»LIGHT COMMERCIAL VEHICLE MANUFACTURER'S STRATEGIES TO MEET CARBON DIOXIDE REGULATIONS POST 2020«

Masterarbeit

zur Erlangung des akademischen Grades „Master of Science (M. Sc.)“ im Studiengang Wirtschaftswissenschaft der Wirtschaftswissenschaftlichen Fakultät der Leibniz Universität Hannover

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1. Introduction

The automotive industry and the manufacturers of light commercial vehicles are currently experiencing a period of dynamic change. This development is primarily driven by increasing urbanization, progressive globalization and ongoing digitalization. In addition there are the so-called megatrends[1], which will generate more and new challenges in the coming years. As can be seen in the figure below, these trends are triggers for a variety of new conditions (or drivers) at different social, economic and political levels. These include discussion about driving restrictions for diesel vehicles, as well as stricter CO_2 regulations and the emergence of new competitors in the context of electromobility.

For manufacturers of light commercial vehicles, it is essential to identify current and future megatrends which may impact on the business environment in order to align and adapt their strategic corporate planning or even their entire business model (Eckert 2014, p. 3).

Figure 1: Problem statement; Source: own illustration[2]

[1] Trends that can lead to long-term changes, which can last for at least 5-10 years or longer Wieden 2016, p. 9
[2] Based on: Löwenberg, Riesen 2011, p. 5

Global warming and related climate change, as well as the scarcity of global oil reserves, represents one of the most important megatrends, which are also triggers of current and future challenges for the automotive industry. This fact is highlighted by the Paris climate protection agreement, which entered into force in November 2016. With this contract, nearly every country worldwide committed to protecting the climate for the first time. The intention of the agreement is to limit global warming to below two degrees Celsius compared to the pre-industrial age. In addition, a balance between the anthropogenic emission of greenhouse gases[3] and the natural absorption of these gases (by vegetation and soils) should be reached in the second half of the century (Erbach 2016, p. 1).

In order to achieve these goals, the reduction of GHG is increasingly being pushed at national and global political levels. In this context, the European Union has set binding targets to reduce emissions caused by anthropogenic activities in the community by at least 40% below the 1990 level by 2030 (Europäische Kommission 2011, p. 11). To achieve this target and a significant reduction, the transport sector, as the second largest emitter of anthropogenic emissions of GHG, is seen as key. The highest share of these transport-related emissions is accounted for by road traffic, which is also the only major sector in the European Union in which GHG emissions are still rising (Umweltbundesamt 2015, p. 70). The CO_2 emissions caused by road traffic are, in particular, due to the combustion process and the burning of petrol and diesel fuels, which are based on fossil energy sources. In total, more than 50% of the global demand for oil is from the transport sector, of which approximately 75% is related to road traffic (International Energy Agency 2011, p. 109).

In order to reduce this high dependency on oil as well as traffic-related CO_2 emissions, some of the strictest CO_2 regulations for passenger cars and light commercial vehicle have been introduced at the European level. From 2020 onwards, CO_2 emission standards specifying an average fleet value of 95 g/km CO_2 for new passenger cars (M_1) and 147 g/km CO_2 for light commercial vehicles (N_1) will be effective. For the period after 2025, additional tightening of these limits is strongly expected.

The manufacturers of light commercial vehicles are particularly affected by these new regulations, since their products are classified as both light commercial vehicles and passenger cars, which are affected by much more stringent CO_2 regulations. To remain competitive in this dynamic environment and to meet the legal CO_2 emission standards, the manufacturer of light commercial vehicles must therefore develop, evaluate and implement innovative and new technical solutions. At a strategic level it is necessary to decide at an early stage which measures to consider and which drive technology to implement in their vehicles, due to the long development and implementation times in the automotive industry.

[3] Abbreviated as "GHG" hereinafter

Research objectives

Against the background of more stringent CO_2 limits worldwide for passenger cars and light commercial vehicles, the identification and evaluation of various options for manufacturers of light commercial vehicles to comply with the new regulations is the target of this work.

A reduction in CO_2 fleet emissions can be achieved with revolutionary innovative technologies (like new powertrain systems) as well as through the further development of existing technologies and conventionally driven vehicles. Manufacturers of light commercial vehicles therefore have various options for reducing a vehicle's CO_2 emissions, such as decreasing its specific energy requirements. Aerodynamic improvements, the reduction of the rolling resistance or more lightweight construction can be used for this end. But more efficient energy conversion through the optimization of the engine and the transmission also has the potential to reduce vehicles' CO_2 emissions.

Given this context, the overall possibilities for the further optimization of conventionally operated vehicles will be examined in this work in order to evaluate whether they are sufficient to meet the legislative CO_2 requirements in place from 2020 onwards. In addition, various alternative drive types are analyzed and compared to identify imperative portfolio extensions. To achieve these objectives, a comprehensive literature review is performed in order to present the current state of research.

The results of these investigations are used for the development of a mathematical optimization model which is intended to serve as a strategic decision support for manufacturers of light commercial vehicles. The model is, on the one hand intended to make the financial impact of the tightening legal framework perceptible, and on the other hand designed to enable analysis of different scenarios in order to derive recommendations for action. Within the scope of the investigations, the following research questions will be investigated and answered to close the identified research gap[4]:

Table 1: Research Questions; Source: own illustration

No.	Type of question	Research questions
1.	**Design**	*Is the optimization of conventionally operated vehicles sufficient to comply with the 2020 CO_2 legislation*?
2.	**Forecast**	*What is the optimal product portfolio for a light commercial vehicle manufacturer in the future*?

[4] This is focused on in chapter 3 (Methodical approach and research design)

Organization of the Research

The following procedure has been selected to achieve the above mentioned objectives:

The motivation and aim of this thesis have been described during the introduction (*chapter 1*), next, the theoretical foundations as well as the relevant legal framework for automotive manufacturers will be described in chapter 2. The relationship between carbon dioxide and global temperature, the historical development and main contributors of this GHG will be explained, as well as the international action taken on climate change (chapter 2.1). This generates a basic understanding of why CO_2 emissions from vehicles are regulated and why these regulations will be increasingly strengthened in the near future. In order to illustrate which vehicle types are affected by these regulations, the application areas concerning commercial vehicles as well as their demarcation for passenger vehicles is presented in section 2.2. Based on this, the legal regulations for CO_2 emissions of vehicles will be shown (2.3).

Subsequently, the methodological approach of this work, which is based on the design science research methodology following PEFFERS ET AL. (2006), is explained and described in chapter 3. In addition, the current state of research on CO_2 reduction measures in the automotive sector is analyzed and evaluated based on a conducted and comprehensive literature review. On the basis of the research methodology and the results from the literature review, potential CO_2 reduction measures are presented, analyzed and evaluated in chapter 4. Vehicle (4.1) as well as engine and transmission measures (4.2) are examined. In addition, alternative drive types and fuels (4.3) are examined due to their potential for CO_2 reduction.

Using the results of the previous chapters, a mathematical optimization model which illustrates the interdependencies of vehicle-related CO_2 emissions, potential fines and company profits will be described and evaluated in chapter 5. The model is then used for the analysis of various predefined scenarios to answer the research questions. The modeling results are evaluated and validated within the context of a sensitivity analysis (5.2). On the basis of the overall results, recommendations for action are derived and formulated for both the automotive industry and for EU policy makers in chapter 6. A critical evaluation of the selected procedure and the results takes place in chapter 7, where the study's limitations and areas with future research needs are also presented. The work concludes with a summary and a short outlook in chapter 8. The figure on the next page gives a schematic overview of the procedure, outlining the purpose of each chapter as well as the links between them.

Fast lane

At the end of each chapter as well as after important milestones, the key facts are summarized in tabular form. If the present work is opened as a PDF (or Word) file, it is possible to use the buttons below to switch between these summaries for a quick overview.

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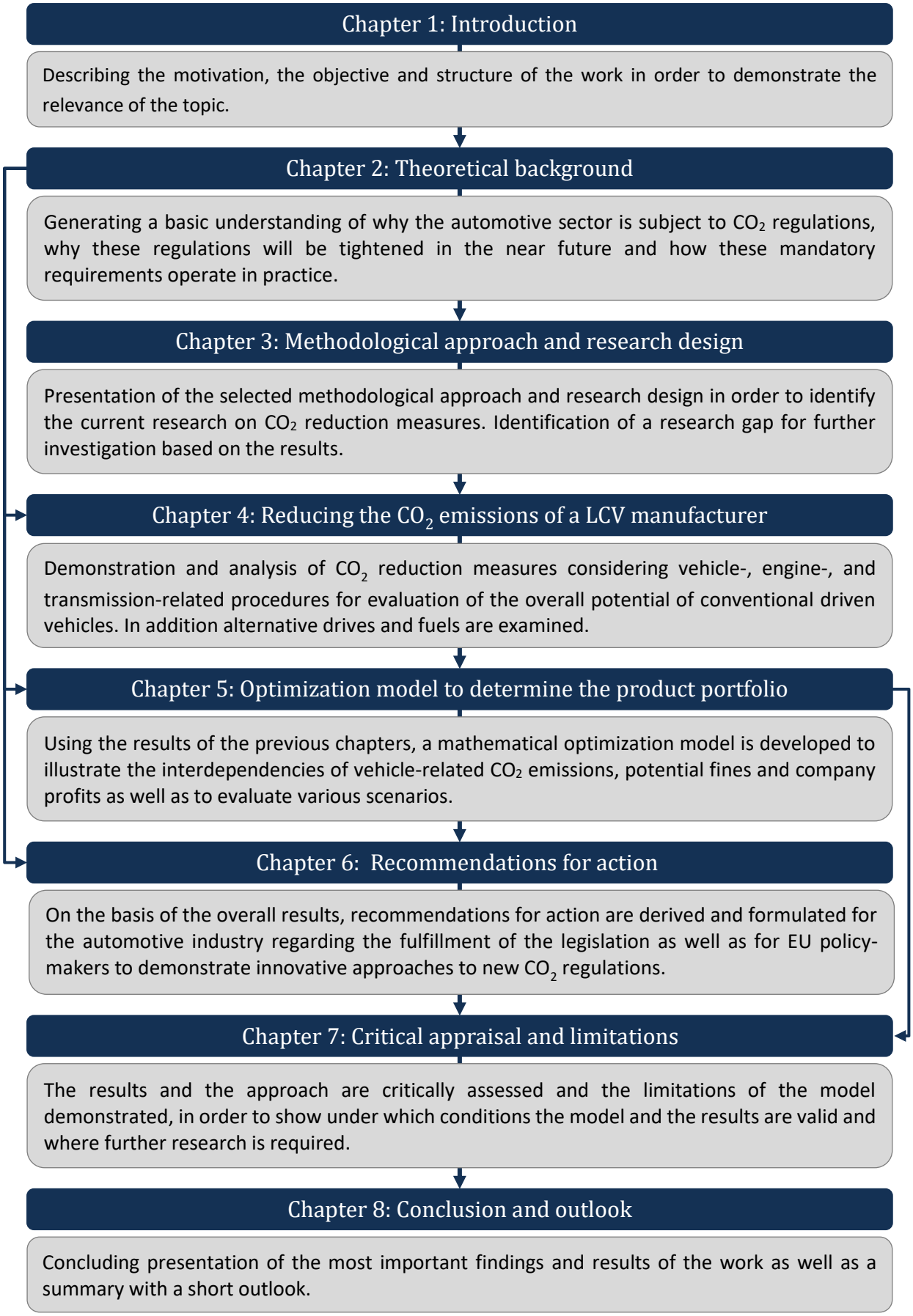

Figure 2: Overview of the procedure; Source: Own illustration

8. Conclusion and Outlook

The automotive industry is currently undergoing a dynamic period and faces numerous challenges and changes. Global warming and the related climate change represent one of the greatest environmental, economic and social challenges for society as well as for manufacturers of light commercial vehicles. In order to stop human-induced climate change, reduction of greenhouse gases, especially carbon dioxide (CO_2), is becoming increasingly important worldwide.

Road transport, as one of the largest sources of anthropogenic greenhouse gases, is seen in this context as a key opportunity for the mitigation of human-induced climate change. For this reason, new and more stringent limits for the CO_2 emissions of passenger cars and light commercial vehicles were introduced in the most important automobile markets worldwide, representing over 75% of global car sales in 2015. In this context, the European Union has implemented some of the strictest CO_2 regulations worldwide, in order to reduce its traffic-related emissions. From 2020 onwards, CO_2 emission limits of 95 g CO_2/km for an average new passenger car (M_1) and 147 g CO_2/km for light commercial vehicles (N_1) will become effective. For the period after 2025, an additional tightening of these limits is expected.

The manufacturers of light commercial vehicles are particularly affected by these new regulations, since their products are classified as light commercial vehicles (N_1) as well as passenger cars (M1), and the former are affected by much more stringent regulations. To remain competitive in this dynamic environment and to meet the legal CO_2 emissions standards, manufacturers of light commercial vehicles must adjust their strategic direction. Against this background, the following research questions were investigated:

1) Is the optimization of conventionally operated vehicles sufficient to comply with the 2020 CO_2 legislation?
2) What is the optimal product portfolio for a light commercial vehicle manufacturer in the future?

To answer this study's research questions, the design science research methodology following Peffers et al. (2006), as a common method, was used. In addition, a comprehensive literature review according to Vom Brocke et al. (2009) was performed in order to identify CO_2 reduction potential and to derive strategic recommendations for light commercial vehicle manufacturers. In this context several approaches to reducing a vehicle's CO_2 emissions are examined, including increasing energy efficiency or reducing the vehicle's mechanical energy demand.

To overcome the driving resistance its specific energy consumption can be reduced via aerodynamic improvements, a reduction in rolling resistance and lightweight construction.

In order to optimize energy conversion, various engine measures are available, such as downsizing and the electrification of auxiliary aggregates as well as various improved transmissions.

Overall, CO_2 potentials for conventionally driven vehicles which can be implemented economically, are determined to be around 15% in the medium term. However, these potentials will be reduced due to the change from NEDC type-approval test cycle to WLTP, which will most likely lead to a deterioration of the current determined CO_2 values.

Against this background, it can be concluded that the CO_2 reduction potentials for M_1 vehicles will not be sufficient to meet the new CO_2 legislation in 2020. Therefore, a manufacturer of light commercial vehicles with a significant proportion of M_1 approval vehicles, has to expand its current product portfolio with alternative drives in order to reduce the overall CO_2 fleet emissions and to avoid fines. In line with the specific requirements in the commercial vehicle segment, plug-in hybrids (PHEV) and Battery electric vehicles (BEV) were identified as promising drive types and useful portfolio additions for the period from 2020 onwards.

For the development and assessment of appropriate strategies for the implementation of alternative drives due to the reduction in the overall CO_2 emissions, the specific effects must be evaluated ex ante and for a period of several years. In the context of literature research, it has been determined that currently no model exists that examines these interdependencies between the legal CO_2 requirements and the specific production volume of a light commercial vehicle manufacturer.

In this context, a mathematical model has been developed which makes the (financial) impact of the new 2020 CO_2 regulation tangible and can be used to examine the extent to which electrical products should be implemented in order to avoid penalty payments and to achieve an optimal operating result. In doing so, the results of the literature research carried out were used for the development of the model.

In summary, the optimization model developed in this work provides an innovative tool for light commercial vehicle manufacturers that can be used to project and analyze the impact of the future CO_2 legislation on their portfolio and production planning. The results serve as a basis for decision-making within automobile manufacturers' strategic planning.

For this reason, the present work provides a relevant contribution to research and offers a suitable base for future research to gain further insights into the interdependencies between CO_2 legislation and the successful market penetration of electric vehicles.

Finally, crucially the reduction of the greenhouse gas CO_2 is not only an important issue at the European but also at global level. Although Europe's CO_2 emissions are constantly diminishing, the corresponding proportion of global CO_2 emissions is far too small to have a significant impact on global emissions.

The recorded successes within the EU have so far been thwarted by the excessive CO_2 emissions of other industrialized countries and emerging economies. Everything the European Union has achieved in recent decades by tightening the CO_2 limits and green electricity subsidies has only compensated for, for example, China's additional CO_2 emissions by about 8%.

The ratification of the international climate protection agreement by China and the US in 2016 is an important milestone in the global reduction of CO_2 emissions. The introduction of new and stricter CO_2 limit values for passenger cars and light commercial vehicles are in this context also conceivable outside the European Union.

The optimization model developed in this work therefore provides a decision-making support for the production program planning of light commercial vehicle manufacturers. In addition, the model also provides a basis for future research focusing on CO_2 emissions in one of the world's largest automotive markets, China or the USA, who are also the main cause of global CO_2 emissions.