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Purchasing Management: The Optimisation of Product Variance

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Abstract

The purpose of this paper is to present a new optimised approach for product variance from the purchasing perspective. The research is based on a case study involving a global acting automotive Tier 1 supplier who produces steering systems for cars and commercial vehicles. The case study analysis the product variance of three components. The data were gathered from 116 variants, 13 sub suppliers for three different types of steering system. 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 generalised method to optimise the existing variance, present cost improvements as well as optimising new key performance indicators to manage product variance out of the purchasing department.

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1. Introduction

The growing importance of supply chain management has led to an increasing recognition of the strategic position of purchasing ([1-2]). Before, purchasing were often an underestimated task in management levels [3] but today purchasing plays a key role in terms of adopting a cooperative approach to create innovation-oriented and

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cost-oriented products [4]. 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 causes the company an enormous effort in terms of costs [5]. In order to meet this challenge, an agile supply chain strategy is necessary which is defined through flexibility by adapting quickly and effectively to rapidly changing customer needs [6] and a cost optimisation approach across the procurement chain [7]. One important approach of cost optimisation across the procurement chain is the elimination of waste in the form of a reduction of unnecessary product variance [7-12]. 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 product variance through the purchasing perspective.

In this study, the research collaboration partner is an automotive Tier 1 supplier with 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 [13], a communication lack between R&D, purchasing and the supplier [14] or simply due to the missing time to examine and if necessary to eliminate unnecessary variants.

RQ. How can a company with a huge amount on purchased parts improve existing unnecessary product variance?

In this research, the product “pressure piece” of this automotive Tier 1 supplier will be analysed regarding variance, evaluated and optimised through a new method. The new method is called ‘cost and variance driver analysis’ and will be applied from the purchasing perspective [15].

2. Theoretical Background

Procurement success has several components: cost, quality, time and flexibility [16,17] which can be used to find the cost optimisation potential across the procurement chain [7]. 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 [3,13]. This is possible through the management of product complexity [18].

2.1. Complexity Management

The purchasing integrates more and more into the strategic corporate management [19] and strategic management means the control of complex systems, in which the complexity increases with the variety of distinguishable states within the system [20]. 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 [21]. Real systems can have many different 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 [20]. Malik [20] 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, Ashby [22], has formulated this insight as follows: “Only variety can absorb variety”. This means, a system is controlled, when it is prevented from moving into undesirable states. For Malik [20], the key element to quantify and to measure the complexity of a system is with the help of the concept of variance management. In this coherence, the variance must be differentiated into external and internal variance. The external variance is useful for the customer in the form of variety of the 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 [23]. The misunderstanding of the customer orientation leads to an expansion in variant figures and strong economic problems for a company connected with a loss of competitiveness [24].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 [25-27]. The second and the third approach of variance-optimisation regarding the internal company complexity are the center of attention in the present study. This 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.

3. Methodology

This research aims to provide information that helps to determine which method can be used in order to improve an existing situation [28]. The research is practically orientated, and refers to the unstructured set of problems of which a practitioner must deal with [29]. The practitioner in this case is a buyer of an automotive Tier 1 supplier as a global acting company, which delivers steering systems for passenger cars and commercial vehicles to well-known 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 the deriving of research findings in form of a new method [30]. The collected and evaluated data of the case study represents decades of the automotive Tier 1 company history. The company produces three different types of car steering systems for different car sizes in Asia, Europe and America and the data is taken from this global database. The assembled steering systems consist of approximately 100 different single components and approximately 90% are purchased parts. Each steering system is individually adapted for the respective customer. For the product case study were 116 different variants of one sub assembly of the steering system "the pressure piece", which consist of 3 single components, analysed and evaluated. The data was gathered from 13 sub suppliers for 80 customers and 350 different types of car steering systems. The data in this research was examined with the help of a cost and variance driver analysis. This kind of analysis is structured into five different phases. The five phases of define, measure, analyse, improve and control (DMAIC) will be used as a reactive method to find the root causes for the number of variants and the optimum solution [31[. The research findings demonstrate the implementation of a new method for the structured analysis of existing product variance from the view of the purchasing department, the so called cost and variance driver analysis and a new KPI, the "variance share". Figure 1 describes the process of the five phases of variance optimisation from the control center purchasing. Next, the method with the five phases will be exemplified and performed for the selected component "pressure piece from the automotive Tier 1 supplier".

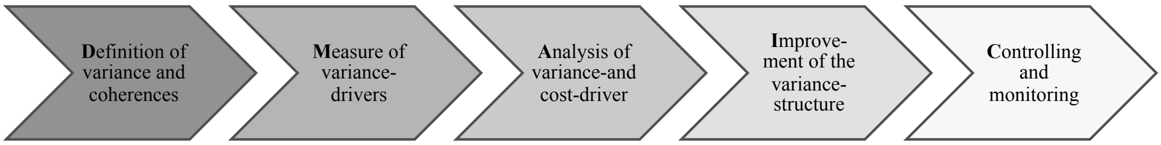

Fig. 1. Process steps of the cost driver and variance driver analysis.

4. Results of the case study "Pressure Piece"

The case study is divided according to the five phases of DMAIC for the subassembly pressure piece. The pressure piece is an assembly of three parts: the pressure part, the insert foil and the O-ring, see figure 2. 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.

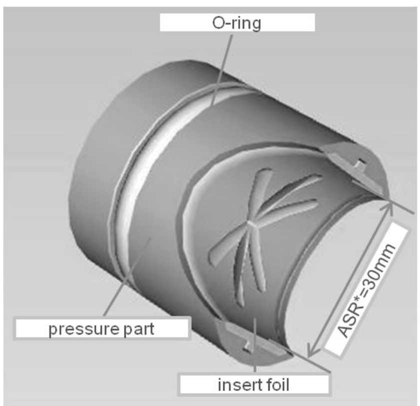

Fig. 2. Pressure Piece.

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. necessaThe next five phases of the cost and variance driver analysis will answer this question for the variance section of the O-rings.

4.1. 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. Figure 3 shows the coherences of the different variance sectors. The software METUS [39] is very easy to use and helps 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 easily create 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.

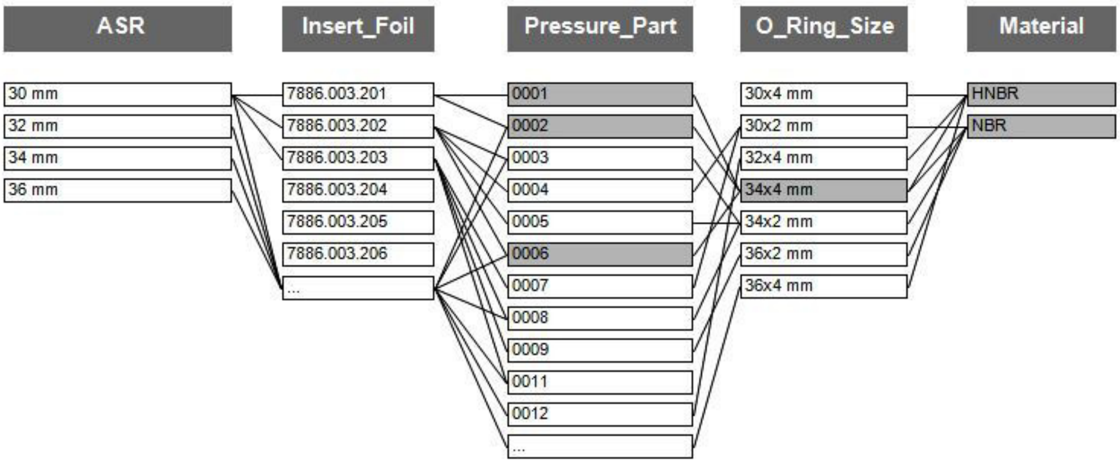

Fig. 3. Net of pressure piece coherences; software METUS [39].

4.2. Phase 2: Measure of variance drivers

Elements with a huge impact on the complexity of a system are called complexity or variance drivers [40]. 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 [32]. In this study the optimisation of the variance sector material is examined as first step. Malik [20] 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. Schuh [33] 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 with a cost driver. For 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 with a cost driver.

4.3. *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. 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 [10]. According to the principal of Pareto [34] 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% [16].
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 illustrates that the pressure pieces 0001 and 0002 have 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.

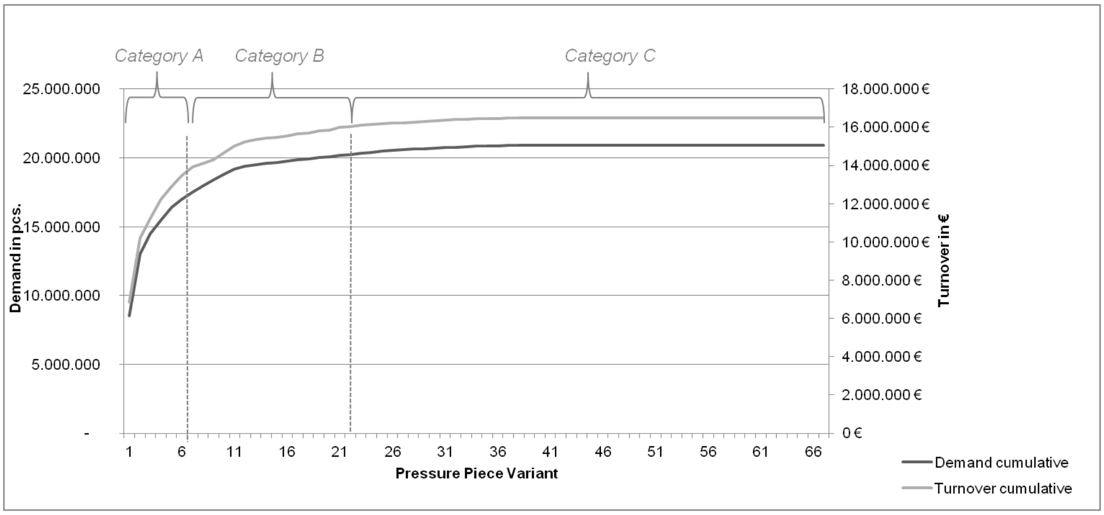

Fig. 4. Pareto analysis of the pressure piece variants.

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€

4.4. *Phase 4: Improvement of the variance structure*

After defining the variance driver for the 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 degrees higher than that 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 is not necessary and considered wasteful. 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 [10]. 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.
Figure 5 shows the initial variance structure with two O-Ring materials compared to the optimised variance structure without the material HNBR.

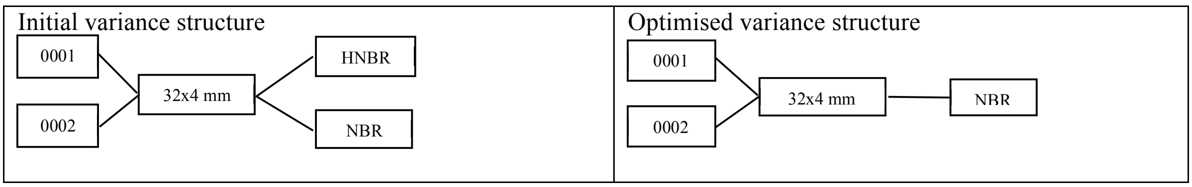

Figure 5: Initial vs. optimized variance structure

The optimised variance structure leads to a yearly cost saving of

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

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 [35]. The purchasing volume of two pressure pieces, which have the highest share, could be reduced by approximately 450 k€/year due to the harmonisation of the O-ring material.

4.5. *Phase 5: Controlling and monitoring*

Numerous time-consuming iteration loops are necessary to reach targets and to optimise the initial situation [41]. 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 [10]. The difficulty in the fifth phase is not to rest, but to question optimised protocols again and initiate appropriate changes. A group of parts like the pressure pieces must be constantly reviewed regarding variance. 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":

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

The variance share puts the number of variants and the purchasing volume (PVO) in proportion. In the case of the initial situation of nine O-ring variants and a PVO of seventeen Mio.€, the variance share is 0,53. The variance share has two impact factors which are the increase or the decrease of the PVO, and the number of 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.

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 [25], Scheer et al. [26] and Grotkamp and Franke [27] 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 engineering process (PEP). For example the insights of Adobor and Mc Mullen [36], Danilovic [37], Sjoerdsma and van Weele [38] cover the avoidance approach through early supplier integration in the PEP. 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, 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).

6. Conclusions and directions for further Research

As strategic purchasing is receiving increased attention, firms strive to implement strategic purchasing to its highest 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 organisations. 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.

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