impact on customer satisfaction.

The research underlines the argument that the analysis of existing variance through the VCP, the cost-and variance-driver analysis and the reporting of the variance share will save money and supports the competitiveness of a company. A future purchasing strategy will be carried from the three pillars lean management, variance optimisation and the categorisation of components in e.g. commodity group. The VCP connects all of these areas: the common interface is the key to optimise an existing complex and non-transparent variance structure.

5.1 Managerial implications

The management of the automotive Tier 1 supplier has the possibility to analyse and evaluate the existing product diversity of the company in its entirety with the VCP and its KPI's. The potentials involved in such an analysis are immense and make the company more competitive on the market. But, the working with the VCP can only be successful if a good data base is available, sub suppliers are open to share information and the employees are well-trained for this method. Another point is that the VCP is a living data base that can only be as good as it is fed. The management has here the task of designing the environment in such a way that every employee has the opportunity to contribute his knowledge and experience. The VCP is a learning element that is to be constantly further developed.

6. Conclusions and directions for further research

As strategic purchasing is receiving increased attention, firms strive to implement strategic purchasing to its best potential. The results of this study are expected to help researchers and decision makers to better understand the effects of advances in strategic purchasing on variance- and complexity management. At this juncture, we acknowledge some limitations of our study that would provide opportunities for further research. The case studies selected for this research are all within the context of one company and thus in a limited context of industries. This introduces the possibility of context-specific findings. Our research should be replicated in other industries and organizations. This research focuses on the problem of the increasing complexity through variance in an automotive company. The whole supply chain and especially the purchasing department build the centre of the study and show a special perspective. The VCP, the derived method of cost- and variance-driver analysis for purchasing and the KPI variance share are new elements and an approach to handle this problem. The insights could be standardised and transformed to other branches and sectors with similar problems. Both, managers for reporting and controlling targets and buyers for the daily business can use the methods, tools and approaches to create improvements for the company.

The finding of the limits of this research is one big future task. In this article one dimension of the VCP is presented with the case study of the pressure piece. A further development and testing of the VCP for the second dimension (process) and the third dimension (supplier) is necessary. After that a further step is the testing of the VCP for different variance sectors within different commodity groups like electrics or turned parts. As presented in the paragraph requirements of the VCP a transformation to other branches than automotive and sections like e.g. logistics is possible.

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