Measuring Future Performance of Fictitiously Merged Motor Vehicle Manufacturers with a Composite Indicator from Economic and Environmental Perspectives

By

J. Patist

Thesis

in partial fulfilment of the requirements for the degree of

Master of Science

in Mechanical Engineering
at the Department Maritime and Transport Technology of Faculty Mechanical, Maritime and Materials Engineering of Delft University of Technology,

Student number:	4381505
Msc track:	Multi-Machine Engineering
Report number:	2023.MME.8835
Supervisor:	Dr. W.W.A Beelaerts van Blokland
Thesis committee:	Prof. Dr. R.R. Negenborn
	Dr. J.M. Vleugel
Date:	July 19, 2023

Abstract

This work investigates company performance measurement in case of a merger by applying a composite indicator for measuring company performance from economic and environmental perspectives. The recent merger between Motor Vehicle Manufacturers (MVMs) Peugeot Société Anonyme (PSA) and Fiat Chrysler Automobiles (FCA) has drawn attention due to its potential positive impact on company performance. The aim of this research is to contribute to the existing knowledge by adding value to the field of company performance measurement in the context of mergers. To achieve this goal, the current situation regarding the merger between automotive companies PSA and FCA was investigated and the state-of-the-art in composite indicators for measuring company performance and merger performance measurement was presented. Furthermore, the relevance of adding Market Capitalization as independent variable to the comprehensive set of measures of the composite indicator for company performance of motor vehicle manufacturers (I_{MVM}) was investigated. The I_{MVM} was extended to assess both historic and future company performance for a hypothetical market of motor vehicle manufacturers in the case that two of these motor vehicle manufacturers were fictitiously merged into one company. A case study focusing on the merger between PSA and FCA is conducted according to the methodology of theory-testing research. The application of the extended model I_{MVMMC} provides valuable insights into merger performance. Moreover, a method for measuring future merger performance was designed. This method provides a framework to evaluate the potential success of mergers and an index quantified this potential. The results showed the potential of value through growth and the potential of the merger between PSA and FCA.

Contents

List of Figures

List of Tables

List of abbreviations

MVM	Motor Vehicle Manufacturers
M&As	Mergers and Acquisitions
FCA	Fiat Chrysler Automobiles
PSA	Peugeot Société Anonyme
COGS	Costs of goods sold
CI	Composite indicator
EV	Electric vehicles
CAR	Cumulative abnormal returns
SAW	Simple Additive Weighing
GM	General Motors
ADF	Augmented Dickey Fuller
SRQ	Sub-Research Question
R&D	Research and Development
MAPE	Mean Absolute Percentage Error
MAE	Mean Absolute Error

1 Introduction

Recently, the merger of car manufacturing companies Peugeot Société Anonyme (PSA) and Fiat Chrysler Automobiles (FCA) has been completed. As will be presented in Chapter 1.1, merger success rate is generally low. This merger could potentially benefit both companies, but is it possible to quantify this potential beforehand? Are there statistics available to sustain such an hypothesis? And is it possible to compare expected future performance of the individual companies with expected future performance of the merged company.

Zeng created a composite indicator for company performance measurement form economic and environmental perspectives, the I_{MVM}, in the work *Development of a Composite Indicator for Measuring Company Performance from Economic and Environmental Perspectives* [43]. This work aims to further develop this composite indicator for application on merger cases.

In this first chapter, the problem that underlies this work will be presented in Chapter 1.1, the Research Gaps and the Goal of Research will be presented in Chapter 1.2 and Chapter 1.3 respectively before the Relevance of Research (1.5) and the Method (2.2) will be elaborated on.
In the following chapter, *Research Design*, the scope of this research will be determined (2.1), the background of the method will be shown, and a literature study will be presented. Furthermore, the data gathering for this thesis will be explained and to complete this chapter, research questions will be formulated (2.3) and research approaches will be handled (2.44.2).
The literature study consists of current literature regarding Merger Performance Measurement (2.5, Composite Indicators for Company Performance (2.6 in general and the Composite Indicator for Company Performance Measurement of Motor Vehicle Manufacturers(2.7 specifically. The final part of this literature study investigates the potential addition of Market Capitalization as an independent variable (2.8) to the composite indicator.

The next chapter, *Measuring* focuses on extending the composite indicator I_{MVM} to I_{MVMMC} by adding the independent variable Market Capitalization and updating the dataset.
In the Chapter *Analysis* , a case study regarding the merger between PSA and FCA will be performed according to the methods of Dul and Hak.
Chapter 5, the design of a method for measuring future merger performance will be presented while Chapter 6 will present the results of this this future merger performance measurement and the quantification of the results.

1.1 Problem statement

According to several studies, between 70% and 90% of mergers and acquisitions fail[20][22].
Companies considering a merger want to know as much as possible about the potential performance of a merger in the future before closing the deal.
In short, the high failure rate of mergers and acquisitions can be seen as a problem for companies considering a merger or acquisition.

1.2 Research gap

In *Development of A Composite Indicator for Measuring Company Performance from Economic and Environmental Perspectives*, Zeng addressed three problems. Firstly, the lack of a standard for company performance measurement from economic and environmental perspectives. Secondly, the lack of rigorous quantitative methods for measuring performance of MVMs from economic and environmental perspectives. The third problem addressed was the lack of trend performance analysis for the following fiscal year.

These three problems led to the following research gap: A method to analyze the historical as well as the future company performance, with consistent measures and rigorous techniques, for MVMs is missing.

Current work related to company performance indicators does not take the possibility of mergers into account. As mergers and acquisitions occur often in automotive industry, it is important to quantify the future possibilities of fictitiously merged companies. In short, there is a lack of a standard for predicting future merger performance.

1.3 Goal of Research

In this work, company performance measurement of motor vehicle manufacturers, and in particular the performance index developed by Zeng in *Development of A Composite Indicator for Measuring Company Performance from Economic and Environmental Perspectives* will play a central role.
The first aim of this investigation is to gather inside in merger performance measurement. The lack of a standard for predicting future merger performance leads to a particular interest in performance indicators with the ability to predict future company performance. The second goal of this work is to explore the possibilities of extending the existing composite indicator I_{MVM} in order to measure future performance of motor vehicle manufacturers.

The third goal of this research is to apply a composite indicator to the case of the merger between FCA and PSA. In *Development of A Composite Indicator for Measuring Company Performance from Economic and Environmental Perspectives* Zeng created a performance measurement method for MVMs for both historical performance and future performance [43]. It is interesting to investigate whether this Index for Motor Vehicle Manufacturers (I_{MVM}) gives insights in the performance of the different companies before and after the merger.
This leads to the final goal. This goal is to Design a Procedure to Predict Future Merger Performance Based on the Results of a Composite Indicator for Company Performance Measurement from Economic and Environmental Perspectives.
More specifically the goal of this work can be formulated as follows:
Create a standard for quantifying potential future merger performance of motor vehicle manufacturers

1.4 Merger between PSA and FCA

In 2019, Fiat Chrysler Automobiles N.V (FCA) and Peugeot S.A agreed on a 50/50 merger of their companies. This merger between two large Motor Vehicle Manufacturers results in the fourth largest car company based on volume and the third largest based on revenue. In *Development of A Composite Indicator for Measuring Company Performance from Economic and Environmental Perspectives* from Zeng, both FCA and PSA were taken into account and their company performance before the merger was measured. The fact that the merger took place shortly after Zeng measured the performance of both individual companies makes it interesting to look into the performance of the merged company.
The automotive industry has changed slowly over the past 100 years. In the first half of the twentieth century, the market was concentrated in Europe and North America. In the 1970s, owning a car became possible for the middle class resulting in a demand for standardized cars. Car manufacturers adapted to this situation by focusing on the production of one model for long periods of time. Due to an increase in productivity and a saturation of the car market in western countries, overcapacity in the industrialized countries became a problem for car manufacturers. This overcapacity issues, as well as the fact that "slow growth in an old industry favors concentration" forced MVMs into mergers, alliances and joint ventures. Increasing market share in markets they were active in and entering new markets were the main goal. At the same time, R&D costs were reduced.

Since the 1980s, the demand of the consumers forced MVMs into a diversification of products. More variety in car models produced in lower volumes became the main focus. In recent years, development of electric vehicles increased the need for R&D investments to be a competitive MVM in the future.

Fiat Chrysler Automobiles (FCA) and Groupe Peugeot Société Anonyme (PSA) both have their origin in the end of the 19th century. During the years, both companies were part of Mergers and Acquisitions (M&As).
In order to describe the history of FCA, the history of Fiat and the history of Chrysler has to be explained individually.
In 1925 the Chrysler company was founded in Detroit. Chrysler introduced Plymouth, DeSoto and Dodge in the late 1920s, Imperial mid 1950s and Valiant in 1960. In 1998, Daimler-Benz and Chrysler agreed on a 50/50 partnership named Daimler Chrysler. In 2007, a majority stake of Chrysler was sold. In 2009, Fiat S.p.A. and Chrysler started an alliance[19].

The first Fiat factory was opened in Turin in 1899 as Fabbrica Italiana Automobili Torino. After achieving success in Italy, the company opened their first FIAT factory in the United States in 1908 and in 1910 Fiat launched their first standardized car Fiat "Tipo". In 1936, the first version of the Fiat 500 was launched. It was the smallest mass-produced car at the time.
During WWII, Fiat was forced to diversify and invest in innovative technology. Besides cars, railways, commercial trucks and airplanes were developed and manufactured during this period. After WWII, Fiat went back to their former operations and especially among young Americans their cars gained popularity. The first version of the Fiat Panda was released in 1980 and this car became a very popular city car because of its robustness and functionality [13] [38]. Fiat Chrysler Automobiles was established in 2014 through the merger between Chrystler Group and Fiat S.p.A.

After being active in multiple industries for almost a century, the family company Peugeot rolled out the first series-manufactured car in 1891. During the next 74 years, the company produced both cars and bikes and the largest plant of France in Sochaux was established. In 1965 Automobiles Peugeot becomes a holding and is named PSA group and in 1976 the company becomes PSA Peugeot Citroën. In 2017, Opel and Vauxhall were acquired by PSA Peugeot Citroën [33].

1.5 Relevance of Research

In the past decades, the concerns about climate change increased massively. Concerns about global warming caused by emissions resulting in problems with fresh water availability [42]. These increased concerns go hand in hand with stakeholder concerns about companies' environmental performance. Such an environmental perspective on company performance helps all type of stakeholders.

In recent economy, there is a clear trend: Mergers and Acquisitions (M&As) are occurring more frequently than ever. But how about the knowledge about such M&As? Is it possible to know the company performance of a merged company before the merger actually happened? The recent merger between PSA and FCA could potentially benefit both companies, but research shows that the majority of mergers fail and have been failing since the beginning of serious research into this topic 4 decades ago [27]. This shows the importance of forward looking studies preventing merger failure.
The concerns about climate change show the relevance to address a substantial contribution to the environmental performance of motor vehicle manufacturers while quantifying their company performance. The high failure merger rate show the relevance of future merger performance measurement.

2 Research Design

This research consists of a theoretical part handling existing knowledge about mergers in general, the case of PSA and FCA, composite indicators for company performance measurement and more specifically the I_{MVM} for measuring company performance of Motor Vehicle Manufacturers. The theoretical part ends with a study regarding the possible addition of a performance indicator to the I_{MVM} in order to improve this CI in terms of comprehensiveness and forward looking abilities.
Furthermore, the I_{MVM} will be applied to the case of the merger between PSA and FCA. In this experimental setup, the theory handled in the theoretical part of this work can be tested.

In *Case Study Methodology in Business Research* from Dul and Hak [11], several different case study methodologies are handled in detail. In order to choose the right methodology, this work will be described systematically. The part of the book called *Theory-testing research* is considered to be the most relevant. In the next section, there will be elaborated on *Theory-testing research*.

2.1 Research scope

This research focuses focuses on company performance measurement from both environmental and economic perspectives, on motor vehicle manufacturers and mergers. In terms of time, this work focuses on historic data from the period between 2008 and 2019 and the "future" from 2020 to 2023.

2.1.1 Company Performance Measurement

This work focuses on company performance measurement from economic and environmental perspectives. In this work, company performance is defined as the output of a composite indicator taking only measurable, publicly available data into account. This composite indicator takes both environmental and economic performance indicators into account.

2.1.2 Motor vehicle manufacturers

Motor vehicle manufacturers (MVMs), also called 'companies' in this work, are investigated and compared in this work. MVMs are defined as "manufacturers that are primarily engaged in the design and manufacture of motor vehicles including passenger cars, light commercial vehicles, heavy trucks, buses and coaches" [43]. From the fifty largest MVMs in terms of production volume, this work focuses on twelve MVMs because of their size and availability of data. The twelve MVMs forming the scope of this work are: Toyota, Audi AG, Hyundai, General Motors(GM), Ford, Nissan, Honda, FCA, Renault, PSA, Daimler Group and BMW.

2.1.3 Mergers

As this work investigates the potential effects of fictitiously merging merging motor vehicle manufacturers, the scope of such mergers needs to be defined. Because of the comparability of results, the scope of mergers investigated in this work is defined as a horizontal merger between two companies.

2.1.4 Environmental and Economic perspectives

This work evaluates MVMs based on both economic and environmental performance. The qualification the different companies is thus done from both perspectives. The composite indicator for company performance measurement, which will be introduced later in this work, also includes two sub-indices, I_{ECON} and I_{ENVI}, to compare the specific performance of companies with their overall performance.

2.2 Method

"A case study is a study in which (a) one case (single case study) or a small number of cases (comparative case study) in their real life context are selected, and (b) scores obtained from these cases are analyzed in a qualitative manner" [11].

The different case study methods described in the book *Case Study Methodology in Business Research* from Dul and Hak are studied in order to determine which method fits best for the case of a merger such as the merger of PSA and FCA.

The method of this research is a step-by-step approach. The first step will be to gather existing knowledge in terms of a literature study. The state-of-the-art regarding different topics related to this research will be handled. The second step is the development of a composite indicator. For the third step, *Case Study Methodology in Business Research* will be used [11]. For the case of the merger between PSA and FCA, the most relevant part of this book is called *theory-testing research*. This part of the book will be used to design an experimental setup for the case study. The test environment, test procedures and results will be described accurately. Processing the results, discussion and accuracy analysis will be the next step before stating conclusions and recommendations.

2.3 Research Questions

The main research question of this research is:

How to measure the future performance of fictitiously merged motor vehicle manufacturers with a composite indicator from economic and environmental perspectives?

This research question will be answered by a step-by-step approach. Firstly, five sub research questions (SRQ_1-SRQ_5) will form the theoretical part. The remaining research questions will be based on the development of a new composite indicator and a case study.

SRQ_1: *What is the state-of-the-art of company performance measurement in case of a merger?*

In terms of state-of-the-art, this field of research will be the most unexplored territory. This question will be answered by investigating mergers in general and looking into literature regarding merger performance specifically.

SRQ_2: *What is the state-of-the-art of composite indicators for company performance measurement of MVMs?*

This question will be answered by looking into the four generations of company performance measurement firstly. Secondly, the phases of constructing a Composite Indicator will be handled.

Finally, the specific topic of a composite indicator for company performance measurement of MVMs will be described. In *Development of A Composite Indicator for Measuring Company Performance from Economic and Environmental Perspectives*, Zeng created a CI for company performance measurement of MVMs. Together with *Composite indicators of company performance: a literature survey* this can be seen as the state-of-the-art of Composite Indicators for company performance of MVMs specifically and therefore forms the basis of the section handling this sub research question and will help to answer these questions properly [43][45].

SRQ_3: *What is the state-of-the-art of Market Capitalization as performance indicator?*

Market capitalization is considered to be an interesting addition to the I_{MVM} and will therefore be investigated in terms of relevance as a potential indicator.

SRQ_4: *How to extend a composite indicator for measuring company performance of MVMs from economic and environmental perspectives in order to measure future company performance?*

SRQ_4 refers to the extension of the composite indicator for future company performance measurement of fictitiously merged motor vehicle manufacturers. This question will be answered by describing the current status of the I_{MVM}, the addition of an extra performance indicator, and the development of a forecasting procedure.

SRQ_5: *How to apply a composite indicator for measuring company performance to the case of a merger?*

SRQ_5 will be answered by performing a case study according to the theory-testing research methods from the book *Case Study Methodology in Business Research* from Dul and Hak on the merger between PSA and FCA[11].

SRQ_6: *How to predict potential future performance of fictitiously merged motor vehicle manufacturers?*

SRQ_6 can be answered by designing a procedure for measuring future performance of fictitiously merged MVMs.

SRQ_7: *How to quantify the potential future performance of fictitiously merged MVMs?*

SRQ_7 can be answered by analyzing the results obtained by following the procedure designed as an answer to SRQ_6. Furthermore, the results of different mergers need to be compared objectively.

2.4 Research Approaches

This research aims to answer the research questions as proposed in Chapter 2.3. Firstly, existing literature will be used to give the state of the art of two research topics. Firstly, mergers in general and merger performance measurement in particular will be handled in Chapter 2.5 to answer SRQ_1. Secondly, the state-of-the-art of company performance measurement in general and more specifically, the current status of the composite indicator for company performance measurement of MVMs (I_{MVM}) will be handled in order to answer SRQ_2. The first part of this thesis is finalized by exploring the possibility of adding Market Capitalization to the I_{MVM} as an independent variable. This section aims to answer SRQ_3.

The next part of this thesis focuses on extending the I_{MVM}. In order to answer SRQ_4, the current status of the model is presented as well as relevant statistics obtained while using the model. In the remainder of this Chapter, all phases of development are completed and the model will be extended.

Subsequently, the extended model I_{MVMMC} will be applied on the case of the merger between PSA and FCA. In order to answer SRQ_5, *theory-testing research* from the book *Case Study Methodology in Business Research* from Dul and Hak will form the guideline for a case study [11].

Finally, a procedure will be designed for measuring future merger performance of MVMs to answer SRQ_6 and the obtained results will form the basis for the next section where SRQ_7 will play a central role.

2.5 State-of-the-Art of Merger Performance Measurement

2.5.1 Introduction

In this section the central question is SRQ_1: *What is the state-of-the-art of company performance measurement in case of a merger?*
This question is handled by first looking into mergers in general before presenting an overview of the current situation regarding merger performance measurement. As the recent merger between PSA and FCA represents a significant event in the automotive industry, an overview of both external analysis and a statement from the companies itself is presented in this section.

2.5.2 Mergers

"A merger is the voluntary fusion of two companies on broadly equal terms into one new legal entity. The firms that agree to merge are roughly equal in terms of size, customers, and scale of operations. For this reason, the term "merger of equals" is sometimes used. Mergers are most commonly done to gain market share, reduce costs of operations, expand to new territories, unite common products, grow revenues, and increase profits—all of which should benefit the firms' shareholders. After a merger, shares of the new company are distributed to existing shareholders of both original businesses" [18]

"An acquisition occurs when a company (acquirer or bidder) acquires a controlling stake in the stock of another company (target), which continues to exist as a subsidiary under the control of the acquirer. In a merger, on the other hand, a company (target) merges into another one (acquirer or bidder) and ceases to exist as an entity. All the assets (and liabilities) of the target company are passed to the acquirer and the stockholders of the target become stockholders of the acquirer. Both mergers and acquisitions are also referred to as takeovers, because, regardless of being friendly or hostile, one company takes control over another [28]".
In this section, two theories of value creation through M&As will be handled as well different types of mergers.

Value Creation

The goal of a business in general is to maximize their profit. This objective can be realized by growth. One of the routes to growth is through M&As. M&A is called inorganic growth and can achieve exponential growth instead of linear, slower growth [25]. In *An insight into Mergers & Acquisitions*, Kumar & Sharma present two value creating theories: *The Synergy Theory* and *The Market for Corporate Control Theory*.

The Synergy Theory

According to Kumar and Sharma, synergy is the most important reason for M&As to take place. Synergy was defined by Magaldi as a group that has more power when working together than the sum of the individuals. In terms of M&A, the goal of combining two (or more) companies is to reduce costs or to increase the profits of the merged company compared to the two individual companies [28].
Furthermore, efficiency in terms of resource allocation can provide economic advantages. Efficiency gain through company size is called *economies of scale*.
In terms of sharing know-how of for example production technology, *economies of scope* are a way of achieving synergy. Especially in highly innovative industries, a great competitive advantage can be gained [25].
Gaining *market power* is the third source of synergy focused on by Kumar and Sharma. A larger market share provides a competitive advantage resulting in higher profits.

The Market for Corporate Control Theory

This theory is based on the thought that acquired companies are not efficiently managed. Buying assets at a lower price than their expected value offers the opportunity to improve operating performance with efficient management and increase the market value.

Types of Merger

Kumar and Sharma present different types of mergers:

- Horizontal merger
- Vertical merger
- Co-generic merger

- Conglomerate merger
- Domestic merger
- Inbound merger
- Outbound merger

For this research, it is interesting to look at the horizontal merger and the co-generic merger. A Horizontal merger is a merger between companies that are competing in the same industry. Such a merger increases the market share of the merged company in this market. The merger between FCA and PSA can be seen as such a merger, but as a co-generic merger as well. A co-generic merger has similarities with a horizontal merger, but the companies in such a merger operate in different product lines in the same market. From a geographical point of view, the merger between PSA and FCA can be classified as an outbound, or *cross-border*, merger [28][25].

2.5.3 Merger performance measurement

In this section, an overview will be provided of different studies concerning company performance measurement in merger, acquisitions and case studies.

Schoenberg

Schoenberg wrote the article*Measuring the Performance of Corporate Acquisitions: An Empirical Comparison of Alternative Metrics* [37]. In this work he looks into the comparability of four frequently used measures for acquisition performance:

- Cumulative abnormal returns
- Managers' assessments
- Divestment data
- Expert informants' assessments

In the field of finance, performance measurement traditionally comes down to objective performance metrics to look at the the outcome of organisational choices. Examples of such performance metrics are price movements and accounting data. Organisational behaviour and strategic management, on their turn, worked with more subjective performance indicators such as reports from managers active in the organisation.

"The selection of appropriate performance metrics is of particular relevance in inter-disciplinary fields such as mergers and acquisitions, where diverse origins have led to the adoption of a broad range of performance measures within contemporary research" [26]. Schoenberg used a sample of 61 British acquisitions of continental European firms during the period of time between 1988 and 1990. This study focused on acquisitions where one company purchased controlling interest ($> 50\%$) for at least £ 5 million. Furthermore, all acquisitions had to be classified as horizontal and performance data from at least three out of the four performance measures had to be attainable.
Schoenberg looked into the calculation of Cumulative abnormal returns (CAR). The CAR is a measure for the "impact of an event" on the share price after a period of time. In order to do so, an expected return price is compared to the actual share price after an event occurred. The calculation of the abnormal share price return can be seen in Equation 2.1.

$$\text{ARit} = \text{Rit} - (\text{ai} + \text{bi Rmt}) \tag{2.1}$$

Where,

ARit: the abnormal share price return of acquiring firm i on day t

Rit: observed share price return of acquiring firm i on day t

ai: market model constant for acquiring firm i

bi: beta of acquiring firm i

The second and the third frequently used measure, *Managers subjective Assessments* and *Expert Informants' Subjective Assessments* are considered to be irrelevant for this work due to the subjectivity.

The final measure, *Divestment Data*, looks into the ownership of the acquired company for a period of 13 years after the takeover. At the same time, this ownership is measured at six and nine years in order to get a clear view on the divestment patterns and improve the comparability with other performance metrics.

As this study is focused on acquisitions with controlling interest, this measures are considered interesting but unapplicable to the case of the merger between PSA and FCA.

Kumar
In *The impact of mergers and acquisitions on corporate performance in India*, Kumar and Bansal reviewed merger performance measurement in literature and they presented a case study on M&A performance in India [24].

Long-term performance of M&As can be measured by looking into the profitability after a period of time. Short-term analysis consists of a extensive fundamental company analysis in order see the "potential and capitalized synergy" of M&As. Ratio analysis and comparative statement analysis are mentioned as possible to methods for such fundamental analysis.

Firstly, the positive impact of M&A on performance. Improvement in liquidity, leverage and profitability position was observed in a case study on 8 mergers by Rao and Sanker. Before acquisition, the acquiring company usually performs above the market's average and the acquired company below average.
Another observation from literature was the Variability in earnings of companies before a merger: the variability in earning, and therefore the risk, is significantly higher before a merger than after merger.
Finally, it was observed that profitability increased post-merger as a result of more efficient use of capital, decrease in tax burden and an increase in fee-related income.

Subsequently, Kumar and Bansal looked into negative impact of M&A on performance in literature. 17% of recently merged companies have positive returns two years after merger or acquisition. Reasons for poor company performance after merger are:

- Manager's desire for position and influence
- Low productivity
- Poor quality
- Reduced commitment
- Voluntary turnover
- Related hidden costs and untapped potential

Finally, literature study on mixed impact of M&A on performance was presented. Four ratios were taken into account for performance measurement of M&As:

- Earning to equity ratio

- Liquidity ratio
- Size ratio
- Pre-tax profit

The first three ratios were positive for companies that were taken over. At the same time, pre-tax profit was negative for the same companies.

The second part of Kumar and Bansal's work focused on their case study on 74 selected M&A cases that met the requirements on financial data availability. Five financial parameters of merging and acquiring companies were taken into account: liquidity position, operating efficiency, overall efficiency, return to equity shareholders and financing composition. The following six ratios are used in order to calculate these parameters:

- Working capital
- Operating profit
- Profit before tax
- Return on net worth and earning per share
- Debt to equity

The analysis of this case study was done for each parameter individually. The analysis of the 22 merging companies is considered more relevant for this work than the analysis of the 52 acquisition cases. For simplicity of the interpretation of results, "more working capital is considered better for the firm as it reduces overall liquidity of the firm". In 13/22 cases the working capital increased. In 6 of those 13 cases, the increase is considered to be "huge". 3 of the 9 cases with a decreased working capital showed a "sharp decrease". For operating efficiency, more operating profits are considered beneficial for the company. In 17/22 cases, the operating profits increased after the merger.In 10 out of those 17 cases, this increase is considered "sharp" while one cases decreased sharply. Furthermore, an increase in profit before tax is considered positive for the merged companies. 20/22 cases had such an increase in profit tax. As mentioned above, the return to equity shareholders is measured by the return on net worth and the earning per share. 10/22 cases had an increased net worth while 14/22 cases showed an increased earning per share. Finally, the in debt-equity ratio increased in 12 out of 22 merger cases which is considered bad for financial health of the companies.

2.5.4 Merger between PSA and FCA

In this subsection the merger of PSA and FCA will be handled. Firstly, the facts about the merger will be summarized. External analyses and a statement by the companies itself on prospects of the new company will be handled.

On December 18th, 2019, both companies communicated the agreement of the horizontal merger of FCA and PCA; both companies get 50% share. The combined company will have combined revenues of nearly 170 billion euro by selling approximately 8.7 million "units'. Furthermore, the merger will create a diversified business able to have large margins in their most important markets (Europe, North America and Latin America) and the possibility to "reshape the strategy in other regions". Annual run-rate synergies are expected to be 3.7 billion euro guaranteeing to avoid plant closures. These synergies give the new company the opportunity to invest in innovation of technologies ready for the future meanwhile focusing on CO_2 requirements [39].

According to Het Financieele Dagblad, Large R&D investments are necessary for self-driving and emission free cars. Costs for development of new models will be reduced by synergy. Purchase costs will be reduced by enforcing discount at suppliers.
Furthermore, the new headquarters of the merged company will be in the Netherlands, as FCA's holding was already located there. In order to equalize the proportions between shareholders, both companies take distance from a few parts of their company [10].

Although the deal have been communicated as a merger between equals, or a 50/50 horizontal merger, analists claim that it can be seen as an acquisition of FCA by groupe PSA. PSA has a small majority in the board of directors, a group of PSA shareholders will hold the largest amount of shares and PSA was officially listed as accquirer [28].

The most obvious motive for M&A is to create value through growth. That can be realized through synergies and expansion.
Carlos Tavares was the CEO of PSA groupe. He had a mandate to get Peugeot back to the American car market. This included a risk for the recovery of group PSA. His solution was the proposal of a merger with FCA. According to Tavares, the merger was appealing because of FCA's activities in the American market, their overlap in several industries and the potential to make scale benefits possible

In *Analysis-For Peugeot and FCA, completing their merger is just the start*, Guillaume et al. made an analysis of the merger at the moment the deal was almost approved by shareholders of both FCA and PSA group.
Firstly, there can be concluded that the combined company Stellantis, after the merger has been completed, will be the world fourth largest MVM behind Volkswagen, the Renault-Nissan-Mitsubishi alliance and Toyota Motor in terms of sales [17].

As a whole, fourteen brands will be included in the new company. Maserati, Alpha Romeo, Jeep, Fiat, Lancia, Dodge, Chrysler, Ram and Fiat as part of FCA. PSA group, on their turn, bring in DS automobiles, Peugeot, Opel, Citroën and Vauxhall.

Guillaume claims that the CEO of the combined company, Carlos Tavares, instantly has to deal with two problems: their position in the Chinese car market and the potential overcapacity as a result of the merger.
According to Guillaume, referring to LMC consultancy, prior to the merger both PSA group and FCA would need to reboot in China as both companies were operating at just 8% of their capacity in the Asia-Pacific region. For both groups individually, this reboot was financially not possible. With combined resources it might be possible to claim a substantial position in the largest car market in the world.

According to LMC Consultancy, the combined network of the Stellantis group can build 7 million vehicles more than they sell. Although they claim not to, it might be necessary to close plants.

Cristovao summed up the most important contributions of both companies for the merger. PSA's contributions:

- EV (Electric Vehicle) Technology
- Opel/Vauxhall know-how
- Turnaround expertise

Although PSA cannot be considered a leader in electrification, they are ahead of FCA. The plan is to have a completely electrified range in 2025. Looking at the quickly increased demand for electric cars, this can be seen as a large contribution to the merger. In 2017, Opel/Vauxhall was succesfully integrated in the PSA group. This experience may help to improve the collaboration, according to Cristovao. Finally, the experience of Tavares' management team with improving the profitability of a poorly performing company significantly.

FCA, on their turn bring the following interesting benefits to the table:

- Acces to North America's wide dealership network
- Bigger SUV range
- M&A know-how
- Turnaround expertise

PSA aims to return succesfully to North America's market, while this is FCA's strength. Their network in terms of "broad dealership" will be of great added value. Secondly, FCA's brands Jeep and Ram can bring their expertise on SUV's to the new company, from which PSA may benefit. While PSA has their experience with integration of Opel/Vauxhall, FCA has experience with M&As in recent history. Although not all of them were evenly successful, this know-how might help the merger with PSA. Finally, FCA can bring their own expertise in turning company results around to the table. Fiat was able to bring Chrysler back from bankruptcy[9].

2.5.5 Conclusions

The central question handled in this section was: *What is the state-of-the-art of company performance measurement in case of a merger?*.
In the first part of this section, reasons for mergers were introduced. Profit maximization was defined as a goal of a company which can be realized by growth. One of the most important reasons for a merger is therefore the creation of value through growth.
In the second part of this section, two types of performance indicators for merger performance measurement were distinguished. The financial indicators were considered to be objective indicators compared to the more subjective performance indicators such as reports of managers.
Furthermore, the there can be concluded that most literature regarding merger performance measurement focuses on long-term performance measured after a longer period of time. Therefore it can be concluded that a forward looking study into merger performance measurement is relevant.
Finally, analysis of the recent merger between PSA and FCA confirms that value creation through growth is the most obvious reason for their merger.

2.6 State of the Art of Composite Indicators for Company Performance

2.6.1 Introduction

In this section, the second sub research question, *What is the state-of-the-art of composite indicators for company performance measurement of MVMs?*, will be handled. Firstly, three generations of company performance measurement were presented as well as the fourth generation as introduced by Zeng in *Development of a Composite Indicator for Measuring Company Performance from Economic and Environmental Perspectives* [43]. Secondly, Composite Indicators and their phases of construction were introduced and finally the Composite Indicator for Measuring Company Performance of Motor Vehicle Manufacturers (I_{MVM} was presented.

2.6.2 Company performance measurement

"Company performance measurement is fundamental for decision-makers to monitor performance and to solve management problems". This section presents the different generations of company performance measurement since the 1980s. With the work*Development of A Composite Indicator for Measuring Company Performance from Economic and Environmental Perspectives*, Zeng contributed to the fourth generation of company performance measurement and is therefore included in this work[43].

First generation The first generation of company performance measurement consists of frameworks such as the balanced scorecard system, the performance prism and the Skandia's navigator. Shortcomings of these frameworks are that they are static and are not able to show the links between the performance measures.

Second generation The second generation of company performance measurement resolved the above-mentioned shortcomings by using strategy maps [21] and success maps [31]. These maps provide companies the possibility to map their what is important for them. Shortcoming of this generation of company performance measurement is that there is no link from "business-oriented methodology to real free cash flow".

Third generation According to Pike and Roos, there are three fundamental criteria for the development of the third generation of company performance measurement:

1. Appropriateness and adequacy

2. Information adequacy

3. Practicality and organizational alignment [34]

Fourth generation Five requirements were presented by Zeng to form the basis for the fourth generation of company performance measurement:

- It is with measures from both an economic perspective and an environmental perspective
- It is developed for MVMs by taking the specific background into consideration
- The measurement is based on publicly available data
- It is mathematically constructed with transparency in generating time series data
- It provides a trend based upon forecasts for benchmarking the future performance of MVMs in the following fiscal years

In Figure1, the four generations are visualized.

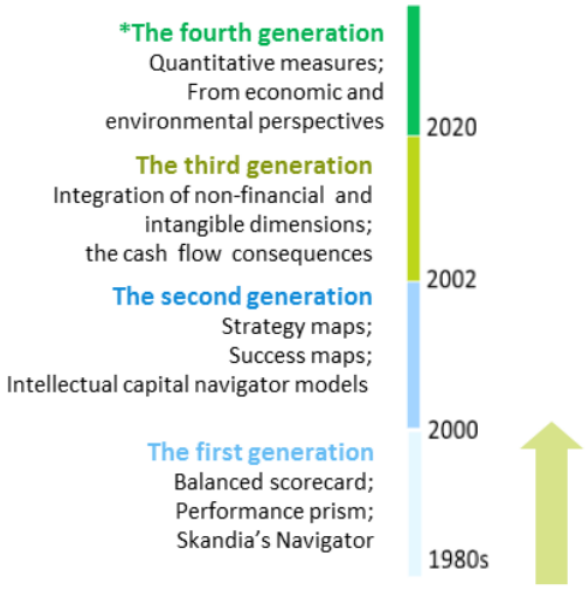


Figure 1: Four generations of company performance measurement, from [43]

2.6.3 Composite Indicators

Introduction to Composite Indicators "A composite indicator may be defined a single index which is formed when individual indicators are compiled into a single index, on the basis of an underlying model of the multidimensional concept that is being measured"[8]. In recent years, CIs have increasingly been accepted as a useful tool for benchmarking, performance comparisons, policy analysis and public communication in different fields [46]. For developing a CI, ten phases have been suggested in the checklist, including a theoretical framework, data selection, imputation of missing data, multivariate analysis, normalization, weighing and aggregation, uncertainty and sensitivity analysis, back to the data, links to other indicators, and visualization of the results [12]. The idea of CIs is so attractive that a large volume of publications has been devoted to this subject. However, the majority of CIs derived are on social and environmental b , and at macro levels, such as at the national level or the regional level [44]. Composite indicators that have been utilized at the company level in specific business sectors such as the manufacturing sector are relatively limited" [43].

About avoiding subjectivity Zeng wrote[43]: "Subjectivity and imprecision always exist during decision-making processes [47]. In general, for weighing measures and calculating the CIs, detailed data is extracted from sample companies' annual financial reports, sustainability reports and global reporting initiative reports. If detailed data is unavailable, researchers need to use MCDM techniques or totally rely on subjective scoring for weighing measures. In this case, the inherent subjectivity or ambiguous information during the weighing process needs to be handled. Fuzzy theories, also called fuzzy logic [23] can be utilized to provide an inference structure for relatively precise deductions [16]."

2.6.4 Phases of constructing Composite Indicators

In constructing CIs five phases were distinguished. In 2, these phases are visualized as Zeng did in her work *Development of A Composite Indicator for Measuring Company Performance from Economic and Environmental Perspectives*[43].

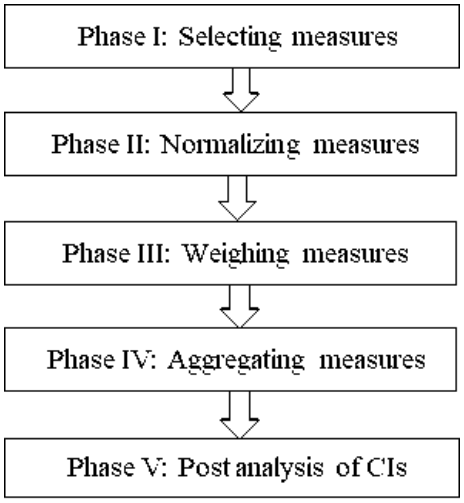


Figure 2: Phases during the development of CIs, from [43]

During these five phases several techniques are used. In Chapter 2.7 there will be elaborated on these phases applied to the I_{MVM}.

2.6.5 Company performance indicators

Market Share In *Measuring business performance in the high-tech manufacturing industry: A case study of Taiwan's large-sized TFT-LCD panel companies*, Tseng identified five dimensions of business performance [40]:

- Competition performance
- Financial performance
- Manufacturing performance
- Innovation capability
- Supply-chain relationships

The performance dimension *Competition performance* is related to the performance indicators sales growth and market share. Market share is considered to be the most important performance indicator for a company's performance. Market share can be calculated as "the percentage of gross sales by the company in the worldwide market in which it competes".

3C model "The 3C model is a method to quantify in which extent a company is able to make use of the value chain innovation process" [4]. Beelaerts et al. identified three drivers of the value chain innovation process.

- Continuation
- Conception
- Configuration

The first indicator, *continuation*, "shows in which extent the employees of the company are able to create value for the customer". In Formula 2.2 can be seen that this indicator is quantified as the relation between company profit and its (long term) employees.

$$\text{Continuation} = \frac{\text{Profit}}{\text{Employee}} \tag{2.2}$$

The second indicator, *Conception*, provides information about the focus on innovation of a company. Formula 2.3 shows that conception can be obtained by dividing the R& D expenses by the amount of (long term) employees.

$$\text{Conception} = \frac{\text{Research and Development expenses}}{\text{Employee}} \tag{2.3}$$

Configuration shows to which extent a company is able to "leverage its assets and resources on the supply chain as most of the production vaule is for a large part transferred to the suppliers, also called co production". The configuration of a company can be seen as a way to quantify the ability of a company to use of its resources on the supply and demand chain. By dividing the Turnover of the company by the amount of employees, the configuration can be calculated, as can be seen in Formula 2.4. [41] [4]

$$\text{Configuration} = \frac{\text{Turnover}}{\text{Employee}} \tag{2.4}$$

Company performance Measurement Truck manufacturers In *Exploring Company Performance Measurement for Truck Manufacturers*, Zeng and Beelaerts looked into company performance measurement from an inventory perspective [3]. Raw materials inventory, work-in progress inventory and finished goods inventory are considered to be the three sub accounts of *inventory*. Too high inventories result in "poor long-term stock returns" while too low inventories lead to "ordinary returns". The *Inventory turnover* shows the overall efficiency of the supply chain. It can be calculated as the sales divided by average inventory and as the cost of goods sold (COGS) divided by average inventory. In Equation 2.5 can be seen that the second method was chosen in this paper.

$$INT_{\mathrm{t}} = \frac{COGS_{\mathrm{t}}}{0.5 * (I_{\mathrm{t}} + I_{\mathrm{t\text{-}1}})} \tag{2.5}$$

2.7 Composite Indicator for Company Performance Measurement of Motor Vehicle Manufacturers

As mentioned before, Zeng developed a Composite Indicator for measuring company performance from both economic and environmental perspectives. In this section, the steps of this development process will be followed in order to get a good picture of the creation of the measurement tool. Zeng used four sources for identifying the measures. The stakeholder theory, literature in the automotive industry, documents released from the industry and documents released by organisations were used. A part of the relevant literature in automotive industry has already been handled in Chapter 2.6.5.

2.7.1 Stakeholders

In order to select the most relevant measures from economic and environmental perspectives, it is necessary to get an overview of the main stakeholders of MVMs. Table 1 provides a list of key stakeholders of MVMs and their concerns from both economic and environmental perspectives created by Zeng [43].

Label	Stakeholders	Concerns
S1	Customers	Product price, product quality, after sales service, response time
S2	Employees	Safe and healthy working condition, remuneration packages, quality of life, welfare measures
S3	Business partners	Procurement policies, green supply chain management, information exchange
S4	Financial organizations	Financial information, repayments, loans, environmental policies
S5	NGOs/NPOs, Governments	Regional contribution activities, donations activities, product footprint, revenue and tax distribution, contribution to GDP, environment compliance, environmental preservation projects
S6	Owners	Profitability, revenue, stock price, grievances and complaints, corporate governance, management of risk

Table 1: Stakeholders of MVMs, from [43]

2.7.2 Development of IMVM

Introduction In Chapter 2.6.4, five phases for constructing a CI were presented. In Figure 3 can be seen that these five phases form the guideline for the developmet of the I_{MVM}.

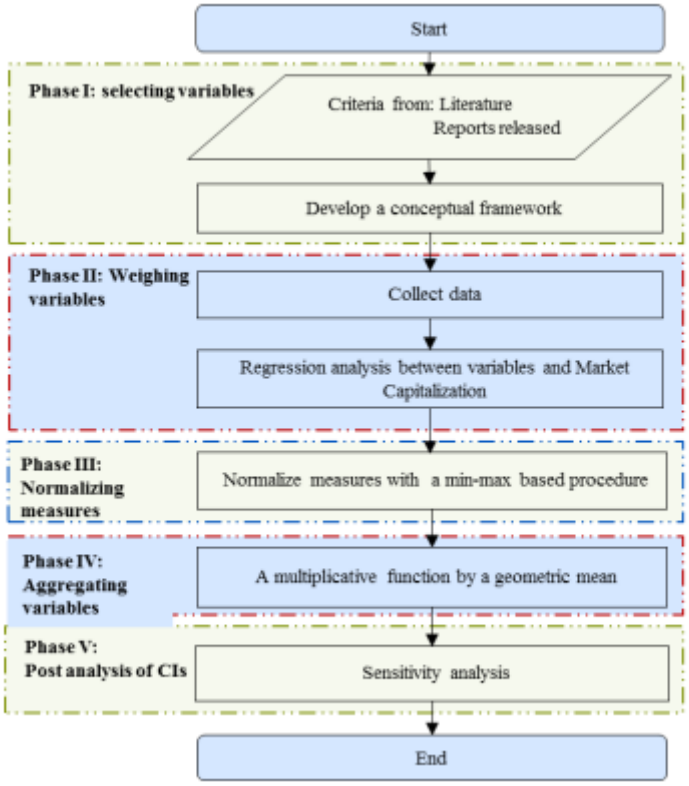


Figure 3: The development of the index I_{MVM}

In this section, the five phases of development of the I_{MVM} and their methods will be described.

Selecting variables

The first phase, *Selecting variables*, refers to a process including a literature review, interviews or surveys, the Delphi technique [30] and content analysis. In this phase, performance indicators and their measures were selected.

Economic measures

The first measures selected by Zeng are the economic measures. These five measures serve the customers, employees, business partners and owners. For all economic measures holds: the higher its value, the better the result is. The impact of these measures is therefore "+" .

V1 - Market share
The size of a company in relation to the market in which its competing can be given by the market share. Increasing market share is a common goal for companies in all sorts of industries.

$$V_1 = \frac{N_i[\#]}{\sum_{i=1}^{n} N_i[\#]} * 100\% \tag{2.6}$$

Where: N is for the motor vehicle production volume of the company i; I is for the MVMs (i=1, 2,. . . , n); n is for the size of sample manufacturers.

V2 - Cash flow margin
For business partners (S_3, liquidity of a company is important. Operating cash flow margin is a measure for liquidity. In Equation 2.7, the cash turnover ratio is calculated as the ratio between the cash flows from operating activities and the net sales of the company.

$$V_2 = \frac{\text{CFO}[\$]}{\text{NS}[\$]} \tag{2.7}$$

Where: CFO is for cash flows from operating activities; NS is for net sales.

V3 - Profit per Employee
For the shareholders ($S_{6)}$, profitability is considered to be the most important indicator. The profitability is a ratio between the pre-tax operating profit and the number of employees of the company.

$$V_3 = \frac{\text{P}[\$]}{\text{E}[\#]} \tag{2.8}$$

Where: P is for pre-tax operating profit; E is for the number of employees.

V4 - Research and Development expenditure per employee
"The measure research and development expenditure per capita focuses on innovation within a company, and co-innovation with suppliers in the development process for new vehicles" [4] This measure was described in this work as conception in Chapter 2.6.5 and is calculated as the R&D expenses divided by the number of employees.

$$V_4 = \frac{\text{R\&D}[\$]}{\text{E}[\#]} \tag{2.9}$$

Where: R&D is for research and development expenditure.

V5 - Inventory turnover
The inventory turnover is an important measure for both shareholders(S_6 and suppliers (S_3) This indicator shows the time it takes to convert a company's inventory into cash. This measure shows the overall efficiency of the supply chain.

$$V_5 = \frac{\mathrm{COGS_t}[\$]}{0.5 * (I_t + I_{t-1})[\$]} \tag{2.10}$$

Where: COGS represents cost of goods sold; t represents the fiscal year (t=0, 1,. . . ,T); I represents the inventory size.

Environmental measures

For all environmental measures holds: the lower its value is, the better the result is. The impact of these measures is therefore "-" .

V6 - Water consumption per vehicle produced
The water consumption of a company is considered as a measure for the impact

of a company on water resources. The sum of freshwater consumption externally sourced, groundwater intake, rainwater utilization amount en surface water from lakes rivers and ocean is taken as the amount of water consumption.

$$V_6 = \frac{\mathrm{WC}[\mathrm{m}^3]}{\mathrm{N_i}[\#]} = \frac{WI - WD[m^3]}{N_\mathrm{i}[\#]} \tag{2.11}$$

Where: N is for the production volume; i is for the manufacturer; Ni is for the volume of auto vehicles produced from the manufacturer i; WC is for water consumption; WI is for water input and WD is for water discharge.

V7 - Energy consumption per vehicle produced The energy consumption worldwide need to be reduced, so the automotive industry is no exception. For this measure, the energy consumption is calculated as the sum of "electricity, the energy from renewable energy sources, heating (including district heating), combustion gases for production processes, and externally supplied refrigeration".

$$V_7 = \frac{\mathrm{EC}[\mathrm{MWh}]}{\mathrm{N_i}[\#]} \tag{2.12}$$

Where: EC is for energy consumption.

V8 - $C0_2$ emissions per vehicle produced Same as for the energy consumption, the CO_2 emission reduction is a worldwide trend. The amount of CO_2 emissions in this work are calculated as the direct and the indirect emissions summed up.

$$V_8 = \frac{\mathrm{CE[t]}}{\mathrm{N_i[\#]}} \tag{2.13}$$

Where: CE is for CO2 emissions.

Normalizing measures

Although earlier called the third phase, *Normalizing Measures* is in fact the second phase in the construction of the I_{MVM}. In this phase of constructing a CI, as introduced in Chapter 2.6.4 the measures need to be made dimensionless.

$$x^{*t}{}_{ij} = \begin{cases} 1 + \frac{x^{t}{}_{ij} - min\, x^{t}{}_{j}}{max\, x^{t}{}_{j} - min\, x^{t}{}_{j}}, \text{for measure with impact "+"} \\ 1 + \frac{min\, x^{t}{}_{j} - x^{t}{}_{ij}}{max\, x^{t}{}_{j} - min\, x^{t}{}_{j}}, \text{for measure with impact "-"} \end{cases} \tag{2.14}$$

t: The fiscal year, t=0,1,...,T.
i: The MVMs, i=1,2,. . . ,n.
j: The individual measures, j=1, 2,. . . ,m.
$x^{t}{}_{ij}$: The value of the measure j for the manufacturer i in fiscal year t.
$max_i\ x^{t}{}_{ij}$: Within manufacturer i, the maximum value of measure j in t.
$min_i\ x^{t}{}_{ij}$: Within manufacturer i, the minimum value of measure j in t.
$x^{*t}{}_{ij}$: The normalized value of x t ij, and x * ij $\in$ [1,2].

As can be seen, there are two different formulas for measures with impact '+' and '-'. As stated in Chapter 2.7.2, the contribution of the economic measures to the I_{MVM} is considered to be positive and therefore the impact is '+' and the contribution of the environmental measures is negative resulting in impact '-'. The normalized measures have a value between 1 and 2 and the higher the value, the better.

Weighing variables In this phase of the construction of the I_{MVM}, the weights of the measures are calculated using Shannon entropy.
Firstly, the evaluation index was normalized(2.15. Secondly the entropy index (2.16) was calculated and thirdly the divergence (2.17) is determined.

$$p_{ij} = \frac{x_{ij}}{\sum_j x_{ij}} \tag{2.15}$$

$$e_{\mathrm{j}} = -k \sum_{j=1}^{n} p_{\mathrm{ij}} \ln(p_{\mathrm{ij}}), \text{where k} = (\ln(\mathrm{n}))^{-1} > 0,\ \mathrm{e_j} \geq 0 \tag{2.16}$$

$$d_{\mathrm{j}} = 1 - e_{\mathrm{j}} \tag{2.17}$$

Finally the normalized weights of indexes are obtained in 2.18

$$W_{\mathrm{j}} = \frac{d_{\mathrm{j}}}{\sum_j d_{\mathrm{j}}} \tag{2.18}$$

pij: The relative frequency of $\mathrm{x_{ij}}$
$\mathrm{d_j}$: The degree of diversification
$\mathrm{w_j}$: The weight of the measure j for the manufacturer i, $\mathrm{w_j} \in (0,1)$ and $\sum\ \mathrm{w_j} = 1$
n: The amount of companies included in the index

Aggregating measures Phase IV of constructing CIs is the aggregation phase. In this phase, the normalized values of the measures are integrated in the single index $\mathrm{I_{MVM}}$. Zeng used the geometric aggregation method as shown in 2.19.

$$CI_{\mathrm{i}} = \prod_{n}^{j=1} r_{ij}^{w_j} \tag{2.19}$$

In Formula 2.20, the equation for aggregating the normalized measures into one index $\mathrm{I_{MVM}}$ is shown.

$$I_{\mathrm{MVM_i{}^t}} = f[x_{\mathrm{ij}}{}^{\mathrm{'t}}, w_{\mathrm{j}}] = \prod_{8}^{j=1} x^{\mathrm{'t}}{}_{\mathrm{ij}}{}^{\mathrm{w_j}} \tag{2.20}$$

Where:
$\mathrm{I_{MVM_i}{}^t}$: The company performance index for MVM i in the fiscal year t.

$\mathrm{w_{ij}}$: The weight of measure j for MVM i, wij $\in (0,1)$ and $\sum\ \mathrm{w_i} = 1$.

Post analysis The post analysis phase consists of a sensitivity analysis. The aggregation method as described in Chapter 2.7.2 is compared with the simple additive weighting approach. In this sensitivity analysis, the weighing methods and the method for normalizing the measures are the same in order to see the effect of the different aggregation methods.

The simple additive weighing (SAW) approach is an aggregation technique used in several studies. In Equation 2.21 this approach is shown.

$$CI_{\mathrm{i}} = \sum_{j=1}^{n} w_j r_{ij} \tag{2.21}$$

After creating set of values for $\mathrm{I_{MVM}}$ using the geometric aggregation method (2.19 and the SAW method (2.21), Pearson's correlation test (2-tailed) was performed.

2.7.3 Measurement of Future Performance of Motor Vehicle Manufactures

Introduction As introduced in Chapter 1.1, Zeng addressed the lack of trend performance analysis for the following years. In *Development of A Composite Indicator for Measuring Company Performance from Economic and Environmental Perspectives*, an approach for generating trend data for the following years was presented for the $\mathrm{I_{MVM}}$.

The method for non-stationary time series analysis that is presented is the autoregressive integrated moving average (ARIMA) model. ARIMA is considered to be one of the most traditional methods in this field and compared to regression models this model provides the opportunity to explain time series "by its passed or lagged values and stochastic error terms.

The Box-Jenkins method applies ARIMA models in order to find the best possible fit for the time series model given the historic results [14]. Compared to other methods, the Box-Jenkins method takes estimation error residuals and lagged dependent variables into account resulting in improved accuracy.

The ARIMA model has three input parameters:

- p: the order of the autoregressive process (AR)
- d: the order of differencing
- q: the order of the moving average process (MA)

According to Zeng, "each AR term corresponds to the use of a lagged value of the residual in the forecasting equation for the unconditional residual." [43]. In Equation 2.22 the form of an autoregressive model of order p, AR(p) is shown.

$$X_t = \alpha_1 X_{t-1} + \alpha_2 X_{t-2} + ... + \alpha_p X_{t-p} + \epsilon_t \tag{2.22}$$

The order of differencing is the amount of times the historic time-series need to be differenced to make sure the data is stationary.

The order of the moving average process(q) refers to the forecast error used in the model. Lagged values of the forecast error are taken into account in order to improve the forecast. "A first-order moving average term uses the most recent forecast error; a second-order term uses the forecast error from the two most recent periods and so on." [43] In Equation 2.23, the form of MA(q) is shown.

$$X_t = \epsilon_t + \theta_1 \epsilon_{t-1} + ... + \theta_q \epsilon_{t-q} \tag{2.23}$$

2.7.4 ARIMA modelling steps

Zeng used a seven step procedure based on three-step procedures as presented by Bowerman [6]:

1. Data examination
2. Data decomposition
3. Stationarity check
4. Order identification
5. Fit ARIMA models
6. Diagnostic analysis
7. Trend values calculation

This seven step procedure will form the basis of the future trend analysis performed later in this work. In the first step, the data will be checked on their patterns and irregularities. Outliers and missing values will be cleaned up if necessary. The second step focuses on removal of seasonal effect from a time series. For the stationarity check, the augmented Dickey Fuller (ADF) test was used. The null hypothesis of this test is that a unit root is present in a series. The alternative hypothesis states that the series is stationary. If the series are non-stationary, differencing is used to accomplish stationarity. Order identification is done inspecting the Autocorrelation function (ACF) and the partial autocorrelation function (PACF). Inspection of these plots helps to tentatively identify the order of the MA(q) model and the RA(p) model respectively. The fifth step is the fitting of the ARIMA models. In this step the models with the lowest value for the Akaike information criteria (AIC) is chosen taking into account that models with non-stationarity in the AR of MA part should be excluded. The sixth step is the diagnostic analysis of the model. The residuals of the model with the lowest AIC value should be white noise, have no patterns and should be normally distributed.

Accuracy In *Development of a Composite Indicator for Measuring Company Performance from Economic and Environmental Perspectives*, the accuracy of the trend analysis is tested with the Mean Absolute Percentage Error (MAPE) [43]. The MAPE is the relative difference between the trend value calculated for the fiscal year 2017 based on the I_{MVM} from 2008-2017 and the I_{MVM} calculated directly for the same year as can be seen in Equation 2.24.

$$MAPE_i = \frac{1}{n} \sum_{t=1}^{n} |\frac{y_t - \tilde{y}_t}{y_t}| * 100\% \tag{2.24}$$

Where:

$MAPE_i$: The mean absolute percentage error between the historical I_{MVM} and the trend I_{MVM} value for the MVM i.

n: the sample size

y_t: The historical or actual I_{MVM} value

$\tilde{y}_t$: The trend I_{MVM} value

2.7.5 Conclusions

The central question handled in this section was: *What is the state-of-the-art of composite indicators for company performance measurement of MVMs?*.

In the first part of this section, the 4 generations of company performance measurement were introduced. The I_{MVM} added to the fourth generation due to its quantitative origin, its focus on MVMs and the economic and environmental perspectives while using publicly available data. In the next part, the five phases of constructing CIs were introduced and subsequently these five phases were handled for the development of the I_{MVM}.
In the variable selection phase, five economic and three environmental measures were introduced.

In the final part, the measurement of future performance of MVMs was introduced. The use of an ARIMA model to quantify the future performance of an individual company was presented. This method rises the question whether it is possible to use such a forecasting procedure to predict future performance of different MVMs compared to each other.

There can be concluded that the I_{MVM} provides the possibility of quantifying the historic performance of MVMs relative to each other as well as a procedure for forecasting a certain future performance of an individual company. It is interesting to look at the possibility of extending the I_{MVM} with an extra variable with forward looking abilities. At the same time, a method for measuring the future performance of MVMs relative to each other could provide interesting insights.

2.8 State-of-the-art of Market Capitalization

2.8.1 Introduction

In this chapter, the state-of-the-art of Market Capitalization in general will be presented as well as the possibility to include Market Capitalization as a measure in the I_{MVM}. In Chapter 2.8.2 the Market Capitalization will be introduced, in Chapter 2.8.3 insights in the relation between Market Capitalization and environmental company performance will be handled before finally in Chapter 2.8.4 the possibility of adding Market Capitalization to the I_{MVM} will be discussed.

2.8.2 Introduction to Market Capitalization

In *Market Capitalization: Pre and post COVID-19 analysis*, Kumar analyses the market capitalization correlation between the performances of shares and the growth of the share market by comparing pre and post COVID-19 stock market data [35]. The following definition was given: "Market Capitalization is the value of a public company in the stock market" Market Capitalization provides information about the size of a company meanwhile giving investors information about the future prospects of the company. The other way around, it gives an indication of the price investors are willing to pay for the shares of the company.
Market Capitalization can be calculated using the following Formula [1]:

$$Market\,Capitalization = N * P \tag{2.25}$$

Where:
N: Number of shares outstanding
P: Price per share

Based on their market capitalization, companies can be divided into three groups:

- Large-cap
- Mid-cap
- Small-cap

Large-cap companies have a market value larger than $10 billion and are therefore fully developed and commonly known companies in established industries. Mid-cap companies have a market value between $2 and $10 billion and are expected to accomplish growth. Small-cap companies have a market value smaller than $ 2 billion. In terms of investment risks, which reflect the company's potential volatility in performance, large-cap companies have the lowest risk and small-cap companies the highest.

One difference between the market capitalization and the other measures as mentioned in 2.7.2 is that a company must go public in order to have a Market Capitalization. Once a company entered the stock exchange, supply and demand determine the value of shares and the Market Capitalization can be calculated as presented in Formula 2.25

2.8.3 Market Capitalization and Environmental Rankings

In *The Value of Green: The Effect of Environmental Rankings on Market Cap*, Blumenshine studied the relationship between environmental rankings and market cap value [5]. The increased awareness of negative environmental effects of business raises the question: does this growing awareness have an effect on companies' market value.

He concludes that investors are willing to pay more for shares of companies with higher environmental rankings if the financial characteristics are similar. Because the model used in his work just uses one set of relevant financial indicators and excluded several non-financial indicators there has to be some caution with this conclusion and future research is necessary.

2.8.4 Market Capitalization in CI

Market Cap can compensate inaccuracy of the other 5 economic measures because it is affected by more variables and therefore gives a more comprehensive view of a company's financial performance. Moreover, as market capitalization is directly dependent of supply and demand, the value of the market capitalization can have a more forward looking contribution. Investors use the most recent information available and the stock value therefore reflects among other things, the confidence of the "market" in future performance.

Bryan describes market capitalization as a market-oriented and forward-looking measure for the size and economic relevance of a company. Furthermore, he suggests that market capitalization might be "the most important single measure of size and economic relevance" [7].
In different studies, Market Capitalization functions as an independent variable [15][29].In this work, Market Capitalization is considered to be an independent variable for the size of a company and is added due to the following characteristics:

- Indicates size of company
- Forward looking abilities
- Dynamic
- Established by external parties

2.8.5 Conclusions

In this section, the third research question of this work is handled. *What is the state-of-the-art of Market Capitalization as performance indicator?* The four abovementioned characteristics make Market Capitalization an interesting performance indicator and therefore it is considered interesting to add Market Capitalization as a ninth measure to the performance index I_{MVM}. Furthermore, the effect of the addition of Market Capitalization on future performance measurement of fictitious mergers is considered to be interesting.

3 Measuring

3.1 Introduction

In this section, a step-by-step approach will be presented for the development of the extended model I_{MVMMC}. *How to extend a composite indicator for measuring company performance of MVMs from economic and environmental perspectives in order to measure future company performance?*, or SRQ_4 will be answered in the remainder of this section. To do so, the following section will go through the phases of development. The addition of Market Capitalization as a ninth measure, the ability to investigate mergers and the generalization of the model will be handled.

3.2 Current status of the model

As presented in Chapter 2.7, the I_{MVM} was developed in multiple phases. In order to create a basis for further development of this model, a "current status of the model" will be presented in this section. As proposed in Chapter 2.8.4, Market Capitalization will be added as a ninth measure. The I_{MVM} can be seen as the current status of the model and therefore will be presented in this section. Twelve MVMs are included in the I_{MVM}: Toyota, Audi AG, Hyundai, GM, Ford, Nissan, Honda, FCA, Renault, PSA, Daimler Group and BMW. As in *Development of a Composite Indicator for Measuring Company Performance from Economic and Environmental Perspectives*, the I_{MVM} values are calculated for the fiscal years 2008-2017.
As presented in Chapter 2.7.2, the first phase of the development of the CI is called *Selecting variables*. V_1 - V_8 are the variables taken into account in this section. After the measures were calculated according to the formulas that were presented in Chapter 2.7.2, the second phase is the phase were these measures are normalized into dimensionless values between 1 and 2.

	V1	V2	V3	V4	V5	V6	V7	V8
Toyota	13.06%	7.70%	-14495.52	28426.73	-11.97	3.80	2.57	0.81
Audi AG	1.45%	12.69%	76477.23	52019.92	-4.32	2.82	2.27	0.19
Hyundai	3.93%	-0.01%	31027.68	22123.84	-3.65	6.13	4.06	0.66
GM	11.71%	-8.10%	-121279.84	32971.19	-11.31	5.13	2.56	1.09
Ford	7.64%	-8.62%	-45778.33	35960.59	-14.75	5.60	3.56	1.09
Nissan	4.80%	10.56%	-8937.66	29550.05	-8.39	7.33	2.27	0.63
Honda	5.53%	3.83%	10517.90	31235.79	-5.96	1.20	0.71	0.12
FCA	6.25%	0.64%	15347.19	13936.68	-4.32	6.47	5.50	0.57
Renault	3.29%	-1.18%	2286.26	20037.11	-5.63	5.10	2.24	0.23
PSA	4.70%	0.04%	3795.46	14112.22	-5.79	3.79	1.78	0.29
Daimler Group	3.07%	1.67%	13908.00	22629.79	-4.73	7.03	5.02	1.74
BMW	2.04%	20.44%	4883.57	39305.06	-6.47	2.56	2.80	1.17

Table 2: Measures current status of the model 2008

	V1'	V2'	V3'	V4'	V5'	V6'	V7'	V8'
Toyota	2.000	1.562	1.540	1.380	1.750	1.576	1.613	1.576
Audi AG	1.000	1.733	2.000	2.000	1.060	1.735	1.674	1.955
Hyundai	1.213	1.296	1.770	1.215	1.000	1.196	1.301	1.670
GM	1.884	1.018	1.000	1.500	1.690	1.359	1.614	1.399
Ford	1.533	1.000	1.382	1.578	2.000	1.282	1.405	1.401
Nissan	1.288	1.660	1.568	1.410	1.427	1.000	1.674	1.686
Honda	1.351	1.429	1.666	1.454	1.209	2.000	2.000	2.000
FCA	1.413	1.319	1.691	1.000	1.060	1.140	1.000	1.724
Renault	1.158	1.256	1.625	1.160	1.179	1.364	1.681	1.933
PSA	1.280	1.298	1.632	1.005	1.193	1.578	1.776	1.898
Daimler Group	1.140	1.354	1.684	1.228	1.098	1.048	1.099	1.000
BMW	1.050	2.000	1.638	1.666	1.255	1.778	1.564	1.352

Table 3: Normalized measures current status of the model 2008

During the third phase, the weights of the measures are determined. In Table 4, the calculated weights according to the methods described in Chapter 2.7.2 are shown. This table shows the values for the weights calculated for the *Current Status of the model*. The table shows the weights (W_j) for each measure, based on their relative contribution to the overall entropy of the set of measures. A measure with a higher weight has a larger contribution to the overall diversity of the set of measures.

FY	**Weight**	**V1'**	**V2'**	**V3'**	**V4'**	**V5'**	**V6'**	**V7'**	**V8**
2008	ej	0.991	0.992	0.996	0.992	0.991	0.991	0.993	0.993
	Wj	0.152	0.127	0.073	0.130	0.150	0.148	0.111	0.110
2009	ej	0.991	0.990	0.992	0.993	0.992	0.995	0.994	0.994
	Wj	0.157	0.173	0.138	0.115	0.129	0.092	0.097	0.097
2010	ej	0.990	0.991	0.990	0.993	0.993	0.993	0.994	0.995
	Wj	0.160	0.149	0.161	0.123	0.116	0.109	0.095	0.087
2011	ej	0.991	0.992	0.990	0.990	0.994	0.995	0.994	0.993
	Wj	0.147	0.126	0.169	0.157	0.105	0.089	0.094	0.113
2012	ej	0.990	0.994	0.991	0.991	0.994	0.994	0.994	0.994
	Wj	0.169	0.100	0.152	0.149	0.110	0.110	0.104	0.105
2013	ej	0.990	0.991	0.990	0.991	0.995	0.993	0.992	0.995
	Wj	0.164	0.146	0.158	0.137	0.078	0.116	0.121	0.079
2014	ej	0.993	0.992	0.989	0.992	0.995	0.992	0.993	0.995
	Wj	0.122	0.138	0.180	0.139	0.085	0.131	0.115	0.091
2015	ej	0.991	0.991	0.992	0.993	0.995	0.994	0.994	0.994
	Wj	0.155	0.164	0.136	0.124	0.091	0.113	0.109	0.106
2016	ej	0.991	0.992	0.994	0.993	0.994	0.994	0.995	0.994
	Wj	0.160	0.150	0.120	0.138	0.117	0.104	0.097	0.116
2017	ej	0.990	0.994	0.991	0.992	0.996	0.995	0.994	0.992
	Wj	0.174	0.109	0.157	0.147	0.079	0.095	0.100	0.138

Table 4: Weights current status of the model

The fourth phase is the aggregation phase. In this phase, the normalized measures are aggregated into one single index. In Table 5, the values calculated for the current status of the model are shown.

Manufacturer	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Toyota	1.619	1.632	1.573	1.444	1.578	1.710	1.687	1.730	1.647	1.674
Audi AG	1.615	1.614	1.681	1.719	1.698	1.707	1.779	1.609	1.537	1.505
Hyundai	1.277	1.419	1.515	1.501	1.477	1.438	1.485	1.439	1.363	1.369
GM	1.442	1.340	1.487	1.562	1.575	1.600	1.437	1.620	1.659	1.687
Ford	1.438	1.398	1.462	1.509	1.528	1.497	1.508	1.587	1.593	1.538
Nissan	1.418	1.521	1.422	1.467	1.481	1.494	1.523	1.593	1.613	1.551
Honda	1.588	1.621	1.375	1.262	1.325	1.318	1.320	1.322	1.356	1.355
FCA	1.242	1.270	1.262	1.272	1.294	1.301	1.295	1.315	1.315	1.328
Renault	1.361	1.439	1.286	1.361	1.368	1.363	1.395	1.481	1.444	1.407
PSA	1.401	1.398	1.321	1.302	1.291	1.277	1.285	1.400	1.445	1.407
Daimler Group	1.151	1.132	1.214	1.178	1.166	1.147	1.132	1.154	1.271	1.288
BMW	1.494	1.507	1.437	1.517	1.513	1.521	1.546	1.428	1.475	1.607

Table 5: I_{MVM} values current status of the model

In order to fulfill the post analysis phase, a sensitivity analysis was performed. The SAW approach was used as an alternative aggregation technique and the results are shown in Table 6

Manufacturer	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Toyota	1.628	1.647	1.602	1.478	1.597	1.728	1.704	1.743	1.662	1.685
Audi AG	1.653	1.650	1.729	1.769	1.751	1.754	1.815	1.651	1.590	1.535
Hyundai	1.293	1.454	1.538	1.531	1.493	1.478	1.509	1.463	1.388	1.394
GM	1.471	1.375	1.523	1.580	1.587	1.611	1.456	1.622	1.666	1.692
Ford	1.465	1.427	1.491	1.527	1.543	1.511	1.522	1.598	1.607	1.558
Nissan	1.438	1.532	1.435	1.482	1.505	1.518	1.542	1.604	1.631	1.572
Honda	1.617	1.648	1.391	1.282	1.341	1.327	1.334	1.334	1.371	1.370
FCA	1.266	1.280	1.288	1.298	1.321	1.331	1.331	1.348	1.349	1.367
Renault	1.384	1.466	1.325	1.395	1.401	1.394	1.428	1.506	1.462	1.443
PSA	1.429	1.421	1.359	1.345	1.322	1.309	1.318	1.422	1.482	1.450
Daimler Group	1.164	1.142	1.222	1.189	1.176	1.161	1.144	1.172	1.294	1.307
BMW	1.524	1.538	1.473	1.553	1.554	1.559	1.578	1.477	1.516	1.651

Table 6: I_{MVM} values with SAW as aggregation technique

Pearson's correlation test was performed with the obtained values from both aggregation techniques and the results were shown in Table 10.

Company	Coefficient r	N	T statistic	DF	P value
Toyota	0.998	10	43.079	8	9E-11
Audi AG	0.996	10	32.396	8	9E-10
Hyundai	0.995	10	29.489	8	2E-09
GM	0.998	10	46.703	8	5E-11
Ford	0.998	10	41.654	8	1E-10
Nissan	0.997	10	38.076	8	2E-10
Honda	1.000	10	101.25	8	1E-13
FCA	0.985	10	15.906	8	2E-07
Renault	0.995	10	29.29	8	2E-09
PSA	0.993	10	24.64	8	8E-09
Daimler Group	0.998	10	42.627	8	1E-10
BMW	0.994	10	24.925	8	7E-09

Table 7: Pearson correlation current status of the model

The results of the historic company performance measurement with the current status of the model are shown in Figure 4.

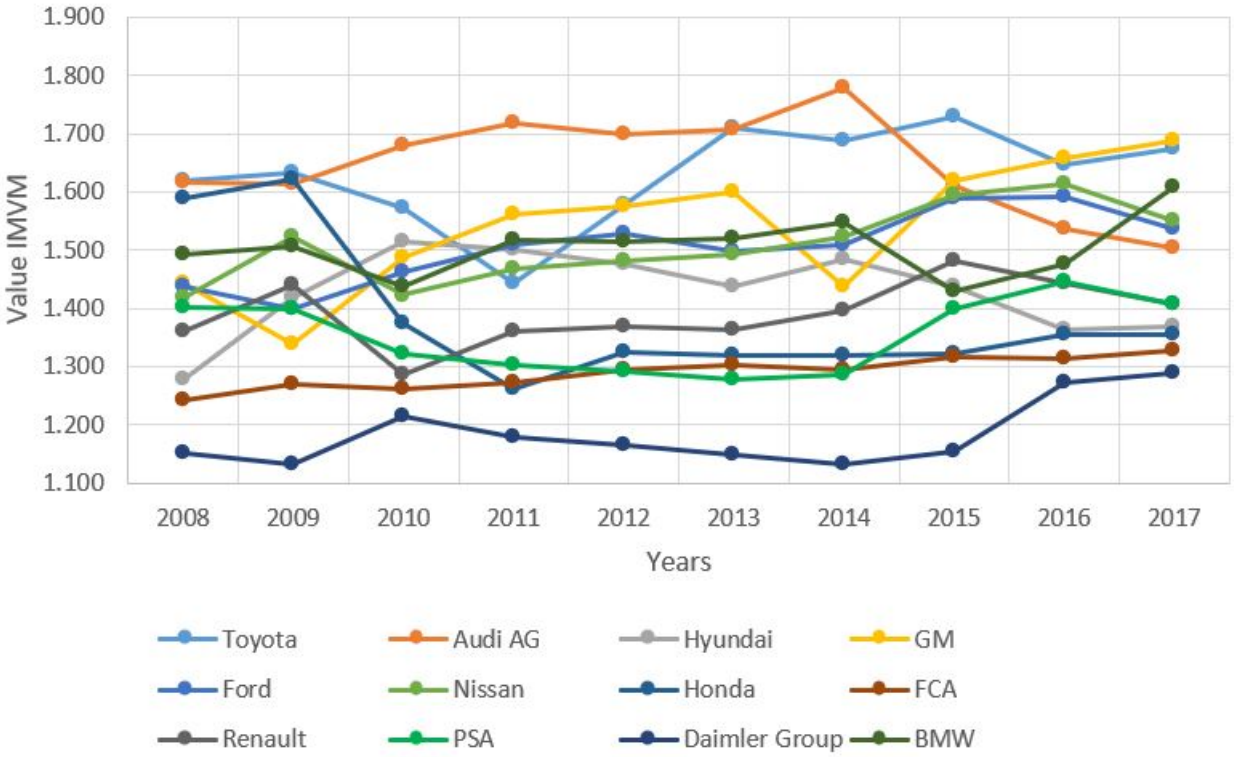


Figure 4: I_{MVM} results current status of the model

3.2.1 Environmental performance

In order to evaluate the environmental performance and the economic performance separately, Zeng constructed the sub indices I_{ENVI} and I_{ECON}. The I_{ENVI} uses the same values for the normalized environmental measures (V_6-V_8) as the general index I_{MVM}. The weights of the sub index are calculated according to the same method as the general index.

3.2.2 Performance matrix

In *Development of a Composite Indicator for Measuring Company Performance from economic and environmental perspectives*, Zeng introduced a performance matrix on the I_{ENVI} vs the I_{MVM}.

The Performance matrix evaluates the performance of the MVMs by combining their general performance (I_{MVM} and their environmental performance (I_{ENVI}. The I_{MVM} values are presented on the horizontal axis, while the I_{ENVI} values are presented on the vertical axis.

The average score of all MVMs on I_{MVM} values and I_{ENVI} values divide the performance matrix into four quadrants.

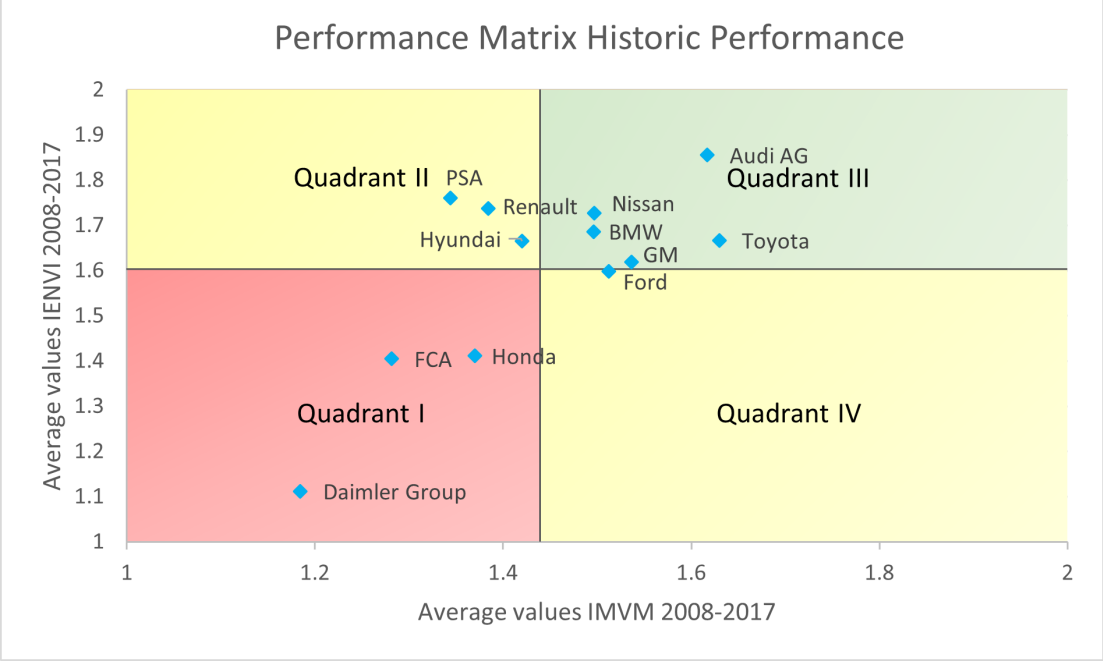


Figure 5: Performance matrix current status of the model

As can be seen in Figure 5, all MVMs are located in the four Quadrants. Quadrant I (Q1) contains the MVMs with scores below average on both environmental performance and general performance. Quadrant II (Q2) contains the MVMs with scores above average on environmental performance but below average on general performance. Quadrant III (Q3) contains the MVMs with scores above average on both environmental performance and general performance. Quadrant IV (Q4) contain the MVMs with scores below average on environmental performance but above average on general performance.

3.3 Extended model

3.3.1 Introduction

In the previous section, the current status of the I_{MVM} was presented as it was described earlier in Chapter 2.7. In this section, the different phases of development, as presented in Chapter 2.7.2 are passed in order to show the thought process of extending the I_{MVM} to the I_{MVMMC}. These phases are shown in Figure 6

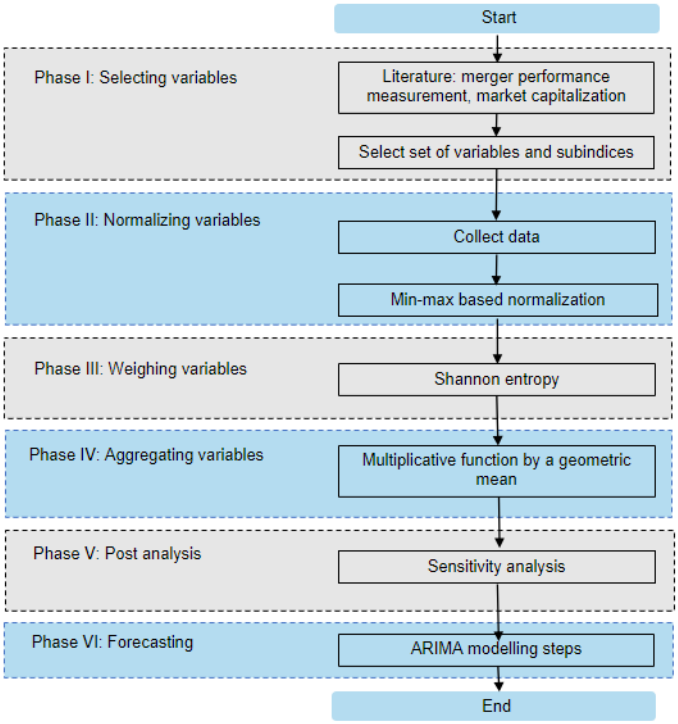


Figure 6: Development of extended model I_{MVMMC}

3.3.2 Phases of Development

Phase I: selecting variables
Selecting variables is an essential part of the development of the CI. The I_{MVMMC} focuses on two categories of variables: economic and environmental variables. These two sets of variables need to give a comprehensive representation of a company's performance in both categories.

For the economic part, 5 variables (V1-V5) were already included in the I_{MVM} as developed by Zeng[43]. In Chapter 1.2, this set of measures is considered to be incomplete. The most important reason for this statements is the absence of a forward looking economic variable.
As stated in Chapter 2.8, reasons to include Market Capitalization as ninth measure are:

- Market Capitalization is a measure that is established by external parties
- Market Capitalization is a dynamic measure
- Market Capitalization can reflect future earning potential
- Market Capitalization is an independent variable

These reasons make it relevant to design a CI with Market Capitalization as a ninth measure (V9).

The formula used for Market Capitalization as introduced in Chapter 2.8 ([35]) is:

$$V9 = N * P \tag{3.1}$$

Where:
N: Number of shares outstanding
P: Price per share

For the environmental part, three variables are taken into account in the I_{MVM}. For this industry, these measures are considered relevant and therefore taken into account in the remainder of this work.

Phase II: Normalizing measures

To incorporate the independent variable Market Capitalization into the I_{MVM} and effectively evaluate future merger performance, it is necessary to gather data on all relevant MVMs up to the most recent fiscal year possible. For the fiscal years 2008-2017, and measures V_1-V_8, the raw data as used by Zeng in *Development of a Composite Indicator for Measuring Company Performance from Economic and Environmental Perspectives* can be utilized. As the actual merger between PSA and FCA happened in 2020, the data with all individual MVMs can be updated until 2019. Furthermore, Zengs dataset needed to be extended with the Market Capitalization for the years 2008-2017.

The data was primarily collected from annual reports, but also from sustainability reports and environmental reports.
Zeng included 15 MVMs from OICAs top 50 based on data availability for all eight measures during the period from 2008 to 2017. The data set used in this work includes nine measures during the period of time from 2008 to 2019 and contains the following 12 MVMs:

- Toyota
- Audi AG
- Hyundai
- GM
- Ford
- Nissan
- Honda
- FCA
- Renault
- PSA
- Daimler Group
- BMW

The units of the measures as presented in Chapter 2.7.2 are summarized in Table 8.

Measures	**Variable**	**Unit**
V1	Market share	%
V2	Cash flow margin	
V3	Continuity	$/#
V4	Conception	$/#
V5	Inventory turnover	
V6	Water consumption per vehicle produced	m^3/#
V7	Energy consumption per vehicle produced	MWh/#
V8	CO2 emissions per vehicle produced	t/#
V9	Market Capitalization	$

Table 8: Measures with corresponding units

After the measures are selected, the required data is collected and the values for the different measures are calculated, all measures need to be scaled. In this case, the min-max normalization method has been modified in such a way that it provides values between 1 and 2. Furthermore, a different equation has been used for normalizing measures with a positive and negative impact respectively. Finally, for the usability, the model for I_{MVMMC} needs to be able to perform these steps automatically. Changing the participating companies in the model can affect the highest and lowest value for each measure. Moreover, when new measures are taken into account in I_{MVMMC}, the right min-max normalization equation needs to be used for positive or negative impacting measures.

Phase III: Weighing variables

The weighing procedure described in Chapter 2.7.2 is considered to be a robust and reliable way of weighing the variables. By calculating the entropy of the distribution, the degree of diversity withing the set of variables can be measured. Therefore the calculated weight for each measure reflects the diversity of the set of variables. This makes sure that the final value of the CI is not dominated by a small number of highly correlated variables.

Phase IV: Aggregating measures
The geometric aggregation method as described in Chapter 2.7.2 is also used in the construction of the extended model I_{MVMMC}. Compared to other methods such as SAW, the geometric aggregation method takes interactions between different indicators into account, which can lead to more accurate results.

Phase V: Post-analysis
In the post-analysis phase, I_{MVMMC} is subjected to a sensitivity analysis in order to analyse the robustness of the I_{MVMMC}.
With the same methods for phase II and III as in the calculation of I_{MVMMC} and the SAW method as aggregation method, the following values are calculated.

Manufacturer	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Toyota	1.677	1.686	1.642	1.533	1.640	1.755	1.737	1.775	1.703	1.721
Audi AG	1.593	1.603	1.678	1.708	1.686	1.696	1.736	1.591	1.534	1.493
Hyundai	1.259	1.424	1.506	1.506	1.469	1.458	1.468	1.407	1.340	1.350
GM	1.410	1.334	1.514	1.550	1.550	1.580	1.427	1.581	1.617	1.645
Ford	1.406	1.404	1.479	1.499	1.513	1.490	1.490	1.564	1.563	1.520
Nissan	1.414	1.503	1.419	1.463	1.474	1.484	1.494	1.554	1.575	1.525
Honda	1.581	1.628	1.397	1.301	1.344	1.326	1.324	1.326	1.356	1.357
FCA	1.236	1.262	1.271	1.269	1.289	1.301	1.295	1.313	1.315	1.343
Renault	1.337	1.425	1.298	1.357	1.365	1.364	1.386	1.461	1.419	1.405
PSA	1.373	1.381	1.323	1.309	1.287	1.278	1.282	1.376	1.429	1.406
Daimler Group	1.175	1.169	1.249	1.201	1.191	1.192	1.171	1.220	1.311	1.320
BMW	1.472	1.502	1.457	1.524	1.530	1.541	1.545	1.469	1.492	1.613

Table 9: Company performance extended model with SAW as aggregation method

In order to test the robustness of the I_{MVMMC}, a 2-tailed Pearson's correlation test was performed: the values of the I_{MVMMC} were compared to the values obtained with the SAW method. The I_{MVMMC} was calculated with both aggregation techniques for the years 2008-2017 for all twelve MVMs.

Company	Coefficient r	N	T statistic	DF	P value
Toyota	0.998128977	10	46.172176	8	5.34957E-11
Audi AG	0.996584839	10	34.135778	8	5.92709E-10
Hyundai	0.996780917	10	35.165227	8	4.67981E-10
GM	0.998415142	10	50.178559	8	2.75494E-11
Ford	0.99769907	10	41.622466	8	1.2229E-10
Nissan	0.99525261	10	28.923572	8	2.20964E-09
Honda	0.999538256	10	93.041932	8	1.98767E-13
FCA	0.978846328	10	13.531956	8	8.53992E-07
Renault	0.995978779	10	31.444026	8	1.13845E-09
PSA	0.993529259	10	24.742145	8	7.61058E-09
Daimler Group	0.997209744	10	37.783103	8	2.64301E-10
BMW	0.996115932	10	31.997687	8	9.91059E-10

Table 10: Results of 2-tailed Pearson's correlation test

Phase VI: Forecasting

The final phase of development of the extended model is the forecasting phase. This phase consists of a forecast generated with the autoregressive integrated moving average (ARIMA) model. The ARIMA model is "one of the most traditional methods of non-stationary time series analysis" [43]. Time series analysis can help to understand the effect on future performance caused by changes in inputs. The ARIMA models can represent pure autoregressive models, pure moving average models and combinations of both.
"Auto-Regressive Integrated Moving Average model, or ARIMA, is a time-series forecasting approach that is used in predicting the future value of a variable from its own past values. It uses auto-regression and moving average, and incorporates a differencing order to remove trend and/or seasonality" [2].
The following equation expresses the model:

$$y'_t = c + \phi_1 y'_{t-1} + ... + \phi_p y'_{t-p} + \theta_1 \epsilon_{t-1} + ... + \theta_q \epsilon_{t-q} + \epsilon_t \tag{3.2}$$

As presented in Chapter 2.7.3, Zeng followed a seven step procedure based on the the three-step procedures as presented by Bowerman [6]. In this section, the procedure used in this work will be introduced and motivated.
As several ARIMA models will be created, it is important for this work to minimize the amount of human checks in the procedure of creating a forecast. The process of creating a forecast using ARIMA modeling will be explained in four steps:

- Identification
- Estimation
- Diagnostics
- Forecasting

Identification

The first step includes a stationarity test and identification of the appropriate model. The input data, in this case the results of the historic company performance measurement for the fiscal years 2008-2019, need to be checked for outliers, missing values or irregularities. There is no seasonal effect because the data is based on annual reports.

For checking the stationarity of the data, the augmented Dickey-Fuller test has been used with the following null hypothesis (H_0) and alternative hypothesis (H_a):

H_0: A unit root is present in the time series data

H_a: The time series data is stationary

If the null hypothesis is accepted, the data need to be differenced until the null hypothesis is rejected. In this work, the data is differenced until the p-value is below 0.05.

Estimation

According to Alabdulrazzac, "relying on only manual visual inspections and following recommended guidelines may work in forecasting a small number of univariate time-series. However, in case large numbers need to be forecasted, manual inspection will not be possible" [2]. Software packages with the ability to automatically select the best model such as auto.ARIMA can be useful in this case.

The next step is the model fitting. The AIC values of different ARIMA (p,d,q) models, with the d-value as determined with the ADF, are calculated. The model with the lowest AIC value is considered to be the best fit.

Diagnostics

After the model's parameters have been estimated, the Box-Jenkins methodology requires checking the residuals of the input data minus the estimated values by the model. If these residuals are random, the model is assumed to be appropriate [36].
The Ljung-Box was used to test whether the residuals of the model have non-significant autocorrelation. The hypotheses of the Ljung-Box test are:
H_0: The residuals are independently distributed
H_A: The residuals are not independently distributed.
If the Ljung-Box p-value is larger than 0.05, the null hypothesis can be rejected and the residuals are independent.

3.4 Conclusions

This chapter focused on SRQ_4: *How to extend a composite indicator for measuring company performance of MVMs from economic and environmental perspectives in order to measure future company performance?*

The current status of the model I_{MVM} was presented in Chapter 3.2. The five phases of development as performed by Zeng were passed. The results of the different phases were presented in order to give an impression of the results obtained with the proposed methods and the gathered data.

Subsequently, the Environmental subindex I_{ENVI} and the performance matrix were introduced as tools for visualizing the environmental performance and the general performance of companies in one graph.

In the next part, the extension of the model was handled. The addition of Market Capitalization as ninth performance indicator was motivated, the forecasting method was presented and the updated data was used.

4 Analysis

4.1 Introduction

In Chapter 1, the recent merger between PSA and FCA was introduced as cause for this research. At the same time, future merger performance measurement was proposed as research gap. In Chapter 2, the composite indicator I_{MVM} was described and Market Capitalization was proposed as extra measure due to its potential forward looking abilities. In order to investigate the recent merger and answer SRQ_5 between PSA and FCA, a case study will be performed according to the methods for theory testing research of Dul and Hak [11]. In the following section theory testing research will be introduced.

4.2 Theory testing research

"The objective of theory-testing research is to test propositions. Theory-testing research consists of:

1. Selecting instances of the object of study, depending on the chosen research strategy – one instance for a single case study, a group of instances for a comparative case study, a population for a survey
2. Formulating a hypothesis about these instances, derived from the proposition of the theory
3. Conducting measurement, depending on the concepts qualitative, quantitative, or both
4. Conducting data analysis – comparing the observed pattern of scores with the predicted pattern."

In order to apply the methods from the book of Dul & Hak, some definitions must be explained. With a *theory*, firstly, the authors mean "a set of *propositions* about an *object of study*. A proposition tells something about causal relations between *concepts*. Concepts are represented by variables. A relation between variables can be stated in a hypothesis [11]. The *object of study* is defined as the stable characteristic in the theory while the concepts are the variable characteristics of the object of study. Concepts are defined as follows: "concepts need to be defined precisely to allow for the measurement of their value in instances of the object of study. When we measure the value of a concept in such instances, we call it a variable." A *conceptual model* visualizes the propositions of a theory. It is a simplified way of showing the relation between the inputs or *independent concepts* and the outputs or *dependent concepts*. The simplest form of a conceptual model can be seen in Figure 7

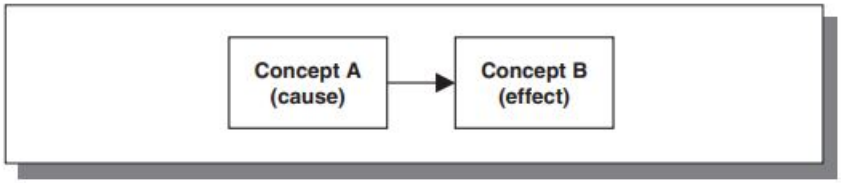


Figure 7: Conceptual model, simplest form from [11]

Different types of propositions can be distinguished. In the book from Dul and Hak, three types of deterministic propositions and one type of probabilistic proposition are handled elaborately.

Propositions that express that concept A is a sufficient condition for concept B

"Propositions that express that concept A is a sufficient condition for concept B can be formulated as follows:"

"If there is A then there will be B"

Propositions that express that concept A is a necessary condition for concept B

"Propositions that express that concept A is a necessary condition for concept B can be formulated as:"

"B exists only if A is present"

Propositions that express a deterministic relation between concept A and concept B

"Propositions that express a deterministic relation between concept A and concept B can be formulated as:"

"If A is higher, then B is higher"

Propositions that express a probabilistic relation between concept A and concept B

"Propositions that express a probabilistic relation between concept A and concept B can be formulated as:"

"If A is higher, then it is likely that B is higher."

For different propositions, *Case study Methodology in Business Research* prescribes different research strategies. In Figure 8, the research strategies for testing the different proposition types as presented above are visualized.

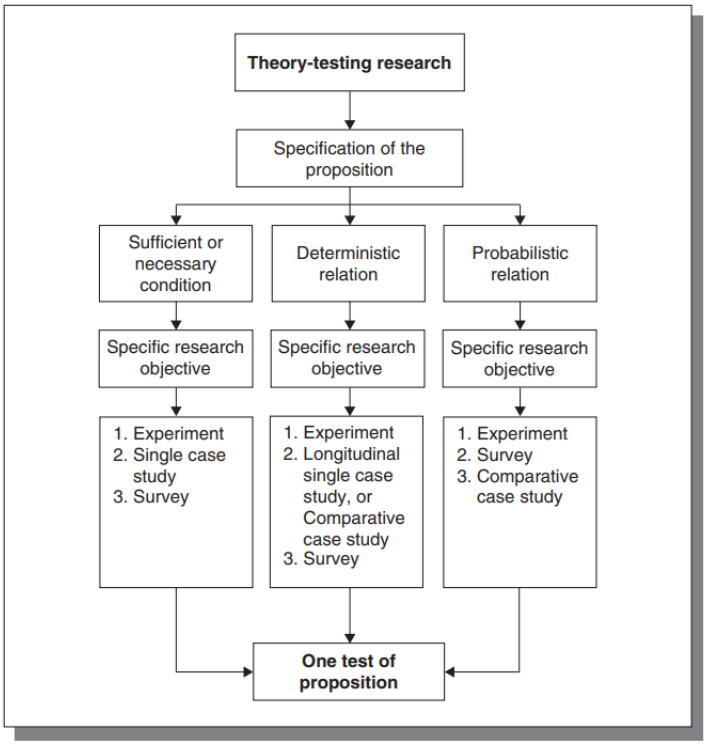


Figure 8: Theory-testing research strategies from Case Study Methodology [11]

In Chapter 4.4.4 there will be elaborated on the chosen research strategy for this research.

4.3 Experimental setup case study

4.3.1 Test environment

The experiments in this research are performed with the model developed in Chapter 3.3. This model includes the raw measures V_1-V_9 of ten selected MVMs. As Zeng described in her work[43], fifteen MVMs were eligible for the I_{MVM}, because of the availability of the required statistics for the selected measures. From the top 50 manufacturers as listed in OICA [32], 35 MVMs were excluded. These companies provided insufficient information in terms of their environmental performance and hence part of the measures could not be calculated. Because of the unavailability of data, another 5 MVMs were excluded from I_{MVMMC} The twelve selected MVMs are Toyota, Audi, Hyundai, GM, Ford, Nissan, Honda, FCA, Renault, PSA, Daimler Group and BMW.

4.3.2 Application of CI on fictitious merger

A hypothetical merger case will be handled in this research: PSA-FCA will be included as a "fictitiously merged" company in the data set used for determining the I_{MVMMC}. New measures were determined for the fictitious merger. Raw data of both individual companies have been used to calculate the correct values for all measures of the fictitiously merged company for the hypothetical case where the merger was completed before 2008. In the remainder of this work, two MVMs will be fictitiously merged horizontally by adding up the raw statistics from the dataset before calculating combined measures. The calculation of V_3 of the fictitious merger between PSA and FCA is given as an example:

$$V_3 = \frac{P_{\text{PSA}} + P_{\text{FCA}}}{E_{\text{PSA}} + E_{\text{FCA}}} \tag{4.1}$$

4.4 Case Study

4.4.1 Introduction

After the state-of-the-art was given in Chapters 1.4 2.6 and 2.5 and the I_{MVMMC} has been introduced this chapter will present a case study. As introduced in Chapter 2.2 and Chapter 4.2, this work aims to follow the chapters about *theory-testing research* from *Case Study Methodology in Business Research* from Dul and Hak [11]. Therefore, the research approach must be expressed in the terms of Dul and Hak. The definitions of these terms are handled in 4.2 and this section the framework of this research will be explained and propositions will be proposed.

4.4.2 Theory

Object of study
The object of study is defined as the stable characteristic. In this case the "application of the I_{MVMMC} to the case of a merger" is considered to be the object of study.

Concepts
The concepts are the variables of the research. The measures, as they can be seen as the input of the I_{MVMMC} are one of the variables. In the case of a merger, the measures are adjusted as explained in 4.3.2. A change in the measures by "creating" a fictitious merger can be seen as the *cause*. Better or worse company performance can be seen as the *effect*.

Propositions

Based on theory a deterministic proposition was formulated.

A merger between two top 10 MVMs performs better than both MVMs individually

Domain
The larger context that the object of study belongs to is called the domain. In this case the domain is defined as: "merger company performance measurement in automotive industry".

Conceptual model
The relation between the concepts as proposed above is visualized in Figure 9.

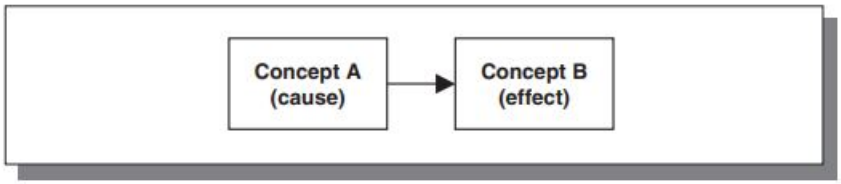


Figure 9: Conceptual model, Causal Relation, from [11]

4.4.3 Research objective

The objective of this research is to contribute to the theory about the impact of a merger on company performance in the field of the automotive industry.

4.4.4 Research strategy

The research strategy can be seen as the things required to be able to test the proposition. Firstly, the historical data, and in particular the measures V_1-V_9, of the MVMs for the period between 2008 and 2019 is required. At the same time, the same data for the fictitiously merged company PSA-FCA is required. In order to quantify the company performance, these measures need to be normalized and weights for all measures for every year need to be determined. Finally the I_{MVMMC} needs to be calculated for all MVMs and the fictitiously merged company.

4.4.5 Candidate cases

In this research, the first case was selected beforehand. The recent merger between PSA and FCA is considered the apparent reason for this research.

4.4.6 Hypotheses

In order to determine whether a merger between MVMs lead to better performance than both MVMs individually can be sustained in a few different ways. The following hypotheses are proposed:

1. *The merger's performance is better than both FCA's and PSA's performance in all instances.*
2. *The merger's performance is better than FCA's performance in all instances.*
3. *The merger's performance is better than PSA's performance in all instances.*
4. *The merger's performance is generally better than both FCA's and PSA's performance.*

4.4.7 Measurement

The data required to calculate all measures is not listed in one available data set. The data is gathered by Zeng for the period of time from 2008-2017 and was updated for this research until 2019. The data was collected from publicly available sources such as:

1. Annual reports
   (a) Financial reports
   (b) Sustainability reports

(c) Environmental reports

(d) Corporate social responsibility

2. Professional websites for stock market information

The measures of the fictitiously merged company were calculated as explained in 4.3.2.
With the collected data all phases as described in Chapter 3.3 were completed.

4.4.8 Data presentation

In this section, three tables are shown to visualize the way the data is structured.

Normalized measures determine the contribution of a measure from a certain company to its I_{MVM}. In Table 11 can be seen that the normalized measures have a value between 1 and 2. The best performing company scores a 2 and the worst performing company scores a 1 for each measure and for all values between 1 and 2 holds: a higher value contributes to a better company performance. The normalized measures of FY2008 are used as an example.

MVM	**V1'**	**V2'**	**V3'**	**V4'**	**V5'**	**V6'**	**V7'**	**V8**	**V9'**
Toyota	2.000	1.562	1.540	1.379	1.666	1.576	1.570	1.576	2.000
Audi AG	1.000	1.733	2.000	2.000	1.460	1.735	1.638	1.955	1.195
Hyundai	1.213	1.296	1.770	1.213	1.022	1.196	1.224	1.670	1.032
GM	1.884	1.018	1.000	1.499	1.697	1.359	1.571	1.399	1.000
Ford	1.533	1.000	1.382	1.577	2.000	1.282	1.339	1.401	1.013
Nissan	1.288	1.660	1.568	1.409	1.440	1.000	1.639	1.686	1.255
Honda	1.351	1.428	1.666	1.453	1.226	2.000	2.000	2.000	1.337
Renault	1.158	1.256	1.625	1.158	1.197	1.364	1.646	1.933	1.025
Daimler Group	1.140	1.354	1.684	1.226	1.000	1.048	1.000	1.000	1.248
BMW	1.050	2.000	1.638	1.665	1.271	1.778	1.516	1.352	1.124
PSA FCA	1.818	1.309	1.648	1.000	1.867	1.328	1.260	1.799	1.069

Table 11: Normalized measures 2008

In Table 12 the weights calculated for all normalized measures are listed from 2008 until 2019.

FY	**Weight**	**V1'**	**V2'**	**V3'**	**V4'**	**V5'**	**V6'**	**V7'**	**V8**	**V9'**
2008	ej	0.991	0.993	0.996	0.992	0.989	0.992	0.994	0.994	0.991
	Wj	0.138	0.102	0.058	0.116	0.161	0.118	0.092	0.089	0.126
2009	ej	0.991	0.991	0.992	0.993	0.988	0.995	0.995	0.995	0.993
	Wj	0.142	0.138	0.112	0.100	0.178	0.073	0.078	0.076	0.102
2010	ej	0.990	0.992	0.990	0.992	0.990	0.994	0.994	0.995	0.993
	Wj	0.140	0.118	0.143	0.110	0.154	0.086	0.084	0.070	0.096
2011	ej	0.991	0.993	0.990	0.990	0.991	0.995	0.994	0.994	0.992
	Wj	0.131	0.101	0.146	0.138	0.132	0.070	0.083	0.090	0.110
2012	ej	0.991	0.995	0.991	0.991	0.991	0.994	0.994	0.995	0.993
	Wj	0.143	0.079	0.136	0.131	0.132	0.087	0.095	0.084	0.113
2013	ej	0.990	0.992	0.990	0.991	0.996	0.993	0.992	0.995	0.993
	Wj	0.147	0.123	0.154	0.126	0.061	0.097	0.114	0.067	0.111
2014	ej	0.992	0.993	0.989	0.992	0.995	0.993	0.993	0.995	0.992
	Wj	0.113	0.112	0.169	0.124	0.082	0.106	0.106	0.074	0.114
2015	ej	0.991	0.992	0.992	0.993	0.996	0.994	0.994	0.995	0.992
	Wj	0.139	0.132	0.134	0.119	0.071	0.092	0.102	0.088	0.124
2016	ej	0.992	0.993	0.993	0.992	0.994	0.995	0.995	0.994	0.993
	Wj	0.140	0.122	0.117	0.134	0.094	0.084	0.091	0.095	0.124
2017	ej	0.991	0.995	0.991	0.992	0.996	0.995	0.994	0.993	0.993
	Wj	0.150	0.089	0.148	0.141	0.066	0.078	0.097	0.117	0.113
2018	ej	0.992	0.994	0.990	0.991	0.993	0.996	0.994	0.994	0.993
	Wj	0.120	0.102	0.162	0.147	0.109	0.069	0.087	0.097	0.108
2019	ej	0.993	0.993	0.991	0.990	0.991	0.996	0.995	0.995	0.993
	Wj	0.115	0.105	0.148	0.154	0.142	0.066	0.080	0.082	0.108

Table 12: Weights 2008-2019, calculated with Shannon entropy

In Table 13 the values of I_{MVM} for all companies including the fictitious merger during 2008-2019 are shown.

Company name	2008	2009	2010	2011	2012	2013
Toyota	1.681	1.674	1.602	1.493	1.606	1.736
Audi AG	1.437	1.428	1.540	1.567	1.563	1.615
Hyundai	1.226	1.355	1.443	1.456	1.444	1.426
GM	1.392	1.272	1.476	1.517	1.520	1.563
Ford	1.397	1.417	1.483	1.499	1.514	1.469
Nissan	1.394	1.466	1.377	1.418	1.413	1.457
Honda	1.530	1.548	1.362	1.267	1.313	1.322
FCA	1.202	1.219	1.220	1.222	1.239	1.255
Renault	1.299	1.361	1.239	1.300	1.314	1.321
PSA	1.326	1.329	1.265	1.249	1.239	1.237
Daimler Group	1.174	1.152	1.225	1.185	1.181	1.190
BMW	1.423	1.441	1.396	1.457	1.469	1.513
PSA FCA	1.448	1.495	1.425	1.383	1.380	1.329

Company name	2014	2015	2016	2017	2018	2019
Toyota	1.714	1.763	1.685	1.713	1.719	1.720
Audi AG	1.654	1.535	1.480	1.471	1.391	1.541
Hyundai	1.444	1.414	1.334	1.350	1.337	1.266
GM	1.400	1.574	1.602	1.641	1.635	1.635
Ford	1.478	1.549	1.543	1.501	1.453	1.467
Nissan	1.458	1.531	1.545	1.469	1.452	1.468
Honda	1.309	1.317	1.344	1.308	1.239	1.309
FCA	1.244	1.255	1.257	1.282	1.315	1.393
Renault	1.341	1.416	1.385	1.364	1.359	1.322
PSA	1.242	1.332	1.366	1.334	1.323	1.418
Daimler Group	1.163	1.209	1.295	1.309	1.256	1.238
BMW	1.510	1.439	1.463	1.585	1.552	1.508
PSA FCA	1.330	1.379	1.408	1.388	1.389	1.437

Table 13: I_{MVM} from 2008-2019 with FCA-PSA included as one fictitious company

4.4.9 Data analysis

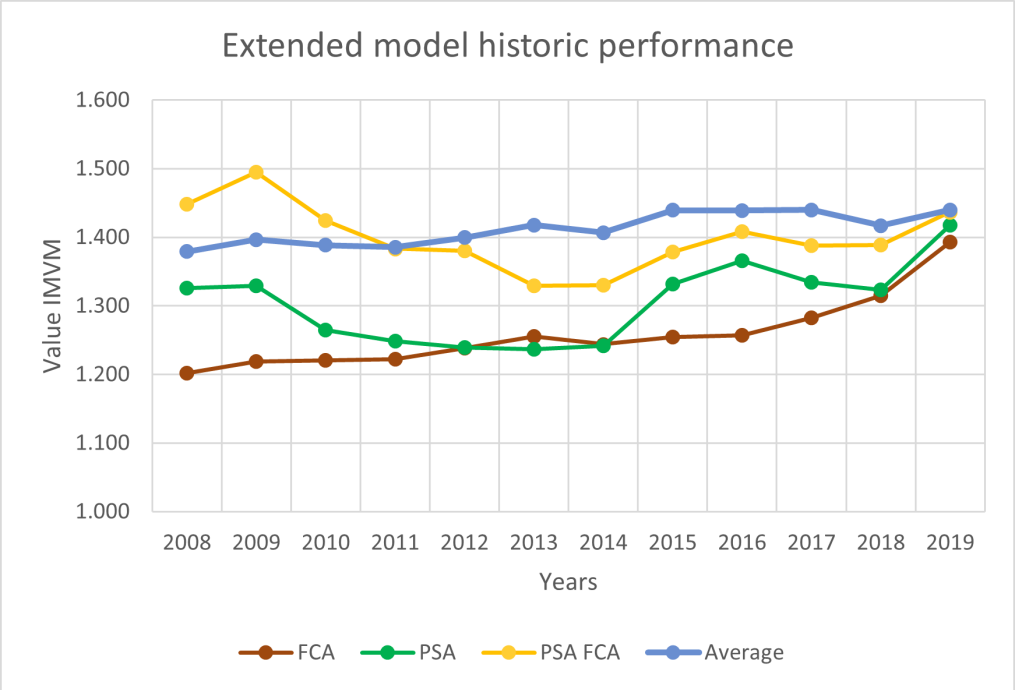


Figure 10: Trend of I_{MVM} during 2008-2019

As can be seen in Figure 10, all hypotheses can be accepted. The fictitiously merged company outperforms the individual companies in every year between 2008 and 2019.
It is interesting to see that the fictitiously merged company performs above average until 2010 and below average afterwards. The positive trend since 2012 might indicate a improvement in the near future. In the next sections, the comparison between fictitiously merged companies and the market average will play a central role.

This case study rises the question whether it is possible to see a relation between the individual results of companies and their performance when fictitiously merged.

4.5 Conclusions

This chapter aims to answer SRQ_5: *How to apply a composite indicator for measuring future company performance to the case of a merger?*

Theory testing research as described in the book *Case Study Methodology* by Dul and Hak was proposed as approach for a case study on the application of the extended model I_{MVMMC} on the merger between PSA and FCA. Adding a fictitiously merged company to the group of MVMs made it possible to compare the historic performance of the merged company to the individual company in a hypothetical market with both the merger PSA FCA and the individual companies PSA and FCA present.
In the remainder of this work, the focus will be on a more realistic simulation of the automotive industry by excluding the merging companies from the market.

5 Design of Future Merger Performance Measurement

5.1 Introduction

This chapter will address SRQ_6: *How to predict potential future performance of fictitiously merged motor vehicle manufacturers?*
The extended model I_{MVMMC}, as described earlier, is able to compare and evaluate a group of selected MVMs based on economic and environmental variables. This historical values provide an overview of a company's business performance in a particular year compared to other companies included in the same year. The performance matrix introduced in Chapter 3.3 provides a comparative view of the business performance of the included companies over a longer period of time (2008-2019). This performance matrix categorizes companies into 4 quadrants based on their overall performance and environmental performance.
In this chapter, fictitious mergers will be created based on their past performance and specifically based on their position in the performance matrix (Q1-Q4).

The steps taken in order to forecast the future merger performance are visualized in Figure 11.

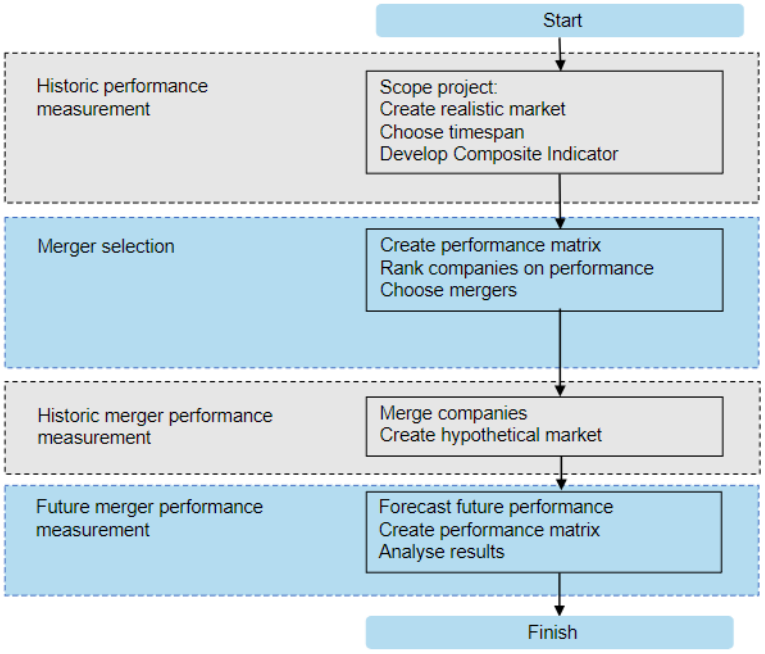


Figure 11: Design of Future Merger Performance Measurement

5.2 Historic Performance Measurement

In order to determine the historic performance of the individual MVM and measure their relative performance, the I_{MVMMC} was calculated with all twelve individual MVMs. This results in a quantified performance for all MVMs for the years 2008-2019. Based on both the environmental performance and the general performance, a performance matrix was created as described and shown in Chapter 3.2.2. In Figure 12, the performance matrix obtained from the historic results of the extended model are shown.

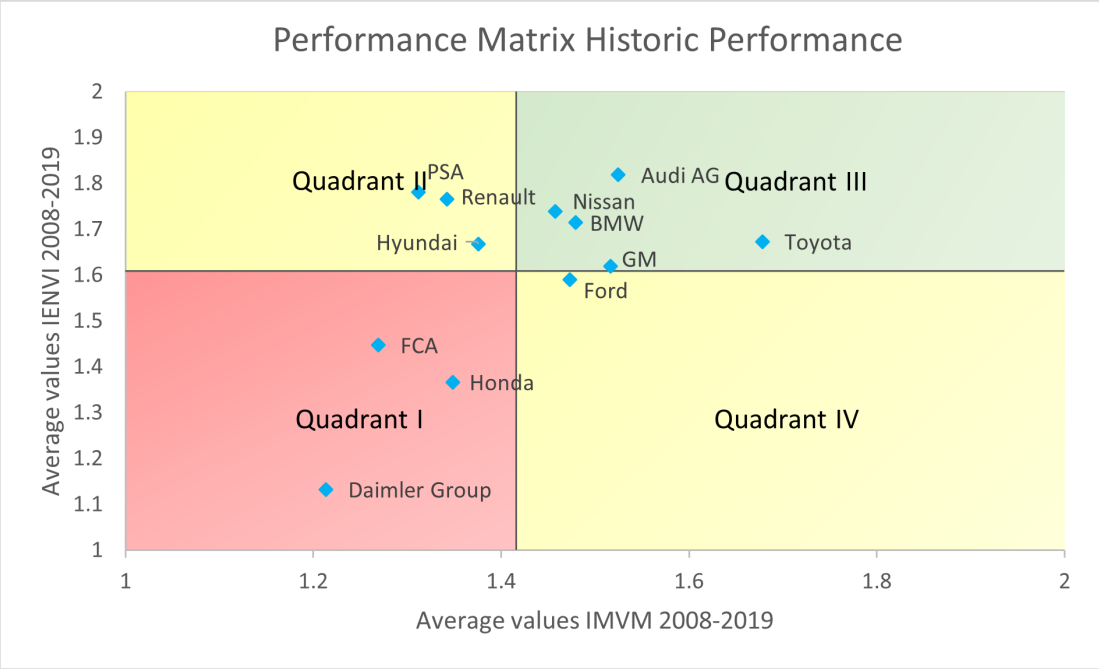


Figure 12: Performance matrix historic results without merger

5.3 Merger selection

Figure 12 shows the Quadrants in which the different MVMs are located. In this thesis a selection of possible fictitious mergers was performed based on the location of the different MVMs in this performance matrix.
All possible combinations of quadrants will be examined, as shown in Table 14. As Ford is the only MVM located in Q4, there is no fictitious merger possible between two different MVMs from that Quadrant.

MVM 1	Quadrant	MVM 2	Quadrant
Honda	I	Renault	II
Honda	I	BMW	III
Honda	I	Ford	IV
Renault	II	BMW	III
Renault	II	Ford	IV
BMW	III	Ford	IV
Honda	I	FCA	I
Renault	II	PSA	II
BMW	III	Audi	III

Table 14: Combinations fictitious merger

These fictitious mergers will be incorporated into the extended model and compared with the remaining companies included in the model. For example, if the merger between Honda and Renault is being examined, it will be included as one company in the MVM and compared with the other 10 companies for the years 2008-2019. By excluding the individual companies from the model, a realistic hypothetical market is created.
In the previous chapter, a case study was conducted based on the merger of PSA and FCA. The results of this case study showed that the fictitious merger of these two specific companies in 2008 based on the historical financial and environmental data from 2008 to 2019 would have a favorable effect on the company performance of this merged company compared to the other MVMs based on the extended model I_{MVMMC}.

5.4 Historic merger performance measurement

The third step in the design of future performance measurement is the historic performance measurement for a realistic market with a fictitious merger included. In Figure 13, the results of the hypothetical market with Honda Renault as fictitious merger are shown in the performance matrix as an example.

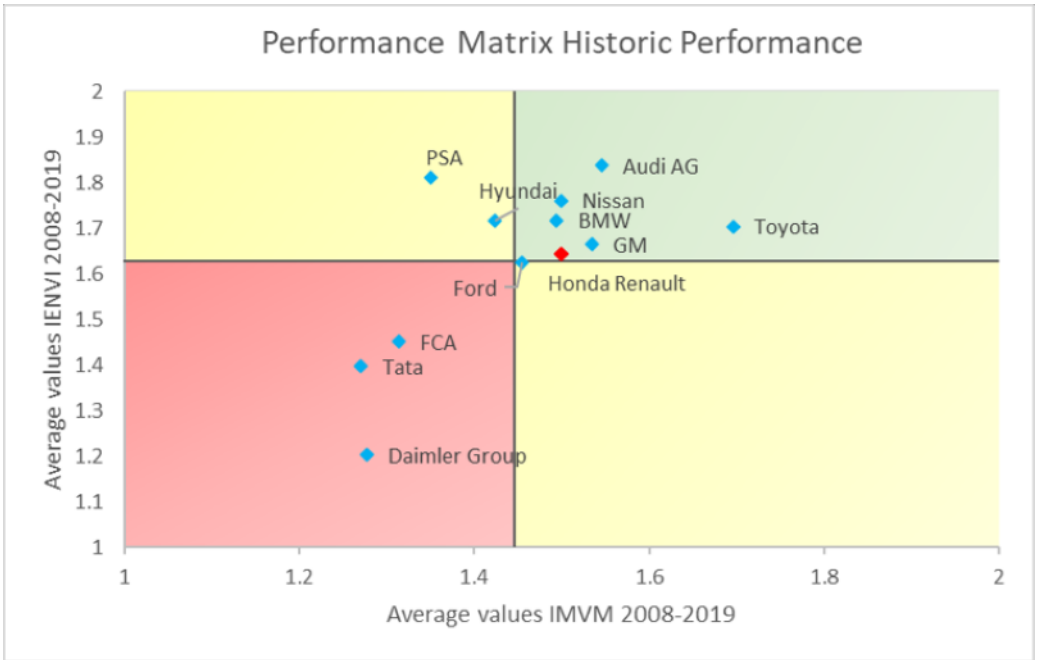


Figure 13: Hisoric merger performance measurement Honda Renault

5.5 Future Merger Performance

In order create an experiment for future merger performance measurement, a forecasting method has been designed. The historic performance matrix without merger (Figure 12) lead to the nine combinations of fictitiously merged MVMs (Figure 14). The next step is to calculate the historic performance, both general and environmental, of these fictitiously merged MVMs and the ten remaining MVMs for each year from 2008 to 2019. For each merger case, there will be eleven MVMs (1 merger and 10 remaining MVMs) with a general performance value and a environmental performance value for each year. These historic results will form the basis of the ARIMA forecasting models. For each specific MVM in each specific merger case, an ARIMA model will be created. This ARIMA model predicts the future performance (I_{MVMMC} and I_{ENVI}) for the years 2020 to 2023.
As proposed in 3.3 the historic data points were checked for stationarity, the ARIMA models were selected based on the AIC value, and their accuracy was evaluated using the MAE. As an example, the results obtained with the fictitious merger Renault Honda are presented in Table 15.

Honda Renault	**IENVI**	**Honda Renault**	**IMVM**
p-value original data	2.90E-04	p-value original data	0.813
p-value first difference	0.010	p-value first difference	0.0281
p-value second difference	1.07E-07	p-value second difference	3.68E-07
Best ARIMA model	(0, 2, 1)	Best ARIMA model	(0, 2, 1)
Ljung-box p-value	0.774556	Ljung-box p-value	0.775317
Mean absolute error	0.137	Mean absolute error	0.151
2020	1.30	2020	1.31
2021	1.27	2021	1.28
2022	1.24	2022	1.24
2023	1.21	2023	1.21

Table 15: Honda Renault ARIMA forecast

The MAE of the forecasts created are mostly between 0.05 and 0.15. In order to draw conclusions about the future performance of MVMs and fictitiously merged MVMs, there was decided to use the average forecast (2020-2023) value as *future performance*.

5.6 Conclusions

In this chapter, the design of future merger performance measurement was proposed. This method uses the extended composite indicator I_{MVMMC} for historic performance measurement. Based on the results, fictitious mergers were created systematically. After these fictitious mergers were created, they were included in a realistic hypothetical market where the two individual companies were excluded. Based on the historic results obtained with the fictitious merger in the hypothetical market, the general performance and the environmental performance of each included company was forecasted using ARIMA models. There has been decided to use the average forecasted value as *Future performance*. In the next Chapter, the experimental setup and the results will be handled in order to complete answering SRQ_6.

6 Experiments

6.1 Introduction

In this chapter, the experimental setup for the future merger performance measurement of all merger cases will be presented and hypotheses on the potential results of the experiments are formulated. Furthermore, the steps taken in the previous chapter will be elaborated on in terms of specific calculation and modelling steps. Finally, the results are presented and interpreted. This chapter will contribute to answering SRQ_6: *How to predict potential future performance of fictitiously merged motor vehicle manufacturers?* Subsequently, SRQ_7, *What is the influence fictitiously merging MVMs on their relative performance as measured by a composite indicator from economic and environmental perspectives?*, will be handled.

6.2 Historic performance

The model starts with the gathering of raw data for the historic performance measurement. The following statistics were collected for all MVMs for every year:

- Market Share
- Revenues
- Profit
- R&D expenditures
- Number of employees
- Inventories
- Operating cash flow
- Costs of goods sold
- Number of vehicles produced
- Water consumption
- Energy consumption
- CO^2 emissions

The formulas as presented in Chapter 2 were used to calculate the measures (V_1-V_9) for each MVM for each year. Subsequently, the relevant MVMs and their measures underwent the steps described in Chapter 2 for each year separately: measures were normalized, variables were weighted, and the geometric aggregation method was used to assign a I_{MVMMC} value to each company. At the same time, a value for the environmental performance (I_{ENVI}) was calculated with the same procedure: as a composite indicator with just the three environmental measures. Based on the specific experiment, MVMs can be turned "on" and "off" in order to create the test environment of choice.

The results of the historic performance measurement are twofold. Each MVM has an I_{MVMMC}-value for every year expressing their relative performance compared to the market for each year. In order to compare the future performance with the historic performance, the average of these values will be used as *historic performance*. The market average can be used as reference point to interpret the results.

6.3 Historic merger performance

As described in Chapter 4.3, the fictitious mergers were created by combining the statistics before calculating the measures. For all measures, the raw data was added before calculating the combined measure. For example: for one specific year, the combined R&D expenditure of two companies was divided by their combined number of employees to calculate V_4.

In order to calculate the historic performance measurement with an included merger as described in the previous chapter, the "market" needs to be adjustable. In the extended model, the two merging companies can be turned "off" and the merger can be turned "on". In this manner, the test environment was created where the fictitiously merged companies replaced themselves as one new company. As the I_{MVMMC} compares different companies with each other, it is important to exclude the two individual companies for a realistic result.

6.4 Future merger performance

Per merger case, the steps taken in the previous section result in a dataset of two times (I_{MVMMC} and I_{ENVI}) 12 datapoints for each MVM. For each of these sets of 12 datapoints, an ARIMA model was created in order to forecast 4 years of future performance of each MVM (both general and environmentally). A comparison between "historic" and "future" results was made based on the average historic performance and the average future performance.

6.5 Hypotheses

Now that there is a set of data, the I_{MVMMC}, a procedure for creating a realistic hypothetical market with a fictitious merger and a procedure for predicting the future performance of this market, it is time to analyse the results.
As described in Chapter 2.5, value creation is the most important reason for merging. Value creation in the automobile industry is comprehensive and has financial, market, technological, strategic, and sustainability aspects. The I_{MVMMC} takes into account several of these aspects.
According to literature, value through growth is an important reason for merging, but do the results of this analysis sustain this theory? Companies with higher growth rates in their key performance indicators are more likely to achieve greater value creation than companies with lower growth rates. As the I_{MVMMC} reflects these key performance indicators, the following hypothesis is proposed:

MVMs with higher growth rates in their historic performance according to the I_{MVMMC} will perform better in the near future as individual company and as part of a merger.

The merger between PSA and FCA was introduced as the cause of this work. The question arose: is it possible to quantify the potential of the merger beforehand? PSA FCA is added to the group of mergers as selected earlier in order to see if PSA FCA has the potential to be a successful merger according to the results of the historic and future merger performance measurement.
The following hypothesis is therefore proposed:

PSA FCA has the potential to be a succesful merger according to the results of the historic and the future merger performance measurement.

6.6 Results

To visualize the potential contribution of the individual MVMs to a merger, Figure 14 plots the average historic performance against the average future performance of all individual MVMs. The red line divides the graph in two parts: the MVMs above the red line improve in performance relative to the market average and the MVMs below the red line drop in performance. As can be seen, PSA FCA and GM improve in terms of performance in the future. Their potential contribution to mergers may therefore be positive.

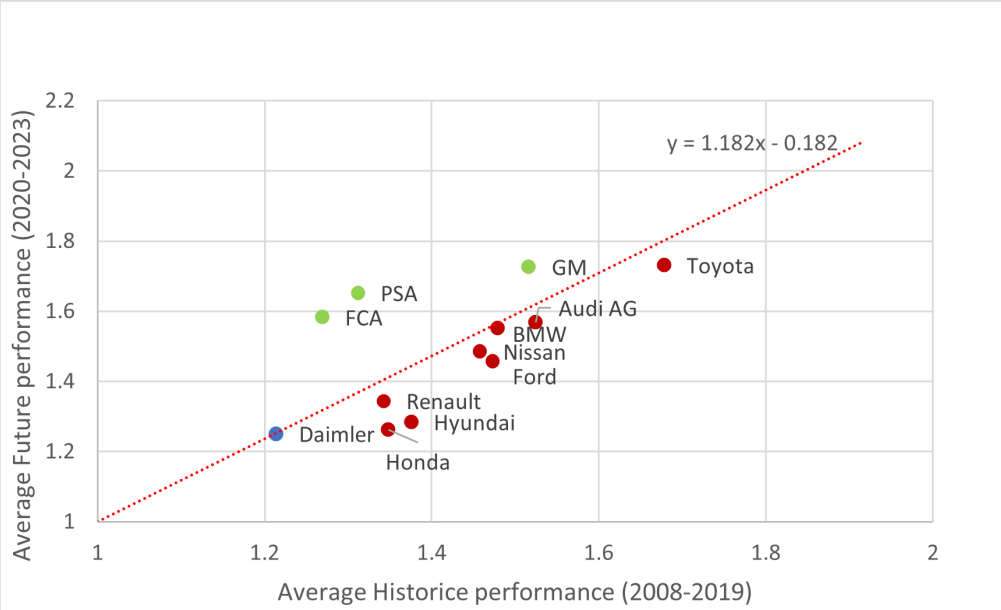
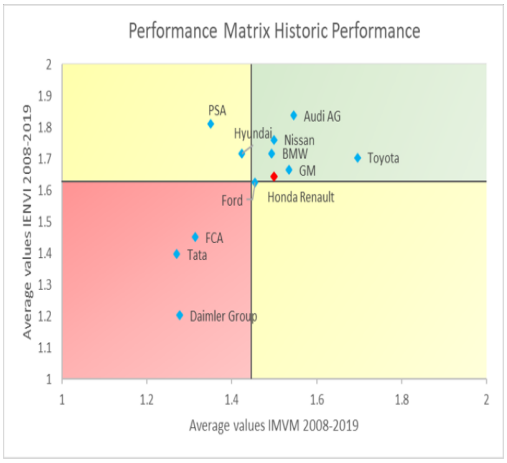
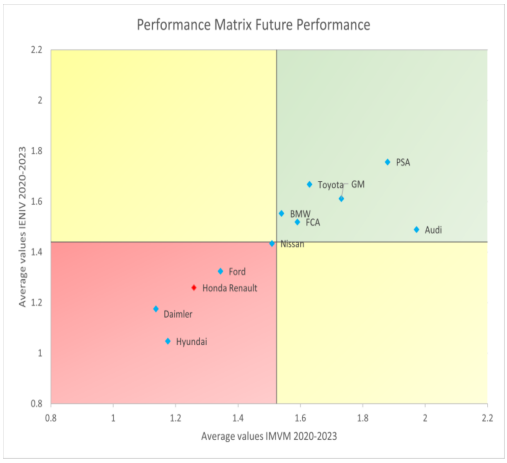


Figure 14: Average historic performance to average future performance

The Performance Matrix, as introduced earlier in Chapter 3.2.2, plays a central role in this analysis. All hypothetical markets with the fictitious mergers as proposed in Chapter 5.3 are visualized in a performance matrix for historic performance and a performance matrix for future performance. PSA FCA is added to this group of mergers due to their potential contribution as shown in Figure 14.
The final sub research question (SRQ_7) addresses the quantification of the potential future performance of fictitiously merged MVMs. In Chapter 6.6.1, an index will be created to answer this SRQ.



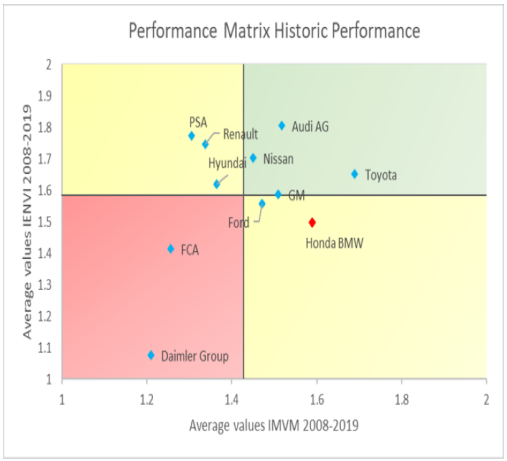
(a) Historic performance Honda Renault



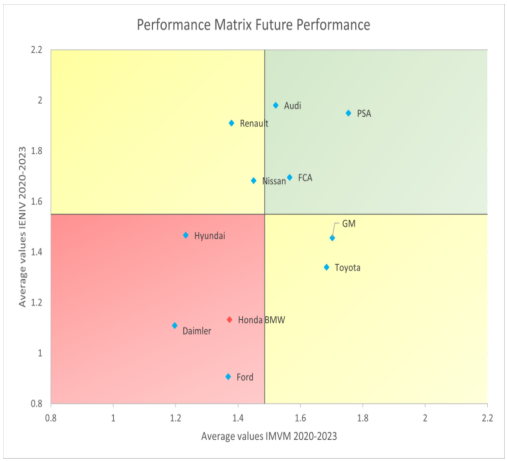
(b) Future performance Honda Renault

Figure 15: Historic results and future results Honda Renault

There can be seen that the future performance of fictitiously merged company Honda Renault is worse than the historic performance. This can be explained by the downward trend of the fictitiously merged company between 2016 and 2019 in particular due to their environmental performance.



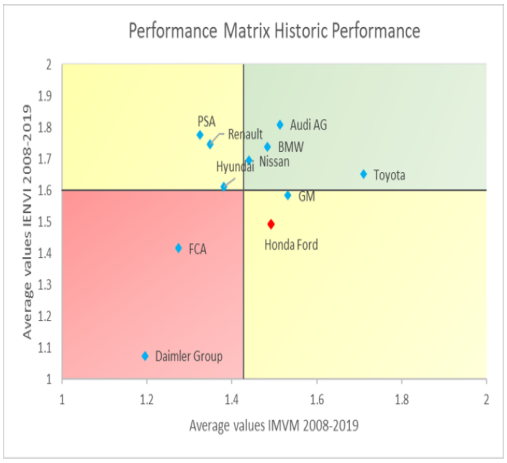
(a) Historic performance Honda BMW



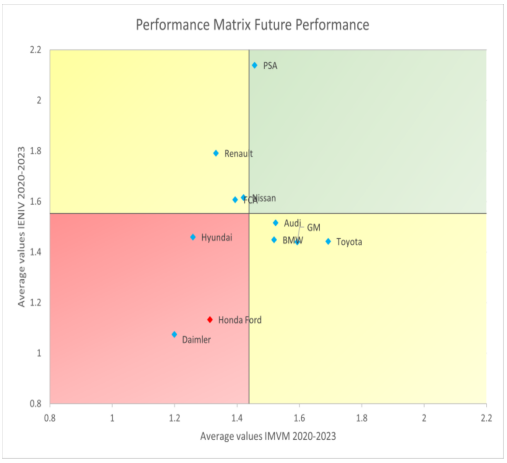
(b) Future performance Honda BMW

Figure 16: Historic results and future results Honda BMW

For the merger between Honda and BMW the same trend is visible. The decreasing trend of Honda's scores is reflected in a lower future performance of the merger. It is interesting to see that the performance of PSA increases in both the market with Honda Renault and Honda BMW as mergers.



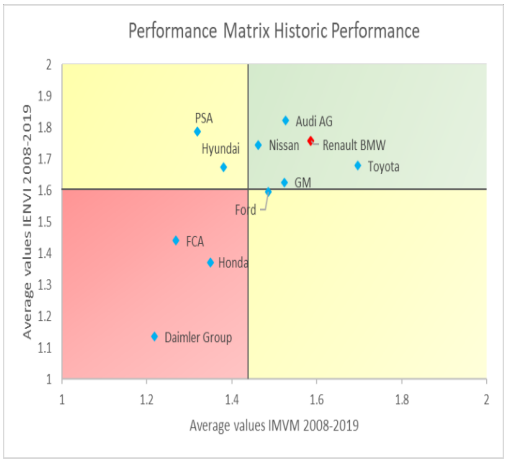
(a) Historic performance Honda Ford



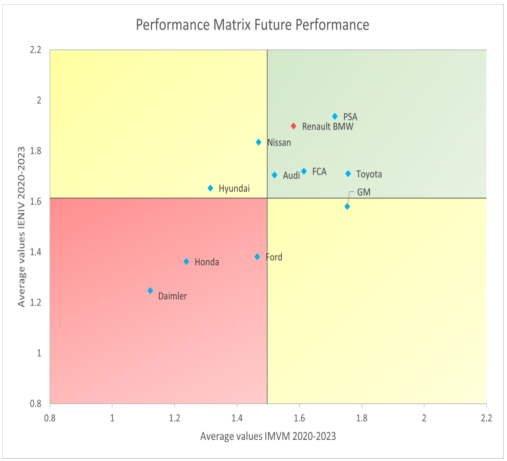
(b) Future performance Honda Ford

Figure 17: Historic results and future results Honda Ford

For Honda Ford the same holds as for Honda Renault and Honda BMW: The downward trend of Honda causes a worse future performance. The downward trend of Ford might also add to the performance getting worse. PSA's increase especially in terms of environmental performance is notable.



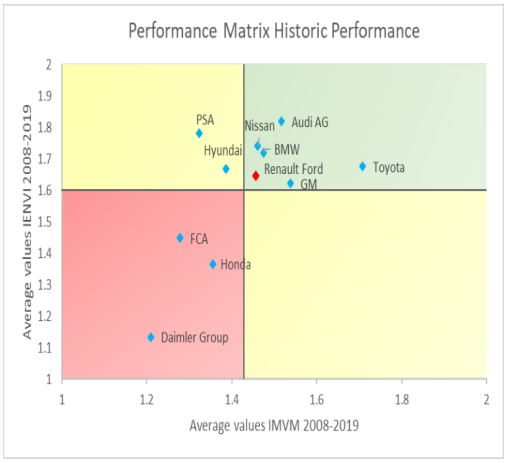
(a) Historic performance Renault BMW



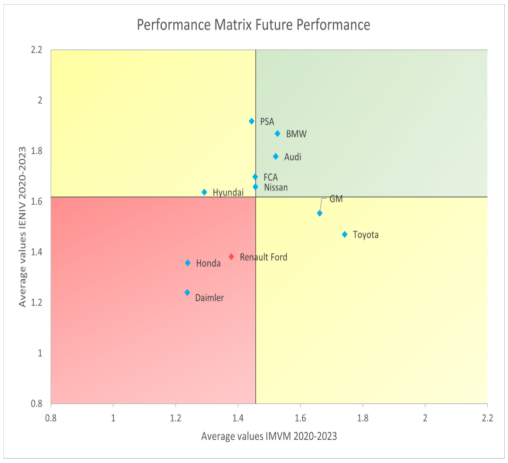
(b) Future performance Renault BMW

Figure 18: Historic results and future results Renault BMW

Renault BMW is the first merger which performance does not get worse. The consistent performance of both individual companies over the years is reflected in a similar future performance. The increased performance of PSA in terms of general performance is notable.



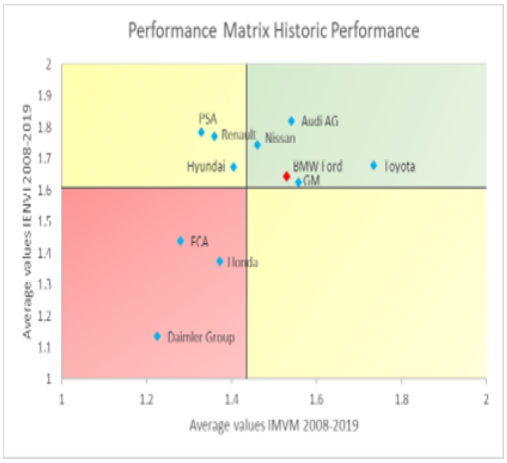
(a) Historic performance Renault Ford



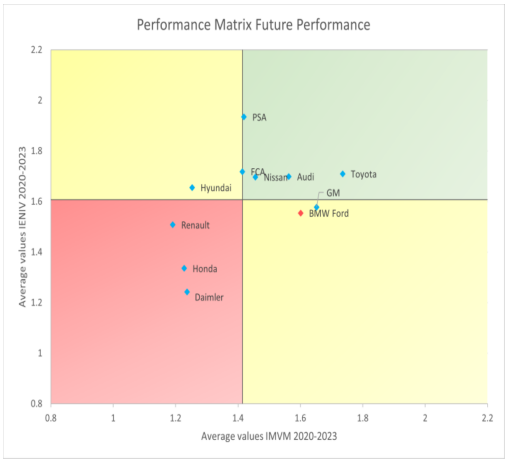
(b) Future performance Renault Ford

Figure 19: Historic results and future results Renault Ford

The future performance of Renault Ford is worse than its historic performance. Ford has a below average environmental performance and a slightly downward trend in historical performance.



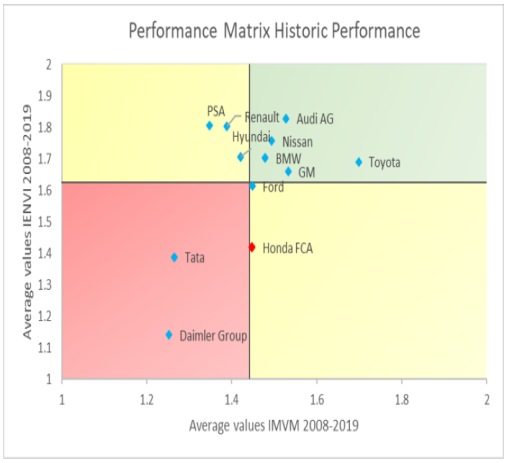
(a) Historic performance BMW Ford



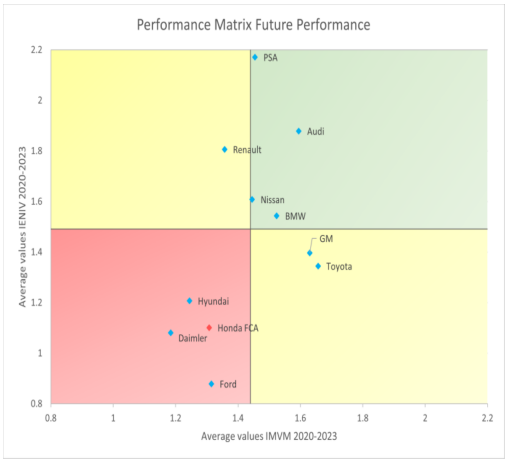
(b) Future performance BMW Ford

Figure 20: Historic results and future results BMW Ford

While Ford had a negative influence on future performance in other merger situations, the future performance of BMW Ford in terms of general performance is comparable to the historic performance. BMW might be have a positive influence.



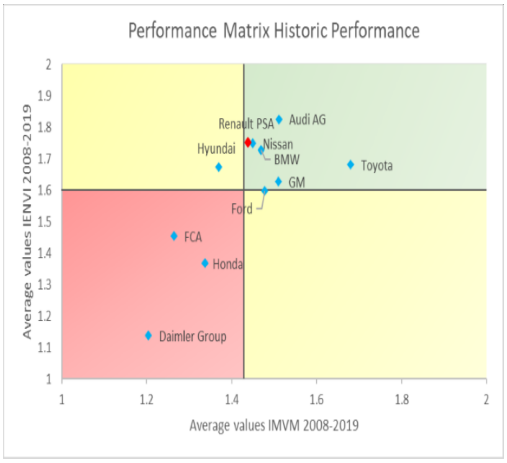
(a) Historic performance Honda FCA



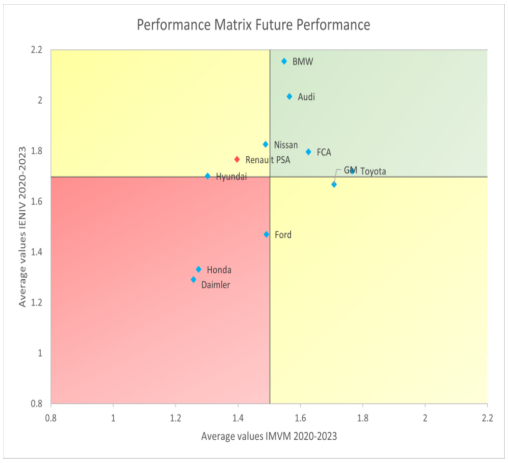
(b) Future performance Honda FCA

Figure 21: Historic results and future results Honda FCA

As might be expected based on the historic performance of the individual companies, the merger between Honda and FCA does not perform very well. The predicted performance is worse than the historic performance.



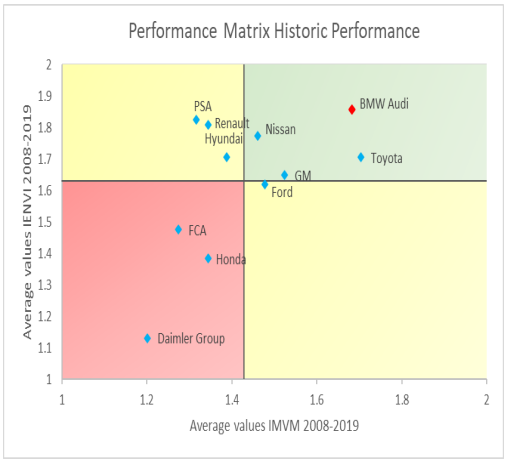
(a) Historic performance Renault PSA



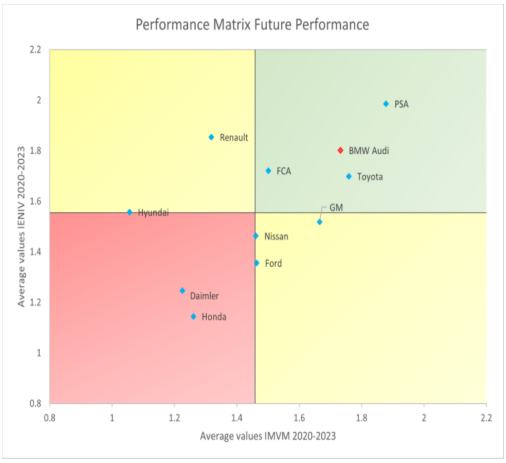
(b) Future performance Renault PSA

Figure 22: Historic results and future results Renault PSA

Interestingly, Renault PSA's future performance decreases relative to the market, while PSA's individual performance was remarkably good in other hypothetical markets. Renault's downward trend must be responsible for this results.



(a) Historic performance BMW Audi

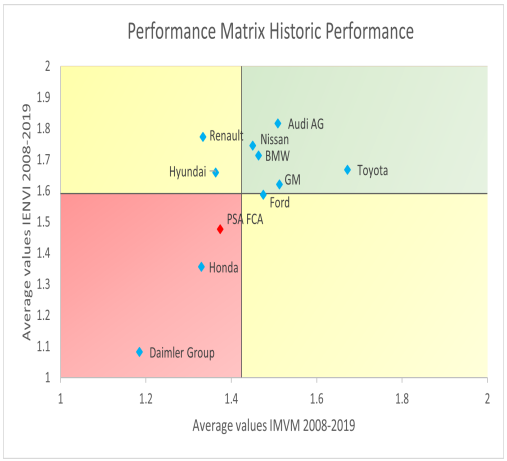


(b) Future performance BMW Audi

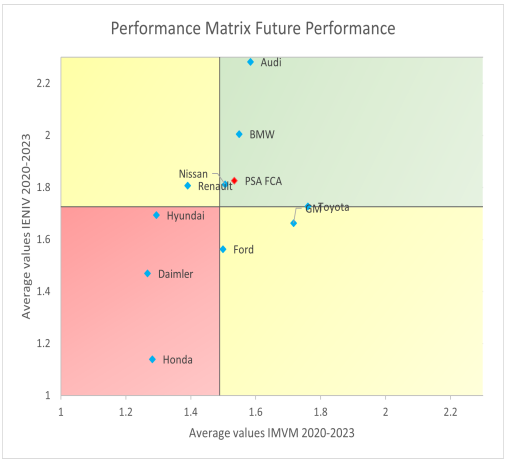
Figure 23: Historic results and future results BMW Audi

BMW Audi is the merger between two of the best performing MVMs. As can be expected, the merger between those two companies performs good as well.

PSA FCA



(a) Historic performance PSA FCA



(b) Future performance PSA FCA

Figure 24: Historic results and future results PSA FCA

As the value through growth theory suggests, the historic performance of the merger between PSA and FCA performs better than both individual companies relative to the market, although the performance is still below average on both economic and general performance and is therefore located in Quadrant I.
As might be expected based on the above average future performance compared to the rest of the market of the individual MVMs shown in Figure 14, the future performance of the merger is relatively good compared to the rest of the market. This is visualized in Figure 25.

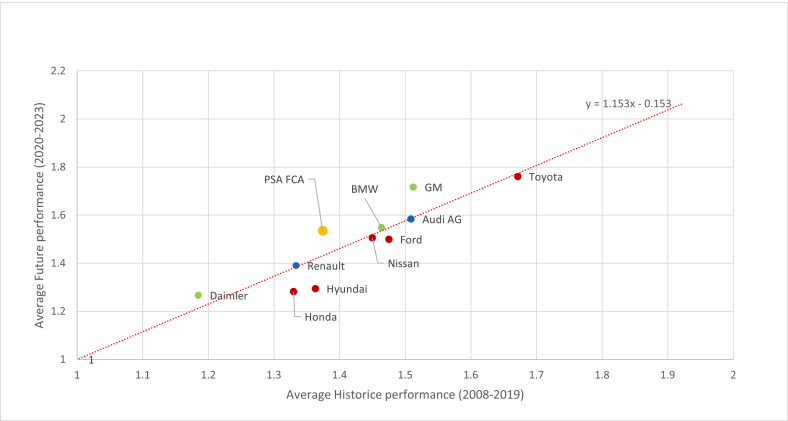


Figure 25: Average historic performance vs average future performance

6.6.1 Merger analysis

To compare the performance of the fictitiously merged companies to each other their relative performance to the market average is investigated. Table 16 shows the values representing the historic and future performance of the mergers obtained with the I_{MVMMC} in their respective hypothetical markets. The market averages M_{avg} are shown and as can be seen, the market averages differ from one hypothetical market to another. In order to be able to compare the mergers with each other, an index value is assigned to the mergers by comparing their performance to the market average:

$$Index = \frac{I_{\text{MVMMC}}}{M_{\text{avg}}} * 100 \tag{6.1}$$

In the final column the relative change from the historic index to the future index is shown.

Mergers	I_{MVMMC}	M_{avg}	Index	Future I_{MVMMC}	M_{avg}	Index	Change
PSA FCA	1,374	1,424	96,49	1,534	1,489	103,02	6,78%
Honda Renault	1,504	1,428	105,32	1,258	1,524	82,55	-21,55%
Honda BMW	1,590	1,427	111,42	1,372	1,475	93,02	-16,48%
Honda Ford	1,494	1,427	104,70	1,313	1,427	92,01	-12,10%
Renault BMW	1,587	1,438	110,36	1,581	1,504	105,12	-4,75%
Renault Ford	1,458	1,428	102,10	1,378	1,450	95,03	-6,88%
BMW Ford	1,530	1,436	106,55	1,600	1,431	111,81	4,93%
Honda FCA	1,452	1,423	102,04	1,308	1,428	91,60	-10,26%
Renault PSA	1,439	1,428	100,77	1,397	1,493	93,57	-7,11%
BMW Audi	1,683	1,429	117,77	1,732	1,483	116,79	-0,87%

Table 16: Historic and future merger analysis compared to market average

BMW Audi is the best performing merger compared to the market average according to both the historic and the future index (117.77 and 116.79). Considering BMW and Audi performed among the best MVMs individually this was expected.
The relative change of the index as indicated in the last column of Table 16 can be regarded as a metric that expresses the potential of the merged company.
The merger between PSA FCA therefore has the potential to be a succesful merger and the hypothesis as proposed in Chapter 6.5 can be accepted.

6.7 Conclusions

This section presents the results obtained by following the design for future merger performance measurement as presented in this work. In this chapter, the performance of fictitiously merged companies in relation to a representative hypothetical market of individual MVMs was shown. From the merger selection phase in the previous section, 9 fictitious mergers were included in 9 hypothetical markets. Due to the improved future performance of PSA and FCA as individual companies, their merger was added. There can be concluded that in terms of historic performance, the mergers perform better than the individual companies.
In terms of future performance, the positive or negative trend of the individual companies contributing to a positive or negative trend in historic merger performance highly influences the future performance of the mergers. In order to objectively compare merger performances in the different hypothetical markets a historical and future index was determined which assigned a value to the merger performance compared to the average performance of the hypothetical market. The potential to be a successful merger was expressed by the relative change between the historic index and the future index. 8 out of 10 mergers showed negative potential.
BMW Audi and PSA FCA showed potential to be a succesful merger.

7 Discussion

Although this research gives insights in the company performance of a fictitiously merged company in the automotive industry, a few shortcomings came to light. In this chapter the most important points for improvement and opportunities for future research will be handled.

Firstly, the differences between model and reality. As presented in Chapter 4.3.2, the performance measures of the fictitiously merged company are calculated by combining the measures of the individual companies over the period of time between 2008 and 2019. In reality, as both the statement published by Stellantis (2.5.4) and theory on mergers (2.5) prove, mergers have an impact on these measures in several ways including synergies and cost savings. Reorganizations may result in a reduction of employees without losses in terms of profit, R&D expenditure, or efficiency of the supply chain. At the same time, for the environmental measures, the question rises whether the performance of a merged company be the combination of the individual companies. Alternatively, it is realistic to think that the merged company will learn from the "best performing" company from environmentally. The worldwide trend of focusing on environmental improvements in terms of reduction of emissions, energy and water consumption sustains this thoughts.
For future research it might be interesting to look at realistic changes in the key performance indicators due to synergy.

Forecasting the future performance of the mergers and the remaining MVMs with trend analysis based on the fiscal years 2008-2019 can be seen as inaccurate. The amount of data points (11) is low for such analysis. For future research, larger data set would be convenient if more accurate forecasts are required. As in this work the average of the forecasts was compared to the average of the historic results, the general trend was more important than the actual result of the forecast for each year and their accuracy.

8 Conclusions

The merger between motor vehicle manufacturers PSA and FCA offers potential advantages, but the high failure rate of mergers raises the question: is it possible to quantify the potential benefits of a merger in advance?.
A comprehensive method for quantification is the composite indicator I_{MVM}, which measures historical business performance of motor vehicle manufacturers. Previous research on merger performance measurement highlights the importance of value creation through growth and objective financial indicators. However, there is a research gap in forward-looking studies on merger performance measurement.
Analyzing the recent PSA and FCA merger confirms the focus on value creation through growth. To address the research gap, this study explores composite indicators for company performance measurement. The I_{MVM} is added to the fourth generation of performance measurement methods due to its quantitative origin, focus on MVMs, and use of publicly available data. The five phases of constructing composite indicators are applied to develop the I_{MVM}.
The I_{MVM} allows quantification of historical performance and forecasting of individual company performance. This study aims to fill the research gap by providing consistent measures and rigorous techniques for analyzing historical and future company performance in the MVM industry. To achieve this, the I_{MVM} is extended to include Market Capitalization as a performance indicator, considering its forward-looking abilities and external validation. The extended model, I_{MVMMC}, is presented, including the environmental subindex I_{ENVI} and performance matrix.
A case study on the PSA and FCA merger demonstrates the impact of company size on historic performance according to the I_{MVMMC}. Additionally, a future merger performance measurement design is proposed, using the extended composite indicator. Fictitious mergers are systematically created and included in a realistic hypothetical market, excluding the individual companies. ARIMA models forecast the general and environmental performance of each company based on the historic results, with the average forecasted value representing future performance.
The historic and future results of the fictitious mergers compared to their respective hypothetical markets show the importance of company size in a competitive market and the positive contribution of higher growth rates in historic performance of individual MVMs.
To compare the different fictitious mergers with each other, an index was developed. This index can assess both the historical and future performance in relation to the market average. The change between the historic and the future index serves as an indicator of the merger's potential and its capacity for generating positive results. PSA FCA showed the potential to be a successful merger according to the results of the historic and future merger performance measurement and this potential has been quantified in the index.

9 Contributions

This work can help decision makers assessing their performance compared to the market and gain insights in potential merger opportunities. The model makes it possible to implement plans hypothetically and easily gain insights in the resulting changes in economic, environmental, overall and future performance.
As stated in Chapter 1.2, one of the research gaps is the lack of a general company performance measurement tool. Although this work focuses on the automotive industry specifically, the possibility to easily create an index similar to I_{MVMMC} for another engineering industry is considered important as a societal contribution of this work. The model that has been used for this work offers the possibility to adjust the timespan of the historic performance measurement, the amount of active companies and the active measures. The creation of a company performance measurement tool for a different industry needs a *Variable selection phase* and a *Data collection phase*. If the data is collected, all companies can be fictitiously merged automatically and included or excluded in a hypothetical market.

References

[1] Mohammad Abdel Mohsen Al-Afeef. "Factors Affecting Market Capitalization: A Practical Study Ase 1978-2019". In: (2020).

[2] H. Alabdulrazzaq. "On the accuracy of ARIMA based prediction of COVID-19 spread". In: (2021).

[3] Wouter Beelaerts van Blokland and Qinqin Zeng. *Exploring company performance measurement for truck manufacturers*. 2018. URL: https://cibw117.org/2018/07/06/exploring-company-performance-measurement-for-truck-manufacturers/.

[4] Wouter W A Beelaerts Van Blokland and Sicco C Santema. *Value Chain Innovation Processes and the Influence of Co-Innovation*. 2006.

[5] Nathan Troutman Blumenshine. "The Value of Green: The Effect of Environmental Rankings on Market Cap". In: *Technology and Investment* (2010).

[6] B.L. Bowerman. "Forecasting, time series, and regression: An applied approach". In: (2005).

[7] Lowell L. Bryan. "The new metrics of corporate performance: Profit per employee". In: *McKinsey Quarterly* (2007).

[8] European Commission. Joint Research Centre., Organisation for Economic Co-operation, and Development. *Handbook on constructing composite indicators : methodology and user guide.* OECD, 2008, p. 158. ISBN: 9789264043459.

[9] Ricardo Cristovao. "PSA-FCA Merger Carlos Tavares' road to glory". In: (Jan. 2021).

[10] Financieel Dagblad. "Peugeot en Fiat Chrystler akkoord over fusie". In: (Oct. 2019).

[11] Jan Dul and Tony Hak. *Case Study Methodology in Business Research*. 2008.

[12] Organization for Economic Cooperation and Development. *The OECD-JRC Handbook on Practices for Developing Composite Indicators*. 2004. URL: http://stats.oecd.org/glossary.

[13] FIAT. "A driven by dreams story". In: (). URL: https://www.fiat.com/history?adobe_mc_ref=.

[14] G.M. Jenkins G.E. Box. "Time series analysis: forecasting and control". In: (2015).

[15] S. Gebbink. "The effect of volatility and market cap on cryptocurrency portfolio's". In: (2021).

[16] Michel Grabisch. *The application of fuzzy integrals in multicriteria decision making*. 1996, pp. 445–456.

[17] Gilles Guillaume, Giulio Piovaccari, and Nick Carey. "Analysis-For Peugeot and FCA, completing their merger is just the start". In: (Jan. 2021). URL: https://www.reuters.com/article/us-fiat-chrysler-m-a-psa-idUKKBN2980R3.

[18] Marshall Hargrave. "Merger". In: *Investopedia* (May 2022). URL: https://www.investopedia.com/terms/m/merger.asp.

[19] Dale Howard. "The history of Chrysler: From the 1920s to Today". In: (Jan. 2020).

[20] C.S. Lineberry J.R. Carleton. "Achieving Post-Merger Success". In: (2004).

[21] Robert S Kaplan and David P Norton. *Putting the Balanced Scorecard to Work*. 1993. URL: www.hbr.org.

[22] G. Kenny. "Don't Make This Common MA Mistake". In: *Harvard Business Review* (2020).

[23] George J. Klir and Bo. Yuan. *Fuzzy sets and fuzzy logic : theory and applications*. Prentice Hall PTR, 1995, p. 574. ISBN: 0131011715.

[24] Satish Kumar and Lalit K. Bansal. "The impact of mergers and acquisitions on corporate performance in India". In: *Management Decision* 46 (10 2008), pp. 1531–1543. ISSN: 00251747. DOI: 10.1108/00251740810920029.

[25] Vinod Kumar and Priti Sharma. *An Insight into Mergers and Acquisitions*. Springer Singapore, 2019. DOI: 10.1007/978-981-13-5829-6.

[26] Rikard Larsson, Sydney Finkelstein, and Kathleen Eisenhardt. *Integrating Strategic, Organizational, and Human Resource Perspectives on Mergers and Acquisitions: A Case Survey of Synergy Realization*. 1999.

[27] P.H. Mirvis M.L. Marks. "Merge Ahead: A Research Agenda to Increase Merger and Acquisition Succes". In: (2011).

[28] Magaldi. *Is Consolidation Necessary to Survive in the Automotive Industry?* 2020.

[29] M. Mulder. "Firm specific risk characteristics and IPO underpricing". In: (2017).

[30] O. Helmer N. Dalkey. "An experimental application of the Delphi method to the use of experts". In: (1963).

[31] Andy Neely, Chris Adams, and Mike Kennerley. *The Performance Prism: The Scorecard for Measuring and Managing Business Success*. 2002.

[32] OICA. “Organization of Motor Vehicle Manufacturers 2017 Production Statistics”. In: (). URL: https://www.oica.net/category/production-statistics/2017-statistics/.

[33] Peugeot. “History of the Peugeot family”. In: (). URL: https://www.peugeot.com.au/brand-and-technology/peugeot-universe/history/a-family-adventure/.

[34] Stephen Pike and Göran Roos. *Measuring and decision support in the knowledge society*. 2001. URL: http://www.intcap.com.

[35] Manoj Kumara Praveen Kumar. “Market capitalization: Pre and post COVID-19 analysis”. In: (2020).

[36] M. Hibon S. Makridakis. “ARMA Models and the Box-Jenkins Methodology”. In: (1997).

[37] Richard Schoenberg. *Measuring the Performance of Corporate Acquisitions:An Empirical Comparison of Alternative Metrics*. 2006, pp. 361–370.

[38] FIAT of Scottsdale. “A Brief History of Fiat and Its Century of Automaking”. In: (Apr. 2015).

[39] Stellantis. “Groupe-PSA and FCA agree to merge”. In: (Dec. 2019).

[40] Fang Mei Tseng, Yu Jing Chiu, and Ja Shen Chen. “Measuring business performance in the high-tech manufacturing industry: A case study of Taiwan’s large-sized TFT-LCD panel companies”. In: *Omega* 37 (3 June 2009), pp. 686–697. ISSN: 03050483. DOI: 10.1016/j.omega.2007.07.004.

[41] P de Vries and Wouter Beelaerts van Blokland. *Developing a benchmark tool to measure company performance of truck manufacturers*. 2014. URL: www.mtt.tudelft.nl.

[42] WMO. “Climate Change 2007: Impacts, Adaptation and Vulnerability”. In: (2007).

[43] Qinqin Zeng. *Development of A Composite Indicator for Measuring Company Performance from Economic and Environmental Perspectives A Study on Motor Vehicle Manufacturers*. 2020.

[44] Qinqin Zeng, Wouter Beelaerts van Blokland, and Sicco Santem. “Company performance measurement for automobile companies: A composite indicator from an environmental perspective”. In: (2018). URL: https://ieeexplore.ieee.org/document/8387131.

[45] Qinqin Zeng et al. “Composite Indicators of Company Performance: A Literature Survey”. In: *Performance Improvement Quarterly* 33 (4 Apr. 2020), pp. 385–418.

[46] P Zhou, B W Ang, and K L Poh. “Comparing aggregating methods for constructing the composite environmental index: An objective measure”. In: (2005). DOI: 10.1016/j.ecolecon.2005.

[47] H.-J Zimmermann. *An application-oriented view of modeling uncertainty*. 1998. URL: www.elsevier.com/locate/orms.