

MASTER

Accelerating the process of pricing automotive options

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Eindhoven, May 2020

Accelerating the process of pricing automotive options

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In partial fulfillment of the requirements for the degree of

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in Operations Management and Logistics

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Management summary

This master thesis was executed at a leading vehicle manufacturer (referred to as AB due to confidentiality reasons). The organization offers a large product range to its customers. This is because AB offers more than 10,000 options to choose from. For all these options, a cost price must be estimated such that the margin on a vehicle can be calculated on which, among other things, order approval is based. The cost price of an option is defined as the added cost relative to the base vehicle.

Currently, calculating the cost price of all the different options is a manual and time consuming process that takes over a year. This is because many data elements and systems are involved in making these calculations, an option can have multiple consequences, and more complex calculations require technical knowledge. The option pricing process always restarts on the first of January; therefore, the option prices are always one year behind, i.e. not up to date¹. As a result, this can lead to wrong order approval. Based on this problem, the following research question was defined:

“How can the current process of calculating option cost prices be accelerated?”

In order to answer this question, this study began by documenting and evaluating the current situation of the option pricing process at the company. This evaluation already revealed some potential improvement opportunities that were later used in developing acceleration ideas. The evaluation concluded that the biggest cause of the lengthy process are the manual aspects of the calculation part of the process. Therefore, the focus to speed up the process was mainly on the calculation part.

Historical order data was then analyzed to get a better understanding of the current situation and to gain more ideas for improvement. This revealed that on average all chosen options account for 9.4% of the total vehicle costs. It also showed that on average 41 options are incorporated in each order and that no vehicles are sold without options. Moreover, the analyses revealed that there are far more options that are rarely sold than there are options that are included in almost all orders.

To gain even more possible improvement ideas, industry practices were identified and compared to the current situation. Initially, it was the aim to find industry *best* practices. However, not enough information could be collected for this. In total, the industry practices of only 5 automotive companies could be identified. Two of these companies could not be compared to AB or had the same approach; therefore, this did not lead to improvement ideas. However, three industry practices could potentially qualify as an acceleration idea. Namely to calculate the total cost of each order instead of calculating the cost price of the base vehicle and all options. Or to perform certain steps before the first of January. Or to incorporate all consequences of an option in its option price, and to eliminate these consequences from the option list that the customer can choose from (method of the company IJ).

Scientific literature was searched for redesign/improvement methods to obtain a guideline for developing possible improvement ideas. This revealed that there are two traditional approaches, the structured and the creative approach. The methods have opposite advantages and disadvantages. Therefore, this thesis used both of them.

¹ Prices are not up to date at option level, i.e. for a specific vehicle. However, high level adjustments are made.

The structured approach was executed by discussing the shortlist of best practices for each task of the current process with process executors. The shortlist of best practices consists of the following: 'task automation'; 'task composition'; 'triage'; 'task elimination'; 'integral technology'; 'resequencing'; 'integration'; 'parallelism'; 'extra resources'; 'exception'; and 'buffering'. Where 'task automation' is especially important to accelerate the process. By discussing the possibilities of 'task automation', it appeared that several tasks of the current process are easy to automate. But for some other tasks, this is a bit more difficult. Especially the tasks that apply when a component is related to multiple options, because several methods for distribution are currently used. Therefore, in order to automate this, three general allocation rules have been developed. The EQC allocation method implies that the common costs are distributed equally. The all-to-1 allocation method implies that the common costs are allocated to only one of the related options. Last, the weighted allocation method implies that a predetermined weight is assigned to the options that have a common component number. Other ideas that emerged from the structured approach include performing the task of assigning the value zero to certain options earlier in the process ('resequencing') and making requested information immediately available instead of waiting at least one night ('buffering').

In order to achieve a large acceleration with the structured approach, several ideas must be combined. Therefore, when referring to the structured approach, a combination of all ideas is meant. Within the structured approach, a distinction is made between the three allocation methods. In addition, a distinction is made between the structured approach with less and more IT involvement.

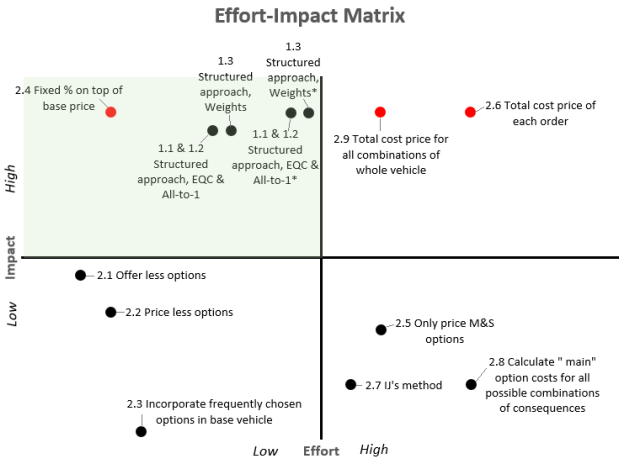
Using the structured approach, the author calculated all options of the most sold vehicle type. For a few orders, the results showed that at order level the weighted allocation method was the best or at least not much worse than the other methods (outcome differed per order). At option level, the weighted allocation method showed the least deviation from the current method. When comparing the structured approach to the current method in terms of time, it can be concluded that the structured approach is faster, even if it is still applied manually (from a throughput time of 2 weeks to 2 days for one vehicle type). Therefore, when all steps of the structured approach are automated, it will even be faster. As a result, the option prices will be more up to date.

The creative approach was carried out by conducting brainstorming sessions with process stakeholders, i.e. process executors and employees from the M&S and IT department. Insights from the process analysis, the historical data analysis, and the industry practices were used to start the creative process. Where both the current process and clean sheet were taken as starting point. The following improvement ideas were developed with this approach:

- Offer less options (2.1);
- Price less options (2.2);
- Incorporate frequently chosen options in base vehicle (2.3);
- Fixed percentage on top of base price (2.4);
- Only price M&S options (2.5);
- Total cost price of each order (2.6);
- IJ's method (2.7);
- Calculate "main" option costs for all possible combinations of consequences (2.8);
- Total cost price for all combinations of whole vehicle (2.9).

Ideas 2.1 to 2.4 were based on the findings from the historical data analysis. The idea of only pricing options that M&S prices (2.5) emerged from the discussions based on the fact that M&S prices fewer options than CA. In addition, ideas 2.6 to 2.9 arose from the findings of the industry practices and the discussion thereof.

Semi-structured interviews were used to evaluate all improvement ideas. These interviews revealed the pros and cons of each idea. In consultation with all interviewees, an effort-impact matrix was populated, see Figure 1. As can be seen, the high-impact low-effort quadrant contains the following ideas: the structured approach and the idea of applying a fixed percentage on top of the base price. AB’s M&S management indicated that they want to hold on to option prices since they use these prices in the negotiation process for explanation reasons. Therefore, only the structured approach with the three allocation methods with both more and less IT involvement remained as best acceleration ideas.



Note: Effort implies the required resources for implementation. Impact means how much the idea shortens the calculation time after the first of January.
Note: The red markers mean that option prices are no longer calculated with the corresponding idea.
*Note: The structured approach with a * implies more IT involvement, and without a * implies less IT involvement.*

Figure 1: Effort-Impact Matrix

Several recommendations are given to AB. First of all, it is recommended to implement the structured approach, since this method saves the most time with the least amount of resources. However, it is up to the company to decide whether to implement the approach with less or more IT involvement as this depends on the company’s available IT capacity. AB has the choice between three allocation methods within the structured approach. However, in order to maintain more control, to not blindly rely on a black box, and to better explain where option prices are based on, AB should choose for the weighted allocation method. Regarding implementation, it is recommended to first execute the structured approach manually, since manual implementation is already faster than the current method. Hereafter, AB should to take automation steps. When the approach is fully automated, it is recommended to stop using common options and to only use vehicle specific options. In addition, after implementation, it is recommended to annually investigate for a number of orders whether the estimated total option costs are close to the actual costs.

Limitations of this research are that no industry best practices could be identified, that improving the determination of missing prices, i.e. finding the price, was not part of this research, and that all improvement ideas were only evaluated on the basis of interviews, i.e. qualitative data. In addition, this study only calculated the cost price of all options for one vehicle type.

Preface

Before you lies my master thesis that has been written to fulfill the graduation requirements for the master program 'Operations Management & Logistics' at the Eindhoven University of Technology. Finishing my master thesis marks the end of my student life and is the start of an entirely new phase. I would like to express my gratitude towards everybody who helped me during my master thesis and my student life in general.

First, I would like to thank Shaunak Dabadghao for his role as my first supervisor and his help and feedback during the project. Additionally, I would like to thank my second supervisor Oktay Türetken for his feedback and tips regarding my project.

Furthermore, I am really grateful for the opportunity to execute my master thesis project at a company, I enjoyed this enriching experience. I would like to thank my company supervisor Tim and everybody from the Management & Cost Accounting department for their contribution, continuous feedback and support during the project. In addition, I would like to thank all other people and departments within the company who helped me.

Last, I would like to thank my family and friends for their support during my entire student period. Throughout these years I made friendships that I will treasure the rest of my life. Thank you for making these years a fun time. To my parents and sister, thank you for your unconditional love, help, and support. You always encouraged me to get the best out of myself. This journey would not have been possible without you.

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April 2020

Contents

- Management summary iii
- Preface.....vi
- Contentsvii
- List of Figures.....ix
- List of tablesx
- List of abbreviationsxi
- 1. Introduction..... 1
 - 1.1 Problem description 1
 - 1.2 Project goal..... 7
 - 1.3 Outline 7
- 2. Research methodology..... 8
 - 2.1 Research method paradigms..... 8
 - 2.2 Research questions..... 9
 - 2.3 Research method 10
 - 2.4 Deliverables 11
 - 2.5 Scope 11
- 3. Current situation 13
 - 3.1 Systems..... 13
 - 3.1.1 MUI..... 13
 - 3.1.2 VES..... 14
 - 3.1.3 VIS..... 14
 - 3.1.4 Relations between MUI, VES, and VIS..... 14
 - 3.1.5 Other systems linked to the option pricing process..... 15
 - 3.2 Current option pricing process..... 15
 - 3.3 Issues with current option pricing process..... 22
- 4. Data analysis..... 24
 - 4.1 Total cost price of options per order..... 24
 - 4.2 Number of options per order 26
 - 4.3 Average price per option 27
 - 4.4 Most sold options..... 27
 - 4.5 Option price calculation dependence 29
- 5. Industry practices 30
- 6. Applicable process improvement/redesign methods 32
 - 6.1 Structured approach..... 34

6.2 Creative approach	34
7. Acceleration ideas	36
7.1 Structured approach ideas	36
7.2 Creative approach ideas	41
7.3 Evaluation	43
7.3.1 Structured approach evaluation.....	45
7.3.2 Creative approach evaluation	48
7.3.3 Effort-impact matrix	52
8. Conclusions and recommendations	53
8.1 Conclusions.....	53
8.2 Recommendations.....	54
8.3 Limitations	55
References.....	56
Appendix A: Structure of standard cost prices.....	60
Appendix B: Examples of MUI and VES	62
Appendix C: Most sold options for most sold vehicle type	63
Appendix D: Option price calculation dependence of one order	65
Appendix E: Redesign methods Dumas et al. (2018)	67
Appendix F: 29 Best practices	70
Appendix G: Literature on allocation rules (Bakermans, 2020)	73
Appendix H: Semi-structured interviews	74
H.1 Setup	74
H.1.1 Summary improvement ideas.....	74
H.2 Results.....	76
H.2.1 Employee A (CA).....	76
H.2.2 Employee B (CA).....	78
H.2.3 Employee C (CA).....	79
H.2.4 Employee D (CA)	81
H.2.5 Employee E (IT Department).....	83
H.2.6 Employee F (IT Department).....	84
H.2.7 Employee G (M&S).....	85
H.2.8 Employee H (M&S).....	87
Appendix I: Examples of total option order costs for all three allocation methods	89

List of Figures

- Figure 1: Effort-Impact Matrix v
- Figure 1.1: High level process of AB 2
- Figure 1.2: Example of calculation input for more complex situations (Calculation number: 073210 020)..... 3
- Figure 1.3: Example of pure calculation input (Calculation number: 079071 001) 4
- Figure 1.4: Example of calculation input with one option remaining to be unknown (Calculation number: 073201 016)..... 5
- Figure 1.5: Problem mess 7
- Figure 2.1: The problem solving cycle (van Aken et al., 2012, p.12) 8
- Figure 2.2: BPM lifecycle (Dumas et al., 2018, p.23)..... 9
- Figure 3.1: MUI and VES (Roording, 2016)..... 13
- Figure 3.2: Relationship between MUI, VES, and VIS..... 15
- Figure 3.3: High level process of option pricing, including the order of calculations 16
- Figure 3.4: Subprocess – Calculating options..... 17
- Figure 3.5: RKCZZ Excel file example (Calculation number: 073210 020) 18
- Figure 3.6: KC8Z example (Calculation number: 073210 020) 20
- Figure 3.7: KC8Z for option 1848..... 22
- Figure 3.8: KC8Z of calculation number 073201 007, where 1848 is a “consequence option” 23
- Figure 4.1: Histogram of Total Cost Price of Options per order 2018..... 25
- Figure 4.2: Histogram of Total Cost Price of Options per order 2019..... 25
- Figure 4.3: Histogram of Number of O options per Order 2018 26
- Figure 4.4: Histogram of Number of O options per Order 2019 27
- Figure 4.5: Chart of the number of times an option is incorporated in an order (2018) (arranged in descending order) 28
- Figure 4.6: Chart of the number of times an option is incorporated in an order (2019) (arranged in descending order) 29
- Figure 6.1: The Redesign Orbit: A spectrum of business process redesign methods (Dumas et al., 2018, p.306)..... 32
- Figure 6.2: Overview of the creative and structured way to process improvement (Mansar et al., 2009, p.3)..... 33
- Figure 6.3: Applied method (based on Mansar et al., 2009)..... 35
- Figure 7.1: Examples of components with and without the feature being specified 38
- Figure 7.2: Selcos (and features) of calculation number 073208 012..... 38
- Figure 7.3: Example of component number related to multiple selcos where the column ‘Option’ is not filled for every feature 38
- Figure 7.4: Effort-Impact Matrix (numbers refer to ideas in Table 7.3)..... 52
- Figure A.1: AB’s MLO structure 61
- Figure B.1: Example of MUI structure 62
- Figure B.2: Example of the VES structure (based on Roording (2016))..... 62
- Figure C.1: Chart of the number of times an option is incorporated in an order (2018) regarding the most sold vehicle type (arranged in descending order)..... 63
- Figure C.2: Chart of the number of times an option is incorporated in an order (2019) regarding the most sold vehicle type (arranged in descending order)..... 64

List of tables

- Table 1.1: Example of relation between component and option changes 4
- Table 1.2: Example of component number change with its related options 5
- Table 2.1: Phases and deliverables..... 11
- Table 4.1: Descriptive statistics TotalCostPriceOptions 2018 24
- Table 4.2: Descriptive statistics TotalCostPriceOptions 2019 25
- Table 4.3: Descriptive statistics NumberOPerOrder 2018 26
- Table 4.4: Descriptive statistics NumberOPerOrder 2019 26
- Table 4.5: Descriptive statistics NumberOrdersPerO 2018..... 28
- Table 4.6: Descriptive statistics NumberOrdersPerO 2019..... 28
- Table 7.1: Summary of ideas that are part of the structured approach 40
- Table 7.2: Number of interviewees per department 43
- Table 7.3: Pro-con table 43
- Table 7.4: Total option order costs for each method, and the deviation of each method with the actual costs and the current method costs (Order with many options: 044850) 48
- Table C.1: Descriptive statistics NumberOrdersPerO 2018 for most sold vehicle type 63
- Table C.2: Descriptive statistics NumberOrdersPerO 2019 for most sold vehicle type 63
- Table D.1: One order of most sold vehicle type 65
- Table E.1: Applicability of Redesign methods based on Dumas et al. (2018, p. 306-330) (Bakermans, 2020)..... 67
- Table F.1: 29 Best practices (based on Reijers & Mansar (2005); Jenniskens (2011); Hanafizadeh et al. (2009)) (Bakermans, 2020) 70
- Table I.1: Total option order costs for each method, and the deviation of each method with the actual costs and the current method costs (Order with many options: 102389) 89
- Table I.2: Total option order costs for each method, and the deviation of each method with the actual costs and the current method costs (Order with many options: 049601) 89
- Table I.3: Total option order costs for each method, and the deviation of each method with the actual costs and the current method costs (Order with many options: 100570) 89
- Table I.4: Total option order costs for each method, and the deviation of each method with the actual costs and the current method costs (Order with fewer options: 039188) 90
- Table I.5: Total option order costs for each method, and the deviation of each method with the actual costs and the current method costs (Order with fewer options: 049762) 90

List of abbreviations

AHP	Analytic Hierarchy Process
APS	AB's Product System
B	Base
BOM	Bill Of Materials
BPM	Business Process Management
BPMN	Business Process Model Notation
BTO	Build to Order
CA	Cost Accounting
CHO	Chosen
DEP	Depending
EA	Enterprise Architect
EQC	Equal Charge
Fkp	Fabricage kostprijs
GS	General Specification
IT	Information Technology
MLO	Material, Labor, Overhead
M&S	Marketing & Sales
MUI	Model Unit Index
O	Optional
OMS	Order Management System
S	Standard
Selco	Selection code
TOPSIS	Technique for Order Preference by Similarity to Ideal Solution
VAS	Vehicle Assembly Structure
VES	Vehicle Engineering System
VIS	Vehicle Item Structure
Vvp	Vaste verrekenprijs

1. Introduction

This master thesis was written for the author's Master thesis graduation project at Eindhoven University of Technology (TU/e) in order to complete the Master 'Operations, Management & Logistics'. The research was executed at an organization which operates in the automotive manufacturing industry. Throughout this report, the organization is referred to as AB due to confidentiality reasons.

The project deals with improving a current process, which is a critical requirement for any organization (Jenniskens, 2011). Process improvement means changing the state of the process in order to be faster, cheaper, more flexible, or to achieve a better quality. This is achieved by changing the state of elements of a business process (Griesberger, Leist & Zellner, 2011). In 2009 and 2010 Gartner even identified business process improvement to be the top business priority of large organizations (Auringer, 2009; Meehan, 2010). Nowadays this is still an important subject that is being investigated extensively (e.g. Malinova, Gross & Mendling, 2019; Olanrewaju, Uzorh & Nnanna, 2019).

This introductory chapter starts by introducing the organization. Thereupon, a problem definition is given, which leads to an overall problem statement and project goal. Last, the outline of this thesis is described.

1.1 Problem description

AB is a leading vehicle manufacturer. The organization applies the 'Build to Order' (BTO) principle, implying that vehicles are built after an order has been received. Therefore, the vehicles are built according to the customer's specifications. The vehicles can be divided into three different series: AA, BB, and CC. All series have different characteristics; therefore, they can be used for various purposes. Differences are also offered within these series, such as the chassis type. This results in a total of approximately 165 vehicle types. On top of these vehicle types, a customer can choose from a broad range of options, such as the size of the fuel tank and the color of the vehicle. To conclude, AB has a large product range available for its customers.

This large product range is caused by the fact that AB offers its customers different options. These different options also come with different cost prices. AB's Finance department, more specifically Cost Accounting (CA), is responsible for forecasting the cost price of options. These cost prices are based on standard cost prices, which are determined on the basis of standard assumptions. These assumptions are fixed for a whole year starting on the first of January. AB's standard cost prices consist of the following elements: Material, Labor and Overhead (MLO), which is explained in more detail in Appendix A. In the rest of this thesis, the terms standard cost and MLO are used interchangeably. The process of calculating all option prices starts again each year on the first of January when the new standard cost prices apply.

The cost price of an order is the total amount of money that is required to produce a vehicle. Since AB applies the BTO principle and provides a large range of vehicles in combination with many options, almost every vehicle has a different cost price.

As already indicated, AB offers its customers many different options, over 10,000 options are available. When an option is chosen, this implies that there is a different specification than the “base”, which is determined by the Marketing & Sales (M&S) department. Therefore, the option price, i.e. the cost price of an option, is not an absolute, independent amount. Instead, it is an added cost relative to the standard choice, i.e. base vehicle². These option prices are necessary for calculating the total cost price of vehicles that are different than the base vehicle.

A visualization of the high level process of AB is presented in Figure 1.1. At the calculator step, the total cost price of the vehicle is determined based on the forecasted cost price as calculated by the CA department. The total cost price of a vehicle consists of the cost price of the base vehicle plus the cost price of the chosen options. Order approval by M&S is based, among other things, on the order’s margin. This margin is calculated by using the forecasted total cost price.

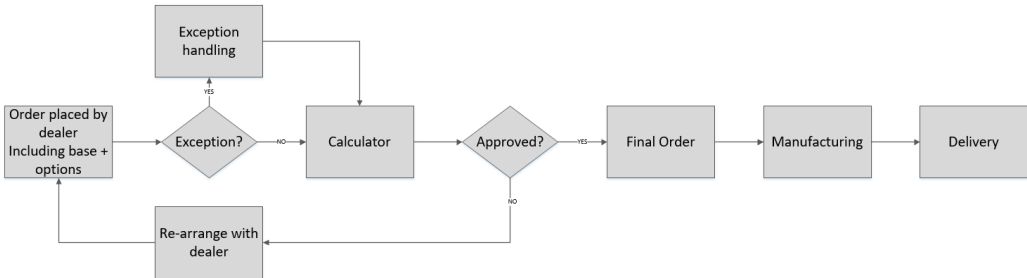


Figure 1.1: High level process of AB

AB’s cost price calculation is based on a base vehicle. This implies that when a customer chooses an option that is different from the base option, which is included in the base vehicle, an “option shift” occurs where the base option is replaced by the chosen option. For example, when the customer orders a red vehicle, the option ‘red vehicle’ replaces the base option ‘white vehicle’. The price difference due to the option shift is allocated to the chosen option, since the cost price of an option is the added cost relative to the base vehicle.

Option prices are currently calculated by taking the price difference, due to component and assembly changes, between the base order and the variant order. Where the base order represents the base vehicle³. And the variant order is an order with only a single option differing from the base order. However, due to this “main” option change, other option(s) may also change automatically such that the vehicle complies with the vehicle restrictions. For example, when the front axle changes, the options ‘Tyre size front 1’, ‘Tyre size rear 1’, and ‘Front underrun protection’ must also change, see Figure 1.2. The information in this figure shows which component numbers and, if applicable, assembly groups are added and/or removed due to the option changes in comparison with the base order. Note that the information provided by the system contains only one possible combination of the consequences of a “main” option change. While the customer often has a choice within the consequences. For example, if the customer chooses the front axle ‘8.00 t-pb-167N’ instead of the base front axle, the system automatically changes the front underrun protection to ‘fup 445 mm’. While the customer can also choose a different front underrun protection.

² Note that the cost price of an option can also be negative if the chosen option is cheaper than the option incorporated in the base vehicle.

³ The base vehicle is different for each vehicle type.

ORDER 073210 020 TAG G0709 A OPT TYPE G0709A SPEC.WEEK 201905														
FEATURE		BASIC				OPTION								
C/D	NUM	DESCRIPTION	SEL	DESCRIPTION	SEL	DESCRIPTION	SEL	DESCRIPTION						
CHO	901	Tyre size, front l	3274	fr1, 315/70R22.5	1387	fr1, 315/80R22.5								
CHO	905	Tyre size, rear l	3479	rl, 315/70R22.5	1389	rl, 315/80R22.5								
CHO	924	Front underrun prot	9867	fup 365 mm	9869	fup 445 mm								
CHO	962	Front axle	2472	8.00 t-pb-163N	2509	8.00 t-pb-167N								
ODEP	290	1st front axle type	9823	1st front axle 163N	9824	1st front axle 167N								
DEP	294	Front axle profile	6746	front axle standard	6745	fr.axl straight beam								
DEP	711	Tyre size rel VAL	7890	tyre size 1 rel VAL	7891	tyre size 2 rel VAL								
1RKCZZ JKC8X /GBR81886 DIFFERENCE MANU COST BY COMPONENT COMPARED TO 073210 000 2019-01-02 19:23 001														
ORDER 073210 020 TAG G0709 A OPT TYPE G0709A SPEC.WEEK 201905 PRICE TYPE VVP PRICE YEAR 2019														
COMP	COMP	ASS	ITEM	COMPONENT	QUANTITY	LABOUR	LABOUR	LABOUR	MATERIAL	MATERIAL	MATERIAL	MATERIAL	TOTAL	
GRP	NUMBER	S	NUMBER	DESCRIPTION		TIME	COST	SURCH	COST	SURCH 1	SURCH 2			
	1102	1958069		Suspens.fr.axle 1									-	
	1102	1958071		Suspens.fr.axle 1									-	
	TOTAL COMP GROUP			Suspens.fr.axle 1									-	
01103	1849330			Stabil. fr.axle 1									-	
	TOTAL COMP GROUP			Stabil. fr.axle 1									-	
01149	1371207			Mudguards rear ax.									-	
	1149	1371208		Mudguards rear ax.									-	
	TOTAL COMP GROUP			Mudguards rear ax.									-	
01171	1837160			F.underrun protec.									-	
	1171	1844663		F.underrun protec.									-	
	TOTAL COMP GROUP			F.underrun protec.									-	
01201	1807561			Fittings,fr.ax.1									-	
	1201	1807568		Fittings,fr.ax.1									-	
	TOTAL COMP GROUP			Fittings,fr.ax.1									-	
01202	1929861			Lh br.plate,fr.ax.1									-	
	TOTAL COMP GROUP			Lh br.plate,fr.ax.1									-	
01203	1929860			Rh br.plate,fr.ax.1									-	
	TOTAL COMP GROUP			Rh br.plate,fr.ax.1									-	
01204	1798810			Axle beam, fr.ax.1									-	
	1204	1798812		Axle beam, fr.ax.1									-	
	TOTAL COMP GROUP			Axle beam, fr.ax.1									-	
01205	1807593			Track rod,fr.ax.1									-	
	1205	1807606		Track rod,fr.ax.1									-	
	TOTAL COMP GROUP			Track rod,fr.ax.1									-	
01207	1397370			Brake cyl.fr.ax.1									-	
	TOTAL COMP GROUP			Brake cyl.fr.ax.1									-	
01460	2033664			Cooling air screen									-	
	1460	2033666		Cooling air screen									-	
	TOTAL COMP GROUP			Cooling air screen									-	
01635	2107728			Mudguards, cab									-	
	TOTAL COMP GROUP			Mudguards, cab									-	
01666	2042446			Mudflap fr									-	
	1666	2042449		Mudflap fr									-	
	TOTAL COMP GROUP			Mudflap fr									-	
TOTAL ORDER														
1RKCZZ JKC5X /GBR81886 DIFFERENCE ASSEMBLY COST COMPARED TO 073210 000 2019-01-02 19:22 001														
ORDER 073210 020 TAG G0709 A OPT TYPE G0709A SPEC.WEEK 201905 PRICE TYPE VVP PRICE YEAR 2019														
ASS	SEL	LABOUR		LABOUR	LOON	MATERIAL		MATERIAL		MATERIAL		TOTAL		
SHP	GROUP	CODE	TYPE	TIME	COST	SURCHARGE	COST	SURCHARGE 1	SURCHARGE 2	SURCHARGE 2				
3	305530	0000										-		
TOTAL SELECTION CODE													-	
TOTAL ASS GROUP													-	
0	3	305540	0000									-		
TOTAL SELECTION CODE													-	
TOTAL ASS GROUP													-	
TOTAL ORDER														
1RKCZZ JKC6X /GBR81886 DIFFERENCE SHOP COST COMPARED TO 073210 000 2019-01-02 19:23 001														
ORDER 073210 020 TAG G0709 A OPT TYPE G0709A SPEC.WEEK 201905 PRICE TYPE VVP PRICE YEAR 2019														
ASS	ASS	MAN	MAN	LABOUR	LABOUR	LABOUR	MATERIAL	MATERIAL	MATERIAL					
PLNT	SHP	PLNT	SHP	TIME	COST	SURCHARGE	COST	SURCHARGE 1	SURCHARGE 2					
7002	5	7002	1											
7002	5	7002	5											
7010	3	7010	3											
7010	4	7010	4											
07002	5	7002										-		
7010	3	7010												
7010	4	7010												
07002	5											-		
7010	3													
7010	4													
07002	5											-		
7010	3													
7010	4													
07002	5											-		
7010	3													
7010	4													
TOTAL ORDER														

Figure 1.2: Example of calculation input for more complex situations (Calculation number: 073210 020)

Note: For reasons of confidentiality all prices are omitted, the same holds for the rest of this thesis.

Note: 'Difference shop cost' represents the total price difference ('difference manu cost' + 'difference assembly cost').

The price difference provided by the system, see for example Figure 1.2, is for all the changed options together and not separately. A changed component can depend on multiple option shifts. For example, when looking at Table 1.1, which lists the options related to each component, the cost price difference of switching from component A to B can directly be assigned to option 5, since the only option shift is from option 4 to 5. However, when going from component A to F, the price difference is related to both options 5 and 6 because two option shifts occur (from option 4 to 5 and from option 3 to 6). Therefore, the system shows the price difference *per component change*, but the price difference *per option shift* is needed.

Table 1.1: Example of relation between component and option changes

Component	Options			
A	1	2	3	4
B	1	2	3	5
C	1	2	6	4
D	1	7	3	4
E	8	2	6	4
F	1	2	6	5

In principle there are three types of option calculations. The first type of calculations, i.e. pure calculations, is when an option has no consequences. Meaning that only this specific option changes. Therefore, the price difference between the base order and the variant order can directly be assigned to this option. An example of this type is when the rear light bulbs are changed to rear LED lights. See Figure 1.3 for the information that results from the system. This type of option calculations is not the problem, since the cost difference per option results directly from the system. While for the other two types of option calculations, only the price difference per component results from the system.

```

ORDER 079071 001 TAG G8709 AA TYPE G8709A SPEC.WEEK 201929
FEATURE BASIC OPTION
C/D NUM DESCRIPTION SEL DESCRIPTION SEL DESCRIPTION
-----
CHO 694 Rear lights 3322 rear light bulbs 3323 rear light LED
1RKCZZ JKC8X /GBR85375 DIFFERENCE MANU COST BY COMPONENT COMPARED TO 079071 000 2019-07-22 19:23 001
ORDER 079071 001 TAG G8709 AA TYPE G8709A SPEC.WEEK 201929 PRICE TYPE VVP PRICE YEAR 2019
COMP COMP ASS ITEM COMPONENT LABOUR LABOUR LABOUR MATERIAL MATERIAL MATERIAL
GRP NUMBER S GROUP NUMBER DESCRIPTION QUANTITY TIME COST SURCH COST SURCH 1 SURCH 2 TOTAL
-----
1822 1848480 Rear light
1822 1982641 Rear light
TOTAL COMP GROUP Rear light
TOTAL ORDER
1RKCZZ JKC5X /GBR85375 DIFFERENCE ASSEMBLY COST COMPARED TO 079071 000 2019-07-22 19:22 001
ORDER 079071 001 TAG G8709 AA TYPE G8709A SPEC.WEEK 201929 PRICE TYPE VVP PRICE YEAR 2019
ASS SEL LABOUR LABOUR LOON MATERIAL MATERIAL MATERIAL
SHP GROUP CODE TYPE TIME COST SURCHARGE COST SURCHARGE 1 SURCHARGE 2 TOTAL
-----
TOTAL ORDER
1RKCZZ JKC6X /GBR85375 DIFFERENCE SHOP COST COMPARED TO 079071 000 2019-07-22 19:23 001
ORDER 079071 001 TAG G8709 AA TYPE G8709A SPEC.WEEK 201929 PRICE TYPE VVP PRICE YEAR 2019
ASS ASS MAN MAN LABOUR LABOUR LABOUR MATERIAL MATERIAL MATERIAL
PLNT SHP PLNT SHP TIME COST SURCHARGE COST SURCHARGE 1 SURCHARGE 2 TOTAL
-----
7002 5 7002 5
07002 5 7002
07002 5
07002
OTOTAL ORDER
1 L' FINEWPAG
1RKCZZ JKCZX /GBR85375 SELECTIONCODES 2019-07-22 19:23 001

```

Figure 1.3: Example of pure calculation input (Calculation number: 079071 001)

The second type of calculations is when a “main” option change results in several other options, but where only one option remains to be unknown/uncalculated. This means that the option price is the difference between the base and variant order after deduction of the already calculated option prices. For example, if the option ‘Lead-up ramps’ is chosen, automatically the option ‘Font Presst-210+40’ also needs to be included, see Figure 1.4 on the next page. For this specific example only one component change is needed. This component change is related to both options. But since option 3249 ‘Font presst-210+40’ is already calculated with type 1, the remaining option is calculated as follows:

$$\text{Option price of 4359} = \text{total order price} - \text{option price of 3249}$$


```

ORDER 073201 016 TAG G0709 A OPT TYPE G0709A SPEC.WEEK 201905
-----
FEATURE          BASIC          OPTION
C/D NUM DESCRIPTION SEL DESCRIPTION SEL DESCRIPTION
-----
CHO 085 Lead-up ramps 9472 no lead-up ramps 4359 lead-up ramps
CHO 992 Fifth wheel 1728 Jost JSK42C 150+40 3249 Font presst-210+ 40
ODEP 064 Fifth wheel make 3204 Jost JSK42C 150 mm 3045 Font 210 pressed stl
1RKCZZ JKC8X /GBR81886 DIFFERENCE MANU COST BY COMPONENT COMPARED TO 073201 000 2019-01-02 19:23 001

ORDER 073201 016 TAG G0709 A OPT TYPE G0709A SPEC.WEEK 201905 PRICE TYPE VVP PRICE YEAR 2019
-----
COMP COMP ASS ITEM COMPONENT LABOUR LABOUR LABOUR MATERIAL MATERIAL MATERIAL
GRP NUMBER S GROUP NUMBER DESCRIPTION QUANTITY TIME COST SURCH COST SURCH 1 SURCH 2 TOTAL
-----
1148 1630255 Fifth wheel
1148 1958419 Fifth wheel
TOTAL COMP GROUP Fifth wheel
TOTAL ORDER
1RKCZZ JKC5X /GBR81886 DIFFERENCE ASSEMBLY COST COMPARED TO 073201 000 2019-01-02 19:22 001

ORDER 073201 016 TAG G0709 A OPT TYPE G0709A SPEC.WEEK 201905 PRICE TYPE VVP PRICE YEAR 2019
-----
ASS SEL LABOUR LABOUR LOON MATERIAL MATERIAL MATERIAL
SHP GROUP CODE TYPE TIME COST SURCHARGE COST SURCHARGE 1 SURCHARGE 2 TOTAL
-----
TOTAL ORDER
1RKCZZ JKC6X /GBR81886 DIFFERENCE SHOP COST COMPARED TO 073201 000 2019-01-02 19:23 001

ORDER 073201 016 TAG G0709 A OPT TYPE G0709A SPEC.WEEK 201905 PRICE TYPE VVP PRICE YEAR 2019
-----
ASS ASS MAN MAN LABOUR LABOUR LABOUR MATERIAL MATERIAL MATERIAL
PLNT SHP PLNT SHP TIME COST SURCHARGE COST SURCHARGE 1 SURCHARGE 2 TOTAL
-----
7002 5 7002 A
7002 5 7002 1
7002 5 7002 5
07002 5 7002
07002 5
07002
TOTAL ORDER
! L" FINEWPAG
1RKCZZ JKCZX /GBR81886 SELECTIONCODES 2019-01-02 19:23 001

```

Figure 1.4: Example of calculation input with one option remaining to be unknown (Calculation number: 073201 016)

The last type of option calculations is where a “main” option shift results in multiple other options, but where multiple options remain to be unknown/uncalculated with the other two types of option calculations. Then the option price is not just the cost price difference between the base and variant order after subtracting the already calculated option prices. Because the remaining price difference must be allocated to multiple uncalculated options. The main issue with this type of calculations is when a component is related to more than one of the changed options. Then a component change cannot just be allocated to only one option. Instead, it must be divided among the (uncalculated) options related to this component, for which technical knowledge from the option pricing employee is currently needed.

An example of this third type of option calculations is where the front axle is changed as “main” option, and automatically the options ‘Tyre size front 1’, ‘Tyre size rear 1’, and ‘Front underrun protection’ also change, see Figure 1.2. Options 1389 and 9869 have already been calculated with the second type of calculations. Therefore, the remaining price difference (after deduction of the already calculated option prices) needs to be allocated to the uncalculated options. What makes it difficult, however, is that a component number is related to several of the changed options. In this example, the component change from 2042446 to 2042449 is due to (related to) the option shifts from 2472 to 2509 and from 3274 to 1387, see Table 1.2. Therefore, the cost price difference due to this component change needs to be divided over both options 2509 and 1387.

Table 1.2: Example of component number change with its related options

Component number	Options			
2042446	6332	2472	1954	3274
2042449	6332	2509	1954	1387



All in all, there exist a lot of different options, over 10,000. Many data elements and systems are involved in estimating the cost price of these options. As indicated before, an option can have multiple consequences, which means that an option can automatically result in (multiple) other options such that the vehicle complies with the vehicle restrictions. Some of these more complex calculations currently require technical knowledge from the option pricing employee to allocate a price difference to several options. Therefore, forecasting the cost price of all the different options is a manual and time consuming process. As a result, there is an increased risk of errors and it costs a lot of money and time. More specifically, the process of calculating all options currently takes more than one year. This, in combination with the fact that the process always restarts on the first of January, means that the option cost prices are always one year behind, so not up to date⁴. Ultimately, this can lead to wrong order approval, because the order approval process is based on the forecasted cost price of the vehicle (including the options). If the estimated cost price is too high, it can lead to the loss of an order, but if the cost price is too low, it can result in the loss of margin. This corresponds to the insights of Niazi, Dai, Balabani, and Seneviratne (2006), who stated that the quality of cost estimation has a direct relationship with the performance of a business enterprise, because overestimation can lead to the loss of business and underestimation can result in financial losses.

For these reasons, the question from AB was to assess the current process of calculating option prices and to identify how this process can be significantly improved or automated. AB namely wants to develop an interface, i.e. link, between the actual cost price of delivered vehicles and the forecasted/calculated cost price on which order approval is based. Because they want these cost prices to be as close as possible to each other, such that (close to) correct margins are used in the order approval process. Currently, the actual cost price of the delivered vehicles are known; however, since the estimated cost price of the options are not up to date, no proper comparison (and thus a link) can be made.

The current problem mess of AB that resulted from the aforementioned observations is visualized in Figure 1.5 on the next page. A problem mess visualizes the dependencies, i.e. causes and effects, between company issues (Van Aken, Berends, & van der Bij, 2012).

⁴ Prices are not up to date at option level. However, high level adjustments are made to correct this.

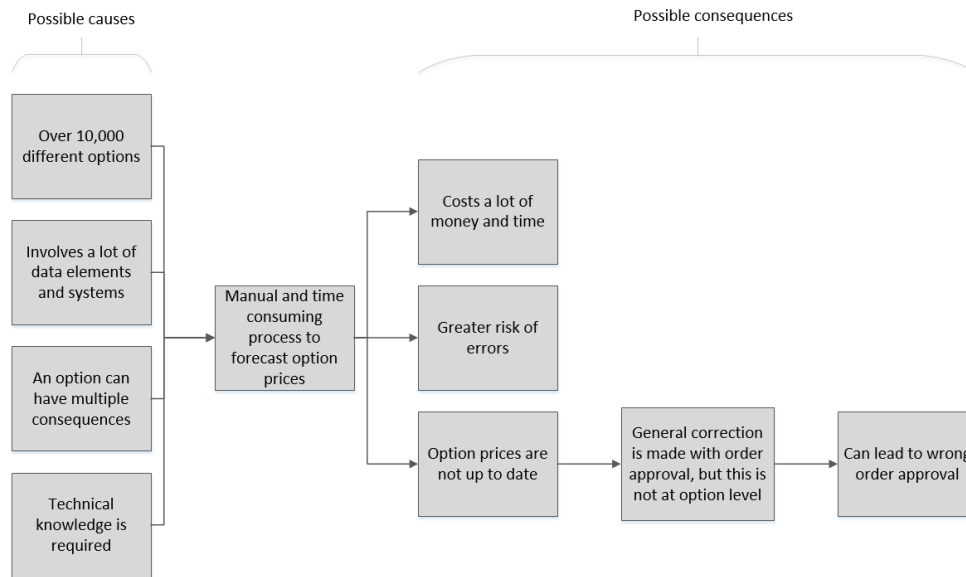


Figure 1.5: Problem mess

Using the problem mess, the problem statement is defined as follows:

“The current process to forecast option cost prices is a manual and time consuming process, causing option prices not being up to date.”

1.2 Project goal

Based on the problem statement, the following main research question was investigated:

“How can the current process of calculating option cost prices be accelerated?”

In other words, how can AB improve or redesign the current process such that estimating option prices takes less time after the new MLO prices apply on the first of January? The research methodology used to answer this question is explained in the next chapter.

1.3 Outline

This thesis is structured as follows. Chapter 2 presents the research methodology, which is followed by a description of the current situation in Chapter 3. Next, Chapter 4 describes the findings of the analyzed historical data. Chapter 5 presents the found industry practices. Hereafter, Chapter 6 describes the applicable improvement/redesign methods found in the literature. Chapter 7 presents possible improvement ideas along with their evaluation. Finally, Chapter 8 provides overall conclusions, recommendations, and limitations.

2. Research methodology

First, the paradigms to define the research method are introduced in this chapter. Second, the research questions and resulting research method are defined. Last, the deliverables and scope of this study are listed.

2.1 Research method paradigms

There exist different types of methodologies for performing scientific research. This thesis used the design science paradigm since it aimed to produce a solution to a specific field problem (van Aken et al., 2012). Therefore, the problem solving cycle methodology from van Aken et al. (2012) was followed, which is visualized in Figure 2.1. The first step of this cycle is to identify and structure the problem mess, resulting in a problem definition. The next step is the analysis and diagnosis phase. The goal of this step is to enhance the understanding of the nature and context of the problem. The third step in the problem solving cycle is the solution design. In this step a solution for the identified problem was designed next to the corresponding implementation plan for this solution. During the intervention phase the solution should be implemented. This study only implemented the recommendation in a short empirical study. Full scale implementation was not possible because it requires IT (Information Technology) resources and personnel. In the final step, the evaluation and learning phase, the research was evaluated and possible recommendations and limitations were identified.

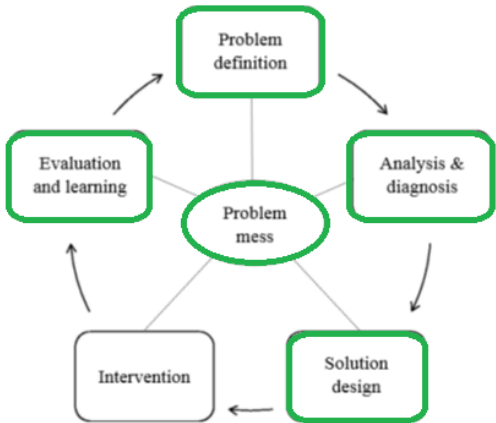


Figure 2.1: The problem solving cycle (van Aken et al., 2012, p.12)

As indicated before, the goal of this master thesis was to accelerate the current option pricing process. This can be done by improving the current process, which is supported by Business Process Management (BPM) (Pufahl & Weske, 2019). Therefore, in addition to the problem solving cycle, a part of the BPM lifecycle of Dumas, La Rosa, Mendling, and Reijers (2018) was also used in this thesis, which is visualized in Figure 2.2 on the next page. The first step of this lifecycle is process identification, the goal of this step is to form an overview of the organization’s processes and relationships. This architecture is then used to select the process that will follow the remaining steps of the lifecycle. At the start of this thesis it was already known which process needed to be investigated; therefore, this first step was not executed. The next step is the process discovery phase, i.e. the AS-IS process modeling phase. In this step the current state of the option pricing process was documented in the form of an AS-IS process model. In the following step, the process analysis, issues and opportunities

for process improvement were identified. The fourth phase is the process redesign step, i.e. the process improvement step. The goal of this step is to identify and analyze potential process changes in order to improve the process. The last two steps of the BPM lifecycle, regarding implementing the TO-BE process model and monitoring this process, were not fully executed within this thesis due to time and resource constraints.

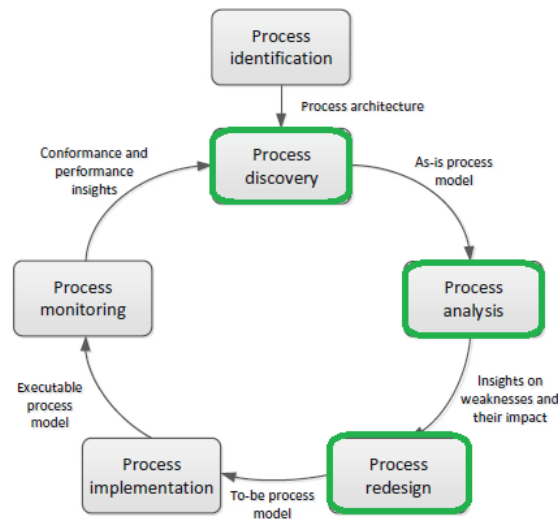


Figure 2.2: BPM lifecycle (Dumas et al., 2018, p.23)

2.2 Research questions

As indicated before, the following main research question was investigated:

“How can the current process of calculating option cost prices be accelerated?”

In order to answer this main research question, several sub-research questions were formulated to further guide this thesis.

1. What is the current situation of the option pricing process at the company?

To determine how the process could be accelerated, the AS-IS situation, i.e. the status quo, was documented with the first sub-research question.

2. What are critical business issue(s) with the AS-IS situation?

In order to identify possible improvement steps for the current option pricing process, the AS-IS situation was evaluated. This was done by identifying critical business issue(s), i.e. problems, with the current process.

3. What information can be extracted from historical data?

Historical data was analyzed to get a better understanding of the current situation. In addition, it was utilized to identify, among others, the most and least sold options. This information was useful for identifying improvement points.

4. What are industry practices?

Industry practices were identified and compared to the AS-IS situation. With this comparison possible improvement ideas for the current option pricing process were identified.

5. Which process redesign/improvement methods are available in the scientific literature?

For developing possible improvement ideas, information that is available in the literature could be used as a guideline. Therefore, the fifth question dealt with gathering this information.

6. What are possible improvement ideas for the company?

Based on scientific literature and on the answers of the other sub-research questions, possible improvement ideas were designed for the option pricing process.

2.3 Research method

In order to describe and visualize the current situation, old documentation of the option pricing process was reviewed. In addition, several interviews were conducted with the option pricing employee who currently executes the option pricing process, but also with other employees who have a broad knowledge about the systems and processes of AB. The option pricing employee also demonstrated how he currently calculates the option prices by showing examples. The methods used to identify the current process, namely document analysis, interview-based discovery, and observation, are all identified by Dumas et al. (2018) as appropriate methods for creating process models. The resulting AS-IS situation was reviewed until the company agreed with the content. In order to answer the second sub-question, the output from the first sub-research question, the AS-IS situation, was used in addition to interviews with the option pricing employee about his struggles with the current process.

To analyze historical data, orders of 2018 and first half of 2019 were used. Only orders within this time frame were utilized due to data availability and because other vehicle models were produced before 2018. The data used for the analyses were the total cost per order, all options that are incorporated per order, the base price per vehicle type, and the base options per vehicle type. The programs Excel, Access, and Minitab were used to analyze this data (descriptive analysis).

The initial aim of the fourth sub-question was to find industry best practices in order to compare AB's current process design to a standardized process (Dumas et al., 2018). To obtain these industry best practices the internet was searched. However, since the option pricing process is so specific, nothing could be found. Therefore, the author of this study contacted many companies within the automotive industry to ask how their option pricing process is designed.

The literature review of the author dealt with finding redesign/improvement methods and indicated which of these approaches can be applied to accelerate AB's option pricing process. The academic articles and books used in this literature review were collected by searching the following databases: TU/e library search, Google Scholar, and ScienceDirect.

To identify possible acceleration ideas, information from all the previous sub-questions was used as input. Possible improvement directions were already identified by answering sub-questions two, three, and four. The improvement approaches identified by sub-question five were used as a guide for further developing improvement ideas. These approaches implied that discussions and brainstorming sessions were held with both process executors and other process stakeholders (M&S and IT). Semi-structured interviews were used to evaluate all the resulting improvement ideas. These interviews were conducted with employees who will be ultimately working with the proposed acceleration idea, using the output, and implementing it. More details about these interviews can be found in Section 7.3.

2.4 Deliverables

The phases that were used within this thesis from both the problem solving cycle and the BPM lifecycle, together with their relevant sub-research questions, the corresponding deliverables, and chapter numbers can be found in Table 2.1.

Table 2.1: Phases and deliverables

Problem solving cycle	BPM lifecycle	Sub-research question	Deliverable	Chapter number
Problem definition	x	x	Problem statement, main research question, sub-research questions	1 & 2
Analysis & diagnosis	Process discovery	1	AS-IS situation	3
		2	Current critical business issue(s)	3
	Process analysis	3	Historical data information	4
		4	Industry practices	5
		5	Scientific literature	6
Solution design	Process redesign	6	Improvement ideas	7
Evaluation & learning	x	x	Evaluation of ideas	7
			Recommendations and limitations	8

2.5 Scope

In order to define the scope of this thesis, research boundaries were formulated.

As already mentioned, this thesis is about accelerating/improving the current option pricing process. Therefore, the process of estimating the cost price of the base vehicle fell outside the scope of this research. In addition, improving the current way of determining the standard cost price at item level was not taken into account (all provided information regarding MLO was assumed to be correct and complete).

Only the options that need to be estimated by the CA department were considered. Therefore, options for the CC series, specific marketing options and options regarding tires, wheels, and software fell outside the scope of this research. Likewise, improving the option pricing process at another production plant was not included. Moreover, the process of forecasting the cost price of *new* options

was also not taken into account. This cannot really be calculated since the underlying required data is not yet available.

It must be mentioned that this thesis did not deliver a programmed tool that incorporates the process improvements. Instead, a recommendation of how the improved process should look like was the end deliverable of this research. In addition, as mentioned before, full implementation of the proposed improvement idea was not part of this thesis.

3. Current situation

In this chapter, the systems related to the option pricing process and the relationships between them are described. In addition, the current process to calculate option prices is explained, visualized, and evaluated.

3.1 Systems

This section explains how a vehicle is composed in the different systems and how this relates to options. An overview of two of these systems, the Model Unit Index (MUI) and the Vehicle Engineering System (VES), is provided in Figure 3.1.

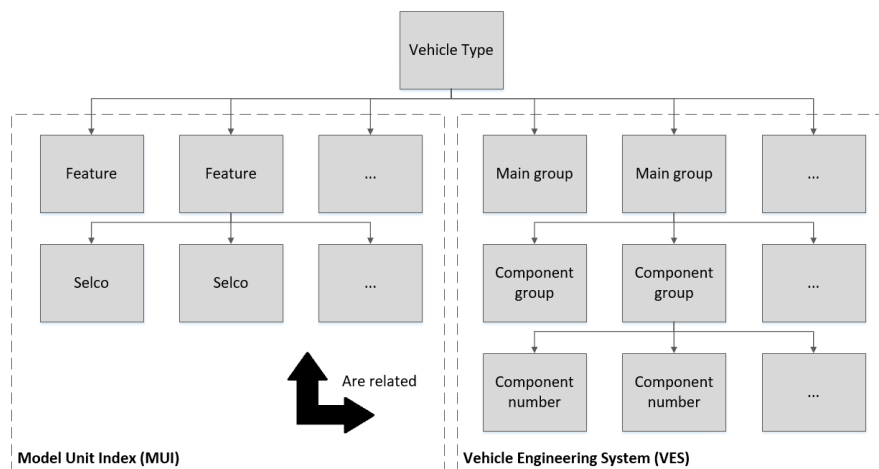


Figure 3.1: MUI and VES (Roording, 2016)

3.1.1 MUI

In the left side of the figure, the MUI structure is presented. As mentioned before, there are a lot of options customers can choose from. All these options, choice combinations and restrictions are incorporated in the MUI, i.e. the rule book, to make sure that the customers can only pick a valid combination of options.

As can be seen in Figure 3.1, a vehicle type consists of different features, which consist of different selection codes (selcos). A feature is an option category from which the customer can choose an option. The chosen option within this category is called a selco. In the rest of this thesis the terms option and selco are used interchangeably. One selco of a feature is always incorporated in the base vehicle, represented by a B (base). The other selcos within a feature are the ones a customer can choose, which are represented by an O (optional). Note that only one selco per feature can be incorporated in the vehicle. There are also features with only one selco, then the customer is not able to choose. These selcos are represented in the system by an S (standard).

The specification of a selco in B, S or O can vary per vehicle type. Therefore, it is possible that a selco is represented by a B for a certain vehicle type, but that it is indicated by an O for another vehicle type. All specifications for each selco per vehicle type are recorded in the General Specification (GS).

Some simple examples regarding features and selcos are visually presented in Appendix B. A feature is for example 'steering' and the corresponding selcos are 'left hand drive' and 'right hand drive', of which 'right hand drive' is incorporated in the base vehicle.

Which features and/or selcos are available for a customer to choose from depends on the vehicle type, other features, and other selcos. When one selco from a certain feature is selected, it is possible that multiple other selcos from other features also have to be chosen. This must be done to ensure that the vehicle is MUI clean, meaning that the vehicle complies to the choice combinations and restrictions of the MUI. Which selcos change as a result of the option chosen by the customer are automatically identified by the system. Note that the option(s) that change accordingly may also be a separate option that a customer can choose.

3.1.2 VES

The right hand side of Figure 3.1 shows the physical vehicle breakdown structure, the VES. This structure is developed by AB's constructors and specifies which materials need to be used in certain situations. As can be seen in Figure 3.1, a vehicle type according to the VES consists of multiple main groups, such as the brake system, engine, and steering gear. These main groups are further divided into one or more component groups, and a component group has one or more component numbers. A component number represents a unique physical component of a vehicle. An example of this breakdown structure is presented in Appendix B. Note that a component group consists of multiple component numbers, but only one of these component numbers is incorporated in the vehicle based on the selco(s) chosen by the customer.

3.1.3 VIS

In addition to the MUI and VES, another administrative system of AB is the Vehicle Item Structure (VIS). Within the VES, the component numbers are the lowest level, while in the VIS these numbers are the highest level. In the VIS, every component (number) has a Bill Of Materials (BOM), with all items, in order for the production department to know what needs to be produced.

3.1.4 Relations between MUI, VES, and VIS

The three discussed systems, the MUI, VES, and VIS, are related to each other. The customer makes choices for a vehicle in the MUI. These choices, i.e. selcos, lead to the components that need to be used, which are defined in the VES. Therefore, the MUI and VES are linked via selcos and component numbers (and therefore also via features and component groups). Now, the structure of the vehicle is known at component level. The content of these components is listed in the BOM, which is part of the VIS. A visual representation of these relationships can be found in Figure 3.2 on the next page.

It must be noted that a feature can be related to one or more component groups and that a component group can be related to one or more features. The same holds for selcos and component numbers. One component number can be related to multiple selcos; therefore, a component can only be integrated if all the related selcos are present. For example, when looking at Table 1.1, component C can only be used if options 1, 2, 6, and 4 are integrated in the vehicle.

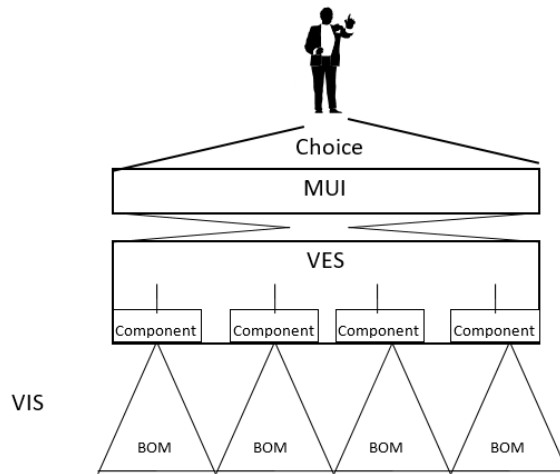


Figure 3.2: Relationship between MUI, VES, and VIS

3.1.5 Other systems linked to the option pricing process

Besides the MUI, VES, and VIS there are other systems linked to the option pricing process, namely Assor, APS, and OMS. Assor is the vehicle cost system, which contains the standard cost prices, i.e. MLOs, for every item on file. These standard cost prices are used as input to the option pricing process. APS is AB's Product System, part of this system deals with maintenance and release of cost prices. Therefore, the outcome of the option pricing process, the option cost prices, are entered into APS where these prices are stored. Last, OMS is AB's Order Management System. This system uses the cost prices from APS, including the option prices, to calculate the margin of each order.

3.2 Current option pricing process

As indicated before, option cost prices are currently calculated by taking the price difference between the base order and the variant order. Where an option price indicates the added cost relative to the standard choice (base order). Therefore, only the selcos indicated by an O, which are the selcos within a feature a customer can choose from, need to be priced because the selcos represented by a B or S are part of the base vehicle price. In this chapter the current process of pricing the O selcos for each vehicle type is explained.

Calculating all O selcos for each vehicle type is done in a certain order. First, all the option prices of the best-selling vehicle type within the AA series are estimated. A distinction can be made between common and vehicle specific options. Common option prices apply to multiple or all vehicle types within a series. Therefore, these option prices only need to be calculated once for multiple vehicle types. While vehicle specific options need to be calculated separately for each vehicle type. After the option prices are calculated for the best-selling vehicle type within the AA series, the common and vehicle specific option prices for the most sold vehicle type within the BB series are estimated.

When all options of the two best-selling vehicle types are calculated, the remaining common and vehicle specific options are priced. First, both common and vehicle specific options are calculated for the vehicle type with the most uncalculated common options, which is then repeated. When all common options are calculated, the remaining vehicle specific options are estimated in order of sales

figures of the remaining vehicle types. This is also repeated until all options are calculated. This process is visualized in Figure 3.3⁵.

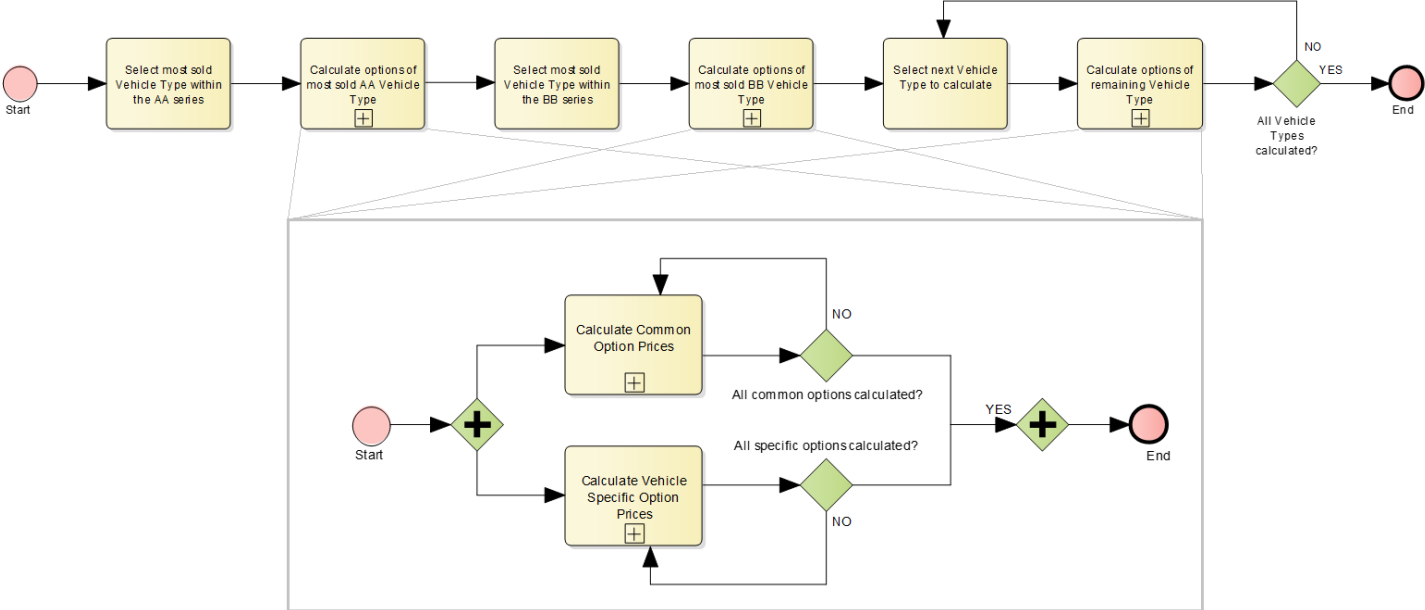


Figure 3.3: High level process of option pricing, including the order of calculations

The tasks ‘Calculate Common Option Prices’ and ‘Calculate Vehicle Specific Option Prices’ in Figure 3.3 have the same underlying process, i.e. subprocess, which is visualized in Figure 3.4 on the next page.

As can be seen in Figure 3.4, the first step in this subprocess is to select the tactical spec week, i.e. the period from which the MLOs are used, and to check if the GS is known. Currently, the tactical spec week is chosen such that it is as far as possible in the future, but that all data is known. Hereafter, information can be retrieved from the system. First, a list of the features that need to be priced for each vehicle type are retrieved. Per *vehicle type* the system generates orders with only a single option differing from the base order. However, this is only possible with a maximum of 15 features per request. Where all options within a feature are used one by one, such that a single option differs from the base order (single option change). Nevertheless, several requests can be placed after each other.

Note that due to the single option change (“main” option), other options must also change such that the vehicle complies to the MUI. This is done automatically by the system and is part of the generated information. This information also indicates which component numbers are added and/or removed due to the option changes compared to the base order. Therefore, the information indicates the cost price difference. This involves both manufacturing costs and, if applicable, assembly costs. All this information is combined into a report named RKCZZ. In addition to RKCZZ, the KC8Z report is also retrieved from the system, the use and content of KC8Z is explained later.

⁵ From the literature review by Bakermans (2020) it resulted that there are many business process modeling languages available. The Business Process Model Notation (BPMN) is a commonly used standard for process modeling. AB’s IT department also uses this language for modeling processes. Therefore, this thesis applied BPMN for modeling the current process to increase common understanding and in order for AB to easily integrate the visualized process with other processes. The visualization tool used is Enterprise Architect (EA). EA is an UML Modeling tool used by AB and supports BPMN.

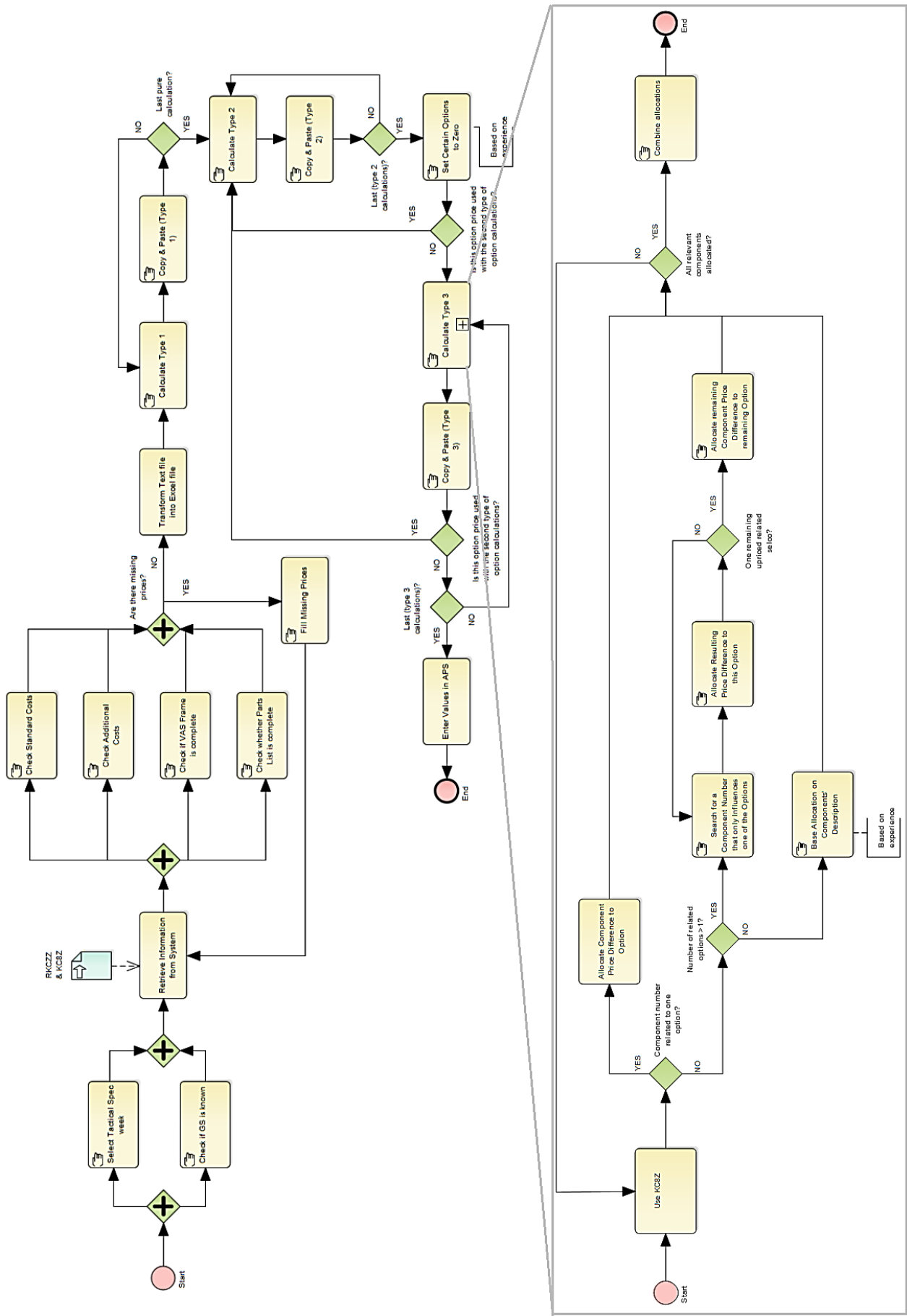


Figure 3.4: Subprocess – Calculating options

Examples of how the retrieved RKCZZ report looks like can be seen in Figures 1.2, 1.3, and 1.4. Note that the retrieved information shows both CHO (chosen) and DEP (depending) options. Only the CHO options need to be priced because the DEP options are part of a CHO option and therefore do not require a price. Within AB, a CHO option can be a cluster option, meaning that there are multiple options within this CHO option. The retrieved information takes this into account and only provides the overarching CHO option. These cluster options have been created by the M&S department to limit and simplify the number of choice variants for the customers.

After the files are received, it is checked whether information is missing. This is done by checking the following aspects for completeness: standard costs (MLOs), additional costs, VAS (Vehicle Assembly Structure) frame, and parts lists. When prices are missing, this needs to be found by getting the required information from the purchasing department or by using the price of a comparable product. This information must then be entered into the system. Hereafter, the step of retrieving information from the system is executed again to ensure that complete files are available. When there are no more missing prices, the RKCZZ and KC8Z text files are transformed into Excel files.

As explained before there are three types of option calculations. Namely, pure calculations (type 1); calculations where a “main” option change results in multiple other options, but where only one option remains to be unknown/uncalculated (type 2); and calculations where a “main” option change results in multiple other options, but where multiple options remain to be unknown/uncalculated (type 3). An example of each of these calculation types can be found in Section 1.2 ‘Problem definition’. Approximately 40% of all options are calculated with type 1, 45% with type 2, and 15% with type 3.

All three types of option calculations are performed in Excel. Figure 3.5 shows how the RKCZZ Excel file looks like for the example of the front axle shift from Figure 1.2. Within this Excel file, ‘nCHO’ represents the total number of changed options per calculation number. With a pure calculation, a value of 1 applies. But when a “main” option shift results in two other option changes, the value of 3 applies. The output of every “main” option change has a calculation number. The ‘requested’ column shows which feature (and thus selco) was the “main” shift that triggered the other option change(s). ‘SelcO’ stands for the changed option, and ‘SelnameO’ provides a short description of each option. The column ‘Nselco’ shows how often this specific option is present in calculation numbers. For example, option 2509 appears in three calculation numbers, one of which is the calculation number in which the option is calculated (in this case 073210 020). This means that this option appears in two other calculation numbers. The ‘TotCost’ column represents the total cost of the respective calculation number, including material and assembly costs, if applicable. While ‘Calculated’ indicates how many costs are allocated to each selco. Finally, the ‘Ref calculation’ column refers to the calculation number where the allocated option cost were calculated.

nCHO	Calc_nr	Requested SelcO	N selco	SelnameO	TotCost	Calculated	Ref calculation
4	073210 020	962 2509	3	8.00 t-pb-167N			073210 020
4	073210 020	#N/A 1387	5	fr1, 315/80R22.5			073208 023
4	073210 020	#N/A 1389	5	r1, 315/80R22.5			073209 002
4	073210 020	#N/A 9869	2	fup 445 mm			073210 020

Figure 3.5: RKCZZ Excel file example (Calculation number: 073210 020)

Note: The columns ‘Calculated’ and ‘Ref calculation’ must be filled in by the option pricing employee.

The first type of calculations performed in the subprocess are pure calculations. Where the option price is the total price difference between the base order and the variant order, since the “main” option has no consequences. This option price is then copied and pasted in the Excel file to other spots (calculation numbers) where this option is needed. This is currently done by manual copying and pasting or by the vertical lookup function in Excel. These steps are carried out until there are no options without consequences left.

After all pure calculations are executed, the second type of option calculations are performed. Where a “main” option change results in multiple other options, but where only one option remains to be unknown. As indicated before, this implies that the option price is the difference between the base and variant order after subtracting the already known option prices. The resulting option price of the remaining option is then copied and pasted within the Excel file to other places where this option is needed. These steps are repeated until there are no more instances with one option remaining to be unknown. Therefore, first calculations are performed with an ‘nCHO’ of 2, then with an ‘nCHO’ of 3, and so on until there are no calculation numbers left with only one unknown option⁶.

Hereafter, certain options are given a value of zero, which implies that the costs are allocated to another option. This is done every year by the option pricing employee based on experience. The reason for this is to simplify some calculations, as it allows a new number of options to be estimated with the second type of option calculations. Because by giving the value zero to certain options, there are new calculation numbers where again only one option remains to be unknown.

The third type of option calculations, with multiple options remaining to be unknown, consists of several underlying steps, i.e. a subprocess. These calculations are performed per calculation number. Where first a selection is made so that only the calculation numbers with the lowest number of unknown options remain. Then, within this resulting list, the calculation number is selected that has the option with the highest ‘N selco’. As a result, the somewhat simpler calculations with the least number of remaining options are calculated first and can be copied and pasted to many other spots, which makes other calculations easier. However, this calculation order is not always followed in practice. The option pricing employee also bases the calculation order on experience. Note that with the third type of calculations, only the unknown options of a calculation number are assigned a cost price.

A help table called KC8Z is used for this third type of calculations. An example of how this Excel file looks like is shown in Figure 3.6 on the next page (same calculation number as in Figure 3.5). As can be seen, KC8Z shows the calculation number, the total material cost of the calculation number, the total material plus assembly cost of the calculation number, and the component group. In addition, the switch from the component number that is part of the base order to the component number that is part of the variant order is provided. The ‘Tot grp’ column shows the material cost price difference per component group. The next column indicates the allocated material costs per component group to the CHO feature (and thus to the option). The column ‘Assy cost’ shows where assembly costs are assigned

⁶ Note that the option pricing employee does not always blindly apply the second calculation method. Some options need to be checked before this type of calculation can be carried out. For some other options, the employee knows out of experience that this second type of calculations is unwise to use. Then the third type of option calculations is applied.

to. The next column, 'Selcos', indicates the number of selcos related to the component. The rest of the columns show the associated features and options, as well as the switch from the base option to the chosen and consequence options. However, only the columns 'CHO fea' and 'Option' are important, because they indicate to which feature (and therefore option) the costs should be allocated because, if applicable, they represent the cluster option. For example, when looking at the first line in Figure 3.6, the columns 'Fea' and 'CHO fea' and the columns 'Option' and 'SelO' do not match, since option 2509 is a cluster option that includes option 9824.

Calc_nr	Mat	Mat+assy	Comp Grp	B comp	O comp	Group description	Tot grp	Mat per grp	Assy cost	Selcos	Note	Fea	Feature name	CHO fea	Option	SelB	Selco B naam	SelO	Selco O naam
073210020			1102	1958069	1958071	Suspens.fr.axle 1				1		290	1st front axle type	962	2509	9823	1st front axle 16	9824	1st front axle 16
073210020			1149	1371207	1371208	Mudguards rear ax.				1		905	Tyre size, rear 1	905	1389	3479	r1, 315/70R22.5	1389	r1, 315/80R22.5
073210020			1171	1837160	1844663	F.underrun protec.				1		924	Front underrun prot	924	9869	9867	fup 365 mm	9869	fup 445 mm
073210020			1201	1807561	1807568	Fittings,fr.ax.1				0	to 962	0		0	0	0			0
073210020			1204	1798810	1798812	Axle beam, fr.ax.1				0	to 962	0		0	0	0			0
073210020			1205	1807593	1807606	Track rod,fr.ax.1				0	to 962	0		0	0	0			0
073210020			1460	2033664	2033666	Cooling air screen				1		924	Front underrun prot	924	9869	9867	fup 365 mm	9869	fup 445 mm
073210020			1635	2107728	2123958	Mudguards, cab				1		901	Tyre size, front 1	901	1387	3274	fr1, 315/70R22.5	1387	fr1, 315/80R22.5
073210020			1666	2042446	2042449	Mudflap fr				2		290	1st front axle type	962	2509	9823	1st front axle 16	9824	1st front axle 16
073210020			1666	2042446	2042449	Mudflap fr				2		901	Tyre size, front 1	901	1387	3274	fr1, 315/70R22.5	1387	fr1, 315/80R22.5

Figure 3.6: KC8Z example (Calculation number: 073210 020)

Note: Most important columns are marked yellow and grey.

Note: The columns 'Mat per grp' and 'Assy cost' must be filled in by the option pricing employee.

When a component is related to only one selco, the associated price difference can directly be assigned to this option. But when a component is not related to one selco, it gets more complicated. If a component is related to "zero" selcos, this can have multiple causes. It is possible that with the option change a component is left out but nothing is added instead, a component is added but nothing is left out, or an intermediate level exists. An intermediate level means that within a main group there are multiple component types, which have their own component groups. For example, for each of the two engines that AB offers there is a separate component type, these component types have their own component groups with component numbers, which may differ for the two engines.

Currently, when a component is related to zero selcos, the corresponding price difference is assigned to a certain selco (or feature) based on the component's description. This is done by the option pricing employee based on experience. For example, when looking at Figure 3.6, all the components related to zero selcos are assigned to feature 962 because they all have something to do with the front axle.

If a component is related to more than one selco, the option pricing employee searches in the VES for a component number where only one of the related selcos has changed in comparison with the base. The resulting price difference is then assigned to this specific selco. These two steps need to be repeated until only one related selco remains to be unpriced. Then the next task can be executed, where the already allocated prices are deducted from the total price difference of the component. The resulting price is then allocated to the remaining unknown selco. For example, when looking at Figure 3.6, component group 1666 is related to two selcos. To determine how much of the total cost should be allocated to each of these two selcos, the VES is searched for a component number that only relates to a tire change and not to an axle change. This results in a price difference of X for the tire shift. Therefore, the remaining price difference (total component price – X) is allocated to the axle change.

After all components related to the unknown selcos are assigned, these allocations are combined by adding the assigned component costs for each unknown feature (or selco). This results in the option price of the unknown options.

When the unknown options of a calculation number are calculated, these prices are copied and pasted to other spots where these options are needed. Hereafter, if applicable, the second type of option calculations are performed again because it is possible that by copying and pasting these option prices, only one option remains to be unknown within other calculation numbers. After performing the second type of option calculations again, another calculation number with multiple unknowns is selected for type 3 calculation. This is repeated until all options are calculated for the respective vehicle type.

There are some exceptions regarding the third type of option calculations. If a component number is related to zero selcos because an intermediate level is present, another method for allocation can also be applied. Namely to manually search for this intermediate level in the system and then base the allocation on this intermediate level. When a component number is related to multiple selcos and the method described above is not executable, the option pricing employee may use other methods for distribution. It is possible to look at the BOM to see which specific items have changed, and to allocate the price difference of these items based on experience. Or the option pricing employee can make an allocation approximation based on his experience. Another rare exception that can be used is to try to request a variant order from the system where only one of the selcos related to the component number differs. However, this is not always possible as the vehicle may no longer comply with the vehicle restrictions (MUI). It is also possible to make a new request where all CHO options of a calculation number are incorporated in the base order, and where the option shift occurs from the originally requested "main" option to the option that was originally in the base order, i.e. the other way around. Note that these last two mentioned exceptions are hardly ever used in practice.

An additional exception with the third type of option calculations is when assembly costs must be allocated to the remaining unknown options. When the RKCZZ report indicates the selection codes that belong to the assembly costs, these costs can directly be assigned to the mentioned selco. However, it is also possible that no selcos are provided with the assembly costs, see for example Figure 1.2. Then the option pricing employee allocates the costs based on the factory where the assembly costs are carried out, which is shown in the 'SHP' column of the assembly cost differences in the RKCZZ text file (see Figure 1.2).

Another notable exception concerns weighing options. This is carried out after all options have been calculated and only when there is a large price difference for an option when another option is also included in the vehicle. For example, the price of option X can be very different when another engine is incorporated than the one of the base order. Therefore, the cost price for this specific option is calculated again with a different base order, which includes the other engine. The different costs of this option, due to the different base orders, are weighted based on the 1-year sales figures of the engines. The options to which this exception applies are determined on the basis of the option pricing employee's experience.

After all options are calculated and approved, the option prices are uploaded into APS, which are then used by OMS to calculate the total cost price of each vehicle.

3.3 Issues with current option pricing process

To be able to identify possible improvement steps for the current option pricing process, the AS-IS situation was evaluated. This was done by identifying issues with this current process. Note that quantitative techniques for analyzing a business process, such as flow and queueing analysis (Dumas et al., 2018), were not utilized because no time-related data was available for all process activities. Specifically, data regarding the third type of option calculations was missing as it is highly dependent on employee’s knowledge and really differs per option and per vehicle type. Therefore, analyzing the AS-IS situation was carried out in a more qualitative way.

First of all, it was identified that in order to get information from the system, it is first necessary to obtain the features from the system that need to be priced for each vehicle type. Hereafter, the RKCZZ report can be requested, but this is only possible with a maximum of 15 features per request. While the RKCZZ report is needed for all features. Therefore, this takes more time than necessary. In addition, it can take a long time before the requested information is actually obtained from the system. Currently this takes at least one night, but if a lot of information is requested it can take even longer because of a restriction on the number of orders that can be run per night.

The RKCZZ report is a text file. Therefore, to use the data from this file, the text file must first be converted into an Excel file. This would be a redundant step if the system automatically delivers the RKCZZ report in the correct file format. The same applies to the KC8Z text file.

As indicated before, AB makes a distinction between common and vehicle specific options. By applying common options, less options need to be calculated, which saves a lot of time. However, it is more inaccurate because the actual option prices are not the same for multiple or all vehicle types within a series. To bring the option prices closer to the truth, all options for each vehicle type can be calculated separately.

With the second type of calculations, calculating the price of the one remaining unknown option is done manually within Excel by summing the already calculated options and subtracting this sum from the total price difference of the calculation number. Since it is a manual task, it takes more time and has a higher chance of errors. Moreover, the method of subtracting the sum of the already known options from the total price difference is not 100% accurate. A combination of options can entail a different price than individual options or different combinations of options. This is because an option is related to multiple component numbers, but a component number is also related to multiple options. And a component can only be integrated if all the related selcos are present. For example see Figure 3.7, option 1848 is estimated with the first type of option calculations and results in A, which is the sum of Q, S, and X. When looking at another calculation number, see for example Figure 3.8 on the next page, where option 1848 is a “consequence option”, the sum of the components related to option 1848 may not be equal to A. Because the combination of options results in some different component changes. However, this usually does not lead to major differences.

Calc_nr	Mat	Mat+assy	Comp Grp	B comp	O comp	Group description	Tot grp	Mat per grp	Assy cost	Selcos	Note	Fea	Feature name	CHO fea	Option	SelB	Selco B naam	SelO	Selco O naam	
073210052			1117	2038023	2038020	Frame EAS		Q		1		623	Catwalk step in tank	990	1848	4021	step in fuel tank		4020	no step in fuel t
073210052			1147	1847524	1900110	Catwalk basis		S		1		623	Catwalk step in tank	990	1848	4021	step in fuel tank		4020	no step in fuel t
073210052			1152	1850045	1849830	Fuel tank		X		1		610	Fuel tank capacity	990	1848	3174	tank 845 l, step		6295	tank 340 l

Figure 3.7: KC8Z for option 1848

Calc_nr	Mat	Mat+assy	Comp Grp	B comp	O comp	Group description	Tot grp	Mat per grp	Assy cost	Selcos	Note	Fea	Feature name	CHO fea	Option	SelB	Selco B naam	SelO	Selco O naam
073201007			1101	2143161	2016080	Chassis frame.				2		34	Wheelbase/re overhng	34	4586	3891	wb380/AE075	4586	wb380/AE099
073201007			1101	2143161	2016080	Chassis frame.				2	to 078	78	Ch component layout	78	4202	1179	std component po	4202	free RH side 2300
073201007			1117	2038023	2038024	Frame EAS	P			2		623	Catwalk step in tank	990	1848	4021	step in fuel tank	4020	no step in fuel t
073201007			1117	2038023	2038024	Frame EAS				2		689	DPF/SCR position	952	0	4220	DPF+SCR RH	4222	DPF+SCR LH
073201007			1131	1910294	1848988	Battery box				1		502	Battery box position	923	3094	3161	battery box hor R	3531	battery box in AE
073201007			1139	2023099		Catwalk ri				0		86	Catwalk	86	0	6606	catwalk standard	0	
073201007			1139	2023099		Catwalk ri				0		94	Catwalk step pos	94	0	7050	catwalk step LH	0	
073201007			1139	2023099		Catwalk ri				0		689	DPF/SCR position	952	0	4220	DPF+SCR RH	0	
073201007			1139	2023099		Catwalk ri				0		701	Exh discharge pos	701	0	6610	exhaust hor low	0	
073201007			1147	1847524	2104100	Catwalk basis	T			1		689	DPF/SCR position	952	0	4220	DPF+SCR RH	4222	DPF+SCR LH
073201007			1152	1850045	1849830	Fuel tank	X			1		610	Fuel tank capacity	990	1848	3174	tank 845 l, step	6295	tank 340 l
073201007			1154	2022473	2021967	Exhaust				1		689	DPF/SCR position	952	0	4220	DPF+SCR RH	4222	DPF+SCR LH

Figure 3.8: KC8Z of calculation number 073201 007, where 1848 is a "consequence option"

As mentioned before, certain options are given the value of zero before calculating them. This is done by the option pricing employee based on experience. However, every year the employee decides from scratch which options to assign the value zero. Since there are many similarities every year with regard to assigning the value zero, this takes more time than necessary. Therefore, this can be accelerated by listing the options that generally receive the value zero over the years, and by listing the options that are not connected to any component number, meaning that they should also receive the value zero. This list only needs to be updated each year.

Many of the tasks of the third type of calculations involve manual aspects, especially when the number of related options is not equal to one. Therefore, it takes a lot of time and increases the chance of miscalculations. In addition, the intermediate level, which is identified as one of the possible causes of a component's relation to zero selcos, is not included in the KC8Z help table. Therefore, if an intermediate level is present, the option pricing employee must search the system for it. However, when this level is built in the KC8Z help table, less manual search is needed.

As indicated before, quite a few tasks are based on the experience of the option pricing employee. These tasks are mainly concerned with the third type of option calculations where a component's price difference needs to be divided over multiple options or when a component is related to zero selcos. This can have a major consequence, namely that when the option pricing employee leaves, a lot of knowledge is lost. Therefore, it may be useful to develop general allocation rules for the third type of option calculations.

After all three types of calculations, the estimated option prices are manually copied and pasted in Excel to other calculation numbers where this specific option is needed. Because this is done manually, it takes more time, but it also increases the chance of errors. Therefore, it is better if this copying and pasting no longer needs to be done by hand.

Currently, only one employee calculates all option prices. Therefore, the calculations for each vehicle type are carried out sequentially. Performing the calculations per vehicle type in parallel would reduce the required time. However, with the current process, this would imply that several employees would have to calculate options for different vehicle types at the same time. This means that the number of man-hours required still remains the same. Therefore, it does not provide any real improvement.

Looking at all the listed issues of the current process, it can be concluded that the biggest cause of the lengthy process are the manual aspects of the actual calculations, which includes the tasks of Figure 3.4 from 'Calculate Type 1' until 'Enter Values in APS'. Therefore, it is important to investigate how these manual aspects can be removed from this part of the option pricing process.

4. Data analysis

In this section, historical order data was analyzed. All orders of the year 2018 and first half of 2019⁷ were used for the analyses. Specifically, the total costs of the order and all options incorporated in each order were used. The years before 2018 were not taken into account, because other vehicle models were produced at the time and different models are not comparable in terms of options.

Before the analyses could start, the data first had to be cleaned. This was done by only including orders built at AB's plant, because only for these orders the order cost prices are known. Therefore, only the AA and BB series were part of the analyses. In addition, vehicles of the old model produced in 2018 and 2019 were not taken into account. Last, vehicles with an abnormal cost price, due to incompleteness, were left out of the analyses.

4.1 Total cost price of options per order

For each order, the base price of the respective vehicle type was deducted from the cost price of the order to get the total cost price of all chosen options. This is represented by the following formula:

$$TotalCostPriceOptions_{Or,T} = OrderCostPrice_{Or} - BasePrice_T$$

where Or represents the order and T the vehicle type.

Note that for all orders the actual base price of the GS was used for the first period of the corresponding year since only minor adjustments were made throughout the year. Therefore, for convenience reasons, it was assumed that the base price was fixed for the whole year.

By calculating the TotalCostPriceOptions per order, i.e. the total costs of all options, the following findings emerged for 2018: the total number of orders is 44,137, the mean total cost price of options is €5,618.45, the standard deviation is 2,851.70, and the minimum and maximum are -€9,754.94 and €24,795.50 respectively, see Table 4.1. The frequency of the TotalCostPriceOptions per order is visualized in Figure 4.1 on the next page. As can be seen, there are only a few orders with a negative total cost price for all options and only a few with a price of more than €20,000. To be more precise, in total there are 110 orders with a negative TotalCostPriceOptions and 6 orders with a price of more than €20,000. A negative cost price for all options implies that the base price is higher than the order price. This can occur if options chosen by the customer are cheaper than the options included in the base vehicle.

Table 4.1: Descriptive statistics TotalCostPriceOptions 2018

Variable	Total Count	Mean	StDev	Minimum	Maximum
TotalCostPriceOptions	44,137	5,618.45	2,851.70	-9,754.94	24,795.50

⁷ Only this data was available at the time of the analyses.

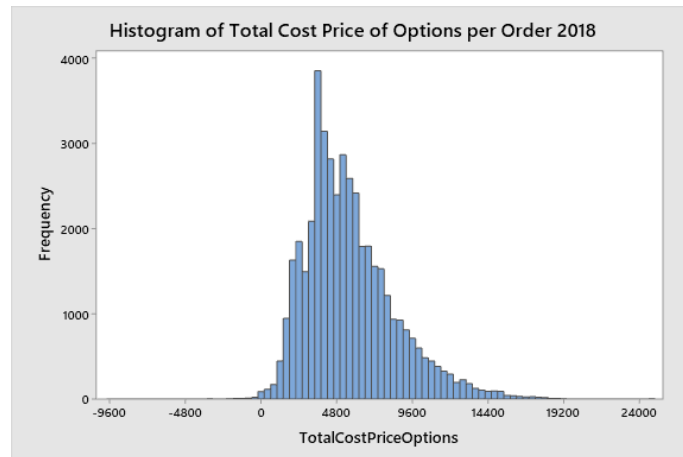


Figure 4.1: Histogram of Total Cost Price of Options per order 2018

The following descriptive statistics were found for 2019: the total number of orders is 20,782, the mean total cost price of options is €6,248.65, the standard deviation is 2,839.95, and the minimum and maximum are -€1,844.95 and €22,305.11 respectively, see Table 4.2. Figure 4.2 shows the histogram of the TotalCostPriceOptions per order. Again, there are only a few orders with a negative cost price for all options, 12 orders, and only 4 orders with a price above €20,000.

Table 4.2: Descriptive statistics TotalCostPriceOptions 2019

Variable	Total Count	Mean	StDev	Minimum	Maximum
TotalCostPriceOptions	20,782	6,248.65	2,839.95	-1,844.95	22,305.11

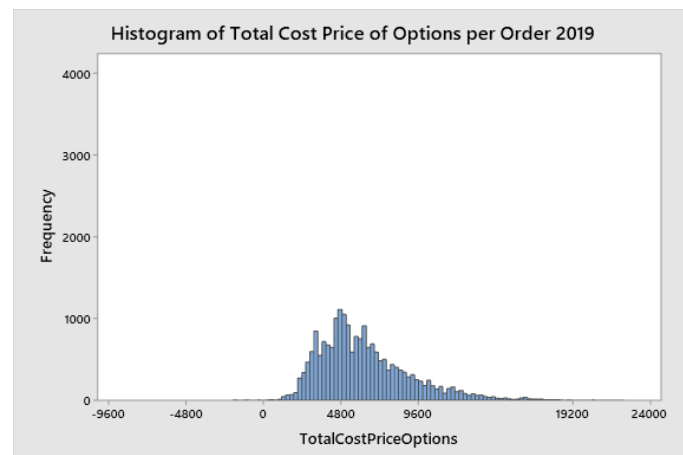


Figure 4.2: Histogram of Total Cost Price of Options per order 2019

The mean total cost price of options per order is higher for 2019 than for 2018. The total number of orders for 2018 is much higher than for 2019, which makes sense because only six months of orders were considered for 2019. Another notable difference is the minimum cost price, namely -€9,754.94 and -€1,844.95 for 2018 and 2019, respectively.

The mean order cost price for 2018 and 2019 is €62,971 and €62,866, respectively. From this it can be concluded that on average all chosen options account for 9.4% of the total vehicle costs.

4.2 Number of options per order

As mentioned before, only the selcos indicated by an O, which are the selcos within a feature that a customer can choose from, must be priced by the CA department. Therefore, to determine the average number of options chosen by a customer, the number of O options per order must be calculated. The GS was used for each vehicle type for the first period of the corresponding year.

The number of O options per order was calculated by linking the B's, O's, and S's of the GS to the options incorporated in each order based on the vehicle type. Because, as previously indicated in Section 3.1.1, the specification of a selco in B, S or O can vary per vehicle type. The DEP options and options that fall within a cluster option are left out of the analysis because they are not priced by the CA department, as mentioned in Section 3.2. The following findings for 2018 emerged: the total number of orders is 44,137, the mean number of chosen options per order is 40.35, the standard deviation is 9.67, and the minimum and maximum are 8 and 84 respectively, see Table 4.3. The frequency of the number of chosen options (O's) per order is visualized in Figure 4.3.

Table 4.3: Descriptive statistics NumberOPerOrder 2018

Variable	Total Count	Mean	StDev	Minimum	Maximum
NumberOPerOrder	44,137	40.35	9.67	8	84

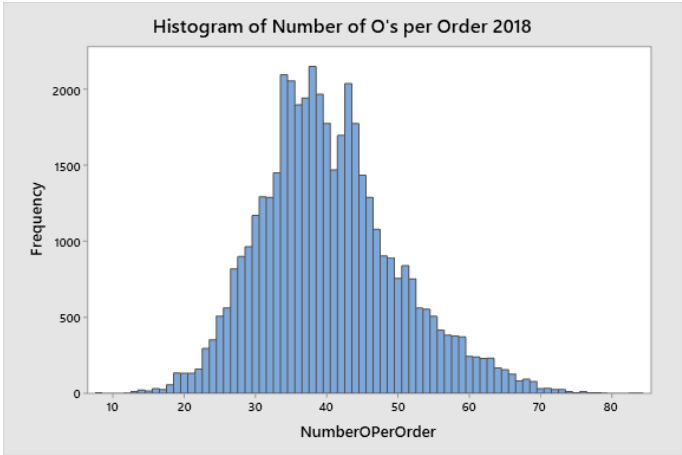


Figure 4.3: Histogram of Number of O options per Order 2018

The following results emerged from the same analysis for the orders of 2019: the total number of orders is 20,782, the mean number of chosen options per order is 41.13, the standard deviation is 9.66, and the minimum and maximum are respectively 10 and 80, see Table 4.4. A histogram of the number of chosen options per order is shown in Figure 4.4 on the next page.

Table 4.4: Descriptive statistics NumberOPerOrder 2019

Variable	Total Count	Mean	StDev	Minimum	Maximum
NumberOPerOrder	20,782	41.13	9.66	10	80

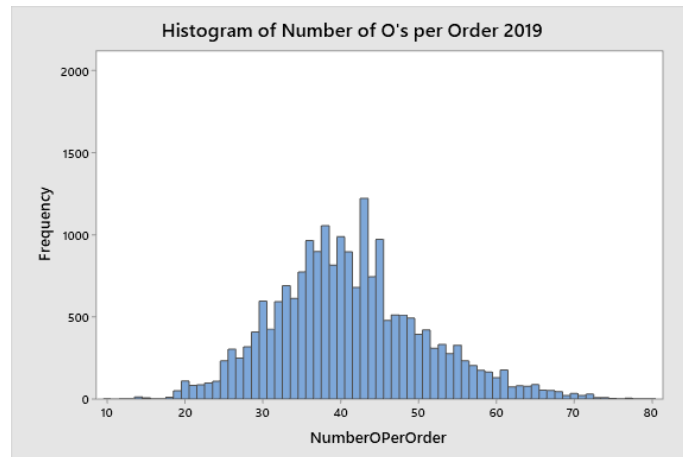


Figure 4.4: Histogram of Number of O options per Order 2019

The mean number of O options per order is slightly higher for 2019 than for 2018. For the same reason as before, the total number of orders for 2018 is higher than for 2019. With regard to the minimum, there is a difference of two options per order between the years, where 2018 has the lowest value. As for the maximum, the number of options per order is lower for 2019 than for 2018, a difference of four options per order.

The minimum number of O options per order is higher than zero for both 2018 and 2019. This implies that no vehicles have been sold that are completely the same as the base vehicle. Instead, O options are always incorporated in the orders, an average of 41 options per order over the years 2018 and 2019. Therefore, the cost of the chosen options need to be taken into account.

4.3 Average price per option

From the above analyses it can be concluded what the average option cost price for 2018 and 2019 are. This can be done by dividing the average total option costs per order by the mean number of options per order. This shows that the average cost price per option for 2018 is €139.24. And for the first half of 2019 it is €151.92, which is higher than that of 2018.

4.4 Most sold options

For each of the selcos identified by an O, excluding the DEP options and options that fall within a cluster option, it was counted how often these options are incorporated in all orders. From this it can be concluded which options are most often chosen by the customer. Tables 4.5 and 4.6 on the next page show the descriptive statistics of this analysis for the years 2018 and 2019, respectively. The total number of O options of all orders in 2018 is 1,037, the average number of times an option is incorporated in an order is 1,717, the standard deviation is 5,021, and the minimum and maximum are 1 and 41,482 respectively. For 2019, the total number of O options of all orders is 980, the average number of times an option is part of an order is 872, the standard deviation is 2,410, and the minimum and maximum are 1 and 19,539 respectively.

Table 4.5: Descriptive statistics NumberOrdersPerO 2018

Variable	Total Count	Mean	StDev	Minimum	Maximum
NumberOrdersPerO	1,037	1,717	5,021	1	41,482

Table 4.6: Descriptive statistics NumberOrdersPerO 2019

Variable	Total Count	Mean	StDev	Minimum	Maximum
NumberOrdersPerO	980	872	2,410	1	19,539

Note that the total number of O options of all orders for both 2018 and 2019 is much lower than the number of options that AB offers as discussed in Section 1.1, namely 10,000 options. This is because options that are offered with multiple vehicle types, but that are not specified as common options, are listed here only once. While they are included separately in the list of 10,000 options because they all have a separate price.

The mean and standard deviation of 2018 is much higher than that of 2019, this makes sense because the data of 2019 covers only half a year of orders. The same reasoning applies to the difference in maximum between the two years.

A minimum of 1 implies that only one order incorporated a specific option. While the maximum of 41,482 and 19,539 for 2018 and 2019 respectively implies that the corresponding option is part of almost all orders. More specifically, the maximum of both years implies that a certain option is incorporated in approximately 94% of all orders.

There is a big difference between the minimum and maximum for both 2018 and 2019. In addition, the mean is much lower than the maximum. With the reason that there are few O options that are part of almost all orders. Figures 4.5 and 4.6 show the trend from high NumberOrdersPerO to low NumberOrdersPerO. This was made by ranking all options from highest to lowest with regard to the number of times they occur in orders. As can be seen in the figures, both years follow a similar trend. However, as mentioned before, 2019 has lower values. Both figures show that there are not many O options that are part of almost all orders. In addition, the figures show that there are many O options that are part of only a limited number of orders. Although these options are hardly ever chosen in a year, they are all currently being calculated. Therefore, a lot of time is spent on calculating options that are not often sold.

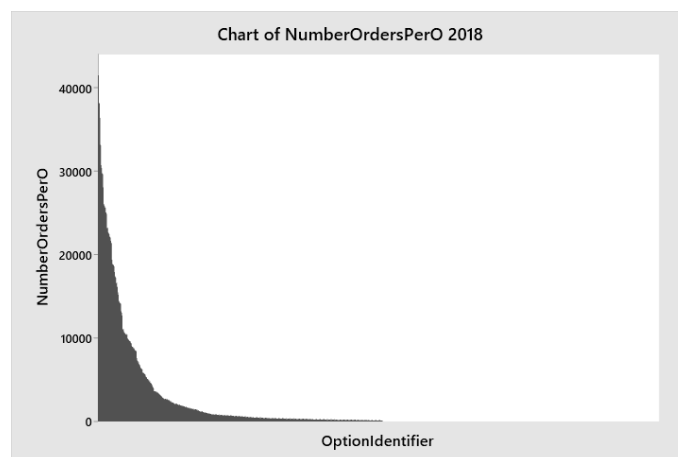


Figure 4.5: Chart of the number of times an option is incorporated in an order (2018) (arranged in descending order)

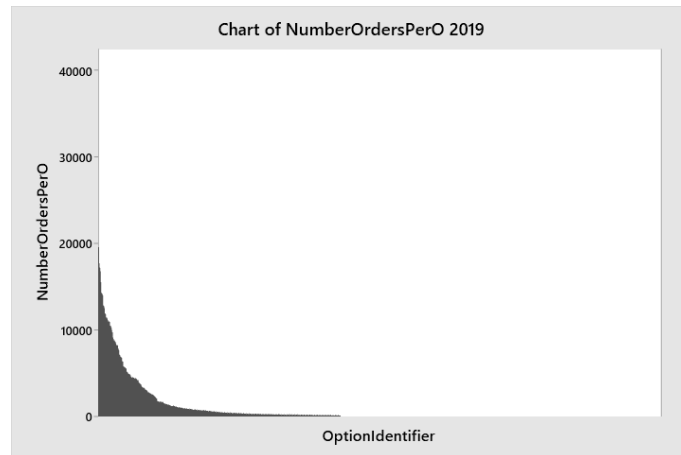


Figure 4.6: Chart of the number of times an option is incorporated in an order (2019) (arranged in descending order)

Note that a selco identified by an O for a vehicle type can be specified by a B or S for another vehicle type. Therefore, this analysis was also conducted solely for the most sold vehicle type, which covers approximately 67% of all analyzed orders. The results of this analysis are presented in Appendix C.

All analyses regarding the best-selling options showed that the following options are most often chosen by the customers for both 2018 and 2019: external sun visor; refrigerator; curtains; side collars; and luxury driver’s seat. The least sold options concern more specific issues, such as options that consist of a combination of wheelbase with rear overhang, of which many exist.

4.5 Option price calculation dependence

To demonstrate the dependence of the option cost price calculations, a complete order of the most sold vehicle type was analyzed. All O options incorporated in this specific order are listed in Appendix D. This table indicates the type of option calculation used by AB for each option, together with the number of times each option appears in calculation numbers, and, if applicable, which other options were used for the calculation.

As shown in Appendix D, some options that are calculated with the second type of option calculation used other options for this calculation that are also incorporated in the vehicle. For example, option 6066 is used to calculate option 4906, which are both part of the order. However, there are also options that are not part of this order, but are used to calculate incorporated options. For instance, option 4081 is used to calculate option 1432, while option 4081 is not part of the order. To calculate option 3094, option calculation type 3 is used. Two component numbers are related to multiple options. Component A is related to both options 3094 and 3484, and component B is related to options 3094 and 4586. Note that option 4586 is also incorporated in this specific order, but option 3484 is not. These examples show the dependencies of the option prices within an order.

5. Industry practices

To obtain industry best practices the internet was searched, but since the option pricing process is so specific nothing could be found. Therefore, many companies within the automotive industry were contacted, taking into account all compliance rules. Note that only information about their current option pricing *process* was requested and no data regarding their cost prices. Unfortunately, most companies did not have time to share their current practices with regard to their option pricing process, because they receive too many information requests from students. Therefore, this chapter was renamed to 'industry practices' instead of 'industry best practices'. Since a best practice is defined as "a tactic or process characteristic that has been employed at one or more other organizations with excellent results" (Sharp & McDermott, 2001, p. 251), and not enough information could be collected to conclude what the best practices are. As a result, only the industry practices found are described in this chapter.

The following findings emerged from e-mail contact with three companies.

A small start-up company, CD, indicated that they do not offer any options. However, this is probably because they are still in the development phase. Therefore, this cannot be considered to be a possible solution direction for AB's current option pricing process.

Another automotive manufacturing firm, EF, pointed out that they do not offer customers many standard options to choose from. Instead, they consider every order to be tailor-made. At AB there are many standard options a customer can choose. Therefore, almost every vehicle is different, and can thus be considered to be tailor-made. A possible approach for dealing with tailor-made orders is to calculate the total cost price of each order instead of calculating the cost price of the base vehicle and possible options in advance to come to the total cost price of a vehicle.

From a small manufacturer of less complex vehicles, GH, it appeared that their basic principle complies with the one applied by AB. They also use a base vehicle and options from which a customer can choose. Where the option prices are calculated by taking the price difference due to the item change(s) and by adding, if applicable, the extra assembly time needed due to the option. However, the option pricing process of GH is less complicated than the one of AB. All option calculations of GH can be considered to be pure calculations because, due to their less complex vehicles, they do not have options that automatically result in multiple other options. Therefore, GH's process cannot really be compared to that of AB.

In addition, interviews with another manufacturing plant of AB, referred to as AC, indicated that although they have another system, their basic process of calculating option prices is the same. The main difference due to the different systems is the retrieval of information. At AC they namely need to make the options MUI clean by hand, i.e. manually select consequence options. While at AB only MUI clean options come out of the system. Making the options MUI clean is performed by AC before the first of January, so before the calculations start. For the rest, all steps performed in Excel are comparable. Therefore, no possible improvement ideas can be identified, besides performing certain steps before the first of January.

From an in-depth interview with another automotive manufacturer, IJ, it appeared that their basic principle complies with the one utilized by AB. They also apply a standard vehicle with a base price and options from which a customer can choose, which are defined as added costs relative to the base vehicle. They currently calculate these option prices by requesting an order from the system with and without the respective option, the resulting price difference is the option price. Another similarity with AB is that IJ also has a system with records of the choice combinations and restrictions of the options. They have options that exclude each other and options that come together.

The main difference between IJ and AB is that IJ defines all its options as pure options (type 1). This implies that the price difference between the base order and the order including the option can directly be assigned to this corresponding option. They can apply this approach to all options because they incorporate all the consequences of an option in the “main” option price, and then as a result these consequences can no longer be selected individually. For example, when a customer chooses the option ‘driver sleeping place’, a ‘role shutter’ is automatically included. This ‘role shutter’ is also a separate option, but when the ‘driver sleeping place’ option is chosen, the ‘role shutter’ option can no longer be selected separately because the ‘role shutter’ costs are already included in the ‘driver sleeping place’ option price. Otherwise, these costs would be counted twice. At AB, these two options are priced separately, when the option ‘driver sleeping place’ is chosen, the option price of ‘role shutter’ and ‘driver sleeping place’ must be added to come to the overall costs.

To conclude, IJ incorporates all consequences of a “main” option in its option price, and eliminates the consequences from the option list that the customer can choose from. This method for calculating the option prices may be faster than AB’s current option pricing method. Therefore, this method is considered to be a possible solution direction for AB, which is covered in Chapter 7.

6. Applicable process improvement/redesign methods

Process improvement is about making things better (Dybå, Dingsøy & Moe, 2004), in this case accelerating the current option pricing process. The literature agrees that the most value-adding phase in the BPM lifecycle, the process improvement phase, lacks specific guidelines (Vergidis, Tiwari & Majeed, 2006; Forster, 2006; Gartner Inc., 2005; Reijers & Mansar, 2005; Sharp & McDermott, 2001; Valiris & Glykas, 1999; Gerrits, 1994). According to Sharp and McDermott (2001): “How to get from the AS-IS to the TO-BE is not explained, so we conclude that during the break, the famous ATAMO procedure is invoked – And Then, A Miracle Occurs”. The literature review conducted by Bakermans (2020) discussed process improvement approaches identified in the literature and indicated which of these approaches are applicable to this thesis. A summary of the literature review is provided below.

Dumas et al. (2018) distinguished a whole spectrum of redesign/improvement methods, which can be found in Figure 6.1. They made a distinction between transactional and transformational methods. Transactional methods deal with small-step, incremental improvements where the current process is taken as a starting point (Chang & Cheng, 1999; Damij & Damij, 2014; Jenniskens, 2011). While transformational methods are a radical, big-step, and clean sheet approach where the business process is radically redesigned (Chang & Cheng, 1999; Reijers & Mansar, 2005). In addition, Dumas et al. (2018) divided all improvement approaches over two design methods, which are creative and analytical methods. A creative redesign method uses human creativity to come up with new ideas for the business process, often within the setting of a workshop (Dumas et al., 2018; Reijers & Mansar, 2005). In contrast, an analytical redesign method aims to use formal theory and techniques for process improvement (Dumas et al., 2018, Reijers & Mansar, 2005). Last, Dumas et al. (2018) made an additional distinction between inward-looking and outward-looking redesign methods. Where an inward-looking method uses the information gathered within the organization itself. While an outward-looking method looks at opportunities and developments outside the organization (Dumas et al., 2018).

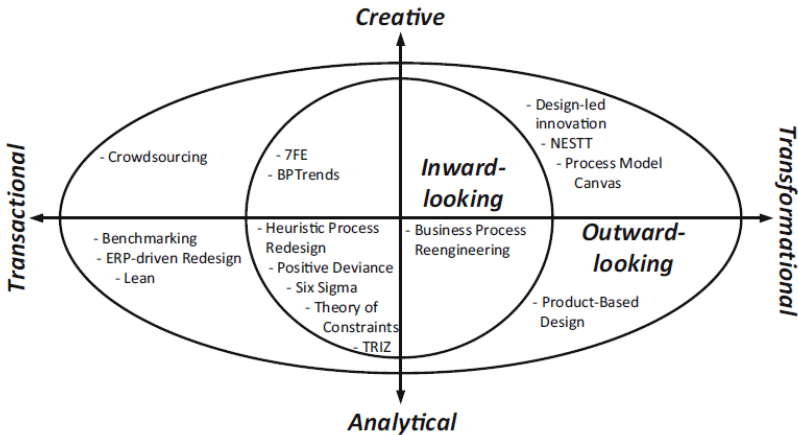


Figure 6.1: The Redesign Orbit: A spectrum of business process redesign methods (Dumas et al., 2018, p.306)

The literature review of Bakermans (2020) described all the methods distinguished by Dumas et al. (2018) and indicated whether the methods are usable for the author’s master thesis, see Appendix E. The following redesign methods were identified as applicable: benchmarking; lean (only improve on

the operational business process level); 7FE & BPTrends; crowdsourcing; heuristic process redesign; process model canvas; NESTT; and product-based design.

According to Mansar, Reijers, and Ounnar (2009), there are only two traditional approaches that lead to an improved design for a business process in a rather systematic way. Namely the creative and structured approach, which are visualized in Figure 6.2. The creative approach starts from a set of goals and applies brainstorming sessions and discussions to reach an improved process design (Mansar et al., 2009). The main advantage of this approach is that there is room for creativity and innovation. However, the disadvantage is that the discussions can lead to biased choices (Mansar et al., 2009). The alternative approach, the structured approach, utilizes best practices as identified by Reijers and Mansar (2005) to come to an improved process design. Each of the best practices is evaluated with process stakeholders, after which simulation is used to judge the improvement (Mansar et al., 2009). The advantages and disadvantages of this approach are the exact opposite of the creative approach (Mansar et al., 2009). Because both approaches have their advantages and disadvantages, this thesis applied both of them to come up with multiple improvement ideas.

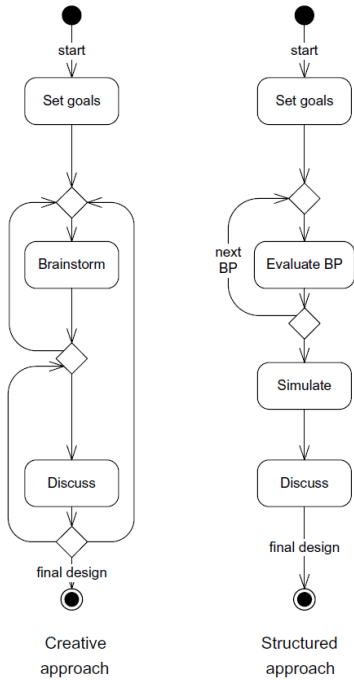


Figure 6.2: Overview of the creative and structured way to process improvement (Mansar et al., 2009, p.3)

The literature review indicated that the applicable redesign methods of Dumas et al. (2018) can be allocated to the two traditional approaches, except for benchmarking (Bakermans, 2020). All of Dumas’s redesign methods that involve workshop sessions can be categorized under the creative approach of Mansar et al. (2009). These “workshop” methods are: 7FE and BPTrends, Crowdsourcing, Process Model Canvas, NESTT, and Product-Based Design. It was identified that the workshop sessions can both use the current process as a starting point or start with a clean sheet. Dumas’s Heuristic Process Redesign method corresponds to the structured approach, since they both deal with rules of thumb to improve the current process, which is taken as a starting point. The remaining applicable redesign method, Lean, where individual process activities are assessed on whether they add value or not, is part of the structured approach. Because the best practices also evaluate process activities based on their added value.

6.1 Structured approach

This project undertook a structured approach by using a shortlist of the 29 best practices from Reijers and Mansar (2005). Shortlisting provides a focus on a smaller set of best practices that may potentially be applied to improve the current process (Mansar et al., 2009). By offering such a shortlist, the scope of the subsequent discussion is narrowed down (Mansar et al., 2009).

Mansar et al. (2009) suggested to use a decision-making tool based on AHP (Analytic Hierarchy Process) to generate a list of preferred best practices for redesign. According to Bakermans (2020), the main drawback of the proposed approach of Mansar et al. (2009) is that the background information required for AHP is not provided. Therefore, shortlisting needed to be done in a different way.

Hanafizadeh, Moosakhani, and Bakhshi (2009) proposed another method for ordering, i.e. shortlisting, the best practices. They used the philosophy TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) to recognize the alignment of best practices with the organization's strategy. This alignment is measured by the indicators cost, time, quality, and flexibility (Hanafizadeh et al., 2009). According to Bakermans (2020), the main drawback of this method is that the resulting shortlist may contain best practices that are not applicable at all to the specific process under investigation.

Therefore, the literature review of Bakermans (2020) created a shortlist of the 29 best practices by using the goal of the project (Jenniskens, 2011; Mansar et al. 2009), which is accelerating. As a result, only the best practices that have a positive effect on time, i.e. decrease time, were considered for process improvement. Bakermans (2020) also assessed the resulting best practices on their applicability, which was evaluated based on the description of the best practices (based on Netjes, Mansar, Reijers & van der Aalst, 2007). This assessment can be found in Appendix F. From this shortlisting the following best practices remained: 'task automation'; 'task composition'; 'triage'; 'task elimination'; 'integral technology'; 'resequencing'; 'integration'; 'parallelism'; 'extra resources'; 'exception'; and 'buffering' (Bakermans, 2020). This thesis used these remaining best practices to generate improvement ideas together with the process executors.

6.2 Creative approach

Besides the structured approach, the creative approach was also executed in this thesis by holding brainstorming sessions with both process executors (7FE and BPTrends) and other stakeholders (Crowdsourcing), namely the M&S department and the IT department. Because the M&S department uses the process output to evaluate order approval and the IT department is ultimately responsible for implementing system changes. Insights from the process analysis step (NESTT), the historical data analysis, and the benchmarking method were used as a guide for starting the creative process. Where both the current process and clean sheet were taken as starting point. Moreover, the brainstorming sessions were executed by focusing on the goal of the outcome of the process (Product-Based Design), which is the total cost price of each vehicle to calculate and approve margins.

Note that the Process Model Canvas and NESTT methods were only partially used. Regarding the Process Model Canvas, the visual aid was not applied. However, the goal of the outcome of the process,

which must comply with the expectations of the customers, was taken into account. In addition, with regard to the NESTT method, a future vision for different time horizons could not be identified.

Multiple ideas for acceleration emerged from the creative and structured approach. These ideas were evaluated by the discussion group, which consisted of process stakeholders.

The method applied in this thesis, as described above, is broadly illustrated in Figure 6.3.

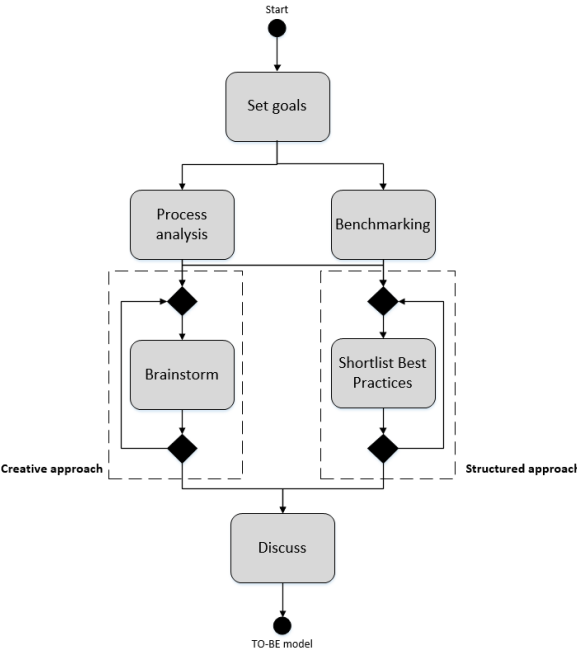


Figure 6.3: Applied method (based on Mansar et al., 2009)

7. Acceleration ideas

This chapter presents possible acceleration ideas for the option pricing process and the evaluation of these ideas. It is important to remember the ultimate goal of this process, which is to calculate the total vehicle costs so that M&S can make the right decisions regarding order approval.

7.1 Structured approach ideas

As indicated in Section 6.1, the structured approach consists of discussing the shortlist of best practices for each task of the current process. This shortlist consists of the following best practices: 'task automation'; 'task composition'; 'triage'; 'task elimination'; 'integral technology'; 'resequencing'; 'integration'; 'parallelism'; 'extra resources'; 'exception'; and 'buffering'. The findings that emerged from the discussions of each of these 11 remaining best practices are presented in this section. A short explanation of each of these best practices can be found in Appendix F.

Task automation

The best practice 'task automation' can directly be applied to the following tasks of Figure 3.4: 'Calculate Type 1', 'Calculate Type 2', and all the 'Copy & Paste' tasks. Checking the retrieved information for incompleteness can also be easily automated. Note that improving the determination of missing prices, i.e. finding the price, is beyond the scope of this study, as stated in Section 2.5. The 'Enter Values in APS' task does not need to be automated, since this task is already automatic at the moment.

In addition, automation can be applied to the 'Retrieve information' task. For each vehicle type the system then automatically retrieves all necessary information for all features that need to be priced. Instead of first retrieving a list of all features and then requesting the RKCZZ and KC8Z reports, which is only possible with a maximum of 15 features per request. Automating this task, however, does not lead to a major acceleration, because the retrieval of information is already executed with a macro (is already partly automated). This macro automatically requests all information for all features of one vehicle type (15 features per request). Running this macro literally takes only seconds. However, improvement is still possible. For example, uploading the list of features in the macro is still done manually. It would also be useful if all information for all features can be obtained in one request.

From Section 3.3 it resulted that the option pricing employee decides every year from scratch which options to assign the value zero. However, because there are many similarities each year, a list can be made of options with zero value. This list only needs to be updated every year, which takes less time than beginning from scratch. In addition, this updating can be executed in advance of the calculations, i.e. before the first of January, which is based on the industry practice of company AC.

When analyzing the subprocess regarding type 3 calculations, the task 'Allocate Component Price Difference to Option', which is executed when a component number is related to one option, can be automated. In addition, the 'Combine allocations' task within this subprocess can also be automated.

The tasks that apply when a component is related to more than one option cannot be easily automated. Because the tasks of the "normal" process, the one visualized in Figure 3.4, are not always

applicable. Instead, alternative distribution methods can be used as described in Section 3.2. Therefore, in order to automate the distribution of the component's price difference across multiple options, general allocation rules need to be developed.

The need for developing general allocation rules for the third type of option calculations also emerged from Section 3.3. This section pointed out that experience of the option pricing employee is currently needed when dividing a component price difference over multiple options. Besides that it takes more time, it also means that a lot of knowledge is lost when the employee leaves. Therefore, allocation rules for dividing component price differences over multiple options can speed up the process. But also lowers the risk that the option pricing process cannot continue if the employee leaves.

The literature study by Bakermans (2020) showed that most of the allocation rules available in the literature, regarding other subjects, do not apply to this specific situation. Appendix G presents the results of this literature study. The equal charge (EQC) method seemed to be a usable allocation rule, where the common costs are distributed equally (Frisk, Göthe-Lundgren, Jörnsten & Rönqvist, 2010). In addition, Bakermans (2020) identified another possible allocation rule, where the common costs are allocated to only one of the related options, i.e. all-to-1 method. This allocation can be done randomly or based on sales numbers, where the most sold option is assigned the common costs so that it is likely that the costs will be included in the total vehicle costs.

Another possible allocation idea emerged from the brainstorming sessions based on the EQC method. The idea is to assign a predetermined weight to the options that have a common component, i.e. weighted allocation. For example, when a component is related to three options, a weight of 50%, 10%, and 40% can be assigned to each of the options. These weights are component specific. Therefore, predetermined weights need to be assigned to all common components that are used in the third type of option calculations for each vehicle type. Assigning these weights can be based on past allocations, on information from the VES, and on experience of the option pricing employee. These weights can be determined before the calculations start, so before the first of January.

For all allocation rules it applies that the options that always have the value zero, as indicated by the zero value options list, now also receive no costs. Therefore, if a component is related to two options and one of these options is always set to zero, all common costs are assigned to the other option.

The part of the process when a component is related to zero selcos is not easy to automate either. Because an allocation based on descriptions requires human knowledge and experience. Part of the problem can be automated if the intermediate level, which is one of the causes of the relationship to zero selcos, is incorporated in the KC8Z help table. It is then known to which feature(s) the costs should be allocated. It may be that when this intermediate level is present, allocation rules must also be applied. Note that including the intermediate level in the KC8Z help table is not necessary when applying the weighted allocation method, as this method can include this information in the weights.

Knowing the intermediate level does not solve the distribution problem for all components related to zero selcos. There are more causes for the relationship to zero selcos besides the intermediate level. However, for these other causes the related features to each component number are provided by the KC8Z help table, which is not the case for the intermediate level cause, see Figure 7.1 on the next page.

Therefore, allocations can be based by linking these features to the options of the corresponding calculation number. Note that although a component number is related to zero options according to the system, it is possible that the same component is listed multiple times. In reality, this component is then related to multiple features. See, for example, component group 1139 in Figure 7.1. If a component group is related to multiple options after making the links, the same allocation rules can be used as described before. When related features are not linked to any of the options of the calculation number, no costs should be allocated to these “non-including” features. For instance, when looking at component group 1139 from Figure 7.1, it can be seen that it is related to four features. However, only feature 689 can be linked to an option of the corresponding calculation number, as can be seen in Figure 7.2. Therefore, all costs of this component group are allocated to option 4222.

Calc_nr	Mat	Mat+assy	Comp Grp	B comp	O comp	Group descr	Tot grp	Mat per grp	Assy cost	Selcos	Note	Fea	Feature name	CHO fea	Option	SelB	Selco B na	SelO	Selco O na	CAUSE
073208012			1139	2023099		Catwalk ri				0		086	Catwalk	086	0000		6606	catwalk sta	0000	Other cause
073208012			1139	2023099		Catwalk ri				0		094	Catwalk step po	094	0000		7050	catwalk ste	0000	Other cause
073208012			1139	2023099		Catwalk ri				0		689	DPF/SCR positio	689	0000		4220	DPF+SCR R	0000	Other cause
073208012			1139	2023099		Catwalk ri				0		701	Exh discharge pc	701	0000		6610	exhaust ho	0000	Other cause
073209030			1506	2189379	2189391	Gearbox				0		000		000	0000		0000		0000	Intermediate level cause

Figure 7.1: Examples of components with and without the feature being specified

Calc_nr	FeatNr	Selco
73208012	689	4222
73208012	034	4586
73208012	923	3094
73208012	990	4469

Figure 7.2: Selcos (and features) of calculation number 073208 012

Also for component numbers that according to the system are related to multiple options, it is possible that for some features the options are not shown in the KC8Z, see Figure 7.3. It is therefore also useful in these cases if a link is made between the features and the options of the corresponding calculation number. Again, if a component number is related to a feature that is not part of the respective calculation number, no costs should be allocated to this “non-including” feature.

Calc_nr	Mat	Mat+assy	Comp Grp	B comp	O comp	Group descr	Tot grp	Mat per grp	Assy cost	Selcos	Note	Fea	Feature name	CHO fea	Option	SelB	Selco B na	SelO	Selco O na	
083769059			1862	2192466	2192469	El.control pto.cab				3		212	Gearbox contro	212	0000		0000		8430	gb control 1
083769059			1862	2192466	2192469	El.control pto.cab				3		230	1st gb-PTO type	230	0000		0000		8335	no gearbox
083769059			1862	2192466	2192469	El.control pto.cab				3		235	1st gb PTO conti	235	2333	3693	no ctl 1st gb	2333	ctl 1st gb P1	

Figure 7.3: Example of component number related to multiple selcos where the column ‘Option’ is not filled for every feature

As mentioned in Section 3.2, an exception to the third type of option calculations is when assembly costs need to be assigned to the remaining unknown options. Taking these costs into account also needs to be automated. Therefore, when the third type of calculations is needed, it must be checked whether there is a difference between the ‘Mat’ and ‘Mat+assy’ columns in the KC8Z table. If there is a difference and the RKCZZ text file indicates the selco that belongs to (part of) the assembly costs, these costs can be directly attributed to the mentioned selco. When no selcos are provided with the assembly costs, these costs can be distributed to options based on the applied allocation rule.

Note that in order to automate the described tasks the RKCZZ Excel file, the RKCZZ text file, and the KC8Z help table must be used as input. In addition, automating these tasks does not have to be performed in Excel, another program may also be used.

Task composition / Triage

If all calculations can be automated, common options are no longer needed. These common options are currently used to reduce the number of options that need to be calculated. When the calculations can be performed automatically, the number of options no longer has a major impact on time. In

addition, it is more accurate to calculate all options per vehicle type. However, if not everything can be automated, it might be better to stick to common options to save time.

The tasks responsible for selecting the vehicle type for the calculations, see Figure 3.3, can be merged if all options for each vehicle type are calculated. These three tasks are currently performed to quickly estimate as many options as possible, because common options are used. Therefore, it is useful to first calculate the options of vehicle types that contain many common options. When the three selection tasks are merged, the three calculation tasks that follow these selection tasks can also be combined.

Task elimination

A task that can possibly be removed is the one that transforms a text file into an Excel file. As indicated in Section 3.3, this would be a redundant step if a file came out of the system that does not require any transformation. Nevertheless, this would hardly save any time, because this is currently done very quickly by refreshing an existing Excel file with new data. Therefore, in the remainder of this report, 'task elimination' is not considered as part of the structured approach solution.

Integral technology

No relevant new technology could be identified during the brainstorming sessions to accelerate tasks of the current process.

Resequencing

The task that concerns assigning the value zero to certain selcos can be executed at an earlier stage of the process. More specifically, it is better to perform this task before executing type 2 calculations, because more type 2 calculations can then be carried out in one go.

Integration

The brainstorming sessions revealed that there are no aspects of the process that can be integrated with the process of the customer nor the supplier. However, one of the creative ideas in Section 7.2 is based on the customer's output.

Parallelism / Extra resources

If all options for each vehicle type are calculated, instead of using common options, these calculations can be done in parallel. However, when everything is automated, it makes no difference in terms of time whether the options for each vehicle type are calculated simultaneously or consecutively. If complete automation is not possible, extra resources in the form of human power are needed if AB wants to calculate the options of several vehicle types in parallel. Nevertheless, the required number of man-hours remains the same. Both ideas do not lead to improvement; therefore, they are not considered as part of the structured approach solution.

Exception

Some options cannot be calculated correctly using the normal calculation method described in Section 3.2. Therefore, these options are currently calculated in a different way. It is important that these exceptional options, which are known beforehand, are also not calculated with the normal flow when implementing acceleration ideas. The same applies to options where a wrong price results from the system. Due to these exceptions, manual actions are still required. When these option prices are

determined before the rest of the calculations start, the correct prices of the exceptions are used in type 2 calculations. Weighing options can also be considered an exception. Only this type of exception must be done after all calculations have been performed.

Buffering

According to Reijers and Mansar (2005, p. 302), “obtaining information from other parties is a major time consuming part in many business process.” They identify that by having information directly available when it is required, throughput times may be reduced. At AB it currently takes at least one night to retrieve data from the system. However, as indicated in Section 3.3, the waiting time for data can be even longer when a lot of information is requested. Therefore, a time saving can be achieved by making the requested information immediately available.

In the rest of this report when referring to the structured approach, a combination of all the discussed ideas is meant, with the exception of those where stated otherwise, because all ideas in isolation do not result in a large time saving. A summary of the ideas that are part of the structured approach is presented in Table 7.1. Within the structured approach, however, a distinction is made between the three different allocation methods because they can result in different outcomes. In addition, a distinction is made between the structured approach with more IT involvement and less IT involvement. The approach with less IT involvement implies that improving the ‘Retrieve information’ task and buffering are not part of the approach. While they are part of the structured method with more IT involvement. These two aspects require considerable capacity from the IT department, while all other aspects of the structured approach can largely be implemented locally.

Table 7.1: Summary of ideas that are part of the structured approach

Best Practice	Improvement idea
	Automate the following tasks: ‘Calculate Type 1’, ‘Calculate Type 2’, and all the ‘Copy & Paste’ tasks. In addition, the tasks that check for missing information can also be automated.
	Improve the ‘Retrieve information’ task, such that for example the information for all features can be obtained in one request.
	Zero value options list.
	Type 3 subprocess:
Task automation	<ul style="list-style-type: none"> - Automate the tasks ‘Allocate Component Price Difference to Option’ and ‘Combine allocations’. - Allocation rules: EQC, all-to-1, and weighted. - Incorporate intermediate level in the KC8Z help table (not necessary for the weighted allocation method). - Link features listed in the KC8Z help table to the options of the corresponding calculation number. - Automate the allocation of assembly costs using the indicated selco. When no selco is specified, use the applied allocation rule.
	Stop using common options. Instead, calculate all options per vehicle type (only if everything is automated).
Task composition / Triage	Merge all three selection tasks and the three associated calculation tasks (only if everything is automated).
Resequencing	Perform the task that assigns the value zero before type 2 calculations.
Exception	Perform exceptions before and after the normal process flow.
Buffering	Make the requested information immediately available.

Note: Improving the ‘Retrieve information’ task and buffering are only part of the structured approach with more IT involvement.

7.2 Creative approach ideas

As indicated in Section 6.2, the creative approach consists of holding brainstorming sessions with both process executors and other stakeholders. The findings of these brainstorming sessions are presented in this section. Both the current process and clean sheet were taken as starting point, and input from the process analysis, historical data analysis and industry practices were also used.

A simplistic idea to speed up the option pricing process is to offer less O options. Figures 4.5 and 4.6 of the historical data analysis showed that there are many options that are not often chosen in a year, while all these options need to be calculated.

Another idea emerged from the finding that there are many options that are not often sold. Namely to price fewer options each year. This can be done by fixing the price of the options that are sold only a few times a year. Since it concerns a forecast, the cost prices do not have to be 100% correct. However, it is important to apply this price fixing only to options with lower costs. Namely, when costs are higher, it must be calculated more accurately regardless of the sales figures. Therefore, for this idea, a rule should be developed of the following form: if an option was sold less than X times last year and the costs of last year's option was less than Y, the price should be fixed for the upcoming year. This implies that these prices are already fixed before the calculations begin. In this way, the fixed prices are used in the calculations of other options. Prices can be fixed by taking over the prices of the year in which all options were calculated and either add the average historic price increase or add inflation. The resulting list of fixed options only needs to be updated every year, which can be performed before the first of January.

From the data analysis, Chapter 4, it resulted that there are a number of O options that are incorporated in almost all orders, i.e. in more than 90% of the orders. Therefore, one of the stakeholders came up with the idea to incorporate these most sold options in the base vehicle. This implies that these options are transformed in the GS from an O to a B. With the consequence that the option currently part of the base vehicle (the one that is replaced by the frequently chosen option) now becomes an O option, which needs to be priced.

Another finding that resulted from the data analysis is that on average all options account for 9.4% of the total vehicle costs. This gave rise to the idea of applying a fixed percentage on top of the base price in order to take the total costs of all incorporated chosen options into account. This percentage can be adjusted every year based on new orders (orders of the previous year). In this way, price changes are taken into account one year later.

The discussions revealed that the CA department prices more options (cost price) than the M&S department (list price). Therefore, the idea arose to investigate whether it is possible for CA to only calculate the cost price of the options that M&S prices. It turned out that M&S prices much fewer options because they do not provide a separate price for the different consequences of options. For example, M&S only give a price to the engine powers and not to the different consequences. Therefore, when a different consequence option is selected, the same list price still applies. However, the cost price does change when another consequence option is chosen. That is why CA cannot just price the options that M&S prices. Instead, CA could take the mean cost of the consequences.

However, due to the number of choices in consequences, for this method to work, CA would have to calculate many averages for a lot of options.

From the industry practices, Chapter 5, it emerged that a possible method to deal with tailor-made orders is to calculate the expected *total* cost price of each order in advance. Instead of calculating the cost price of the base vehicle and all possible options to come to the total cost price of an order. With this new method, option prices are no longer calculated. The MLOs that apply at the time of the calculation are used directly to calculate the total costs of each order. This calculation is already built into the system, because the base and variant orders are currently calculated in the same way. If the costs for the base vehicle are still being calculated, the total option costs can still be retrieved by deducting the base costs from the total order costs. This is important because a different discount percentage is applied to the base vehicle than to the options.

Another possible improvement idea that resulted from the industry practices is to include all consequences of a “main” option in this “main” option’s price and eliminate these consequences from the option list that the customer can choose from (IJ’s method). This method can only be applied if options always have fixed consequences. According to M&S, this only applies to a limited set of options at AB. With most options, the customer also has a choice within the consequences. For example, if a customer chooses a certain size fuel tank, this automatically results in a certain wheelbase. At AB, however, the customer also has the possibility to choose a different wheelbase as long as it complies with the MUI. In order to implement this method, the customer can no longer have a choice within the consequences or averages must be calculated for the different consequences.

Based on IJ’s method, the idea emerged during the brainstorming sessions to calculate a “main” option price for every possible combination of consequences. This implies that there will be multiple “main” option prices for the same option, one for each combination of consequences. To get all these possible combinations per “main” option out of the system, something would have to be developed since only one combination now results from the system.

Another idea that arose during the brainstorming sessions from IJ’s approach is to calculate the total vehicle costs for all possible option combinations of a whole vehicle. This will likely result in many combinations, estimated at over 2 million. The system must then calculate the total cost price for all these combinations. As indicated before, this calculation mechanism is already present in the system. However, something needs to be developed so that all possible combinations that comply with the MUI arise from the system. It also applies to this idea that the total option price per order can be retrieved by deducting the base price from the total order price.

In conclusion, the following possible improvement ideas emerged from the creative approach: offer less options; price less options; incorporate frequently chosen options in the base vehicle; apply a fixed percentage on top of the base price; only price M&S options; calculate the total cost price of each order; IJ’s method; calculate the “main” option costs for all possible combinations of consequences; and calculate the total cost price for all combinations of a whole vehicle.

7.3 Evaluation

In this section, each of the discussed improvement ideas are evaluated. In order to evaluate all these improvement ideas, semi-structured interviews were conducted. During these interviews, the interviewee's opinion on all ideas was asked. These meetings were held with employees from different departments in order to obtain information from different perspectives. Specifically, employees (and the manager) from the CA department were interviewed, since they will be the ones ultimately working with the proposed improvement idea. In addition, interviews were held with employees from the M&S department because they need to use the end product that results from the option pricing process, i.e. the cost price of the options. Last, interviews were also conducted with employees from the IT department since they know what is really possible within AB's systems. An overview of the number of interviewees per department is presented in Table 7.2. All these interviews were recorded and transcribed. Note that the interviews were conducted in Dutch. Appendix H shows the setup and (translated) results of the interviews.

Table 7.2: Number of interviewees per department

Department	Number of interviewees
CA	4
M&S	2
IT	2

A summary of the pros and cons of each idea that emerged from the interviews is presented in Table 7.3. Note that the ultimate goal of an improvement idea should be that the cost prices are known as soon as possible after the first of January.

Table 7.3: Pro-con table

	Pros	Cons
<u>Task automation</u>	<ul style="list-style-type: none"> ▪ Less chance of manual errors. ▪ Time saving. (Option prices more up to date.) ▪ Does not require a lot of time and effort to implement. ▪ No big cultural change necessary. 	
- <u>1.1 EQC</u>	<ul style="list-style-type: none"> ▪ Really quick. 	<ul style="list-style-type: none"> ▪ Causes a deviation. (Larger deviation than weighted allocation.) ▪ Harder to explain where the option prices are based on.
1. Structured Approach		
- <u>1.2 All-to-1</u>	<ul style="list-style-type: none"> ▪ Really quick. 	<ul style="list-style-type: none"> ▪ Causes a deviation. (Largest deviation of all three.) ▪ Harder to explain where the option prices are based on.
- <u>1.3 Weighted allocation</u>	<ul style="list-style-type: none"> ▪ Keep control. ▪ Most precise of all three. 	<ul style="list-style-type: none"> ▪ Takes a little more time than the other two, due to updating (but same calculation throughput time).
<u>Task composition / Triage</u>	<ul style="list-style-type: none"> ▪ Small vehicle specific errors removed/more precise. ▪ Maintenance per vehicle type possible. 	<ul style="list-style-type: none"> ▪ Only possible if the calculations are fully automated. ▪ More maintenance.

	<u>Buffering</u>	<ul style="list-style-type: none"> ▪ Time saving. 	<ul style="list-style-type: none"> ▪ Requires some system adjustments.
	<u>2.1 Offer less options</u>	<ul style="list-style-type: none"> ▪ Less options need to be calculated. 	<ul style="list-style-type: none"> ▪ Undesirable from sales perspective. ▪ Increases number of special requests. ▪ Certain option costs may be needed to calculate other options.
	<u>2.2 Price less options</u>	<ul style="list-style-type: none"> ▪ Still a price for all options present. 	<ul style="list-style-type: none"> ▪ Reduced option price quality. ▪ Questionable whether it saves time.
	<u>2.3 Incorporate frequently chosen options in base vehicle</u>		<ul style="list-style-type: none"> ▪ Undesirable from sales perspective. (Reduces margin.) ▪ Does not result in any time savings.
	<u>2.4 Fixed percentage on top of base price</u>	<ul style="list-style-type: none"> ▪ Options no longer have to be calculated. 	<ul style="list-style-type: none"> ▪ Reduced option price quality. (Possibility of losing orders, possibility of losing margin, always 1 year behind.) ▪ No individual option prices. (Undesirable from sales perspective.) ▪ Way of working needs to change.
	<u>2.5 Only price M&S options</u>	<ul style="list-style-type: none"> ▪ M&S prices less options. 	<ul style="list-style-type: none"> ▪ Determining averages does not result in a time saving. ▪ Less accurate at order level.
<u>2. Creative Approach</u>	<u>2.6 Total cost price of each order</u>	<ul style="list-style-type: none"> ▪ Options no longer have to be calculated. ▪ As accurate as possible. 	<ul style="list-style-type: none"> ▪ No individual option costs. (Undesirable from sales perspective.) ▪ Way of working needs to change. ▪ Loss of information. ▪ A lot of data. ▪ Should work really fast. ▪ Large system adjustments. ▪ Needs real life data.
	<u>2.7 IJ's method</u>		<ul style="list-style-type: none"> ▪ Could only be applicable to a small amount of options. ▪ Limits customer's choice. ▪ Determining averages does not result in a time saving.
	<u>2.8 Calculate "main" option costs for all possible combinations of consequences</u>		<ul style="list-style-type: none"> ▪ System adjustments. ▪ Cannot get rid of double costs.
	<u>2.9 Total cost price for all combinations of whole vehicle</u>	<ul style="list-style-type: none"> ▪ Options no longer have to be calculated. ▪ As accurate as possible. 	<ul style="list-style-type: none"> ▪ No individual option costs. (Undesirable from sales perspective.) ▪ Way of working needs to change. ▪ Loss of information. ▪ Enormous amount of data. ▪ Large system adjustments.

7.3.1 Structured approach evaluation

It was identified by all interviewees that the structured approach will probably result in a significant time saving. Although it is difficult to say, interviewees indicated that it is likely that the structured approach will not require a lot of time and effort to implement (Employees B, C, E, and F). However, the approach with more IT involvement will require more resources than the one with less IT involvement, because some system adjustments are needed.

The structured approach implies that the cost price for all options is still calculated. Therefore, no cultural changes within the chain are necessary. Only within CA the way of working must be adjusted, from manual to automatic. Another identified benefit due to automation is that there is less chance of manual errors (Employee A).

According to employees A and C, calculating all options for each vehicle type, i.e. no longer applying common options, would lead to more precise option prices due to the removal of small vehicle-specific errors. Employee D also indicated to prefer not to have common options if everything is automated, because CA is ultimately responsible for calculating (close to) correct cost prices. When only vehicle specific option prices are applied, maintenance can be carried out per vehicle type. However, this also entails a disadvantage. For example, when the costs of a steering wheel change, the option price must be adjusted for each vehicle type. While this used to be just one price. With the result that maintenance on the APS system may increase (Employee A).

All three allocation rules were also discussed with the interviewees. This revealed that the EQC and all-to-1 method require less time than the weighted allocation method. For the reason that weightings must be determined for this latter method. However, interviewees indicated that splits must be made every year for approximately the same options, and that weights will not greatly deviate over several years (Employees B, C, and D). Once these weightings are assigned, it is therefore pure maintenance in the coming years, with the exception of new options. This requires less time than beginning from scratch every year. In addition, reviewing these weights can be executed before the first of January, so before calculations start. In this way, when the new MLO prices apply (on 1 January), the option cost prices can be calculated quickly because all the preparatory work has already been done (Employee D). As a result, the option price calculations have an equal duration after the first of January for each of the three allocation methods.

According to employees A, C, and D, the EQC and all-to-1 method result in less accurate cost prices than the weighted allocation method. In addition, for these two more “inaccurate” methods it is harder to explain where the option prices are based on (Employee A). Employees C and D indicated a strong preference for the weighted allocation method because of accuracy reasons. But also because this method retains more control and does not blindly rely on a general rule, i.e. no black box. Maintaining more control means that knowledge of the option pricing employee is still needed. But there is now a lesser degree of dependence, because after the one-time determination of the weightings, it is a matter of reviewing.

In addition to the interviews, the author conducted an empirical study by calculating all 552 options of the most sold vehicle type using each of the three allocation methods. A step-by-step explanation of

how this was done is described in the next paragraph. Note that the intermediate level was not yet included in the KC8Z, since this could not be implemented by the author. Therefore, the same allocation rule was used for these components. If this intermediate level would be present, it is most likely that the results would be more accurate (Employee A). However, as mentioned before, incorporating the intermediate level in the KC8Z help table is not necessary for the weighted allocation method, as this method can also include this information in the weights.

Before starting on the calculations, a zero-value options list was created based on historical data. Hereafter, the following steps were performed:

1. All type 1 calculations + copy & paste.
2. Fill in the costs of the exceptions (these costs were already calculated by the option pricing employee, and must be calculated before the normal flow of calculations start⁸) + copy & paste.
3. Set zero value options to zero using the zero value options list + copy & paste.
4. All type 2 calculations (first the ones with the lowest number of 'nCHO' and then from top to bottom in the resulting list) + copy & paste.
5. Calculations with multiple unknowns (type 3).

Order of calculations: first a selection is made so that only the calculation numbers with the lowest number of unknown options remain. Then, within this resulting list of calculation numbers, the calculation number is selected that has the option with the highest 'N selco'. When there are multiple calculation numbers with the same number of 'N selco', pick the upper-listed calculation number.

- First assign the component numbers that are related to only 1 option.
- Then look at component numbers related to multiple options of which at least one option is unknown.
 - First check if the related options always get the value zero, because then no costs are assigned to this option.
 - Then look if the other related options are part of the calculation number. If not, do not assign any costs to it. If they are part of the calculation number, then apply the chosen allocation rule. With the EQC method, this implies that the common costs are evenly distributed among the options related to the component. With the all-to-1 method, all the costs are assigned to one of the related options. Last, with the weighted allocation method the costs are assigned to the related options based on the weights.
- Hereafter, look at the component numbers that are related to zero selcos.
 - If both the 'CHO fea' column and the 'Option' column in the KC8Z help table only show zeros, then there is an intermediate level. No information is currently available about this in the help table; therefore, the corresponding allocation rule is applied for this. With the EQC method, this means that the costs are evenly distributed over all unknown options. With the all-to-1 method, all the costs are assigned to one option. Finally, with the weighted

⁸ According to employees C and D, calculating the exceptions can also be done before the first of January. Especially if the concerned amounts are relatively small.

allocation method the costs are assigned based on the predetermined weights.

- If the 'CHO fea' column is known, it is first checked whether the features can be linked to an option of the calculation number. If not, no costs are allocated to this. If the feature(s) can be linked, it is first checked whether the related option(s) always get the value zero, because then no costs are assigned to this option. If only one feature can be linked, all costs are assigned to the option which is linked to this feature. If several linked features remain, the corresponding allocation rule is used.
- Next, check if there are other component numbers that are only related to feature(s)/option(s) that are not part of the calculation number. Assign these costs to the unknown options by using the corresponding allocation rule. Note that this is an exception, only occurred in one calculation number when calculating all options of the most sold vehicle type.
- Hereafter, check if there are assembly costs.
 - If there are assembly costs that are related to a certain option, assign these costs to this option.
 - If there are assembly costs that are not directly related to an option then:
 - With EQC: divide these costs by the total number of options of the calculation number. Assign this amount to the unknown options. (Used in this manner to prevent double counting of assembly costs.)
 - With all-to-1: assign these costs to one option.
 - With weighted allocation: assign these costs to options based on the predetermined weights.
- Finally, copy & paste the calculated options.

6. Perform type 2 calculations again + copy & paste.

7. Perform one type 3 calculation again + copy & paste.

Continue until all options are calculated. After this, if necessary, the exception of weighing options can be executed⁹.

In total, the author used the type 3 calculation 19 times for each of the three allocation rules.

To compare the costs of the three allocation methods with the actual costs, an order with many options was examined. The total option costs of the order for each method together with the method's deviation from the actual costs and the current method costs are presented in Table 7.4 on the next page. The same was done for a number of other orders, of which the results are shown in Appendix I. As can be seen for the order of Table 7.4, the weighted allocation method is the most accurate, even better than the current method. However, the same cannot be concluded for the orders from the appendix. For one of those orders, the all-to-1 method is the most accurate, although it is only a slight difference. While for a number of other orders, multiple methods give the same result. Note that they give the same result at order level but not at option level, because type 2 calculations take deviations from type 3 calculations into account. If options of both calculation types are part of the order, the total order amount is still the same.

⁹ The author did not perform this exception, as it requires technical knowledge from the option pricing employee.

Table 7.4: Total option order costs for each method, and the deviation of each method with the actual costs and the current method costs (Order with many options: 044850)

Method	Total option order costs	Deviation with actual	Deviation with Current
Actual	€15,652.74		
Current method	€15,742.05	€89.31	
EQC method	€15,866.73	€213.99	€124.68
All-to-1 method¹⁰	€16,013.83	€361.09	€271.78
Weighted allocation method	€15,694.12	€41.38	- €47.93

Note: Actual costs can in principle change every day, while option prices are calculated only once a year. So the day after calculating all options, these calculated prices are no longer 100% correct. The time of calculating the option prices was slightly different from the time of calculating the actual costs of this example. Therefore, the difference with the actual may be due to a timing effect.

Note: Exactly the same price information was used for all 4 calculation methods, so no time effect can be of influence here.

Looking at the option cost price level, no comparison can be made with the actual costs because no actual option costs can be retrieved, only the actual total option costs per order. When the option prices are compared with the current method, the weighted allocation method shows the least deviation. With the weighted method, only 2 options out of the 552 have a price difference with the current situation of more than €100. Whereas with the EQC method this is the case with 11 options, and with the all-to-1 method with 10 options. In addition, there are more options with the EQC and all-to-1 method where the method leads to positive costs, while the current methods leads to negative costs or vice versa (this is especially true for the EQC allocation method).

When comparing the current method with the structured approach in terms of time, it can be concluded that the structured approach is faster, even if it is still applied manually. Calculating all options of the most sold vehicle type takes the option pricing employee about two weeks when applying the current method. While manually calculating all options with the structured approach took the author approximately two days. Where the weighted allocation method took a little longer because the weights had to be determined from scratch first. However, in the normal process, reviewing these weightings can be done before the first of January. Therefore, this does not affect how long the calculation takes after the new MLO prices are known. To conclude, the structured approach is already faster when it is still carried out manually, but if the steps described before are automated, it will even be faster. Then it may even be possible to calculate all options for all vehicle types within a few days. As a result, the option prices will be more up to date, and not always one year behind.

7.3.2 Creative approach evaluation

This section presents the evaluation of all ideas that resulted from the creative approach.

Offer less options

The main advantage of offering fewer O options to the customers is that the number of options for which the cost price must be calculated is reduced. However, it was identified by many interviewees that this is undesirable from a sales perspective. AB namely wants to offer and sell a maximum amount of options (Employees D and G). While a large time saving can only be achieved if many options are no longer offered. According to employee G, it is even the case that by offering fewer options, a small part

¹⁰ In this case, the all-to-1 allocation was based on sales figures.

of the margin is lost. In addition, it is likely that more special requests will be received. Because there are still customers who want the options that are no longer standardly offered. This is undesirable since special orders take a lot of time (Employees D and G). Employee A also indicated that options cannot simply be omitted because they may be needed to calculate the cost price of other options with type 2 calculations. Due to all these reasons, it is questionable whether offering fewer O options leads to a time saving.

In the literature there is also no unambiguous answer to the question whether it is good to offer the customer a lot of choice. Various studies have shown that an increase in the number of options can lead to negative consequences, such as a decrease in the satisfaction with the finally chosen option (i.a. Bell, 1982; Diehl & Poynor, 2007). Other studies did not find such an effect or found that more choices instead could increase satisfaction and facilitate choice (i.a. Boatwright & Nunes, 2001; Oppewal & Koelemeijer, 2005). The meta-analysis of Scheibehenne, Greifeneder, and Todd (2010) showed that the overall effect size of the number of choice options is virtually zero. Their meta-analysis, however, did confirm that “more choice is better” if decision-makers had well-defined preferences prior to choosing. It is likely that customers in the automotive industry have a preference in advance for what they will use the vehicle for. In other words, it is likely that in the automotive industry it holds that “more choice is better”.

Price less options

Pricing fewer options by using a fixed price for the options that are hardly ever sold and have low costs has the advantage that all options are still equipped with a cost price. Therefore, this is definitely possible from a sales perspective. However, it entails a risk for CA. For example, if the purchasing policy changes or something becomes a make product instead of a buy product, prices can change drastically (Employee G). Therefore, the quality of the cost price of the options will decline. In addition, employees C and D indicated that they were wondering whether this idea would really save any time because the method would not be changed.

Type 1 and type 2 calculations do not take much time. Only type 3 calculations where allocations must be made require a lot of time. Therefore, this idea would only save time if the options that are not often sold and have low costs need to be calculated with type 3 calculations. The author investigated this by looking at two vehicle types (one of which is the best-selling vehicle type). This showed that type 3 calculations are almost never needed for this type of options. If the same applies to all vehicle types, then it is indeed true that the idea of pricing less options will not result in a time saving.

Incorporate frequently chosen options in base vehicle

This idea does not save time because the cost price for the same number of options still has to be calculated. In principle, it only implies a shift of options. The current O option becomes a B option and vice versa. Furthermore, it was identified by some interviewees that including frequently chosen options in the base vehicle is also not desirable from a sales perspective. This namely implies that the base vehicle would become more expensive. While AB wants to keep a low base price (Employees A and G). In addition, margin may be lost when incorporating more options in the base vehicle (Employees C and G), because more discount is given on the base price than on O options.

Fixed percentage on top of base price

By applying a fixed percentage to take the option costs into account, many vehicles will be underestimated or overestimated. In the mix, i.e. on average across all orders, it will be fine. However, orders can be accepted or rejected, whereas the decision based on real data would be different (Employee D). Therefore, orders and margin can be lost (Employees A, B, C, D, E, G, H). In addition to this loss, there is also the risk of abuse if customers discover that a fixed percentage is being used regardless of the number of options (Employee C). As indicated before, price changes are taken into account one year later. With the result that this method does not lead to more up to date cost prices. The only advantage of this idea is that option prices no longer need to be calculated. Only the fixed percentage needs to be determined (in order to be more complete, this should be done per country), which requires less time than calculating all options. But this also has its drawbacks. The way of working needs to be adjusted since there are no longer option prices. The management of M&S indicated that they want to hold on to option prices. Because individual option cost prices are used in order negotiations, to explain cost differences. The same holds for other ideas where option prices are no longer calculated. In conclusion, the many disadvantages of this idea outweigh the time advantage.

Only price M&S options

The M&S department provides less options with a price. For this idea to work, averages for a lot of options need to be calculated to cover all costs. However, according to the employees of the CA department, it is unlikely that this will result in an acceleration. Determining averages also takes a lot of time (Employees A and B). Many separate orders for all consequences need to be retrieved from the system together with the sales numbers of all options in order to determine averages. In addition to the timing issue, working with averages means that the cost price at order level will be less accurate. In the mix, however, it will still be fine.

Total cost price of each order

With this method no option prices are calculated anymore. This means that the way of working must also be adjusted (Employees C, F, and G). Everyone is used to working with individual option prices. These prices are even used in deal negotiations. While with this method only the total option costs per order are known. Therefore, a lot of information will be lost in the chain (Employees C, G). If the extra costs of adding an option have to be determined for a specific case, multiple orders with different options must be requested from the system. In other words, where extra costs come from must be discovered through trial and error by comparing the BOM of these different orders (Employees G and H). In addition, if AB wants to make cost comparisons over several years, the BOM of all orders must be stored, which requires quite some data storage.

In order for this method to work, it is very important that the total order costs can be calculated very quickly to avoid losing orders due to time constraints (Employees B, D, and H). Therefore, real-life data must be available for the calculations. However, it currently takes a whole night before this type of information can be obtained from the system. That is why, combined with the fact that everything needs to change because option prices are no longer used, really large system adjustments are necessary to implement this method (Employees C, D, G, and H). Despite all these disadvantages, there is also an advantage to this method, namely that it leads to the most accurate cost prices. Since, as described in Section 3.3, a combination of options can entail a different price than single options or different combinations of options. With this method the correct costs of the combination of options

of the specific order are always included. However, this means that the costs of the exact same vehicle may differ after a few weeks. This is not desirable for the M&S department, because they want to maintain fairly constant cost prices.

IJ's method

As already identified, this method can only be carried out if options always have fixed consequences, which only applies to a limited number of options at AB. Therefore, if this method would only be implemented for the options with fixed consequences, it would lead to almost no time saving. Extra administrative work would also be required because the fixed consequences can differ per vehicle type (Employee G). Applying this method to all options would mean that the customer no longer has a choice within the consequences or that averages would have to be calculated for all the different consequences. Both are not desired. Many of the interviewees indicated that limiting the customer's choice within the consequences is not something AB wants to do. They want to continue to offer the customer choice flexibility (Employee D). In addition, as indicated before, calculating averages does not save time.

Calculate "main" option costs for all possible combinations of consequences

In order for this method to work, something would have to be developed to retrieve all possible combinations per "main" option out of the system. Another large system adjustment would also be needed such that each option can have multiple cost prices in the system together with the associated consequences. Because the system currently only allows one price for each option. After further analysis of this method, an even bigger problem emerged. Namely the double counting of costs. In fact, certain options can be the consequence of several "main" options. If these "main" options are chosen by the customer, the costs of the consequences will be charged double. When the consequences are of type 1, i.e. pure calculations, the costs can easily be deducted. However, this does not apply to all other options because of the coherence of options. Many interviewees also indicated that this double counting of costs is a major problem that is not easy to solve.

Total cost price for all combinations of whole vehicle

This method partially corresponds to the method where the total cost price per order is calculated. Therefore, some of the pros and cons are also similar. Again, no option cost prices are calculated anymore, which is undesirable from a sales perspective because they use these costs in deal negotiations. Not having option prices has the result that the way of working needs to be changed, that information is lost, and that certain price differences can only be detected by comparing different combinations of vehicles (Employees D, E, and G). The advantage that the total option cost price would be more accurate also applies to this method for the same reason. Where this method is only slightly less accurate because the total cost price for all combinations are calculated at the beginning of the year. While the other method calculates the total costs per order such that any price changes that occur throughout the year are taken into account.

The big difference between the two methods is the number of calculations. Where the other method only calculates the costs of the requested orders, this method calculates the costs for all possible combinations. For all 2 million combinations the total cost price must be saved. In addition, for analysis purposes, the BOM must also be stored for each of these combinations. That is why a lot of data storage is required (Employees A, C, D, F, G, and H). In order to implement this method, major system

adjustments are needed to obtain all possible combinations, to store all data, and to use all data (Employees C, D, G, and H).

7.3.3 Effort-impact matrix

In consultation with all interviewees, an effort-impact matrix was populated with all described ideas. Where effort implies the required resources for implementation, and impact means how much the idea shortens the calculation time after the first of January. Figure 7.4 shows this effort-impact matrix.

The focus must be on high impact ideas that can be achieved with a relatively low effort, i.e. the high-impact low-effort quadrant (Tan & Raghavan, 2004). In this case: the structured approach and the idea where a fixed percentage is applied on top of the base price. From the evaluation it appeared that the ideas part of the other three quadrants save little time and/or require a lot of resources for implementation. Therefore, they are not considered to be the best candidates for acceleration.

AB’s M&S management indicated that they want to stick to having option prices, since these prices are used in the negotiation process. Therefore, all red marked ideas in the effort-impact matrix are dropped. This means that the idea of applying a fixed percentage on top of the base price, which is part of the high-impact low-effort quadrant, is also dropped. To conclude, of the ideas that have a high impact and that can be achieved with a relatively low effort, only the structured approach with the three allocation methods and with less and more IT involvement remain as possible improvement approaches.

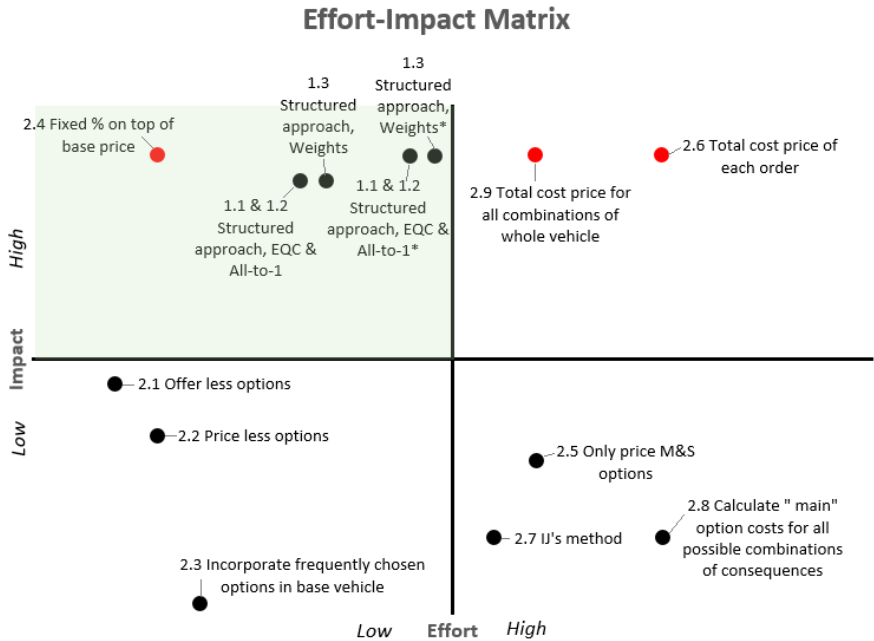


Figure 7.4: Effort-Impact Matrix (numbers refer to ideas in Table 7.3)

Note: Effort implies the required resources for implementation. Impact means how much the idea shortens the calculation time after the first of January.

Note: The red markers mean that option prices are no longer calculated with the corresponding idea.

Note: The structured approach with a * implies more IT involvement, and without a * implies less IT involvement.

8. Conclusions and recommendations

In this final chapter, conclusions and recommendations for AB are presented. Furthermore, the limitations of this study are discussed.

8.1 Conclusions

The aim of this study was to analyze how AB's current process of calculating option prices can be accelerated, by developing several acceleration ideas and evaluating them. First of all, the current situation was mapped out and evaluated. A description of the current process is visualized in Figures 3.3 and 3.4. The evaluation of the current process, Section 3.3, already revealed some possible improvement ideas, such as developing a zero value options list and incorporating the intermediate level in the KC8Z help table. In addition, it was identified that the part of the process where the option cost prices are actually calculated takes the most time. Therefore, the focus to speed up the process was mainly on the calculation part.

To understand the current situation even better and to gain more ideas for improvement, historical data was analyzed. This revealed, among other things, that on average all chosen options account for 9.4% of the total vehicle costs. Moreover, Figures 4.5 and 4.6 showed that there are many more options that are rarely sold than there are options that are included in almost all orders.

In order to gain even more ideas for improvement, industry practices were collected and compared to AB's current situation. Initially, the aim was to find industry *best* practices. However, not enough information could be collected for this. In total, the industry practices of only 5 automotive companies of different sizes could be identified. Three of these practices could potentially provide an acceleration for AB, which was further discussed and evaluated in Chapter 7.

To obtain a guideline to arrive at even more improvement ideas, literature was searched for process redesign/improvement methods. This revealed that there are two traditional approaches, the structured and the creative approach. Both approaches have their advantages and disadvantages; therefore, this thesis applied both of them. The structured approach was carried out by discussing the shortlist of best practices for each task of the current process with process executers. While the creative approach was executed by holding brainstorming sessions with process stakeholders, taking both the current process and clean sheet as starting point. In addition, input from the process analysis, historical data analysis and industry practices were also used for the creative approach.

In Chapter 7, several possible ideas for acceleration were developed using the two improvement approaches. The structured approach requires that several ideas are combined to achieve a great acceleration. Therefore, the structured approach implies a combination of all ideas discussed in Section 7.1, with the exception of the ideas where stated otherwise. A summary of the ideas part of the structured approach is presented in Table 7.1. Within this approach, however, there is still a distinction between the three allocation methods. Namely, the EQC method, the all-to-1 method, and the weighted allocation method. In addition, there is a distinction between less and more IT involvement.

The ideas that emerged from the creative approach together with the origin of the idea are listed below:

- Offer less options – based on historical data analysis;
- Price less options – based on historical data analysis;
- Incorporate frequently chosen options in base vehicle – based on historical data analysis;
- Fixed percentage on top of base price – based on historical data analysis;
- Only price M&S options – based on discussions (M&S prices fewer options than CA);
- Total cost price of each order – based on industry practices;
- IJ's method – based on industry practices;
- Calculate “main” option costs for all possible combinations of consequences – based on industry practices;
- Total cost price for all combinations of whole vehicle – based on industry practices.

All improvement ideas were evaluated using semi-structured interviews with employees from different departments. A summary of the pros and cons of each idea is presented in Table 7.3. In consultation with all interviewees, an effort-impact matrix was also created, which is shown in Figure 7.4. According to Tan and Raghavan (2004), the focus must be on the high-impact low-effort quadrant of the effort-impact matrix. In this case: all three methods of the structured approach and the idea to apply a fixed percentage on top of the base price. However, AB's M&S management indicated that they want to stick to having option prices because they use these prices in the negotiation process for explanation reasons. Therefore, all ideas that no longer calculate option prices were dropped, including the fixed percentage on top of the base price idea. As a result, only the structured approach with the three allocation methods with both less and more IT involvement remained as possible acceleration ideas.

This research can be considered to be a case study. It investigated a problem that is specific to AB. However, if such a problem also arises at a comparable company, i.e. a company where orders can be customized through options, the same approach as used in this study can be applied. Possibly even the developed improvement ideas can be used for evaluation at another company. Since this study only investigated acceleration possibilities for the option pricing process at one company, it would also be interesting to see what improvement ideas would result from the same research (by using the same approach) at a comparable company.

8.2 Recommendations

First of all, it is recommended to AB to implement the structured approach improvement idea, as described step by step in Section 7.3.1. The evaluation showed that this approach achieves the biggest time saving with the least resources required. It is up to the company to decide whether to implement the approach with less or more IT involvement, since this depends on the available IT capacity.

This study presented three allocation methods within the structured approach: the EQC method, the all-to-1 method, and the weighted allocation method. All three methods are located in the high-impact low-effort quadrant of the effort-impact matrix. Therefore, AB has the choice between these three allocation methods. In order to maintain more control, to not blindly rely on a black box, and to better explain where option prices are based on, AB should choose for the weighted allocation method. With

the reason that option cost prices do not have to be 100% correct and the results of the three allocation methods are not very far apart. The examples of this study even showed that the weighted method is the best or at least not much worse than the other two methods. For the weighted allocation method, it is also possible to spend less time on determining the weightings for smaller amounts of money, for example by applying the EQC method. AB can decide this itself when determining the weightings.

For implementing the structured approach, it is recommended to first perform this approach manually for all vehicle types. The empirical study in Section 7.3.1 showed that although performing the steps manually, it is already faster than the current approach. Namely from a duration of 2 weeks to 2 days for one vehicle type. Hereafter, AB should take automation steps, because after automation the throughput time of calculating all options for one vehicle type will be much less than 2 days. When the approach is fully automated, it is recommended to abandon common options and to only apply vehicle specific options.

Even after the structured approach is implemented, it is recommended to annually investigate for some orders whether the forecasted total option costs are close to the actual costs. If large deviations are found, adjustments can be made with the weighted allocation method. While this is not possible with the other two allocation methods. Once the structured approach is fully implemented (including automation), the CA department has more time (because of the time savings) to carry out these type of checks and to investigate where major deviations come from such that adjustments can be made.

8.3 Limitations

A limitation of this study is that no industry *best* practices could be identified. A best practice is namely defined as “a tactic or process characteristic that has been employed at one or more other organizations with excellent results” (Sharp & McDermott, 2001, p. 251). This study was unable to collect enough information to draw such conclusions. In total, only the industry practices of 5 automotive companies could be identified. Most of the contacted companies did not have time to share their current practices regarding their option pricing process. If more industry practices can be identified (or even industry best practices), more insights can be gained about possible improvement ideas.

Investigating how to improve the determination of missing prices, i.e. finding the price, fell outside the scope of this research, since it was assumed that the provided data is correct and complete. However, there is a limitation here, since there are missing prices in practice. Currently, finding these missing prices is performed by hand. Therefore, the CA department (or a student) can investigate this further as it can lead to more time savings.

The evaluation of all improvement ideas was only performed on the basis of interviews, i.e. qualitative data. Because in order to obtain quantitative data on all ideas, all these ideas would actually have to be implemented, which is quite difficult for some of the improvement ideas. Along the same line, it is a limitation of this study that the structured approach using each of the three allocation methods has only been empirically tested for one vehicle type, i.e. all options for only one vehicle type have been calculated. AB can calculate the options for several other vehicle types to see if the same results hold.

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Appendix A: Structure of standard cost prices

Cost estimation in the manufacturing sector is the procedure of estimating the costs of producing a product before the actual production process starts (Cheung, Newnes, Mileham, Marsh & Lanham, 2007). AB distinguishes three cost items, namely material/fabrication costs, assembly costs, and additional costs. Material costs include both purchased products and products AB manufactures itself. Assembly costs speak for themselves, and additional costs include among others tooling, fuel, oil, and coolant costs. AB's system, however, allocates the additional costs to the assembly costs. Therefore, the information that is retrieved from the system, as shown in Figure 1.2, only displays material and assembly costs.

There exist different production costing approaches in the literature, such as job costing, standard costing, ABC costing, direct costing, and target costing (LillyWorks, n.d.). AB currently makes use of standard costs. Although standard costing is an "older" accounting method, it is still frequently used by many firms (Marie, Cheffi, Louis & Rao, 2010; Sulaiman, Nazli Nik Ahmad & Mohd Alwi, 2005; Stratton, Desroches, Lawson & Hatch, 2009).

Standard cost can be defined as 'the expected cost per unit of the product' (Business Jargons, n.d.). For manufacturing firms, the standard cost of each unit consists of the standard cost of direct materials (M), direct labor (L), and manufacturing overhead (O) (Lumen Learning, n.d.). This complies to the definition of standard costs within AB, namely MLO. Therefore, in the rest of this thesis, the terms standard cost and MLO are used interchangeably. In addition, at AB the term vvp ("vaste verrekenprijs") is also used to represent the standard cost.

The categorization of AB's cost elements into M, L, and O largely corresponds to the cost breakdown structure identified by Roy, Souchoroukov and Shehab (2011). They found a generic breakdown of the cost elements for the automotive industry by categorizing the costs into material, factory value-added and general overheads. The content of the material and general overheads elements speak for itself, but the factory value-added elements require further explanation. The factory value-added part consists of both direct and indirect labor, and machine and tooling costs.

AB has two cost price levels. Namely, the actual cost price (fcp, "fabricage kostprijs") and the standard cost price (vvp). The fcp fluctuates throughout the year, it is calculated every period (4 weeks) and reflects the actual MLO, which is used to measure cost development. While the standard cost price is calculated once a year, at the end of the year, and is then fixed for the upcoming year starting from the first of January. However, there are cases in which the vvp is adjusted throughout the year, for example when going from an estimated price to a final price, or if a product change takes place in the BOM of a manufacturing product. It must be noted that the vvp is used by AB to calculate option prices. Therefore, the option prices are also fixed for one year. The process of calculating all option prices starts again each year on the first of January when the new vvp's apply. Due to the length of the current option pricing process, more than one year, the vvp's of 2018 were used to calculate the option prices of 2019.

AB's MLO structure that applies to all three cost items is shown in Figure A.1 on the next page. As can be seen the M consists of direct material and material value surcharge. The L includes direct labor.

Depending on the cost item, the labor costs are based on fabrication time or assembly time. The O consists of material burden, and labor burden. The M or L can get the value zero, depending on the cost item. For example, a purchased item does not have any labor costs.

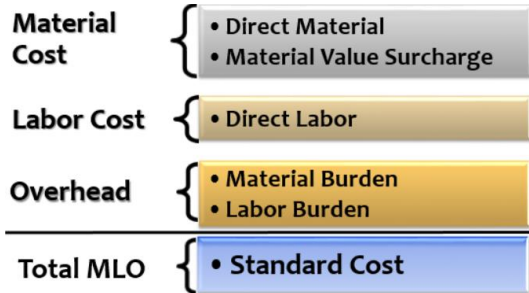


Figure A.1: AB's MLO structure

Now a short description of each part of the MLO is given. Regarding the M, standard material costs are based on the actual material prices (fkp) of the end of the previous year. For example, for the MLO of 2019 the actual material prices of the end of 2018 were used. The material value surcharge is applied as a percentage of standard material costs and it covers costs for inbound freight and small materials. Direct labor rates, where L consists of, are based on actual direct wages and fringe over the first 9 months of the previous year. Regarding the O, material cost surcharge (material burden) is applied as a percentage of standard material costs and covers factory overhead costs for Purchasing and Logistics. The labor cost surcharge (labor burden) is a burden rate per hour to cover the factory overhead costs of each plant including depreciation and allocated costs.

According to AB, there are certain advantages of applying standard costing. Namely, it encourages cost awareness, it creates a focus on material and labor variance analysis, and it provides a fixed starting point for margin analysis.

Appendix B: Examples of MUI and VES

Simple examples regarding features and selcos are presented in Figure B.1. Other examples of features are the color, predictive cruise control, external camera system, audio system and engine.

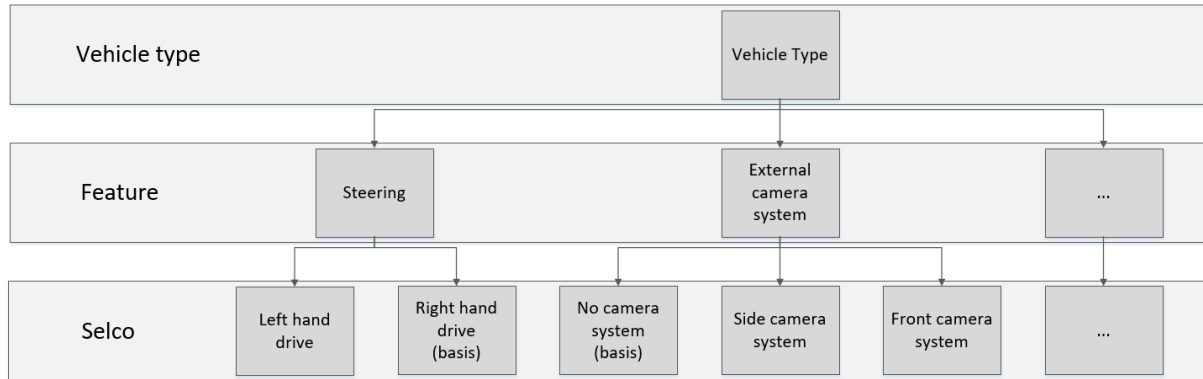


Figure B.1: Example of MUI structure

An example of the breakdown structure of the VES is presented in Figure B.2.

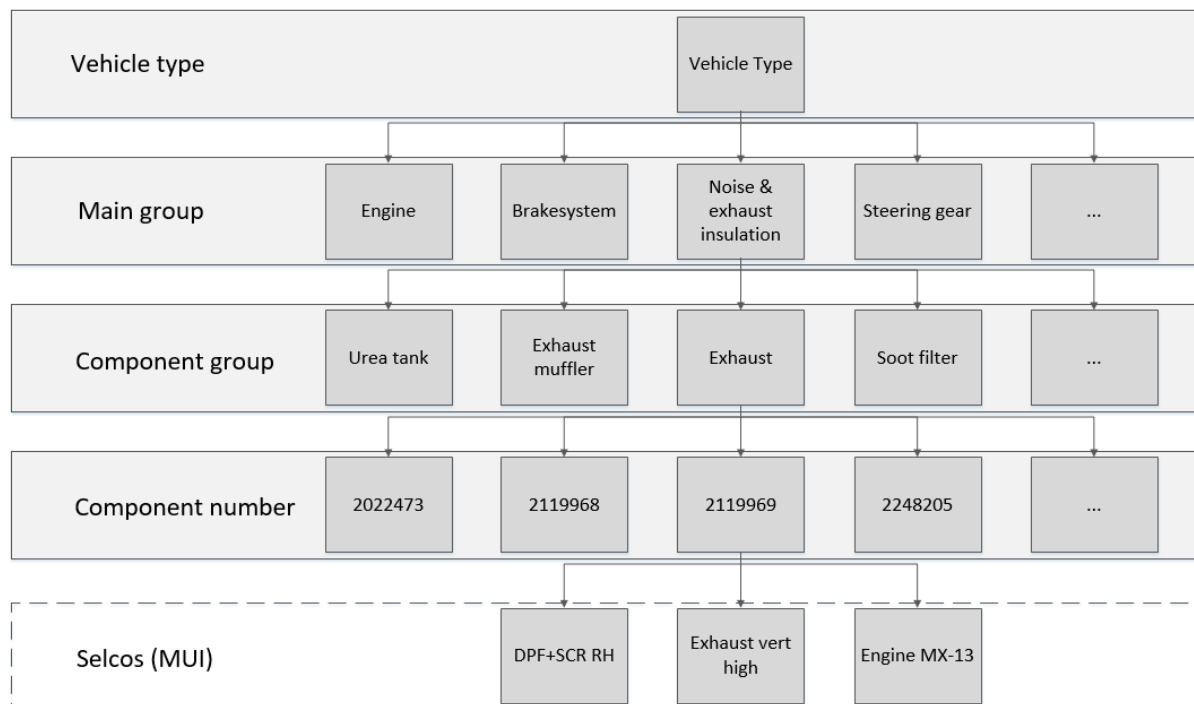


Figure B.2: Example of the VES structure (based on Roording (2016))

Appendix C: Most sold options for most sold vehicle type

The descriptive statistics for the most sold options analysis for 2018 and 2019 regarding the best-selling vehicle type are presented in Tables C.1 and C.2, respectively. For 2018, the total number of chosen options of all orders is 446, the average number of times an O option is incorporated in an order is 2,675, the standard deviation is 5,304, and the minimum and maximum are 1 and 28,037 respectively. The total number of options of all orders for 2019 is 424, the average number of times an option is part of an order is 1,340, the standard deviation is 2,564, and the minimum and maximum are 1 and 13,223 respectively.

In comparison with Tables 4.5 and 4.6, the average number of times an option is chosen is higher when only considering the most sold vehicle type. This also appears from Figures C.1 and C.2. The total number of chosen options is lower when only taking the most sold vehicle type into account. This makes sense because certain options are not available for this vehicle type. In addition, a selco identified by a B or S for the most sold vehicle type can be specified by an O for another vehicle type. Similar to Tables 4.5 and 4.6, the minimum number of orders for a selco is 1. The maximum for both years is lower than in Tables 4.5 and 4.6. This is logical since the total number of orders is lower when only considering the most sold type. For both years, the maximum implies that a certain option is incorporated in approximately 95% of the orders of the most sold vehicle type.

Table C.1: Descriptive statistics NumberOrdersPerO 2018 for most sold vehicle type

Variable	Total Count	Mean	StDev	Minimum	Maximum
NumberOrdersPerO	446	2,675	5,304	1	28,037

Note: Total number of orders of the most sold vehicle type is 29,444.

Table C.2: Descriptive statistics NumberOrdersPerO 2019 for most sold vehicle type

Variable	Total Count	Mean	StDev	Minimum	Maximum
NumberOrdersPerO	424	1,340	2,564	1	13,223

Note: Total number of orders of the most sold vehicle type is 13,922.

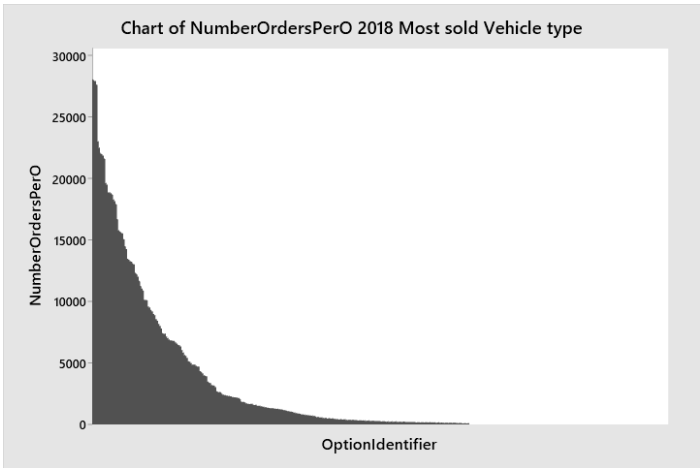


Figure C.1: Chart of the number of times an option is incorporated in an order (2018) regarding the most sold vehicle type (arranged in descending order)

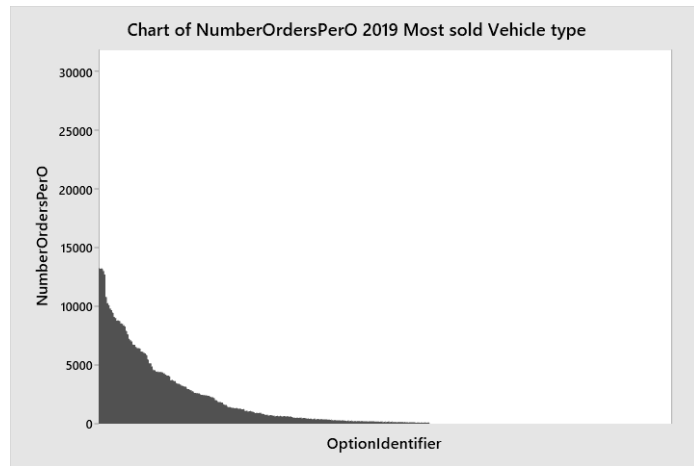


Figure C.2: Chart of the number of times an option is incorporated in an order (2019) regarding the most sold vehicle type (arranged in descending order)

Appendix D: Option price calculation dependence of one order

Table D.1: One order of most sold vehicle type

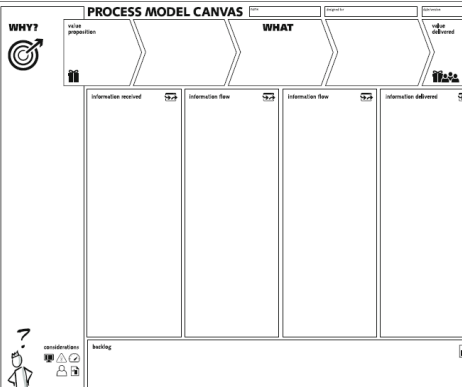
Option	Option calculation type	Number of times O occurs in calculation numbers	Other options used for the calculation	Note
0116	1	1		
0365	1	1		
1066	1	1		
1432	2	1	4081	
1520	1	1		
1522	2	1	4586 and 3094	
1712	1	1		
1725	1	1		
1737	2	1	7903	
1789	1	1		
2366	1	1		
2851	1	5		
3088	1	1		
3094	3	27		Two components are related to multiple options: Component A is related to both 3094 and 3484. Component B is related to both 3094 and 4586 .
3673	1	29		
4558	Spoiler price was wrong - Manual	5		
4586	1	32		
4840	2	1	2851	
4906	2	5	6066	
6017	Option equals zero	9		
6066	Option equals zero	4		
6306	1	1		
6334	Option equals zero	3		
6340	1	1		
6491	1	1		
6539	1	1		
6991	1	1		
7117	1	1		
7608	1	4		
7707	2	2	7491 and 2090	

7733	1	1	
8030	1	1	
8191	2	1	7608
8261	1	1	
8311	1	1	
9280	1	1	
9303	2	2	9842
9627	1	1	
9681	1	2	

Appendix E: Redesign methods Dumas et al. (2018)

Table E.1: Applicability of Redesign methods based on Dumas et al. (2018, p. 306-330) (Bakermans, 2020)

Redesign method	Transactional or Transformational, Creative or Analytical, and Inward-looking or Outward-looking	Redesign method description	Applicable?	Reason
Six Sigma	Transactional, Analytical, and Inward-looking	"A number of process performance measures is closely monitored for deviations of a norm or target value."	NO	There are no closely monitored targets present.
Theory of Constraints (TOC)	Transactional, Analytical, and Inward-looking	Focus on lifting the one constraint that limits any production system in reaching its goals. "If successful, performance will improve yet another constraint will manifest itself. So, the steps of identifying and lifting a constraint need to be repeated. As such, the TOC puts much emphasis on process improvement as an ongoing process."	NO	Thesis deals with a one-time improvement instead of an ongoing improvement process, due to time constraints.
TRIZ	Transactional, Analytical, and Inward-looking	TRIZ is a generic theory of problem-solving and is based on an evolution of patterns.	NO	This is not a method with clear steps to follow.
Positive Deviance	Transactional, Analytical, and Inward-looking	"The assumption is that individuals or groups sometimes intentionally behave differently than what is considered the norm, yet with remarkable positive effects."	NO	Only one person is currently executing the process at the company. If this person deviates from the norm, this already becomes the norm.
Benchmarking	Transactional, Analytical, and Outward-looking	Compare competing designs, by identifying best practices.	YES	Can be applied if best practices can be identified.
ERP-driven redesign	Transactional, Analytical, and Outward-looking	"A specific variation of the benchmarking approach is one where a process redesign effort is driven by an enterprise IT system." Which is the case when an organization starts the implementation of an ERP system.	NO	Since no ERP system will be implemented.
Lean	Transactional, Analytical, and Outward-looking	"Lean is concerned with improving business activities (1) on the overall enterprise level as well as (2) on the more operational business process level." (1): "value stream mapping, which aims at capturing an entire value chain." "Mapping value streams serves the purpose of identifying dependencies between processes and, if possible, shaping them into so-called Just-In-Time dependencies." (2): "individual process activities are assessed on whether they add value or do not."	(1): NO (2): YES	(1): Not applicable, since the focus is not on the entire value chain, but on a relatively individual process. (2): Applicable, since the focus is on all the activities of an individual process and involves clear steps from how to go from the AS-IS to the TO-BE.

7FE & BPTrends	Transactional, Creative, and Inward-looking	“Aim to bring together people with knowledge of an existing business process during a series of workshops.” “Workshop participants identify process weaknesses, question the assumptions underlying the process, and then generate ideas to change aspects of that process for the better.”	YES	Applicable by holding workshops with people involved in the respective process.
Crowdsourcing	Transactional, Creative, and Outward-looking	“While no full-fledged methods in this sphere yet exist, it can be imagined how crowds of customers or suppliers may help to identify process weaknesses and generate improvement ideas.”	YES	Sort of applicable, by involving people related to the process in the workshops.
Heuristic Process Redesign	Transactional, Analytical, and Inward-looking	Use redesign heuristics, which are rules of thumbs, for deriving a different process from an existing one.	YES	Since this method involves clear steps from how to go from the AS-IS to the TO-BE.
Business Process Reengineering	Transformational, Analytical, and Inward-looking	Business Process Reengineering “is generally considered as the first call for the redesign of business processes and the first attempt to identify enduring patterns.”	NO	Is not a method with clear steps that can be applied, it is just the clean state method. “The principles of Business Process Reengineering are not embedded in an explicit, staged view on how to carry out process redesign.”
Design-led Innovation	Transformational, Creative, and Outward-looking	“Aims to provide organizations with an understanding of the deep emotional ties that consumers develop with their products.” “Based on this understanding, organizations may pursue innovations that customers do not expect, but which they eventually grow passionate about.”	NO	Since the process is purely functional, namely cost prices to calculate the margins on each order.
Process Model Canvas	Transformational, Creative, and Outward-looking	 <p>The diagram is titled 'PROCESS MODEL CANVAS'. It is divided into two main horizontal sections: 'WHY?' on the left and 'WHAT' on the right. The 'WHY?' section contains 'Value Proposition'. The 'WHAT' section contains 'Channels' and 'Revenue Streams'. Below these are four vertical boxes representing 'Information received', 'Information flow', 'Information flow', and 'Information delivered'. At the bottom, there is a 'Building' section with icons for 'coordination', 'resources', and 'activities'.</p>	YES	Applicable by holding workshops with people involved in the respective process.

NESTT	Transformational, Creative, and Outward-looking	“Navigate, Expand, Strengthen, and Tune/Take-off”	YES	Applicable by holding workshops with people involved in the respective process.
<p>Within a workshop setting, participants start by formulating a vision of the new process. “By committing to this vision, the participants determine how to overcome problems and seize opportunities to realize that vision, while using insights from the existing process (the Now), available and required resources, as well as relevant procedures.”</p>				
Product-Based Design	Transformational, Analytical, and Outward-looking	<p>“The characteristics of the end product (or the service) are used to, in fact, reason back to determine what the process should look like.”</p> <p>“The idea behind Product-Based Design is that by ignoring the existing process and purely considering the features of the product, it becomes feasible to develop the leanest, most performative process possible.”</p>	YES	Applicable by focusing on the goal of the outcome of the process (the so-called product).

Appendix F: 29 Best practices

Table F.1: 29 Best practices (based on Reijers & Mansar (2005); Jenniskens (2011); Hanafizadeh et al. (2009)) (Bakermans, 2020)

Best Practice	Description	Applicable?	Time	Cost	Quality	Flexibility
Task automation	Consider automating tasks.	YES	+	-	+	0
Task composition	Combine small tasks into composite tasks and divide large tasks into workable smaller tasks.	YES	+	+	+	-
Triage	Consider the division of a general task into two or more alternative tasks or integration of two or more alternative tasks into one general task.	YES	+	+	+	-
Task elimination	Eliminate unnecessary tasks from a process.	YES	+	+	-	0
Integral technology	Try to elevate physical constraints in a process by applying new technology.	YES	+	-	0	0
Empower	Give workers most of the decision-making authority and reduce middle management.	NO, because there is no middle management involvement with calculating the option prices.	+	+	-	0
Order assignment	Let workers perform as many steps as possible for single orders.	NO, has negative effect on time.	-	0	+	-
Resequencing	Move tasks to more appropriate places.	YES	+	+	0	0
Specialist-generalist	Consider to make resources more specialized or more generalized.	NO, has negative effect on time.	-	-	+	-
Integration	Consider the integration with a process of the customer or supplier.	YES	+	+	0	-
Parallelism	Consider whether tasks may be executed in parallel.	YES	+	-	-	-
Extra resources	If capacity is not sufficient, consider increasing the number of resources.	YES	+	-	0	+
Numerical involvement	Minimize the number of departments, groups, and persons involved.	NO, has no effect on time.	0	-	+	-
Control relocation	Move controls towards the customer.	NO, has no effect on time.	0	-	+	0
Contact reduction	Reduce the number of contacts with customers and third parties.	NO, there is currently no contact with customers and third parties during the process.	+	-	+	0

Order types	Determine whether tasks are related to the same type of order and, if necessary, distinguish new processes.	NO, all parts of the business process are specific for the business process they are part of.	+	+	-	-
Order-based work	Consider removing batch-processing and periodic activities.	NO, has negative effect on time.	-	-	0	0
Knock-out	Order knock-outs in an increasing order of effort and in a decreasing order of termination probability.	NO, has negative effect on time.	-	+	0	0
Exception	Design business processes for typical orders and isolate exceptional orders from normal flow.	YES	+	0	+	-
Flexible assignment	Assign resources in such a way that maximal flexibility is preserved for the near future.	NO, because only one employee is involved in this process.	+	0	+	0
Centralization	Treat geographically dispersed resources as if they are centralized.	NO, because there are no geographically dispersed resources.	+	-	0	+
Split responsibilities	Avoid assignment of task responsibilities to people from different functional units.	NO, has no effect on time.	0	0	+	-
Customer teams	Consider assigning teams out of different departmental workers that will take care of the complete handling of specific sorts of orders.	NO, has negative effect on time.	-	0	+	-
Case manager	Appoint one person to be responsible for the handling of each type of order, the case manager.	NO, has no effect on time.	0	-	+	0
Control addition	Check the completeness and correctness of incoming materials and check the output before it is sent to customers.	NO, has negative effect on time.	-	+	+	0
Buffering	Instead of requesting information from an external source, buffer it by subscribing to updates.	YES	+	-	0	0
Interfacing	Consider a standardized interface with customers and partners.	NO, because this is already present.	+	+	+	0
Outsourcing	Consider outsourcing a process in whole or parts of it.	NO, since the process deals with confidential information, namely cost prices.	+	+	-	-

Trusted party	Instead of determining information oneself, use results of a trusted party.	NO, the process deals with confidential information, which is company specific.	+	+	-	-
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Appendix G: Literature on allocation rules (Bakermans, 2020)

One of the more complicated calculations in the option pricing process is when an option results in multiple other options and if these options have common components, which is the case with the third type of option calculations. These common costs need to be allocated to the corresponding options, which is currently carried out manually.

There are no allocation rules available in the literature for this kind of common cost allocation. Much of the literature regarding cost allocation deals with allocating costs of joint product processes, where several outputs result from processing a common input. The methods available to allocate the joint costs of the joint product processes are the net realizable value method; the physical measures method; the relative sales value at split off; and the relative gross margin (Wouters, Selto, Hilton & Maher, 2012; Horngren, Datar & Foster, 2006). However, these methods are not applicable when allocating the costs of the common component to the options, since this type of allocation does not involve a joint product process with a split-off point¹¹.

Some other articles deal with joint cost allocation in a collaborative setting where people work together to save costs (Guajardo & Rönnqvist, 2016; Frisk et al., 2010; Tijs & Driessen, 1986; Verdonck, Beullens, Caris, Ramaekers & Janssens, 2016). A number of cost allocations have been proposed in the literature for this collaborative setting. Of which some are based on simple proportional rules and others on theoretical concepts of game theory (Guajardo & Rönnqvist, 2016). These cost allocations are: shapley value; nucleolus; allocation based on shadow prices; allocation based on volumes; equal profit method; and allocations based on separable and non-separable costs including the equal charge method, the alternative cost avoided method, and the cost gap method (Frisk et al., 2010; Guajardo & Rönnqvist, 2016; Tijs & Driessen, 1986). A detailed explanation of each of these methods can be found in Frisk et al. (2010) and Guajardo and Rönnqvist (2016).

Not all of these collaborative cost allocation methods are applicable to the author's thesis. Most of the methods are based on coalitions, which is a subset of participants of the collaborative setting. While the concept of coalitions is not applicable in the author's project, because the options are an automatic consequence of another option. Therefore, the following methods are not relevant: shapley value; nucleolus; equal profit method; alternative cost avoided method; and cost gap method. The 'allocation based on shadow prices' method is also not applicable because it uses supply and demand constraints, while the company under investigation applies the BTO principle. Therefore, supply and demand are the same. As a result, the applicable allocation rule that results from the literature is the equal charge method, where the non-separable costs are distributed equally (Frisk et al., 2010). It must be noted that the common component costs can be considered to be non-separable costs.

An alternative allocation rule that can be considered is to distribute the common costs to the related options relative to the other costs of the options. However, this is not feasible if an option is related to multiple common components. Another possibility is to allocate the common component costs to only one of the related options. This allocation can be done randomly or based on sales numbers (variation on 'allocation based on volumes' method).

¹¹ A split-off point is the point at which joint products appear in the production process (Wouters et al., 2012).

Appendix H: Semi-structured interviews

H.1 Setup

The interviews started with a brief introduction of the project if the interviewee was not already familiar with it. Hereafter, each of the identified possible improvement methods were explained. A summary of all these improvement ideas was used for this, which is presented below in Section H.1.1. Questions regarding the advantages, disadvantages, usability/impact, and required effort for each of these acceleration methods were asked. Note that the interviews were conducted in Dutch. A summary of the translated results is presented in Section H.2.

H.1.1 Summary improvement ideas

Structured approach

The structured approach consists of discussing the shortlist of best practices for each tasks of the current process.

Task automation

Directly applied to: 'Calculate Type 1', 'Calculate Type 2', all the 'Copy & Paste' tasks, and the tasks that check the retrieved information for incompleteness.

Can be applied to the 'Retrieve information' task.

Make list of options that receive the value of zero every year. Update this list every year, and then retrieve information from this list.

Subprocess Type 3:

- Directly automated: 'Allocate Component Price Difference to Option' (when a component number is related to 1 option); and 'Combine allocations'.

- Component related to more than 1 option → not easy to automate. Because different methods are used in practice → therefore develop allocation rules.

Allocation rules ideas:

- Equal charge method (EQC).

- Based on equal charge → Weighted allocation (30-70, 60-40 charge). This allocation is then fixed for one year, it needs to be developed in advance of the calculations and then updated every year.

- Allocate all costs to one of the related options (all-to-1) → can be done randomly or based on sales volume.

- Component related to zero selcos → not easy to automate. But possible if intermediate level is incorporated in the KC8Z help table, and if features are linked to the options of the corresponding calculation number.

Task composition / Triage

If everything can be automated → calculate all options for each vehicle type (so no more separation between general and specific options).

If all options for each vehicle type are calculated → the specific order of calculating options for vehicle types are no longer needed.

Task elimination

Eliminate task that transforms a text file into an Excel file.

Integral technology

NO

Resequencing

Do the task where options are set to zero earlier in the process.

Integration

NO

Parallelism / Extra resources

NO

Exception

Perform exceptional options, the ones that cannot be calculated with normal flow, otherwise. This is currently also the case.

Buffering

By having information directly available when it is required, throughput times may be reduced. At AB it currently takes at least one night to retrieve data from the system. Therefore, a time saving can also be achieved by making the requested information immediately available.

Combination of ideas is necessary for a significant time saving.

Creative approach

Consists of coming up with more out-of-the box ideas, where both the current process and clean sheet were taken as starting point.

Offer less options.

Price less options → if option is sold less than X times last year & price is below Y, then fix the option price in advance of calculations.

Incorporate frequently chosen options (>90% of the times) in the base vehicle → the option that was part of the base vehicle (the one that is replaced by the frequently chosen option) is now an option that a customer can choose, and therefore needs to be priced.

Fixed percentage for options on top of the base price.

Only price the options that the M&S department prices → M&S do not price consequence options. If you want this to work you need to use averages for all possible consequences.

Calculate total cost price of each order in advance.

Incorporate all consequences of a “main” option in its option price and eliminate these consequences from the option list that the customer can choose from.

Calculate a “main” option price for all the consequences and combinations of consequences that are possible.

Calculate all possible choice combinations for a whole vehicle, and provide a total price to each of these combinations.

H.2 Results

H.2.1 Employee A (CA)

Structured Approach

Task automation

Type 1 and 2 calculations, and copying and pasting can definitely be automated. This can be done in Excel or in another program. Its main advantages are less chance of errors and speed gain.

When determining the zero value options, we now also look at previous years, but this could be introduced more officially by using a standard table. The advantage of this is that it is easy to implement. However, it only results in a small acceleration compared to the current situation.

Regarding EQC and all-to-1, the disadvantage is that it can deviate somewhat from reality. In addition, it is harder to explain where the option prices are based on. An advantage of these methods of automation is that it is a way to do it much faster. Moreover, it may indeed be that the total costs at order level are acceptable, but that the costs at option level are not entirely correct.

For the weighted allocation method you have to determine your weights about a month before the end of the year. After the first of January, the system uses these weightings to calculate all options. This really saves time. However, these weightings need to be updated every year, because it is possible that other options need to be calculated with type 3 calculations if for example new options are added. This method takes more time than the other two allocation methods because you have to determine/update weightings. But the time between start calculation and end calculation is the same for all three methods.

It would really be an improvement if for each feature within the KC8Z it would be specified what the linked option is, if there is one. Then you can immediately make a selection based on that. If a feature cannot be linked to any options, then you do not assign any costs to it. The common costs can then be assigned to the remaining options based on the used allocation rule.

If the intermediate level would be added to the KC8Z, the accuracy would improve. I think that the somewhat larger deviations in the examples at option level are caused by the fact that the intermediate level was not yet present when performing these examples. Therefore, when the intermediate level is present in the KC8Z, these deviations would become smaller.

Task composition / Triage

No longer applying common options is only possible if everything is automated, since more calculations must then be carried out. Its main advantage is that small vehicle specific errors are removed. In addition, maintenance can be executed per vehicle type. However, a disadvantage is that if, for example, the price for a steering wheel changes, you now have to adjust this price for each vehicle type. While first this was just one price. Therefore, maintenance on the APS system can increase.

Task elimination

If we no longer need to convert the RKCZZ report to Excel, it would only save a small amount of time.

Parallelism / Extra resources

If everything is automated, calculating the options for each vehicle type consecutively or in parallel does not make a big time difference.

Exception

It is indeed possible to perform the exceptions before (or after) the normal flow of calculations.

Creative Approach

Offer less options

I think this is unacceptable for the selling process.

Options cannot simply be omitted, since they may be needed to calculate the costs of other options with type 2 calculations.

Price less options

This might indeed be possible. Then you still have a price for all options.

Incorporate frequently chosen options in base vehicle

From a sales perspective this is not desirable, since they want the base price to be as low as possible. In addition, no time savings can be gained with this.

Fixed percentage on top of base price

It is indeed true that there is the possibility that orders will be lost due to this. If the cost price is too high, orders will be lost. If the cost price is too low, too much discount is given (less profit per vehicle).

Only price M&S options

Determining averages does not make it any faster for us.

Total cost price of each order

I find it difficult to assess whether this could be implemented. A major disadvantage is that only the total costs per order are known and that the costs per individual option are no longer present.

IJ's method

Excluding choices within the consequences is unacceptable for the sales process.

Calculate “main” option costs for all possible combinations of consequences

Then you actually get option combinations. You can indeed not easily get rid of the double costs.

Total cost price for all combinations of whole vehicle

I think this is a really good idea. You do not have individual option prices any more, you only have a price in combination with the other options.

The advantage of this idea is that it is the most accurate that you can get because other combinations of options have different costs.

On the first of January the system needs to find out all possible combinations, and then it needs to calculate the total price of each combination.

You get an enormous amount of data.

H.2.2 Employee B (CA)

Ultimately what matters is that the total costs of the vehicle is about right, and not the individual option costs.

Structured Approach

Task automation

I am really in favor of automation. It would result in a drastic time saving. In addition, no major cultural changes are needed for this approach. Only within CA the way of working must be adjusted, from manual to automatic. But it has no impact at all for other departments.

Implementing this automation would not take much time and effort.

I think a general allocation rule could certainly be used.

With a weighted allocation you have more control in comparison with the other two allocation methods. A table with allocations needs to be developed once for all vehicle types, and then updated every year. In general, splits must be made each year for approximately the same options. That is why it is useful to have last year’s weightings as input, so you do not have to begin from scratch every year. If everything is automatic, we can also check certain orders throughout the year whether the price calculated in advance is close to the actual price. If there are major deviations, we will analyze where they come from and possibly adjust the weightings. By automating, we have much more time left to conduct analyses.

In December you can update the zero-value list and the weightings, such that calculations can start immediately in January.

Exception

Exceptions can still be executed in advance and afterwards.

Creative Approach

Offer less options

From an M&S perspective, I think this is not desirable.

Price less options

It is possible to calculate everything once and then use it in a creative way.

You can indeed use the price of last year for those options which are rarely sold and have a low price, such that this is used as input for calculating other options. Throughout the year you will then analyze orders to check where things go wrong, and possibly adjust the copied amounts.

Fixed percentage on top of base price

It may indeed be the case that you will lose orders as a result.

Only price M&S options

I do not think this is a really good idea. Determining averages takes a lot of time.

Total cost price of each order

From an M&S perspective I cannot really judge this.

But it should work really fast.

IJ's method

We have so many more options than IJ. And limiting the customer's choice is not something we want.

H.2.3 Employee C (CA)

Structured Approach

Task automation

Type 1, type 2, and the coping & pasting tasks can indeed easily be automated, these are quick wins. For automating you do not need big system adjustments. You could even do it outside the system. It is a relatively cheap solution. But you do need IT support to develop it. However, this holds for almost every idea.

Regarding the allocation rules, if you go for quantity and quickly use the EQC method, because the all-to-1 allocation method is even less accurate than EQC. If you want it faster, but to be more precise and to keep more control, use the weighted allocation method. With this method the human factor still has influence.

I prefer the weighted allocation method. Then we do not just blindly apply the equal distribution. Because there is absolutely no control over that method and can lead to larger deviations, which is less with the weighted distribution. To determine the weights you do need the expertise of the employees. In order for the weighted allocation method to work, you first need to identify which calculation numbers require type 3 calculations. To the common costs in these calculation numbers you assign weights. You need to monitor this every year, because changes can take place due to new options or new components. However, it is most likely that most of the options that need some allocation remain the same over the years. Therefore, if you have given these weightings once, it will be pure maintenance the following years.

To conclude, I really like this idea, I see it as a big solution to save time. No large system adjustments are needed. In addition, no changes to the chain are necessary because all option costs are still being calculated.

Task composition / Triage

With automation you also go to what I would prefer to see, that you no longer have common options. But that everything is calculated for each vehicle type specifically, which is more precise.

Exception

Exceptions can indeed be calculated outside the normal process flow. An example of an exception is feature 250. However, the prices of this feature can be used for the entire series, which entails that you only need to calculate this exception twice a year. You can even calculate this exception before the first of January because it concerns relatively small amounts of money, so a small deviation makes almost no difference.

Creative Approach

Offer less options

From a cost view I think this is a good idea. But from a selling perspective this is not going to work.

Price less options

Why should I put a lot of energy into an option that is almost never sold. It is a forecast; therefore, it does not have to be 100% accurate. But it is important to only apply this to options with lower costs, because then on average on all orders you are not far off.

This does not change your method. This does not change the workload of what you do. I wonder how much time it will save you.

Incorporate frequently chosen options in base vehicle

I think that M&S would not be happy with this. They make extra money on options.

In addition, the total amount of options that need to be calculated stays the same. Therefore, it has no added value for us.

Fixed percentage on top of base price

I am not in favor of this idea.

This fixed percentage needs to be calculated for each vehicle type, but also for each country. Since the costs of a base vehicle can differ per country.

Another disadvantage is with fleet sales. Fleet sales often do not have many options. The sales price of fleet sales is often a bit lower, because it concerns many vehicles. These orders would not get through the margin approval, due to this fixed percentage.

I do not see how this could work in the chain. I think it is really risky. It entails that no matter what options the customer chooses, the same percentage is applied. If customers find out, they may abuse this. I think you really lose control with this method.

Only price M&S options

I do not know whether this is possible.

M&S do not have a calculation system behind their prices. The selling price should not be guided at all by the costs, but by the market price. That is why the prices of CA and M&S are two separate things.

But for the margin calculations you have to know the cost price. I do not really care what options M&S prices or not. All costs must simply be included.

Total cost price of each order

I am in favor of this. We no longer need to calculate option cost prices. However, you do need a lot of computing power and large system adjustments.

This would have consequences in the chain, since option prices are no longer present. Therefore, the chain would lose a lot of information.

You need real life data for this, since options and code numbers are continuously adjusted.

If you only have the total price, you no longer understand where costs come from. You lose the overview of what is happening.

IJ's method

This method cannot easily be applied, since we have a lot more choices within the consequences than IJ. We cannot reduce the number of choices for the customers within the consequences.

I think that calculating averages does not lead to a time saving, you will just be shifting time.

Calculate "main" option costs for all possible combinations of consequences

You indeed have the problem of double counting costs.

Total cost price for all combinations of whole vehicle

From a CA perspective this is a really good idea, because then we no longer need to calculate the costs of options. We then only need to perform analyses.

If you take the same combination from two different calculation moments you can compare where the cost differences come from. We can do this on component level, item level, but also on material, labor, and overhead level. However, in order to do this comparison you really need to compare apples with apples (so the exact same combination), and the complete BOM is needed.

In order to implement this method, you need to let the system calculate the total cost price of all the 2 million combinations using the MLOs.

We could still apply the base price in the same way that we do now, including all current analyses. If there are differences in the base price, these can already be explained by these current analyses.

Making all possible combinations is a bit difficult to develop. In addition, something needs to be developed such that the system calculates the total price of all 2 million combinations automatically. Such that you do not have to manually enter a calculation order for all 2 million combinations.

H.2.4 Employee D (CA)

Structured Approach

Task automation

Automation would definitely lead to a time saving.

Linking features to options is necessary for automation.

I have a strong preference for the weighted distribution method. In particular because the other two are less accurate. And because you not only rely on a general rule, but also use the knowledge of the option pricing employee.

If you have a component that only costs 5 euros, then I would say that it does not matter so much, then you could also apply the EQC method. But when concerning larger amounts, I think it needs to be more precise.

I also do not think that the weights will deviate greatly over several years. For the most part, allocations must be made for the same options every year. Therefore, I think that you have to determine these weightings once and that it just needs to be reviewed in the subsequent years. Reviewing these weights can be done before the first of January, so before the calculations start. In this way, if the new MLO prices apply (on 1 January), the option cost prices can be calculated much faster because all the preliminary work has already been done.

I do not prefer the allocation method where all costs are allocated to one option because then you are much more inaccurate. Then it is possible that you assign no costs to an option, while it actually does have costs. As a result, you are further away from the truth.

The table with zero-value options can also be updated before the first of January.

No cultural changes are needed because you would still have option prices.

Task composition / Triage

In the end we are responsible for calculating the right cost prices. If everything is automated then I would prefer to have no common options.

Task elimination

This will not lead to a lot of time saving.

The focus for accelerating needs to be more on the calculation part of the process.

Exception

It is also possible to calculate the exceptions, the ones that need to be calculated before the normal process flow, before the first of January. Because there will be no major differences. Certainly if the amounts involved are relatively small. If you then include these amounts with other type 2 calculations, any deviations will be taken into account.

In this way you can already perform some tasks before the first of January.

Creative Approach

Offer less options

This is quite simplistic. I wonder if this has ever been looked at.

Our flexibility is the most important, we want to offer a lot. And we do not want to receive more special requests, because they also take a lot of time.

Price less options

This is not my preference, because I wonder how much time you will save with this.

Incorporate frequently chosen options in base vehicle

You still have to calculate the same number of options. I do not see any advantages.

Fixed percentage on top of base price

With this idea you may underestimate or overestimate many vehicles. You will be fine in the mix (on average). But it is possible that orders will be approved or rejected, while the decision based on correct data could be different. That is why I do not think that this is the direction to be taken.

It can also be that you will lose orders because of this.

Only price M&S options

This is certainly not preferable if I compare it to automation.

I also do not think that a time saving will be achieved.

Total cost price of each order

I think you have a timing issue here. We want to have short lead times. And I do not think that this will work with this process, because we have those night interfaces.

It should work really fast. Therefore, large system adjustments would be necessary.

IJ's method

People want flexibility in what we offer. I do not think the organization sees this as a solution.

Calculate "main" option costs for all possible combinations of consequences

I find this difficult to assess. However, this also still requires system adjustments.

Total cost price for all combinations of whole vehicle

I think this is a pretty good idea. Of all creative ideas, I think this is the best one. The only question is whether it is possible from an IT perspective.

You no longer know individual option prices. We are still able to know the total option price per order if we continue to use a base vehicle price. Then the difference between the total price and the base price is the total option cost price.

To see certain price differences, they will have to request multiple orders. To be able to perform analyses properly, you actually need the BOM for every possible combination. The only question is whether this is technically feasible. Because this would involve a lot of data. I think you have to save this data from several years to be able to perform analyses over several years.

In terms of accuracy, this one is the best solution.

This idea would require quite some system adjustments, but also some possible cultural changes.

H.2.5 Employee E (IT Department)

Structured Approach

Task automation

If everything is automated, it will only take a fraction of the current time. It is not difficult and time consuming to implement.

If weighted allocation would not result in a larger accuracy, then why would you spend extra time on assigning these weights. But I think that it does make a difference.

With weighted allocation you still need to puzzle. It would indeed help if historical data would be provided regarding the weightings.

Creative Approach

Offer less options

I think this idea will not be implemented, is not doable.

Price less options

This one is doable, because you still offer a cost price to all options.

Incorporate frequently chosen options in base vehicle

This will not result in any time saving.

Fixed percentage on top of base price

This is very risky. Because on orders with a lot of options, we will make a loss. While orders with few options will be confronted with a higher price, which may lead to losing orders.

Total cost price for all combinations of whole vehicle

Then you no longer look at options, but at the whole vehicle.

I think this is a very interesting approach, since it will result in the most accurate costs.

Why would this not work for M&S? Because they really want to operate based on options? From my point of view this method could work. But from an M&S perspective apparently not, since they use options to make their lives easier.

If you have the total costs for all combinations, is it then not possible to retrieve the individual option prices from this? Author: No this is not possible, due to the coherence. This option price then only applies in combination with all other options. It may be that you get several different prices for one option for each combination with other options.

H.2.6 Employee F (IT Department)

Structured Approach

Task automation

I think this is a good solution direction.

Automation is possible within AB's current system or in another program such as Excel, Access or Matlab.

The system itself can indicate for which calculation numbers type 3 calculations are required.

This solution would not require a lot of effort from a programmer. Since you have already devised the concept, which often takes the most time.

For this solution no cultural changes are needed.

Weighted allocation could be based on historic data.

Important for the weighted allocation method is that the weights are not fixed within the code, but that the user is able to fill in a table which is then used by the program. Such that the code does not need to be changed every year when weights change.

The structured approach belongs to the less effort, high impact quadrant.

Creative Approach

Offer less options

I think this is really interesting. Because why do we offer options that are hardly ever sold?

Every option that you take out is one less to calculate.

Advantage is that less options need to be calculated. But the disadvantage is that it is not customer friendly, and therefore probably not desirable from a sales perspective.

Price less options

Basically on the ones you are allowed to have a small deviation, do not calculate exactly. I think this is an interesting one.

So not only based on the quantity sold, but also on the price.

Fixed percentage on top of base price

I think this would be possible.

Only price M&S options

I do not know a lot about this.

Total cost price of each order

I do not think that it is a good approach to no longer price options, since they will always want to know this. The mentality will not change.

IJ's method

I think this is very difficult to realize.

Total cost price for all combinations of whole vehicle

Then you get an enormous amount of possibilities, which is not desirable.

H.2.7 Employee G (M&S)

Structured Approach

How option prices are calculated does not matter from an M&S perspective. As long as the costs are shown per option.

Creative Approach

Offer less options

This is definitely a no-go. As AB we want to offer and sell a maximum amount of options. If you offer fewer options because then option prices are easier to calculate, you will lose a small amount of margin. If you then still want to offer these options to the customer, they need to request a special order, for which we have no capacity since these special orders take more time.

Price less options

This is possible from an M&S perspective. However, it entails a risk for CA. For example, if the purchasing policy changes, or something becomes a make product instead of a buy product, the prices can change drastically.

Incorporate frequently chosen options in base vehicle

Then you are going to make our base vehicle more expensive. While we are searching for cost-saving aspects for the base vehicle, which is an assignment of the board. Because when the cost price decreases with the same selling price, the margin increases.

Moreover, when incorporating more options in the base vehicle, margin may be lost. Because a discount of approximately 50% is given on the base vehicle. While about 30% discount is given on options. By putting more options in the base, you will therefore also give more discount on this, which reduces the margin.

Fixed percentage on top of base price

From a marketing perspective this is not a good idea. You will lose orders, and you will lose margin on orders. Because customers must pay too much or too little.

With fleet sales it is about that one euro that you can be cheaper, so you really cannot work with a general percentage for all options.

Only price M&S options

You then need to use averages.

Total cost price of each order

This could be possible. But then the way of thinking at M&S would have to be completely changed. People want to know what the costs are of adding an option. With this method you will not be able to estimate in advance what these costs will be. This would then only be possible by requesting multiple orders with different options.

For this to work you need large system adjustments and the way of working needs to be changed. I do not see this happening in the short-term.

IJ's method

In comparison with IJ we have a lot more options, with many choice possibilities.

Sometimes an option has a fixed consequence, but in most cases it does not. Therefore, this would only apply to a very small amount of options, and would entail a lot of administrative work. Because fixed consequences can be different for each vehicle type. Therefore, I do not think that this leads to a time saving.

In addition, from my perspective limiting the customer's choice is certainly not desirable.

Calculate "main" option costs for all possible combinations of consequences

It is not easy to get rid of the double costs.

Total cost price for all combinations of whole vehicle

Then you would indeed have a lot of possible combinations.

I think that this will bring a lot of extra administration. Because you cannot predict in advance what something will do. People will still want to know what the costs are of an option. Because this makes it easier to explain to the customer where a price difference comes from.

In addition, also for this method large system adjustments are needed as well as cultural change.

Something that I also think is possible in the far future is to offer option packages. This would really shorten the time to calculate the options, since only the price of all the option packages has to be calculated. However, this limits the choice of the customers. If the options that now require allocation are in the same package, this allocation would no longer be necessary. But this is really for the future. I don't see this happening quickly.

H.2.8 Employee H (M&S)

Structured Approach

Task automation

This method is definitely doable, and can be implemented without deviating from the current process. It would really help the option pricing employee.

Creative Approach

Offer less options

It is basically not done to do something which results in offering less options to the customers.

Price less options

Is possible. However, look at the desired accuracy and whether this approach complies to that.

Incorporate frequently chosen options in base vehicle

You still have to calculate the same amount of options. Therefore, it does not lead to a time saving.

Fixed percentage on top of base price

Nonsense, I do not like this at all. Sometimes the total cost of all options could be 5,000 euros but also 30,000 euros. With these 30,000 euros more discount can be given than with cheaper options. But when an average percentage is applied, all orders would imply the same costs for all options, which is certainly not the case. This could therefore lead to losing orders.

Only price M&S options

It is true that M&S do not always price the different consequences, while there is a different cost price.

Total cost price of each order

The system should really be adjusted for this. Because the system calculator currently uses the cost price per option and also shows these prices.

However, it is possible, but only if this total cost price is calculated very very fast. Then some kind of service must be provided to the system that calculates the total cost price.

Disadvantage is that the transparency would decline, which might make explaining things to the customer more difficult. Because currently they can see the selling price and cost price of each option next to each other. If this approach would be implemented, they would need to find out by trial and error where extra costs come from (from which option).

IJ's method

Might be possible.

Calculate "main" option costs for all possible combinations of consequences

It indeed has the disadvantage of double counting.

Total cost price for all combinations of whole vehicle

Sounds nice, but then you would need to save all these combinations, which requires a lot of data storage. This is really gigantic. It also has some of the disadvantages of the 'total cost price of each order' method.

Appendix I: Examples of total option order costs for all three allocation methods

Tables I.1, I.2, I.3, I.4, and I.5 show the total option costs for the respective order for each method together with the method's deviation from the actual costs and the current method costs. These are examples of both orders with many options and orders with fewer options.

Table I.1: Total option order costs for each method, and the deviation of each method with the actual costs and the current method costs (Order with many options: 102389)

Method	Total option order costs	Deviation with actual	Deviation with Current
Actual	€15,253.23		
Current method	€15,666.29	€413.06	
EQC method	€15,673.03	€419.80	€6.74
All-to-1 method	€15,651.06	€397.83	- €15.23
Weighted allocation method	€15,666.01	€412.78	- €0.28

Note: The time of calculating the option prices was slightly different from the time of calculating the actual costs of this example. Therefore, the difference with the actual may be due to a timing effect.

Note: Exactly the same information was used for all 4 calculation methods, so no time effect can be of influence here.

Table I.2: Total option order costs for each method, and the deviation of each method with the actual costs and the current method costs (Order with many options: 049601)

Method	Total option order costs	Deviation with actual	Deviation with Current
Actual	€13,805.15		
Current method	€13,992.79	€187.64	
EQC method	€14,001.55	€196.40	€8.76
All-to-1 method	€13,992.79	€187.64	€0
Weighted allocation method	€13,992.79	€187.64	€0

Note: The time of calculating the option prices was slightly different from the time of calculating the actual costs of this example. Therefore, the difference with the actual may be due to a timing effect.

Note: Exactly the same information was used for all 4 calculation methods, so no time effect can be of influence here.

Table I.3: Total option order costs for each method, and the deviation of each method with the actual costs and the current method costs (Order with many options: 100570)

Method	Total option order costs	Deviation with actual	Deviation with Current
Actual	€12,276.19		
Current method	€12,667.37	€391.18	
EQC method	€12,676.13	€399.94	€8.76
All-to-1 method	€12,667.37	€391.18	€0
Weighted allocation method	€12,667.37	€391.18	€0

Note: The time of calculating the option prices was slightly different from the time of calculating the actual costs of this example. Therefore, the difference with the actual may be due to a timing effect.

Note: Exactly the same information was used for all 4 calculation methods, so no time effect can be of influence here.

Table I.4: Total option order costs for each method, and the deviation of each method with the actual costs and the current method costs (Order with fewer options: 039188)

Method	Total option order costs	Deviation with actual	Deviation with Current
Actual	€2712.74		
Current method	€2584.58	- €128.16	
EQC method	€2584.58	- €128.16	€0
All-to-1 method	€2584.58	- €128.16	€0
Weighted allocation method	€2584.58	- €128.16	€0

Note: The time of calculating the option prices was slightly different from the time of calculating the actual costs of this example. Therefore, the difference with the actual may be due to a timing effect.

Note: Exactly the same information was used for all 4 calculation methods, so no time effect can be of influence here.

Table I.5: Total option order costs for each method, and the deviation of each method with the actual costs and the current method costs (Order with fewer options: 049762)

Method	Total option order costs	Deviation with actual	Deviation with Current
Actual	€3143.49		
Current method	€3141.86	- €1.63	
EQC method	€3141.86	- €1.63	€0
All-to-1 method	€3141.86	- €1.63	€0
Weighted allocation method	€3141.86	- €1.63	€0

Note: The time of calculating the option prices was slightly different from the time of calculating the actual costs of this example. Therefore, the difference with the actual may be due to a timing effect.

Note: Exactly the same information was used for all 4 calculation methods, so no time effect can be of influence here.