INDIRECT COST IN SHOULD COST CALCULATIONS – HOW CARMAKER'S COST ENGINEERS SEE IT

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ABSTRACT

In a world of intense competition, automotive manufacturers are continually increasing their outsourcing activities and, as a result, automotive companies have built extensive cost engineering departments within their organisations. Staff in these units provide Should Cost Calculations for externally manufactured components, which are utilized as supplier targets to support buyers in fact-based negotiations. This paper aims to explore potential differences in the direct and indirect cost categories in the context of Should Cost Calculations. Based on a sample survey among cost engineers, it was possible to determine differences in cost knowledge, risk of suppliers concealing unjustified costs, level of analytical detail, and suitability to conduct fact-based negotiations depending on the length of job experience, industry, and especially the type of costs. The evaluation is carried out through analysis of variance, and a contingency table homogeneity test, and the results are presented using correspondence maps. The results show significant differences between the direct and indirect cost categories, including a higher risk of cost hiding and a lower suitability for price negotiations for the indirect cost category.

KEY WORDS

analysis of variance, automotive industry, correspondence analysis, cost engineering, direct cost, indirect cost, questionnaire survey, Should Cost Calculation

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1 INTRODUCTION

In a world of growing global competition, carmakers increased their outsourcing activities within the last decades. Today externally sourced components contribute between 50–70% to the total cost structure of a car (Large, 2009) while carmakers' annual purchase volumes have climbed up to hundreds of billion USD (Gramatins and Zabota, 2007; Mayer and

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Volk, 2017). One consequence of this development is the need for highly coordinated supply chains that help increase carmaker productivity (Douglas and Griffin, 1996). Even by realizing small cost improvements on a purchased component car manufacturers can realize huge lifetime savings (Batson, 2011). For that reason, automakers have built up cost engineering organizations. A crucial task of these divisions is to provide Should Cost Calculations (SCCs) before supplier nomination to set challenging sourcing targets and to support purchasing in fact-based negotiations. Although cost reduction is the ultimate goal here as well, this paper is not focussing on direct cost modelling and cost optimisation as it is described in academic literature e.g. Bolfek (2021).

Few researchers have described in detail the process of how carmaker cost engineers create these analytic bottom-up calculations and what type of information requirements are needed to generate them (Roy et al., 2011). These authors focussed primarily on the direct cost categories in SCCs. Hence it remains unclear if and on what level of analytic detail indirect cost categories are currently considered in SCCs. This is surprising since the impact of modern manufacturing processes on indirect activities and indirect cost has been recognized and deeply discussed by economic researchers in the field of cost accounting already in the 80s of last century (Cooper and Kaplan, 1988a; Cooper and Kaplan, 1988b).

Study Hoffjan and Lührs (2010), which involved key account managers of automotive suppliers confirmed in expert interviews that automotive suppliers provide biased and manipulated cost breakdown information to protect their profit margins. Authors state that there is a higher chance to generate additional profits by not communicating profits transparently to their customers but by including them in the overheads of to-be-delivered cost breakdowns (Hoffjan and Lührs, 2010). This indicates a certain "black box character" and a potential weakness in carmakers SCC. Tah et al. (1994) provide survey points to the fact that methods of indirect cost estimation used in practice are highly subjective; statistical methods are used rarely in this field. Deevski (2019) focuses on indirect cost determination methods generally. A survey addressed to companies of different sizes and industries on cost allocation methods used in company practice is provided there. The management of indirect costs is identified in the paper as one of the most complex areas to manage. Among their results, Farooq and Jibran (2018) note that studies dealing with indirect costs are a literature gap, particularly in developing countries, and further research is desirable to address the determinants of indirect costs.

The aim of this paper is to identify potential differences in the perception of direct and indirect costs by cost engineers engaged in SCC. This objective is decomposed into the following research questions:

- RQ_1: Is the carmaker's cost engineers' cost knowledge in indirect cost categories lower compared to the direct cost categories?
- RQ_2: Do carmaker's cost engineers perceive a higher risk, that not justified cost or profits are potentially hidden within the indirect cost categories?
- RQ_3: Do car manufacturers' cost engineers perform their SCCs within different levels of analytic detail within direct and indirect cost categories?
- RQ_4: How do carmaker's cost engineers rate the suitability to conduct fact-based negotiations within direct and indirect cost categories of their SCC?

Why are these questions important? The cost engineer's cost knowledge includes two dimensions. The first dimension is based on the individual knowledge of a cost engineer concerning type, size, and relationship among different cost elements, that have a crucial impact on a specific cost type or category. The second dimension refers to cost knowledge management (e.g. specific cost libraries or databases) in cost engineering departments, that enables cost engineers to access reliable and accurate input factors and cost rates for Should Costing. Analytic detail refers to a formal and transparent calculation of cost in a cost category based on multiple cost elements and variables. Analytic detail is not given in case costs are rather determined based on rules of thumb instead of applying an analytic and repeatable arithmetic methodology. Finally, the suitability to conduct fact-based negotiations refers to the possibility of discussing identified cost gaps between Should Cost Calculation and the supplier's price breakdown in a detailed and transparent manner.

2 MATERIAL

In order to collect individual responses from a global population of cost engineers an electronic survey was created to place it within an appropriate internet channel, to ensure a convenient and efficient process of data collection and analysis. The data was collected within the timeframe May–July 2022. Theoretically, approximately 6000 cost engineers were contacted (see below), of whom 128 completed the questionnaire.

The survey was placed within a channel on LinkedIn, which is administered by the "Society of Product Cost Engineering and Analytics" (SPCEA) in which more than 6000 cost engineering professionals perform networking and share information dedicated to the field of cost engineering (SPCEA, 2022a). The SPCEA is a non-profit organization which is focusing on knowledge sharing, education, networking, and the establishment of standards within the field of cost engineering. This includes promotion and understanding of cost engineering principles and methods (SPCEA, 2022b). Due to the reason of huge number of active cost engineering experts – especially with automotive and aerospace backgrounds – the platform is frequently used by researchers to place surveys that are dedicated to the field of cost engineering.

In the automotive industry, direct and indirect costs can be distinguished as follows. Direct costs include Raw material costs (D_1), which include costs for raw materials (e.g. specific type of resin). Material costs are a direct cost category since they can be directly traced to the calculated product based on the to be considered weight. Direct labour costs (D_2) include the cost of direct labour activities (e.g. assemblers, machine operators). Based on different qualification levels for different operations they are directly traced to the calculated product. The cost allocation to the calculated product is performed by considering fully fringed hourly rates, headcount and required process cycle times of the required manufacturing processes. Finally, Machine costs (D_3) include costs of depreciation, financing, machine capital, cost for energy, consumables, spare parts, and maintenance. The reason for considering machine costs within the direct cost categories is based on the cost engineering practice to trace machine costs in a direct and activity-based manner to the calculated product. Annual machine budgets are aggregated in individual machine cost centres within the first steps. Afterward, single-machine hourly rates can be determined by dividing the total annual cost of single-machine cost centres by total productive machine hours. That way machine cost can be traced in a direct and activity-based manner to the calculated product based on the manufacturing cycle times of to be considered manufacturing processes.

Among indirect costs, two categories will be considered: Material- and Manufacturing overheads. Material overheads (I_1) include overheads on raw materials and purchased components. This includes the cost of warehouses, that are required to store incoming goods. The cost to pay salaries for indirect labour, which performs activities in material ordering, planning, inspection, and storage is also considered in this cost category. The second category of indirect costs is Manufacturing overheads (I_2) which includes all residual overheads of manufacturing within a factory, which are not covered in the machine hourly rates. This includes exemplarily salaries of plant management and indirect labour, which is not covered in the material overheads. Another typical example, that falls into this cost category is the costs of the finished goods warehouse or shared facilities.

The survey structure contained a total of 6 major questions. The initial two questions were used to determine the work experience of cost engineers and in which industries they are employed. The remaining 4 questions rate:

- Y_1 – cost engineer's cost knowledge within the different cost categories,
- Y_2 – perceived risk that suppliers hide successfully not acceptable costs in a cost category,
- Y_3 – level of analytical detail that is applied in the cost category,
- Y_4 – suitability to conduct fact-based negotiations within the cost categories,

where the participants had to provide their Likert Scale ratings with values between 1–5 for direct cost categories D_1, D_2, and D_3 and indirect cost categories I_1 and I_2 defined in the previous section.

For each respondent and all Y_i, the direct cost score is determined as the average of the values for D_1 to D_3 and the indirect cost score as the average of the values for I_1 and I_2. For the initial factor analysis of variance, a "Cost type" factor was constructed with "Direct" and "Indirect" levels, based on cost score type. In this manner, data for a three-way analysis of variance were prepared consisting of factors Cost type, Industry (with levels Aerospace, Automotive-carmaker, Automotive-supplier, Other), and Experience (with levels Three and less years of praxis; More than three years of praxis).

Based on the results of the factor analysis of variance, a more homogenous group of respondents was selected, consisting of 47 respondents. Only these responses were finally taken into consideration for further analysis in case participants were marked to be employed by a carmaker. Whenever participants indicated to work for an automotive supplier or in another industry their responses were not considered within the final analysis. In addition to that responses were excluded, whenever participants declared to have three or less years of job experience within the field of cost engineering. Within this sample, two respondents were excluded due to distortions in response quality (they answered all questions with the same level of response), resulting in the final sample of 45 respondents for analysis in the contingency table.

3 METHODS

Three-way analysis of variance was performed in the form of a general linear model. Schematically, we can write

$$\text{Score}_{ijk} = \text{Cost type}_i + \text{Experience}_j + \\ + \text{Industry}_k + e_{ijk},$$

where e stays for error term, $i = 1, 2$, $j = 1, 2$ and $k = 1, \ldots, 4$. Since the score is an average of only a few values, the normality assumed for this analysis is only approximate. After the determination of the significance of the factor, post-hoc analysis was employed using the least significant difference approach. For the reduced dataset we tested the following hypotheses:

- H_1: Cost engineers rate their cost knowledge higher in indirect cost categories compared to the direct cost categories of their SCC.
- H_2: Cost engineers rate the risk that a supplier is successfully hiding not acceptable cost or profit higher within indirect cost categories compared to the direct cost categories of their SCC.
- H_3: Cost engineers rate the level of analytic detail lower in indirect cost categories of their SCC compared to direct cost categories.
- H_4: Cost engineers rate the suitability to conduct fact-based negotiations lower in indirect cost categories compared to direct cost categories of their SCC.

For this purpose, we employed the test for homogeneity in a contingency table. For this test we assume fixed row counts (in rows different cost types are placed). Technically, we test whether the multinomial distributions in the rows of the contingency table are identical or not. The null hypothesis is that the multinomial distributions are the same; the alternative is that they are not, which can be represented by our hypotheses H_1 to H_4. Testing statistics is the same as for χ^2-test of independence in the contingency table (Walliman, 2018). This test assumes theoretical frequencies greater than 5 in 80% of cases and greater than 2 in the remaining 20% of cases. If the null hypothesis is rejected, it is necessary to find out where the homogeneity violation lies. For this purpose, we have used correspondence analysis, the outputs of which will allow us to describe the relationship between the row and column variables of the contingency table using the so-called biplot (Greenacre, 2007). Specifically, we used a symmetric model applied according to Lorenzo-Seva et al. (2009).

Statistical testing was performed on a significance level of 0.05. The general linear model was estimated in the software Genstat 23, and data manipulation, homogeneity tests in a contingency table, and correspondence analysis were performed in the computational system Matlab R2023b.

4 RESULTS

A description of the surveyed dataset is given in Tab. 1. Cost engineers from the Automotive-carmaker industry with longer experience predominate (38.5%). Less experienced experts make up about a quarter of the respondents. Of note is the low proportion of cost engineers with shorter experience in the Automotive-carmakers industry compared to other industries. This may mean that cost engineers find employment in the Automotive-carmakers industry only with more experience in the same position in another industry, as the job of a cost engineer in the Automotive-carmakers industry is considerably more demanding.

Tab. 1: Composition of original dataset presented by contingency table, in %

Experience	Auto-carmaker	Auto-supplier	Aero space	Other	Total
Three years and less	3	7	6	8	24
More than three years	39	15	7	15	76
Total	42	22	13	23	100

Three-way analysis of variance is applied to data for variables $Y_1, \ldots, Y_4$ gradually. All three factors are statistically significant when assessing cost engineer's cost knowledge within the different cost categories, see Tab. 2. Automotive-carmaker industry with a predicted score of 2.87 is not statistically different from the Aerospace industry (2.72) and these industries significantly differ from the Automotive-supplier and Other industries with scores 3.37 and 3.12. Significantly lower scores for Automotive-carmaker and Aerospace industries are given by more complex production based on many components. Cost engineers with three and less years of experience evaluate themselves by a significantly lower predicted score (2.65) than cost engineers with longer practice (score of 3.14). This result indicates a healthy self-criticism of less experienced cost engineers and suggests the credibility of the questionnaire survey. The predicted score for indirect cost knowledge 2.21 is significantly lower than the score for direct cost knowledge (3.83) of cost engineers. This preliminary result is consistent with our hypotheses.

Tab. 2: ANOVA table for Y_1 – cost engineer's cost knowledge within the different cost categories

Factor	d.f.	s.s.	m.s.	F	p
Industry	3	10.63	3.54	3.81	0.011
Experience	1	9.77	9.77	10.52	0.001
Cost type	1	160.40	160.40	172.64	< 0.001
Residual	238	221.13	0.93		
Total	243	401.93	1.65		

Statistically significant differences between predicted scores of indirect and direct costs are detected in all cases, see Tab. 3: the risk that a supplier is successfully hiding not acceptable cost has a predicted score of 4.89 for indirect cost vs. 2.96 for direct cost; score of analytic detail for indirect cost 2.13 is significantly lower than the score for direct cost 3.81; score of suitability to conduct fact-based negotiations for indirect cost 2.01 is significantly lower than score for direct cost 3.74. For different industries were statistically significant differences detected between the Aerospace industry (2.67) and other industries (Automotive-carmaker 3.00, Automotive-supplier 3.18, and Other 2.92) in the case of analytic detail level. Suitability to conduct fact-based negotiations is significantly lower in the Aerospace industry (2.46) than in the Automotive-carmaker (2.82) and Other (2.87), and these industries have significantly lower scores than the Automotive-supplier industry with a predicted score of 3.21. Note that a complete overview of predicted scores is present in Tab. 4.

Tab. 3: Statistical significance of factors related to variables $Y_1, \dots, Y_4$ expressed by p-values

Factor	Y_1	Y_2	Y_3	Y_4
Industry	0.011	0.744	0.036	0.003
Experience	0.001	0.489	0.215	0.278
Cost type	< 0.001	< 0.001	< 0.001	< 0.001

Tab. 4: Predicted scores for all factors related to variables $Y_1, \dots, Y_4$

Factor	**Factor levels**	Y_1	Y_2	Y_3	Y_4
Industry	Aerospace	2.73	3.57	2.67	2.46
	Automotive-carmaker	2.87	3.74	3.00	2.82
	Automotive-supplier	3.37	3.62	3.18	3.21
	Other	3.13	3.66	2.92	2.87
Experience	More than three years	3.14	3.65	3.02	2.91
	Three years and less	2.65	3.73	2.85	2.75
CostType	Direct costs	3.83	2.96	3.83	3.74
	Indirect costs	2.21	4.39	2.13	2.01

Overall, the results of the analysis of variance indicate a different assessment of direct and indirect costs across all questions examined. In addition, cost engineers with shorter experience self-critically rate their knowledge as not as extensive as their colleagues with longer experience. Since it usually takes three years to have full job experience and knowledge to provide independent Should Cost Calculations, ratings from potential newcomers could potentially distort the feedback of the entire sample. It should also be noted that cost engineers working for carmakers have a different view of their level of knowledge and have a different assessment of suitability to conduct fact-based negotiations than cost engineers working for carmaker suppliers. This may be due to the much more varied range of problems dealt with by carmakers, where suppliers only focus on a specific part of production. Thus, cost engineers working for suppliers may indeed have more knowledge to apply in fact-based negotiations, but only within a narrowly defined range of products. For these reasons, in the following detailed analysis, we will focus only on respondents with more than three years of experience and exclusively employed by carmakers.

We use a specifically defined set of respondents for detailed analysis using contingency tables and homogeneity tests of the underlying multinomial distribution. Indicative characteristics using median ratings of each type of cost for the research questions are shown in Tab. 5. Indirect costs (Material overheads and Manufacturing overheads) are visibly differentiated here, however there is also variability between direct cost types.

Tab. 5: Medians of assessment of different cost types for particular research questions

Cost type	Y_1	Y_2	Y_3	Y_4
Raw material cost	3	3	3	3
Direct labour cost	4	2	4	4
Machine cost	3	3	4	3
Material overheads	2	4	2	2
Manufacturing overheads	2	5	1	1

Before testing, we verified that the assumptions about the theoretical frequencies were met in all cases. The only case of theoretical frequencies less than 5 (but greater than 2) occurred in the case of the assessment of the risk that a supplier is successfully hiding not acceptable cost. Cost engineers were less likely

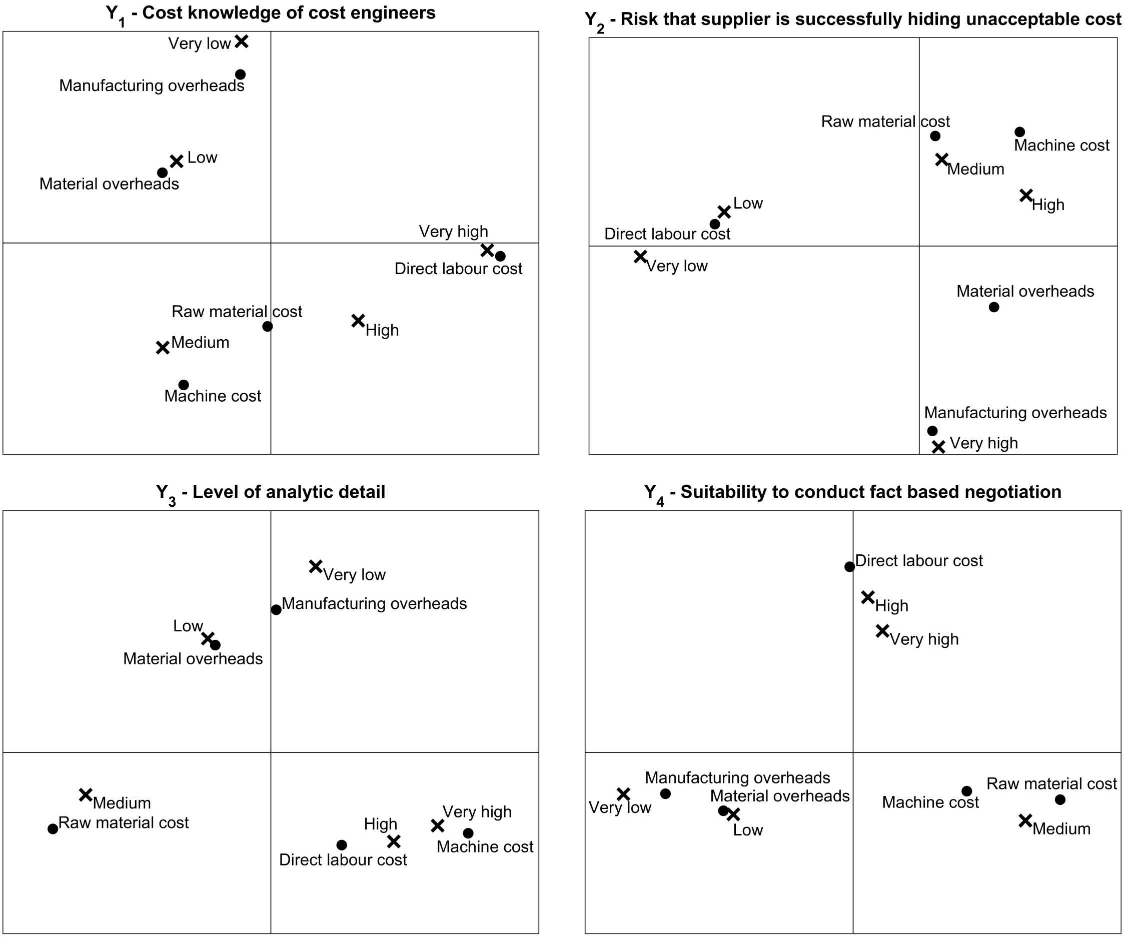

Fig. 1: Correspondence maps for tested hypotheses

to give a rating of "Very low" for all cost categories, reflecting their liability.

The null hypothesis that "Cost engineers evaluate their cost knowledge equally in the indirect cost categories as in the direct cost categories of their SCC" was rejected with $p < 0.001$ and $\chi^2 = 157.5$. We use the output of the correspondence analysis in the form of the correspondence map in Fig. 1, top-left graph, to explain where the differences lie for each type of cost. Knowledge of Direct labour cost is rated as very high, knowledge of Raw material cost as high to medium, and knowledge of Machine cost as a medium. In contrast, for indirect costs, cost engineers typically rate their knowledge of Material overheads as low and their knowledge of Manufacturing overheads as very low.

The next null hypothesis "Cost engineers rate the risk that a supplier is successfully hiding not acceptable cost or profit equally in indirect cost categories as in the direct cost categories of their SCC" was rejected with $p < 0.001$ and $\chi^2 = 214.7$. In Fig. 1, the top-right graph we can see that the low risk that a supplier is successfully hiding not acceptable costs is only associated with Direct labour costs. This risk is medium for Raw material cost and medium to high for Machine cost. For Indirect cost, the risk is high to very high for Material overheads, and for Manufacturing overheads the risk is typically very high.

After rejecting the null hypothesis "Cost engineers rate the level of analytic detail equally in indirect cost categories of their SCC as in direct cost categories" ($p < 0.001$ and $\chi^2 = 240.0$) we can identify very high analytic detail for Machine cost, high for Direct labour cost and medium for Raw material cost. Manufacturing overheads are associated with very low and Material overheads with low analytical detail (Fig. 1, bottom-left graph).

The last null hypothesis "Cost engineers rate the suitability to conduct fact-based negotiations equally in indirect cost categories as in direct cost categories of their SCC" was also rejected ($p < 0.001$ and $\chi^2 = 205.0$). With the help of Fig. 1, bottom-right graph, we can conclude that the suitability to conduct fact-based negotiations is high for Direct labour cost and medium for Raw material cost and Machine cost. For indirect costs, we get that the suitability to conduct fact-based negotiations is low for Material overheads and very low for Manufacturing overheads.

The findings highlighted in this section have shown significant differences in how carmaker's cost engineers rate direct- compared to indirect cost categories to be considered in their Should Cost Calculations. Cost Engineers indicated to have a lower cost knowledge and to perceive a higher risk that suppliers hide unjustified costs in their price breakdowns. In addition to that cost engineers declared to perform a lower level of analytic detail and see a lower suitability to conduct fact-based negotiations in indirect compared to direct cost categories in their Should Cost Calculations.

5 DISCUSSION

Although statistically significant differences could be identified among the cost categories within the different investigated topics Y_i, the real causalities standing behind the identified statistical relationships are missing and subject to readers' interpretation. Hence the question might be raised as to why the specific pattern in ratings could be detected that finally resulted within the statistical findings. In order to answer this question, qualitative research is needed. Semi-structured interviews with experts in the field of cost engineering could explore and investigate the root causes and real causalities of the observed phenomena and can generate a deeper understanding. As a starting point for these interviews, the statistical findings of this paper could be presented to field experts to ask them to give their comments and interpretations. Furthermore, their knowledge could be used to generate ideas that focus on improving the calculation of indirect cost categories in Should Cost Calculations. A consolidation of their quantitative feedback could finally result in an analysis that identifies, addresses, and mitigates potential weaknesses of currently applied cost estimation techniques, that are utilized to consider material- and manufacturing costs in Should Cost Calculations.

Research conducted using a questionnaire survey may raise doubts about its relevance if the respondents are not sufficiently representative and competent. Random selection is a very important criterion to ensure the representability of survey data. For that reason, the previously introduced cost engineering channel on LinkedIn which is administered by the Society of Product Cost Engineering and Analytics has been recognized as the idle platform to place the electronic anonymous survey. Based on a review of the population it is obvious, that automotive cost engineers hold a large fraction of the total international community. The members of this community work in different worldwide regions, companies, and industries including the automotive industry. Since the channel is not focussing on a single carmaker or a certain group of carmakers it may be assumed that survey participants and dedicated responses were randomly selected from an international population of cost engineers, that are employed at different global acting automotive OEMs. Though the study was fully anonymous, and most survey participants provided anonymous feedback, some utilized the chance to provide their contact data, to indicate their willingness to attend potential follow-up interviews. That way it may be at least indirectly confirmed that a minimum of 3 European and 2 US American carmakers are represented within the study. Furthermore, it may be confirmed that a broad mix of nationalities is represented in the study.

Similarly focused research by other authors is rarely available. Indirect costs are elaborated as a challenging problem for management in Deevski (2019), where a simple mathematical model of department cost allocation is introduced. The author concludes in line with our findings that indirect costs, in the sense of the most detailed allocation of costs, are "essential to place a competitive product on the market, take effective managerial decisions as well as monitoring company's performance and making strategic analysis". The automotive industry is currently facing enormous pressure on environmental friendliness and sustainability. Related to this are concepts such as full-cost accounting, which seeks to capture the full cost of production. In the context of the automotive industry, this issue has been addressed in a broad literature search by Jasinski et al. (2015). A better knowledge of indirect cost pricing will also help to assess total costs more accurately within full cost accounting.

6 CONCLUSIONS

Overall, we can conclude that the type of cost plays a significant role in the work of carmaker's cost engineers. The research questions posed in the introduction can be answered as follows:

- RQ_1: Knowledge of indirect cost categories is lower compared to the direct cost categories.
- RQ_2: Higher risk, that is not justified cost or profits are potentially hidden, is related within the indirect cost categories.
- RQ_3: Should Cost Calculations is performed for indirect cost categories with a lower level of analytical detail.
- RQ_4: Suitability to conduct fact-based negotiations is lower within indirect cost categories.

Our findings reinforce the impression of existing weaknesses in presently applied methods, that aim to consider supplier's material- and manufacturing overheads in Should Cost Calculations. The results of this paper indicate that there could be a lack of practical approaches that are better suited to decompose and calculate supplier overheads analytically and transparently. A similar gap can be recognized in academic literature. In the context of Should Cost Calculations academic literature is focussing strongly on analytic cost modelling in the context of direct cost categories while it ignores the need for analytic cost modelling within the indirect cost categories. The only recommendation that academic literature highlights to consider indirect cost in Should Cost Calculations is to apply percentage markups on the direct cost elements, without explaining in detail how to calculate these percentage markups analytically and transparently. This is a potential gap in academic research that needs to be filled. In addition to that it might be interesting if cost engineers face similar difficulties in considering appropriate costs for supplier's General and Administrative Expenses (SG&A) and Research and Development (R&D). Since this paper focused on material- and manufacturing overheads that incur within supplier's manufacturing facilities it might be interesting how cost engineers consider SG&A and R&D in their Should Cost Calculations. Since indirect labour might be not only a strong contributor to material-, manufacturing overheads but also to SG&A and R&D it might be interesting if similar results may be detected for these indirect cost categories.

Another implication of our results is that further research could be conducted on the analysis of existing cost estimation techniques without limiting the scope to Should Cost Calculations or a specific industry. The intention could be to identify and probably modify existing cost estimation techniques, which are better suited to consider indirect cost within the cost engineer's SCC. These techniques might potentially increase cost engineers' cost knowledge and the level of analytic detail in which material- and manufacturing overheads are presently considered in Should Cost Calculations. In addition to higher cost knowledge and higher calculation accuracy, further positive side effects could be generated. An increased level of analytic detail might potentially result in a higher suitability to conduct fact-based negotiations. Similarly, it might be possible to lower the risk that suppliers hide not acceptable cost within indirect cost categories of their quote.

Improving methods for estimating indirect costs will entail additional demands for more data acquisition and, in particular, higher data quality concerning cost engineering. An inspiring and ambitious goal stated by Roy (2003) is "to capture and reuse human expertise or knowledge used during the development of a cost estimate". Xu et al. (2012) mention working with data under uncertainty as one of the important aspects of cost engineers' future work. These challenges, however, are confronted with the current problems with the quality of education in general (Chládková et al., 2021) and the declining level of mathematical knowledge, not only in the Czech Republic (Hampel and Viskotová, 2021), for example, but also in Germany (Büchele, 2020). An appropriate mix of statistically based courses integrated into the traditional curricula for engineers in the automotive industry will allow for desirable synergy effects leading to improved indirect cost estimation techniques.

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