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SOCIO-ECONOMIC CHALLENGES IN SUSTAINABILITY AND RESOURCE MANAGEMENT

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Author's declaration

Whilst registered as a candidate for the above-mentioned degree, I have not been registered for any other research award. The results and conclusions embodied in this dissertation are the work of the named candidate and have not been submitted for any other academic award.

In preparation for this dissertation, three peer-reviewed scientific publications were published by the author as being the lead-author or as publishing as the sole author. These publications have been incorporated into this dissertation. Some of the data used in the papers has been updated to the current state-of-the-art.

Abstract

This dissertation uses in first stage a macroeconomic investigation to examine the dependence, influence and corruption of socio-economic development through effects of sustainability and resource management. The conducted research found that the state's dependence on its citizens decreases when the state's sources of revenue are largely detached and independent of the citizens' financial resources. In this case, financial resources are taxes and duties provided by the citizens. One possible consequence is the restriction of state investment in its citizens. Both the qualitative literature review and the quantitative data analysis revealed a negative correlation between socio-economic development and the resource economy's share of GDP for the period under study. The microeconomic investigation was primarily conducted through an intensive literature review. It was shown that the rebound effect as such is already very well researched. However, it also became clear that avoidance strategies for the rebound effect and links to sustainability initiatives are scarce or non-existent. The need for a redesign of the impact analysis with regard to technological innovations and their influence on resource consumption and resource management has become clear on the basis of the present study. Further, emerging and developing countries in particular, which will be confronted in the foreseeable future not only with the fundamental problems of resource abundance in the overall economic context, but also with the issues of their sustainable use, should be confronted with these problems as early as possible in order to find solutions in a timely manner.

Keywords: efficiency side-effects, resource-optimization, rebound effect, socio-economics

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List of Abbreviations

GDP	–	Gross Domestic Product
GNP	–	Gross National Product
IT	–	Information Technologies
JP	–	Jevons Paradox
PPP	–	Purchasing Power Parity
RE	–	Rebound Effect
RD	–	Research Design
UN	–	United Nations

CHAPTER 1

GENERAL INTRODUCTION: CONCEPTUAL FRAMEWORK, RESEARCH PROPOSITIONS AND RESEARCH DESIGN

1. General Introduction: Conceptual Framework, Research Propositions and Research Design

The efficient and effective use of resources, which in addition to materials in the sense of the macro- and microeconomy also includes e.g. labour force, is of particular importance in the context of the current global challenges. This thesis uses 3 disciplines to analyse these challenges. In order to be able to examine the effects on both states and companies, research was first conducted at the macroeconomic level[1] and then at the microeconomic level[2].

This is done under the umbrella of socio-economics, which is an interdisciplinary field between social sciences and economics that examines how economic activity and social processes influence and change each other, possibly reciprocally (Becker, 1974; Davis & Dolfsma, 2008). In this dissertation, socioeconomics is defined by how societies in different forms develop, stagnate or decline due to their local or regional economy, politics and socio-cultural characteristics or also due to global economic events (Szirmai, 2015). In this consideration, a subdivision of the respective societies into three different clusters takes place: the economic cluster, the social cluster and the cultural cluster. In particular, how social and economic factors influence the environment and what measures can be taken to guarantee sound environmental protection can also be a decisive point (Szirmai, 2015).

[1] Publication 1: Sustainable Development: A Quantitative Analysis Regarding the Impact of Resource Rents on State Welfare from 2002 to 2017; Publication 2: The Rebound Effect – A Systematic Review of the Current State of Affairs

[2] Publication 3: An Evaluation of Corporate Sustainability in Context of the Jevons Paradox

As a further core topic, sustainability management is dealt with in this thesis and was incorporated by an according scientific publication of the author. Nowadays, private companies in particular are judged by the public on the basis of their strategy for sustainable growth, production and sales. In the context of this, different approaches are pursued which both force the sustainable development of the company and embed the establishment of a corporate social responsibility code in the company. Sustainability management therefore pursues a holistic perspective, which includes financial, personnel and resource-technical factors (Baumgartner & Ebner, 2010). In addition to successful business development in the long term, the conservation of resources is also a decisive factor (Binswanger, 2001; M. A. Camilleri, 2017).

Therefore, resource management is another key topic in this thesis and is illustrated by two scientific publications of the author, dealing with this subject on a macroeconomic perspective. The core approach of resource management is the efficient (as a quantitative factor) and effective use (as a qualitative factor) of the resources of a company, organisation or state (Buluş & Topalli, 2011). In addition to microeconomic perspectives referring to companies, a macroeconomic perspective is also possible, which analyses and evaluates the use of resources by states and associations of states. Therefore, resource management encompasses not only financial resources but also such resources as business inventory, human labour, production resources, information technology and, in addition, natural resources such as coal, gas, diamonds and other raw materials (Haq, 1995; Torvik, 2009).

This thesis gives an interdisciplinary insight into these research areas and visualises them through so-called use cases. First, a macroeconomic view

of the issue is taken and then narrowed down to a microeconomic view. Since this document was written as a cumulative thesis, the three scientific papers written in the process of the doctorate are listed for this purpose, which are linked thematically and thus follow the logic described above.
Due to limitations in time and scope, some research questions still allow for further approaches in terms of advanced research. Especially in the analysis of the influence of resource wealth on state welfare, it is possible to use further or more extensive data sets, which may shed light on other aspects. The progressive socio-cultural development of the countries studied must also be considered in further research, so that assumptions can be adjusted and updated if necessary. Likewise, the developed model for reducing the rebound effect can be further expanded at the microeconomic level and, if necessary, adapted to individual needs. Here, too, the aim is not to provide a complete picture of reality, but to test the assumed attributes within the framework of the model landscape and to analyse them under the given conditions.

1.1 Conclusions Based on the Literature

As a very young scientific subject, the literature on socio-economics (sometimes also social economics) is not yet particularly well defined as an independent discipline (Mikl-Horke, 2015). This is also due in particular to the fact that the scientific field of socio-economics is an interdisciplinary field of research between economic factors and their social context (Hellmich, 2017). Other important core aspects of socio-economics relate to political, ecological and social developments, effects and processes in connection with economic decisions, procedures and structures (Hedtke, 2015a). The interweaving of socio-economic development and resource wealth under the consideration of the Human Development Index has also

only been sparsely examined so far. Socio-economics is not defined as a single science, but encompasses various facets of different scientific disciplines. This makes it a useful subject when it comes to examining the impact of resource-oriented state management and technological efficiency effects on the economy and society. Due to this fact, the range of definitions of the term socio-economics varies greatly. Amitai Etzioni is considered to be one of the first authors to have dealt with the topic and to have coined the term socio-economics. As early as 1988, Etzioni wrote a book entitled "The Moral Dimension. Toward a New Economics" on the extension of classical economics to include a moral constant (Etzioni, 2014). In 1990, Amitai Etzioni wrote a chapter entitled "Socio-Economics: The Next Steps" in the book "Socio-economics: Toward a New Synthesis" (Etzioni, 2016).

A major incubator for today's research in this area as well as a motivator for the integration of socio-economics into current social debates is the realisation in recent years and decades that classical economic models only provide inadequate forecasts and also explain past social upheavals caused, for example, by economic or natural disruptions only with difficulty or inadequately (Hedtke, 2015b). Beneath others the areas of influence that socio-economics aims to make more explainable and treatable are the ever-increasing environmental pollution and the greater frequency of natural disasters, as well as the changed dynamics in households and destabilising processes such as rainforest deforestation (Rahman et al., 2014; Schmutter et al., 2017). The characteristics and area of application can therefore differ greatly depending on the basic scientific approach. Another definition of socio-economics, to which this thesis also refers, was published in 2008 by John Bryan Davis, Wilfred Dolfsma. The authors define the field by saying

that economic and social processes cannot be considered separately, so socio-economics examines the (economic market) from a social point of view with a strong influence of ethics. Ethics is defined here as "how values are inescapably intertwined with social relationships" (Davis & Dolfsma, 2008).

1.2 Researching Sustainability

This dissertation intends to examine the interconnectedness of resource use, consumption and utility with regard to socio-economic developments and decisions. A central aspect is therefore the question of the scientific basis on which an optimised use of resources can be achieved. Hence, both in terms of economic efficiency and ethical to social considerations. The theory chosen for this purpose is sustainability management, which addresses both the aspect of sustainability itself and the governance of sustainability (Kerekes, 2021; Williams et al., 2017). Sustainability-Research and Sustainability are interdisciplinary fields that requires an ethical, moral, social and ecological perspective in addition to an economic view (Baumgartner & Winter, 2014).

Developing and conducting corporate sustainability, along with country level sustainability approaches, has great influence on global socio-economic developments (M. A. Camilleri, 2017; Szirmai, 2015). Hence, above mentioned points must always be placed in relation to each other to ensure successful implementation (Kerekes, 2021). Further this supports the efforts of companies and states to achieve their goals in the area of environmental protection and the conscious use of resources in a forward-looking, plannable and economically attractive manner (Baumgartner & Ebner, 2010).

1.2.1 Sustainability Management

According to the literature review conducted, sustainability management is dealing with economic, political, social and ecological challenges (Williams et al., 2017). Further it is a consideration of entrepreneurial processes and business management procedures in the context of sustainability (Stacchezzini et al., 2016). Even though it strongly depends on the context, sustainability in the sense of this work describes the conscientious and long-term use of available resources (Brown et al., 1987).

One of the best-known tools for developing and implementing sustainability processes within companies is the so-called Sustainability Balanced Scorecard. The original Balance Score Card developed by Kaplan and Norton is a strategic business tool to measure and effectively manage and document the strategic activities of a company or organisation (Kaplan & Norton, 2007).

Based on the Balanced Score Card (BSC), the Sustainability Balanced Scorecard (SBSC) adds environmental and social aspects to the consideration (Figge et al., 2002). Analogous to the BSC, this enables a forward-looking, effective and stringent orientation of the company with regard to sustainability aspects.

1.2.2 Ethics in Sustainability

In addition to the efficient and effective planning of operational resources, sustainability management requires a certain mindset and operational ethics that support this undertaking in a responsible manner (Williams et al., 2017). Ethical in this context means treating employees, stakeholders (including natural ressources) and partners in a way that meets standards considered acceptable in civilised societies, including economic responsibility

(M. A. Camilleri, 2017; Murray, 1891). Not only in processes within the company must these operational ethics be followed, but also in dealings and communication with external stakeholders (van Marrewijk, 2003b).

1.2.3 Corporate Sustainability

Since resources are not only used by states, but also intensively by companies, this is an important factor to consider in the microeconomic analysis of the scientific questions presented. In context of corporate sustainability, the environment or nature is also a stakeholder of the company (Vastag et al., 1996). Therefore, the overarching business objective must be to be productive, considering fair and sustainable treatment of stakeholders, and at the same time to increase profitability by using resources sparingly for stakeholders within the company (Figge et al., 2002). In the literature examined, there are various ways of defining sustainable (economic) development. Across the literature, the Brundtlandt Report published in 1987 is frequently cited, which treats human development and human action with responsibility for the environment as a central point (Kopfmüller et al., 2007). In line with the ecological development of sustainable standards, companies and governments have to adapt to national and international guidelines, principles and regulations. Examples are the Sustainability Reporting Guidelines of the Global Reporting Initiative and the UN Global Compact as well as the Sustainable Development Goals. These guidelines create incentives for companies to design their processes, codes of conduct and production in such a way that they are conducive to the sustainable use of resources and a careful approach to the environment (M. A. Camilleri, 2017).

1.3 Rebound Effect

The rebound effect is an economic theory that examines the fundamental relationship between efficiency and resource use. The extent of the rebound effect is measured by how strong the increase in total consumption is compared to the (realised) savings potential. The rebound effect does not necessarily have to lead to ecological dissonance, but can take on various forms in a steady gradation. If, for example, new consumption exceeds the savings achieved through the introduction of the new technology by more than 100%, this is referred to as a full rebound effect (Sorrell et al., 2018). In the following investigations, this dissertation therefore attempts to present the basics of research on the rebound effect, to outline the (current) scientific models and theories, as well as to point out research gaps and make limits visible.

1.3.1 Jevons Paradox

A subtype of the rebound effect is the Jevons Paradox, a (logical) paradox by definition according to the current literature which raises socio-economic awareness issues (Alcott, 2005). A paradox is defined as a finding, statement or phenomenon that contradicts the generally expected, the prevailing opinion or the like in an unexpected way or leads to a contradiction in the usual understanding of the objects or concepts concerned (Kirchner, 2016).

In the case of the Jevons paradox, however, it is strictly speaking only a lack of information for evaluating and classifying future events (York & McGee, 2016). Thus, in the context of this theory and resource-consumption, it can be assumed that certain technologies or actions that increase efficiency must lead to a decrease in total resource consumption. In fact, however, the consequence of some of these technologies or actions is that

total resource consumption increases (Berkhout et al., 2000). At first glance, this appears to be a paradox, since an increase in efficiency, viewed in isolation, always produces the same output with less input or a higher output with the same input. However, with a more holistic perspective, it can be seen that previously unknown or unrecognised mechanisms may mean that the previously made assumption is no longer valid (Polimeni & Polimeni, 2006).

One of these cases is, for example, the introduction of LED technology, which, according to policy assumptions, should lead to an overall reduction in electricity consumption because LED technology is significantly more efficient than the previously used energy-saving bulbs.
In fact, over a period of time, the opposite has been the case. This may sound paradoxical when viewed in isolation, but it becomes clear when previously ignored market mechanisms are included in the analysis.
Classically, a reduction in the price of a demand-elastic or proportional-demand-elastic good leads to an increase in demand. In this case, the price for consumers to illuminate their environment decreased. The consumer can either keep the light on longer for the same price, or illuminate more places than before. However, it was only assumed that electricity consumption would have to decrease if use and consumer behaviour remained unchanged.

Here, too, it is shown that an informed economic view of things must be considered in addition to an ecological one (Gillingham et al., 2015).

1.4 Rentier State

In the context of the macroeconomic consideration of resource management, the theory of the so-called rentier state has been identified in literature to be relevant for the ongoing research and analysis.
The developer of this theory was Mahbub ul Haq, who in his original work "Reflections on Human Development" addressed the problem that many countries, especially in Africa and the Middle East, possess large natural resources, but the respective states do not profit from them (Cook, 1970). Mahbub ul Haq's approach was based not only on purely economic indicators, but also incorporated socio-economic characteristics into the assessment of a country's development.

The core of the rentier state theorem is the analysis of correlations between a country's existing raw materials and its socio-economic development (Hofmeier, 2004). A country or state classified as a rentier state derives a predominant or very large share of its government revenue from external rents (Boeckh & Pawelka, 1997). The term "rent" is used here in the economic sense, and describes the receipt of any kind of income without the need of direct compensation in return. What is meant here, for example, is that existing oil reserves do not have to be "produced" by the state in order to sell them, i.e. there is no initial investment to create the good. Instead, the state confines itself to extracting the already existing oil, processing it if necessary and exporting it. This generates income from a good that did not have to be created beforehand (Yates, 1996). Accordingly, the literature assumes a decoupling of input and output, which produces corresponding (negative) effects on the scale of a state.

1.4.1 Human Development Index

The measurement of these negative effects, such as the dissolution of the reciprocal dependence of state and (tax-paying) citizen, has been carried out in the context of this thesis using the Human Development Index.
The Human Development Index takes up many socio-economic aspects to evaluate the development of a country. Among other things, the level of education, child mortality, unemployment, medical care, relative productivity per person and other relevant aspects are used to make the human and socio-economic development of different countries comparable (UNDP, 1999-2019).

However, both the Rentier State model and the Human Development Index do not claim to fully represent reality. They approximate provide decision-makers and states with a picture that is as close as possible to a realistic assessment of their country from a socio-economic point of view.
Since the publication of the original work on the rentier state in 1970, there have been various studies and further research examining and analysing the impact of resource wealth on countries and the corresponding effect on economic growth and social development.
In this thesis, particular attention was paid to the paper by Thorvaldur Gylfason entitled "Natural resources, education, and economic development", because it transfers the core assumptions of Mahbub ul Haq to the time of writing and enriches them with new views (Gylfason, 2001; Haq, 1995).
In addition, the authors Adebiyi Oyeyemi Omodadepo and Olomola Philip Akanni are considered, who used the two countries Norway and Nigeria as reference for their research. Building on their findings, further research was conducted (Omodadepo, 2013). This comparison is particularly meaningful and interesting because both countries have very different civilisational and

cultural characteristics, but are both very rich in natural resources. In contrast to Norway, which has been ranked first in the Human Development Index for the last 20 years, Nigeria is far behind in 161st place out of 189 for the same period (Dahl & Elstad, 2001; Olabanji Olukayode Ewetan & Ese Urhie, 2014; UNDP, 1999-2019).
Other important research has been carried out by the author Ragnar Torvik, who addressed the question "Why do some resource abundant countries succeed while others do not? Here, too, particular reference is made to the destructive effect of resource abundance and illustrated with various key figures (Torvik, 2009).

The link between resource surpluses and economic growth was further explored by Cecilia Szigeti, Gergely Toth and Daniel Robert Szabo, with a focus on the agricultural sector. In particular, the sustainable development of the central European agricultural industry and the corresponding development of production capacities have been studied (Cecilia Szigeti et al., 2017).

Concluding, a lot of research has already been done on the economic, social and ecological development of both countries. However, the relationship between a country's natural resource wealth and its corresponding HDI ranking has received little or no research attention. This research gap is to be filled in part by this thesis. The aim of the study was therefore to analyse rentier states and a possible correlation of their HDI rating. For this purpose, the relevant literature and databases were researched, which provide indications of a possible connection in the area in question[3].

[3] e.g. World-Bank and United-Nations Data

1.4.2 Further Indices

Due to its presented nature, applicablity and structure, the author has used the HDI as the primary index. However, the HDI is only one index among many others that deal with sustainability, social justice and economic growth (Cecília Szigeti et al.). But unlike other indices, it already includes GNI/ GDP, IHDI (inequality adjusted HDI), GDI (Gender Development Index), GII (Gender Inequality Index) and MPI (Multidimensional Poverty Index, which include variables under investigation by the author. Other indices that may be applicable are however:

- OECD Better Life Index
- Fragile States Index
- Broad measures of economic progress
- Genuine Progress Indicator

1.5 The Objectives of the Dissertation

In the context of this thesis, various goals are to be addressed and, in the best case, new knowledge is to be created. Furthermore, the aim of this thesis is to obtain a comprehensive overview of the topics dealt with and to enable a classification of the relevant thematic literature in the field of resource and sustainability management in the context of socio-economics. In particular, the following objectives are also within the scope of the thesis and are presented and dealt with in the given scientific papers in chapter “Publications”:

- The rebound-effect is to be demonstrated, processed and analysed in the context of socio-economics, especially in corporate sustainability and resource management perspectives

- To provide a theoretical approach on how to reduce or avoid the rebound-effect in context of corporate sustainability

- Evaluation of the impact of resource surpluses on socio-economic factors in both developed and developing countries using Norway and Nigeria as examples.

- Analyse to what extent there is a relationship between a country's HDI Value (proxy value of socio-economic development) and the share of resources in its GDP

- Analyse whether the integration of corporate sustainability in companies leads to an increase in total resource production and consumption through efficiency gains.

1.6 The Methodology Summary of the Dissertation

This thesis maps both theoretical and practical approaches to the research field, therefore it was intended to validate the research relevance for the fields of resource and sustainability management before commencing the research. In addition to the analysis and interpretation of secondary data, an intensive and detailed literature review was conducted (Baumeister & Leary, 1997). In the following, the results of the data analysis and the literature research were compared and merged.

Additionally, a scientific survey was developed and distributed to business professionals in 28 face-to-face interviews and another 65 digitally to verify the relevance of research for the micro-economic part of investigation. A cumulative of 62 questionnaires met the quality standard and were validated and analysed to highlight the relevance of the topic (Rowley, 2014). The analysis of the results shows that sustainability management is seen as useful to increase both the company's reputation and productivity.

However, the analysis also showed that sustainability measures are hardly used despite this attitude. Furthermore, stakeholders seem to have a growing interest in the concept of sustainability management, while the practical

applications are not yet very well known. Lastly, the information collected is intended for further research and has been prepared accordingly. This is supported by a clear, scientific definition of each source used through the APA 7th edition citation system.

1.6.1 Ethical Issues in Conducted Research

The word or term "ethics" can be defined in its original form as "the science of those manners and customs which form the laws of human action and give character to human life" (Murray, 1891). Further, ethics in the context of scientific work and research can be interpreted as "rules, principles, and a standard of conduct that apply to analysis" (McMillan & Weyers, 2007). In order to meet basic scientific standards, a reference to the origin and source was given for all data collected and analysed. Even though the topic of the thesis basically touches on several ethical issues, the author does not currently see any problems with regard to ethical standards in this thesis, as most of the information was collected through secondary data, literature and anonymised statistical analyses. The survey and interviews were anonymised.

1.6.2 Research Methodology: Basic, Applied and Evaluation Research

There are different approaches within the research methodologies. According to the book Management & Business Research, there are 3 types of research to consider (Easterby-Smith et al., 2015):

- Basic research: aims to gather and derive new knowledge and also hopes to establish general principles and theories that can be used to explain it.

- Applied research: aims to understand how the results of basic research can be translated into a form that helps alleviate a particular organisational or policy problem. In addition, applied research provides sound guidelines for remedial action.

- Evaluation research: is concerned with the systematic assessment of the value or merit of an object. Furthermore, it involves the systematic collection and assessment of information to provide useful feedback about an object.

In this thesis, the applied research approach is followed as the research is based on existing theoretical concepts and interprets them with the collected data.

1.6.3 Research Methodology: Deductive vs Inductive Approach

In addition to the basic choice between basic, applied and evaluation research, there is also the decision of whether to pursue a deductive or inductive research approach.

The deductive research style uses theory as a basis (here, among others, the Rentier State Model and the Jevons Paradox) and, based on this, builds up corresponding hypotheses which are then tested according to scientific standards. The deductive research approach is therefore always appropriate when a lot of (secondary) literature is already available, as the research is based on existing theories (Azungah, 2018).

In contrast, the inductive research methodology proceeds in exactly the opposite way. Field studies are conducted and empirical research is carried out (Trochim & Donnelly, 2008). On the basis of the primary data collected, new theories can then be established.

In this thesis, the hypotheses are identified after the author has obtained a basic overview of the relevant literature and was thus able to identify the appropriate research method to test the hypotheses H1, H2 and H3.
Orientation regarding the two research approaches can be found in the book "The Research Methods Knowledge Base" by Trochim and Donnelly from 2008.

In this context, the inductive method is characterized as one that proceeds from the particular to the general, whereas the deductive method begins with general premises and ends with the particular. Literature further advises that research based on empirical observations is best conducted inductively, while research based on known laws, rules and conclusions is best conducted deductively (Guest & Fleming, 2015).
Another approach to this can be found in the literature by the authors Creswell and Plano Clark. They state that the deductive researcher "works from the 'top down', an approach based on hypotheses, in some cases even to infer, add to or believe a theory" (Clark, 2010).

Hence, when considering the inductive approach to research, one is more likely to speak of someone who uses a bottom up principle, using for example interview participants or study participants to determine and narrow down the scope of the research, the understanding, capacity and content of the research subject (Clark, 2010).

1.6.4 Research Methodology: Qualitative vs Quantitative Approach

Furthermore, in both approaches, the choice of data collection and use is also very important and crucial to the specific approach. In conducting research, the two principal methods of gathering and using data are usually either quantitative or qualitative. These two methods are not in any way mutually exclusive, however, but can tackle the same issue using different approaches. The key distinction between the two methods is the way in which they view the real world. The quantitative theorists accept "an individual absoluteness in the application of valid and accurate principles. The qualitative theorists "believe in associated, constructed realities that acquire changing meanings for different individuals and whose interpretations depend on the lens of the researcher" (Onwuegbuzie & Leech, 2005). Thus, it is particularly the relationship between the researcher and the subject under study that is characterized by the discipline in question. In quantitative research, researchers are assumed to distance themselves from participants, whereas qualitative researchers are assumed to have a good relationship with participants. In addition, quantitative researchers believe that "research should be value-free", while the qualitative researcher believes that "analysis is strongly influenced by the values or ethics of the researcher" (Onwuegbuzie & Leech, 2005).

1.6.5 The Methodological Approach Used

The thesis follows different methodological approaches which, however, are principally pursued through a deductive research approach. It should be noted that the conclusions of a deductive argument can only be correct if all the premises established in the inductive studies and theories are true and the concepts are clear. Since scientifically sound theories and models were used, this is a matter of course. No own inductive research has been

done but scientifically established models and theories were chosen. As the author undertook the research deductively, he started his research by selecting those applicable theories after conducting critical literature reviews at both macro and micro level as shown in Figure *1*. In the following, the authors formulated three different hypothesises:

H1 The share of resource revenues in GDP has no influence on the HDI value and thus, on the socio-economic development of a country classified as a rentier state.

H2 Integration of corporate sustainability measures results in increased overall resource output and resource consumption through efficiency gains.

H3 Demand elasticity and consumer behaviour has a positive impact on the effectiveness of sustainability measures in companies.

Accordingly, the data for testing the hypotheses was collected by analysing numerical and literature databases. Then, all three hypotheses were tested individually using different scientific approaches (see Figure *1*). Finally, the hypotheses were rejected or accepted depending on the results of the data analysis and the research conducted.

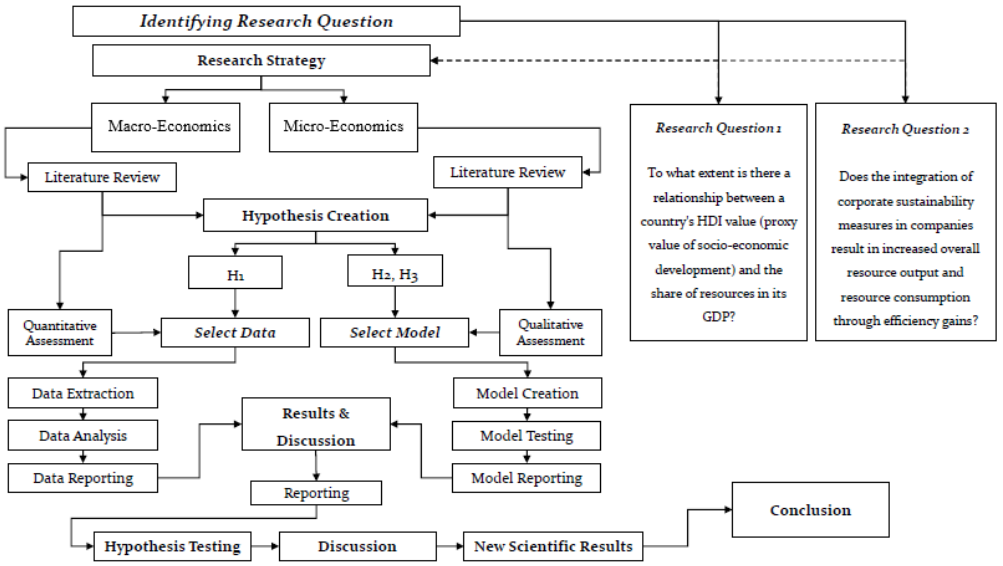

Figure 1: Research Methodology visualisation, own figure

1.6.6 Stages of Analysis

In order to adress both micro- and macro-economic levels, three different papers have been published. The first paper is focusing on the research question "*to what extent is there a relationship between a country's HDI value (proxy value of socio-economic development) and the share of resources in its GDP*". This paper prepared a literature review on the topic and then addressed the research questions by first creating a dataset and then using a quantitative analysis conducting linear and polynomial regression analysis. Further, two more papers have been published addressing the micro-economic research question "*does the integration of corporate sustainability measures in companies result in increased overall resource output and resource consumption through efficiency gains*". This was achieved through critical literature reviews of present scientific models (beneath others the rebound effect and steady state model) and literature. Based on inclusion and exclusion criteria, from which corresponding findings were then presented. According to the review conducted, models have

been chosen to test against the created hypothesis later on. After merging, preparing and processing the data of all three papers, the relevant data is transferred to the results and discussion phase. Hence, a three-stage rigorous review process was followed for the investigation (Kitchenham, 2004).

The planning phase:

The overall objective of this stage was to establish a specific and clear review topic. This was in turn done through the development of the review protocol and the framing of the research questions.

The implementation phase:

This phase followed the previous planning process and is the core of the whole analysis. For this purpose, inclusion and exclusion criteria of the analysis were defined based on the research question. Consequently, based on the criteria and limitations, topic-related primary studies were identified, screened, categorised and subsequently reported.

The reporting phase:

A systematic review report is prepared based on the findings to date.

Qualitative Research Stage

Qualitative analysis methods were applied in the thesis by collecting and analysing valid secondary data and literature. The secondary data collected was obtained by analysing and collecting literature sources such as relevant journals, scientific reports, books and especially scientific publications and number-based databases such as the Worldbank. In a further step, online

research was utilized as a data collection method to examine literature databases such as Scopus in order to collect and analyse metadata, for example.

The data gathered in the research was checked for its consistency and reliability using a scientific framework. This was carried out using an integrated approach suggested by Saunders to prevent bias and error in research, data collection and data analysis (M. Saunders et al., 2009). In addition to the methodological approach of creating a literature review using secondary data, the research also included a meta-data analysis, which was conducted using the Scopus literature database.

This made it possible to create a systematic overview of the state of publications in the field of resource and sustainability management. First, corresponding research questions were defined which then led to the applied search strategy. Based on the defined search scheme, results were then searched for both manually and automatically in the most renowned journals as well as in the Scopus database.

Quantitative Research Stage

Quantitative research has been applied, by collecting data-sets from World Bank and other credible sources to analyse those data-sets and find out how specific factors potentially correlate with each other. To carry out this analysis, the collected data was merged into customised csv files. This csv file was then loaded into the analysis software RStudio. Using the integrated data sets, various statistical methods were used to examine the extent to which certain, previously defined, factors potentially correlate with each other or to determine how these factors are mutually dependent.

Due to the high complexity of the area under investigation, the data sets used only offer an approximation to reality with a partially high uncertainty factor. The analysis used both linear and polynomial regression analysis to identify correlations of the values inspected. In addition to a linear regression, a polynomial regression was chosen because the analysed data in the visualisation is not linear. A polynomial regression is better able to show the best fitting line. The data sets used consists of the following parameters addressing both Nigeria and Norway individually:

Table 1: Quantitative Research Parameters used

Indicator	*Value*
Time Period	Year
Resource Rents	Percent of Resource Rents in GDP
Human Development Index	HDI Value
GDP per Capita	2017 PPP USD
Linear Regression	Y = a + bX
Polynomial Regression	y = a0 + a1x1 + a2x12 + … + anx1n

CHAPTER 2

PUBLICATIONS

2. Publications

Macroeconomic Views on Socio-Economics

This chapter will focus on the analysis of Socio-Economics using a Macroeconomic perspective and consists of one paper examining the topic.

Paper 1: Sustainable Development: A Quantitative Analysis Regarding the Impact of Resource Rents on State Welfare from 2002 to 2017

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Marcel Biewendt

Abstract: This paper uses a quantitative analysis to examine the interdependence and impact of resource rents on socio-economic development from 2002 to 2017. Nigeria and Norway have been chosen as reference countries due to their abundance of natural resources by similar economic performance, while the ranking in the Human Development Index differs dramatically. As the Human Development Index provides insight into a country's cultural and socio-economic characteristics and development in addition to economic indicators, it allows a comparison of the two countries. The research presented and discussed in this paper was researched before from a different perspective. A qualitative research approach was used in the author's master's thesis "The Human Development Index (HDI) as a Reflection of Resource Abundance (using Nigeria and Norway as a case study)" in 2018. The management of scarce resources is an important aspect in the development of modern countries and those on the threshold

of becoming industrialised nations. The effects of a mistaken resource management are not only of a purely economic nature but also of a social and socio-economic nature.
In order to present a partial aspect of these dependencies and influences this paper uses a quantitative analysis to examine the interdependence and impact of resource rents on socio-economic development from 2002 to 2017. Nigeria and Norway have been chosen as reference countries due to their abundance of natural resources by similar economic performance, while the ranking in the Human Development Index differs significantly.

As the Human Development Index provides insight into a country's cultural and socio-economic characteristics and development in addition to economic indicators, it allows a comparison of the two countries.
This paper found out in a holistic perspective that (not or poorly managed) resource wealth in itself has a negative impact on socio-economic development and significantly reduces the productivity of the citizens of a state.
This is expressed in particular for the years 2002 till 2017 in a negative correlation of GDP per capita and HDI value with the share respectively the size of resources in the GDP of a country.

-1.- Introduction

The Human Development Index (HDI) gained more and more relevance over the past decades. Since GDP does not adequately reflect the economic and especially the social development of a country (Mohajan, 2018), indices such as the Human Development Index, but also alternative indices such as the Happy Planet Index are becoming increasingly important (Marks & Murphy, 2006). Norway and Nigeria, which have similar economic performances in regular GDP numbers (current difference of

roughly 10 percent in unadjusted GDP; USD 437 billion vs. USD 397 billion), are examples of this (World Bank, 2018). Even though GDP claims that both perform similarly in economic terms, the individual reality of life for the citizens of these two countries is very different, which is more cleary shown by GDP in constant 2017 PPP USD and the according GDP per Capita in const. 2017 PPP USD (Table1). There are several resource-rich countries around the world, but they have very different standards of living. Besides Nigeria and Norway, these include Venezuela, the United States of America, Saudi Arabia, Australia, Brazil, China, Canada and Russia. It can thus be stated that resource-rich countries are not only among the richest, but also among the poorest nations in the world (Torvik, 2009).

Table 2: Comparison of GDP (2018), GDP per Capita (2018), HDI value (2019) and Ressource-Rents (2017) among selected resource rich countries

Country	**GDP in trillion (constant 2017 PPP USD)**	**GDP per Capita (constant 2017 PPP USD)**	**Resources rents in % of GDP**	**HDI Index in points**
USA	20.129	62,527	00.50	0.920
China	**21.229**	16,117	01.50	0.758
Brazil	3.073	14,652	03.50	0.761
Canada	1.809	49,031	01.70	0.922
Russia	3.914	27,044	10.70	0.824
Australia	1.228	49,756	07.20	0.938
Saudi-Arabia	1.604	46,962	**23.8**	0.857
Congo, (Dem. Rep.)	0.091	1,098	11.80	0.726
Norway	0.488	**64,341**	05.90	**0.954**
Nigeria	1.01	5,155	08.70	0.534

Source: (UNDP, 1999-2019; World Bank, 1990-2019)

Table 2 compares different economic values on a country-by-country basis. It is noticeable that countries with a much lower GDP can have a much better HDI value (cf. Australia and the USA). Furthermore, one has to pay attention to how much of the GDP is generated by revenues from the sale of resources. Here Saudi Arabia leads the selected countries with 23.8 percent, followed by Venezuela with 11.8 percent and Russia with 10.7percent. In other words, some of these countries generate more than one-fifth of their GDP from the exploitation and sale or export of natural resources[4].

It is questionable whether such a high share of GDP has an impact on the development (social, economic and ecological) of a country and to what extent it influences the HDI ranking. One possible answer to this question is the so-called Rentier State Model, which was first developed in its modern version by Hossein Mahdavy in the 1970s (Cook, 1970) and later on by Hazem El Beblawi and Giacomo Luciani at the end of the 1980's (Hazem & Luciani, 1987). Moreover, especially in today's public consciousness, the ecological price of economic growth is a key issue to assess when discussing the reciprocal effects of GDP growth and resource welfare and consumption. One trend is that countries tend to achieve the so-called "strong decoupling" of the two variables, while the average ecological footprint intensity of countries in general has improved significantly (Cecilia Szigeti et al., 2017). In addition to the natural exploitation of resources such as gas, oil, coal, etc., resources such as agricultural products from a nation's agribusiness can also be used as an indicator of a country's specific productivity performance, which probably affects the overall HDI value. A corre-

[4] Including oil rents, natural gas rents, coal rents (hard and soft), mineral rents, and forest rents

sponding comparison was made by Baráth and Fertő (2017), who concluded that European countries generally converge in this case (Baráth & Fertő, 2017). Probably meaning, that a strong and reciprocal cooperation between countries stabilises and equalises productivity differences.
Taking into account a wide range of the different theoretical frameworks that address this question, the overall picture that emerges from the qualitative research perspective is that the hypothesis can be confirmed independently and through different literature sources that correlate HDI ranking with a country's resource wealth (Biewendt, 2018).

-1.1- Research Methods

The research derived here used qualitative analytical methods in preparation for the actual analysis by collecting and analysing secondary data. Primarily, however, quantitative primary data from the World Bank were used. These are supplemented by other credible online sources that were analysed with RStudio and, together with World Bank data, form the basis of the research presented here. Secondary data for qualitative and quantitative analysis were also collected from relevant literature sources such as journals, reports, books, relevant and credible newspapers, as well as from sources such as the World Trade Organization, the World Economic Forum and the United Nations. The data collected has been checked for consistency and reliability by comparison with other sources (M. Saunders et al., 2009). The analysis is consequently showing possible correlations, but is limited to three variables therefore not depicting the absolute reality. In absolute reality, there are significantly more factors and variables that influence the HDI value of a country, whereas this research may only present results based on the given model within a specific time frame.

-1.2- State of Affairs

The Human Development Index is defined as follows: "…*a measure for assessing progress in three basic dimensions of human development: a long and healthy life, access to knowledge and a decent standard of living"* (UNDP, 1999-2019). The Human Development Index has its origins in the work and research of the well-known economist Mahbub ul Haq which thrived to *"...explore a new development paradigm whose central focus is on human well-being"* (Haq, 1995). With his work "Reflections on Human Development", Mahbub ul Haq thus introduced a new way of looking at human development which, in contrast to previous approaches, also includes socio-economic characteristics in the assessment of a country's development.

Hence, the rentier state model uses socio-economic attributes as the basis of its approach, possibly showing a link between countries that are classified as rentier states and rated accordingly in the Human Development Index. It should be noted, however, that the Human Development Index is also only a model that reflects reality under certain aspects, thus simplifying reality in certain areas. The results, even if they are scientifically sound, therefore only represent an approximation of reality and should be viewed critically as such.

Over the decades, several studies have explored and analysed the impact of countries' resource wealth and the corresponding effect on economic growth. Beneath others Thorvaldur Glyfason wrote an essay with the title "Natural resources, education, and economic development" (Gylfason, 2001), Ragnar Torvik wrote a paper dealing with the question "Why do some resource abundant countries succeed while others do not?" (Torvik, 2009), the authors Adebiyi Oyeyemi Omodadepo and Olomola Philip

Akanni dealt with the topic “Oil wealth; meat in Norway, poison in Nigeria: An analysis of human capital as a transmission channel of resource curse” (Omodadepo, 2013). The ecological price of economic growth is another factor that must be considered, for instance the decoupling of ecological footprint and GDP growth. Reciprocal effects of resource welfare and a nation’s economic growth may heavily impact the sustainable development of industry and production capacities when taking natural protection and sustainability into account which has been researched by Cecilia, Szigeti, Gergely, Toth and Daniel Robert Szabo (Cecilia Szigeti et al., 2017).
However, there are barely any studies on how the abundance of natural resources of a country that can be classified as a Rentier State affects the HDI ranking or how the two are related.
The aim of this article is therefore to quantitively analyse the significance of the HDI ranking in relation to countries classified as Rentier States by using Nigeria and Norway as reference countries. The objectives of this paper are also to research the relevant literature in the field of interest and to review the conceptual frameworks.

-1.3- Results and Discussion

In the following chapter, the statistical analyses of Nigeria and Norway are presented. In their entirety, it is examined whether and what influence the share of resource rents in GDP and GDP per capita (in constant 2017 PPP US$) has on the corresponding country-specific HDI value. The object GDP per capita was chosen as the test reference value. The HDI value of a country is influenced by the corresponding value of GDP per capita, since the latter is used as part of the calculation basis.

The following parameters, in the period 2002 to 2017, were examined:

- HDI Value
- Share of Resource Rents of GDP
- GDP per Capita in constant 2017 PPP US$

First the results for Nigeria and then for Norway will be presented. The results are summarised, compared and evaluated in the corresponding conclusion. In addition to a graphical representation with an AB trend line and a polynomial trend line, the respective sub-hypotheses are checked by means of ANOVA. The data analysis carried out considers the three variables "HDI value", "GDP per capita in constant 2017 PPP-US$" and "Resource rents as a percentage of GDP" on the basis of 30 properties (among the years and on average between 2002 and 2017 are considered. The comparison of the HDI value and GDP per capita serves as a test value, as the HDI value is also calculated by taking GDP per capita into account. A correlation is therefore imperative. However, it should be noted that the HDI value is calculated using the special indicator "PPP US$ 2011" and not "PPP US$ constant 2017" as used in this analysis. The difference is marginal and has no impact on the result. It should also be noted that the information value is limited to the period analysed. When viewed over a longer period of time, results may vary. Especially as unforeseen influences and external factors not covered here influence the informative value. Above all, political decisions that take effect over a longer period of time, for example in the form of economic upheavals or extreme events such as wars, distort the picture. Particularly in Nigeria, with a very dynamic development in society, politics and lifestyle of the population, the results are therefore of limited informative value. The detailed analysis below shows possible correlations graphically and shows both a linear and a polynomial trend line for the case of Nigeria.

-1.3.1- Country Information of Nigeria

With a total area of 923,768 km², Nigeria is two and a half times the size of the Federal Republic of Germany (357.385,71 km²) and almost three times the size of Norway (323.8021 km²). The longest extension from west to east is 1,300 km, from north to south 1,100 km. The length of the coast is 853 km. Oil and gas have been firstly found 1956 in Oloibiri and afterwards produced and exported since 1958 (OPEC, 2020). Currently, Nigeria has a population of about 196 million people (World Bank, 2021).

The massive pollution and destruction of the environment still cost the lives of thousands of people, despite mass protests by the ethnic groups living there i.e., in the Niger Delta (Odeyemi & Ogunseitan, 1985). The destruction of the environment and habitat in the Niger Delta as a result of oil production is described in detail in a report by Amnesty International (Amnesty-International, 2019).

Table 3: Key Indicators of Nigeria

Year	Life expectancy at birth	Expected years of schooling	GDP per Capita (constant 2017 PPP USD)	Resource rents (% of GDP)	HDI Value
1990	45.9	06.70	3,259	**24.87**	
1995	45.9	07.20	2,901	20.51	
2000	46.3	08.00	2,977	23.66	
2005	48.3	09.00	3,997	20.61	0.467
2010	50.9	08.40	4,932	14.86	0.484
2011	51.3	08.70	5,056	19.19	0.494
2012	51.8	08.90	5,131	16.71	0.512
2013	52.2	**10.0**	5,329	12.89	0.519
2014	52.7	09.80	**5,516**	10.32	0.524
2015	53.1	09.70	5,514	05.06	0.527
2016	53.5	09.50	5,284	04.86	0.528
2017	**54.0**	09.70	5,190	04.40	**0.533**

Source: (UNDP, 1999-2019; World Bank, 1990-2019, 2018)

Nigeria's GDP per capita increased according to Nigeria's 2020 HDI Report from 1990 until 2017 by 59.25 percent as seen in Table 3. Further Table 3 shows that the HDI value has increased from 2005 to 2017 by 14,13 percent, the life expectancy raised from 1990 to 2017 by 17,65 percent and the expected years of schooling in the same time by 44,78 percent. No HDI value data are currently recorded for Nigeria for the years 1990 to 2004, whereas these years could not be included in the analysis (UNDP, 1999-2019).

-1.3.2- Statistical Analysis of Nigeria

In the following Chapter a statistical data anaylsis for Nigeria will be provided.

-1.3.2.1- Quantitative Analysis and Key Indicators of Nigerian Regression of Nigerian HDI Value and Share of Resource Rents of GDP

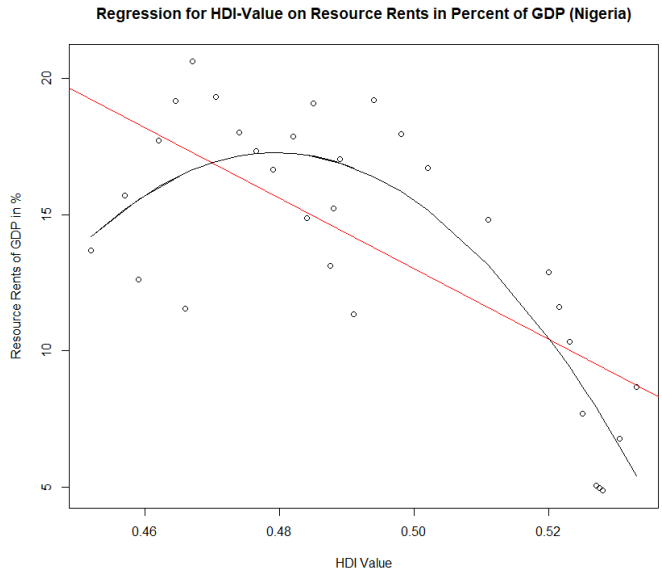

Figure 2: Regression & linear (red) poynomal (black) trendline for Resource Rents in percentage of GDP to according HDI-Value of Nigeria for years 2002-2017* with linear regression line (red) and polynomal regression line (black); own figure, data source: (World Bank, 2002-2017)

Figure 2 shows a graph showing resource rents as a percentage of Nigerian GDP on the Y axis and the Nigerian HDI value on the X axis. It shows a linear AB trend line and a polynomial trend line. The data collection period extends from 2002 to 2017. It can be seen that as the HDI value increases, the percentage of resource rents decreases, respectively the graph shows that the higher the percentage of resource rents, the lower the HDI value. Therefore, it can be concluded at this point that, based on the available data, countries that want to improve their HDI value should consider diversifying or reducing a GDP with a high percentage of resource rents.

-1.3.2.2- Regression of Nigerian GDP per Capita in constant 2017 PPP US$ and HDI Value

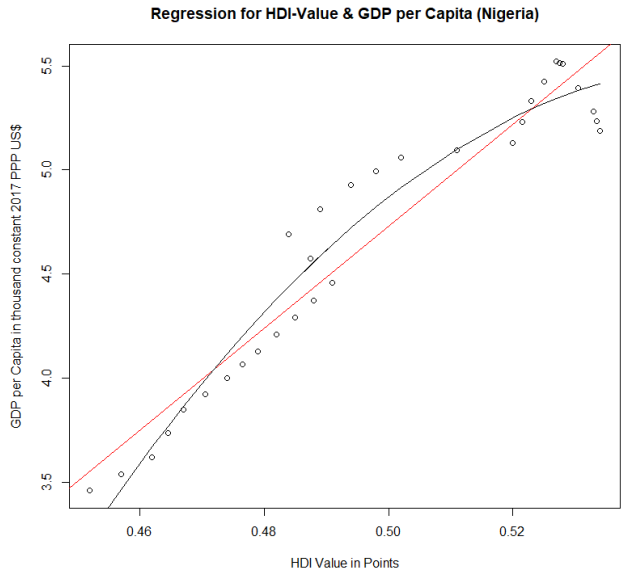

Figure 3: Regression & linear (red) poynomal (black) trendline for HDI-Value to according GDP per Capita of Nigeria for years 2002-2017; own figure, data source: (World Bank, 2002-2017)

Figure 3 shows a graph displaying Nigerian GDP per capita in constant 2017 PPP US$ on the Y axis and Nigerian HDI Value on the X axis. Further a linear AB trend line and a polynomial trend line is shown. The data collection period is from 2002 to 2017 and shows that the higher the HDI value, the higher the GDP per capita, respectively the graph shows that the higher the GDP per capita, the higher the HDI value. Since the GDP per capita indicator is part of the HDI value (and is used here as a test value), there must be a correlation between the two values. A higher value of GDP per capita therefore "automatically" produces a better HDI value.

-1.3.2.3- Regression of Nigerian Share of GDP Resource Rents and GDP per Capita in 2017 PPP US$

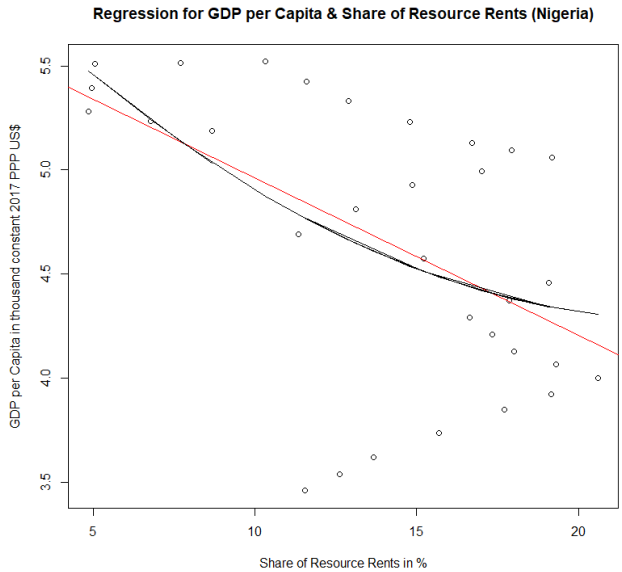

Figure 4: Regression & linear (red) poynomal (black) trendline for Resource Rents in percentage of GDP to according GDP per Capita in constant 2017 PPP US$ of Nigeria for years 2002-2017; own figure, data source: (World Bank, 2002-2017)

Figure 4 shows a graph displaying Nigeria's resource rents as a percentage of GDP on the Y axis and Nigeria's GDP per capita on the X axis. It shows a linear AB trend line and a polynomial trend line. The AB trendline displays that with increasing Nigerian GDP per capita the percentage share of resource rents in Nigerian GDP decreases, respectively the graph indicates that the higher the percentage share of Nigerian resource rents in GDP, the lower the Nigerian GDP per capita. It thus indicates that even without the other factors of the HDI value, a direct negative impact on the economic productivity of citizens can be proven. Possible reasons for this are suggested in the author's qualitative study (Biewendt, 2018).

-1.3.3- Country Information of Norway

At 323.8021 km², Norway is almost as large as Germany (357.385,71 km²) and a little bit bigger than Italy (301.338 km²) with a population of 5.305.000 inhabitants. The length of the country is 1,572 km as the crow flies from Kristiansand in the south to Hammerfest near the North Cape. The border to Sweden is 1,619 km long, that to Finland 727 km and that to Russia 196 km. Per capita income in Norway is one of the highest, as is in child benefit (World Bank, 2018).

In Norway, oil and gas have been produced mainly through offshore facilities since the early 1970s (Baten, 2017). Norway is one of the largest oil and gas exporters in the world. The deposits of the Norwegian state pension fund, established in 1996 and composed of revenues from the oil and gas business, have a market value of around €1 trillion (Norges-Bank, 2021). By adopting the "rule of action", the Norwegian government may withdraw a maximum of 3 percent of the capital stock from the fund for financing the state budget each year (Financial-Times, 2020).

Table 4: Key Indicators of Norway

Year	Life expectancy at birth	Expected years of schooling	GDP per Capita (constant 2017 PPP USD)	Resource rents (% of GDP)	HDI Value
1990	76.50	14.00	41,406	07.67	00.85
1995	77.70	15.60	48,407	04.98	00.88
2000	78.7	17.50	56,137	**11.86**	00.92
2005	79.9	17.50	60,798	10.53	00.93
2010	81.00	17.50	60,290	08.91	00.94
2011	81.30	17.60	60,097	10.99	00.94
2012	81.45	17.50	60,916	10.38	00.94
2013	81.75	17.70	60,806	08.86	00.95
2014	82.10	17.70	61,308	7.94	00.95
2015	82.30	17.80	61,895	05.33	00.95
2016	82.41	18.00	62,010	04.13	00.95
2017	**82.51**	**18.10**	**62,940**	05.93	**00.95**

Source:own table, (World Bank, 1990-2019)

Norway's Gross Domestic Product per capita increased according to Norway's 2020 HDI Report from 1990 until 2017 by 52.01 percent as seen in Table 4. Further Table 4 shows that the HDI value has increased from 1990 to 2017 by 11,77 percent, the life expectancy raised from 1990 to 2017 by 7.86 percent and the expected years of schooling in the same time by 29.2 percent (UNDP, 1999-2019).

-1.3.4- Statistical Analysis of Norway

In the following Chapter a statistical data anaylsis for Nigeria will be provided.

-1.3.4.1- Quantitative Analysis of Norwegian Key Indicators Regression for Norwegian Share of Resource Rents of GDP and HDI Value

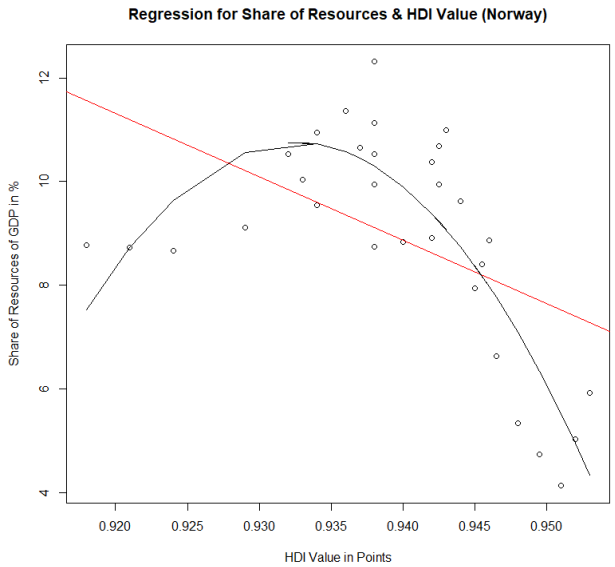

Figure 5: Regression & linear (red) poynomial (black) trendline for Resource Rents in GDP in percentage to according HDI Value of Norway for years 2002-2017; own figure, data source: (World Bank, 1990-2019)-

Figure 5 shows a plot graph displaying Norwegian share of resource rents of national GDP in percent on the Y axis and the Norwegian HDI-Value on the X-Axis. A linear AB trendline and a polynomial trendline are shown. The data collection period is from 2002 to 2017. It can be seen thatwith increasing HDI value the GDP per Capita increases, respectively the graph shows that the higher the GDP per Capita, the higher the HDI value.

1.3.4.2- Regression of Norwegian GDP per Capita in constant 2017 PPP US$ and HDI Value

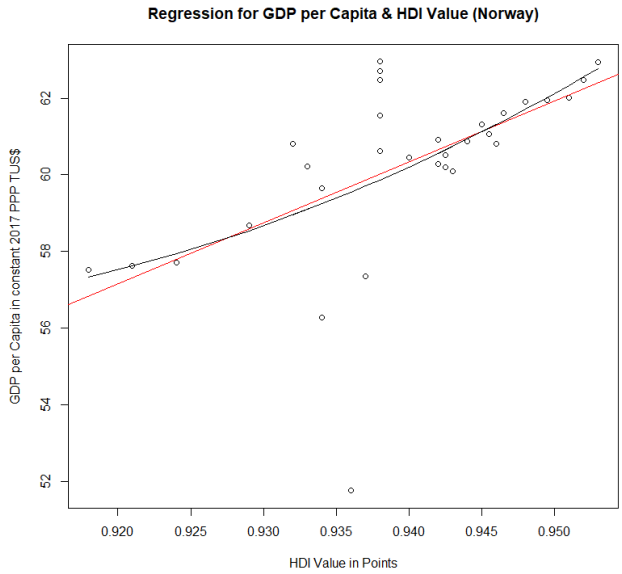

Figure 6: Regression & linear (red) poynomal (black) trendline for HDI-Value to according GDP per Capita of Nigeria for years 2002-2017; own figure, data source: (World Bank, 2002-2017)

Figure 6 shows a plot graph displaying Norwegian GDP per Capita in constant 2017 PPP TUS$ Y axis and the Norwegian HDI-Value in points on the X-Axis. A linear AB trendline and a polynomial trendline are shown. The data collection period is from 2002 to 2017. It can be seen that with increasing HDI value the GDP per Capita increases, respectively the graph shows that the higher the GDP per Capita, the higher the HDI value.

-1.3.4.3- Regression of Norwegian GDP per Capita in constant 2017 PPP US$ and Share of Resources in Percent

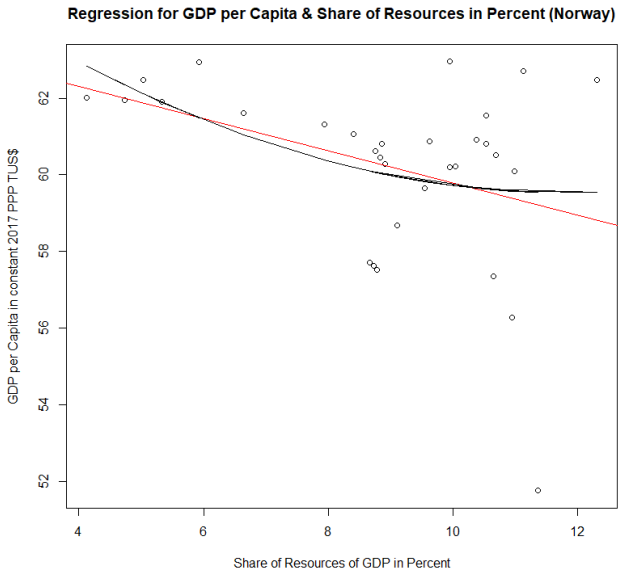

Figure 7: Regression & linear (red) poynomal (black) trendline for Share of Resource Rents to according GDP per Capita of Nigeria for years 2002-2017; own figure, data source: (World Bank, 2002-2017)

Figure 7 shows a plot graph displaying Norwegian share of resource rents in GDP in percent on the Y axis and the Norwegian GDP per Capita on the X-Axis. A linear AB trendline and a polynomial trendline are shown. The data collection period is from 2002 to 2017. Analogous to the Nigerian analysis, the Norwegian model also shows that resource wealth has a negative, albeit less pronounced, influence on the individual productivity of citizens.

-1.4- Conclusion

The literature review indicated that there are currently several approaches and theories for determining the general impact of resource wealth on the economic and social behaviour of a country. In any case, the influence of

the rentier state construct or a country's wealth of natural resources on the corresponding HDI value has not been sufficiently researched yet.

An earlier executed qualitative research project by the author found that the current literature shows that resource wealth tends to have a negative impact on a country's socio-economic development. This is beneath others, due to an imbalance of dependence between the state and its citizens, which is decoupled, for example, by the rents generated by oil. In this paper a quantitative assessment was made of whether and to what extent the HDI value of a country correlates with the share of resource revenues in GDP. The analysis is able to point out that the null hypothesis that the share of resource revenues in GDP has no influence on the HDI value and thus on the overall socio-economic development in the countries studied can be rejected. A higher share therefore leads to a lower HDI value or to slower or less favourable development of the respective country due to a negative correlation. An impact on the productivity of the individual citizen, expressed as GDP per capita, can also be demonstrated. Here, too, there is a negative correlation, indicating that resource wealth reduces individual productivity. It is noteworthy that this correlation is valid for both Nigeria and Norway for the observed period, even though national cultural and society strongly differs. However, since not all influencing factors are included in this analysis and the observation period is limited to 15 years, further research is needed to analyse and discuss these results from other perspectives, if necessary.

Microeconomic Views on Socio-Economics

This chapter will focus on the analysis of Socio-Economics using a Micro-economic perspective.

Paper 2: The Rebound Effect – A Systematic Review of the Current State of Affairs

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Florian Blaschke (Germany)
Arno Böhnert (Germany)

Abstract: This publication is intended to present the current state of research on the rebound effect. First, a systematic literature review is carried out to outline (current) scientific models and theories. Research Question 1 follows with a mathematical introduction of the rebound effect, which shows the interdependence of consumer behaviour, technological progress, and interwoven effects for both. Thereupon, the research field is analysed for gaps and limitations by a systematic literature review. To ensure quantitative and qualitative results, a review protocol is used that integrates two different stages and covers all relevant publications released between 2000 and 2019. Accordingly, 392 publications were identified that deal with the rebound effect. These papers were reviewed to obtain relevant information on the two research questions. The literature review shows that research on the rebound effect is not yet comprehensive and focuses mainly on the effect itself rather than solutions to avoid it. Research Question 2 finds that the main gap, and thus the limitations, is that not much research has been

[5] Lead Author

published on the actual avoidance of the rebound effect yet. This is a major limitation for practical application by decision-makers and politicians. Therefore, a theoretical analysis was carried out to identify potential theories and ideas to avoid the rebound effect. The most obvious idea to solve this problem is the theory of a Steady-State Economy (SSE), which has been described and reviewed.

Keywords: Review, Critical, Systematic, Literature, Rebound-Effect, Sustainability, SSE)
JEL Classification: O33

-1.- Introduction

Technology, efficiency gains, sustainability, and automation play an important role in today's economy and society. Disruptive technologies influence the way work is done, people are educated, and products are consumed. Many of the new technologies aim to reduce resource consumption through efficiency gains. In public perception, but also in politics, this approach is rarely questioned. In fact, however, this approach should be critically questioned, especially if the so-called "rebound effect" is considered when considering i.e. sustainable management. Already in the 19th century, William Stanley Jevons discovered that efficiency gains through technological progress can have a negative impact on the overall consumption of resources.

This finding became known as the Jevons Paradox (Jevons, 2016b). Among other gradations, the Jevons paradox describes the highest degree of the rebound effect (X > 100 percent). Even though this case is rare, it is best to explain the effects of the rebound effect in and impressive way.

The introduction and application of LED technology, for example, has led to a situation where a single LED consumes only one-twentieth of the power of an energy-saving lamp but has increased electricity consumption increase in many places. This was due to the fact that individual electricity costs were initially lower due to lower electricity consumption. However, consumers could either leave their lamps on longer at the same cost, use more lamps than before, and allow people to buy and install lighting fixtures that were previously too expensive. Both have increased the total power consumption caused by lighting (McRae, 2019).

The rebound effect is now measured by how strong the increase in total consumption is in compared to the savings potential. If, for example, the new consumption exceeds the savings achieved by the introduction of the new technology, this is called a rebound effect (Sorrell et al., 2018). Depending on how strong and in what form this effect occurs, it can be classified differently. The present publication therefore attempts to present the fundamentals of research on the rebound effect, to outline the (current) scientific models and theories as well as to reveal research gaps and make limitations visible.

-1.1- Review Method

This paper is based on the systematic review approach, which has been used to answer the research questions presented below. The aim of this working paper is, therefore, to identify all relevant studies of the rebound effect and to aggregate the current state of scientific research (Petticrew & Roberts, 2012). Therefore, an evaluation of relevant literature and an examination of the current state of affairs will be undertaken. In addition,

knowledge of the terminology and the conceptual framework that determines the development of the rebound effect is analysed.
To provide a detailed overview, the focus should also, but not exclusively, be on the following objectives (Arksey & O'Malley, 2005):

RQ1: What are the general scientific fundamentals of the rebound effect?
RQ2: What are the limitations and gaps in current research on rebound effect?
Due to limitations in processing time, capacity, and scope, the paper cannot summarise all the investigations carried out in a mutually exclusive manner. Rather, this paper is intended as a summary and basis for further specific research in this area; for instance, how the rebound effect and econometrics can be used as a scientific framework for mathematical and quantitative analysis to predict and review operational business decisions. In line with (Kitchenham, 2004), a three-stage coherent review process was applied. Each phase has specific, cohesive, and clear objectives, which are visualized in Figure 8.

I. Planning: The first and overarching aim is to define a specific and clear review topic. This process is followed by developing the review protocol and generating research questions. The research protocol predefines all important components of the systematic review and must be adapted for each study. The research protocol will serve as a guide throughout the project and therefore already contains an estimated time frame. Furthermore, the predefined protocol is designed to avoid the possibilities of biased review based on the selection of individual studies or personal expectations. Due to the crucial importance of the review protocol, a review in medically relevant research topics and even peer-review is necessary.

II. Implementation: Once the planning process is successfully completed, the implementation phase can begin. The implementation of a systematic review is based on the research protocol and a research strategy, which are the guidelines throughout the process. However, the selection of inclusion and exclusion criteria must be provisional, based on the research question, and documented in the review protocol. Within the defined boundaries, as many subject-related primary studies as possible must be identified, reviewed, categorized, and subsequently reported.

III. Reporting: The composition of a systematic review report depends on the review topic and audience. An individual composition of contents is therefore necessary.

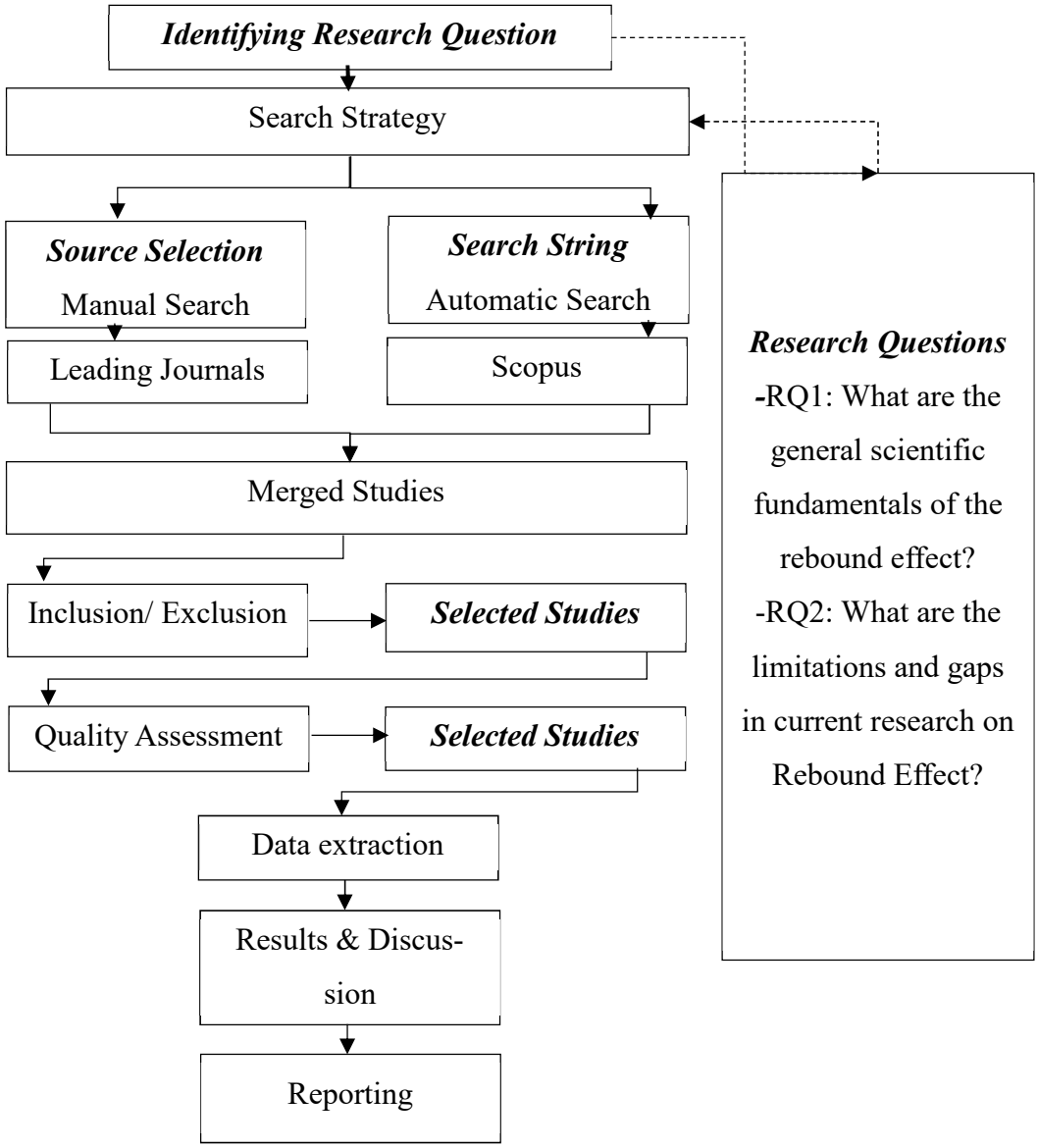


Figure 8: Systematic review – Structure and Concept Source: own figure

Two research questions have been identified for this paper, which are to be answered in a conclusive order.

-2.- Results of Research Question I

This chapter answers the question of how the rebound effect is defined, what the general principles of the rebound effect are, and to what extent the rebound effect can be subdivided, applied, and abstracted. In addition, a systematic overview of the framework, concepts, and current state of affairs relevant to the theory of rebound effect will be given. The chapter concludes with an overview of studies that show the intensity and extent of the rebound effect in different areas using various parameters.

Research Question 1: What are the general scientific principles of the rebound effect?

The rebound effect (R) is generally understood to be the interstice between potential energy savings from energy efficiency improvements (P) and actual energy savings (A).

The rebound effect is therefore mathematically represented by the formula:

$$R = [1 - \frac{A}{P}]$$

Furthermore, the authors Chitnis & Sorrell et al. have mathematically decomposed the rebound effect (Chitnis & Sorrell, 2015). The rebound effect is mathematically represented in a shortened form as follows:

$$R_T = n_{qs,qp} - \sum_{i(i \neq s)} Uin_{qi,ps}$$

$$R_D = -n_{\mathrm{qs,ps}}$$

$$R_1 = \sum_{i(i \neq s)} Uin_{qi,ps}$$

$$x = p_s q_s + \sum_{\mathrm{i=1,2...N}} pi\ qi$$

$x = Total\ household\ expenditure$

$R_T = Total\ Rebound\ Effect$

$R_D = Direct\ Rebound\ Effect$

$R_1 = Indirect\ Rebound\ Effect$

$p_i = Price\ per\ unit\ of\ good\ i$

$q_i = Quantity\ per\ unit\ of\ good\ i$

$p_s = Energy\ cost\ of\ energy\ service\ (i.e.\ \$\ lumen)$

$q_s = Energy\ efficiency\ of\ energy\ service\ (i.e.\ lumen\ kWh)$

According to Saunder's paper "Fuel conserving (and using) production functions", the rebound effect is divided into 5 gradations. These can be described as follows (H. D. Saunders, 2008):

1. Super conservation (RE < 0): Efficiency gains lead to resource savings that are higher than previously expected. This type of rebound effect is negative. This specification always occurs when the increase in efficiency sustainably reduces the overall resource consumption.
2. Zero rebound (RE = 0): If the resource savings correspond to the expected savings, the rebound effect is neutralized.
3. Partial rebound (0 < RE < 1): In case of a partial rebound, the resource savings are less than previously expected. The rebound effect in this classification is between 0 percent and 100 percent. This is sometimes referred to as "take-back" and is most common in the economy or in "real world" applications.
4. Full rebound (RE = 1): Classified if the actual measured resource savings correspond exactly to the increased resource consumption. The rebound effect is therefore exactly 100 percent.
5. Backfire (RE > 1): The actual resource savings are negative, or the resource savings are less than the increased consumption triggered by efficiency gains. To the extent that consumption increases beyond the initial savings potential generated by efficiency gains, the rebound effect is higher

than 100 percent. As already noted in the introduction, this state is also classified as Jevon's paradox.

According to papers of Andreas Goldthau, H. Herring, and S. Sorell, the classification of rebound effect can also be described as follows (Goldthau, 2017):

Economy-wide rebound effect: A fall in the real prices of energy services will reduce the prices of intermediate and final products throughout the economy and lead to a number of price and volume adjustments for energy-intensive goods. Improvements in energy efficiency can also increase economic growth, which in turn can lead to an improvement in energy consumption (A. Greening et al., 2000; Goldthau, 2017; Herring & Roy, 2007). The economy-wide rebound effect is represented by the following direct and indirect forms of the rebound effect (Sorrell et al., 2009).

Direct rebound effect: Improved energy efficiency for a given service will reduce the effective price of that service and lead to an increase in energy consumption. This will compensate for the expected reduction in energy consumption due to efficiency gains (A. Greening et al., 2000; Goldthau, 2017; Herring & Roy, 2007). The direct rebound effect itself is further divided into direct rebound effects for consumers and direct rebound effects for producers (Sorrell et al., 2009).

Direct Rebound Effects for Consumers:

- Substitution: A substitution effect where the use of the energy service replaces the use of other goods and services for the same benefit or consumer satisfaction.
- Income Effect: Increasing real income by improving energy efficiency will allow higher levels of utilization and consumption by increasing

the level of consumption of all goods and services, including energy services.

Direct Rebound Effects for Producers:

- Substitution effect: The more inexpensive energy service supersedes the use of capital, labour, and inputs to achieve a constant level of production.
- Output effect: The cost reductions achieved by improving energy efficiency make it feasible to deliver a higher level of performance – and thus increase the consumption of all inputs, including energy services.
- Indirect rebound effect: A lower effective price of energy services will lead to changes in demand for other improvements in goods and services (A. Greening et al., 2000; Goldthau, 2017; Herring & Roy, 2007). Furthermore, the indirect rebound effect can be split further into the embodied energy effect and the secondary effects in addition to the direct rebound effect (Sorrell et al., 2009).
- Embodied energy: Indirect energy consumption required to improve energy efficiency, such as the energy required to construct and install thermal insulation (Herring & Roy, 2007).
- Side effects: These result from the improvement of energy efficiency, including supply and demand mechanisms or the increase in demand in the event of a price reduction.

Table 5: Economic estimates of the direct rebound effect for consumer energy services in the OECD

End-use	Range of values in evidence base (%)	Best guess (%)	Number of studies	Degree of confidence
Personal automotive transport	3-87	10-30	17	high
Space heating	0.6 – 60	10 – 30	9	Medium
Space cooling	1 – 16	1 – 26	2	Low
Other consumer energy services	0 – 41	X < 20	3	Low

Source: own table, data derived and modified from (Sorrell et al., 2009)

Table 5, based on the book "Energy Efficiency and Sustainable Consumption: The Rebound Effect" (Sorrell et al., 2009), shows various gradations of the rebound effect in consumer energy services. It is based on various studies, a range of the rebound effect results, which contributes to a rough estimate or classification of the rebound effect. Due to its concept, the rebound effect is always closely interwoven with technology and technological developments. As a result, the total energy consumption of the world between 1980 and 2010 is shown in the following diagram. Efficiency gains and technological progress should, in principle, lead to a reduction in relative energy consumption since a larger output should be generated from a constant input.

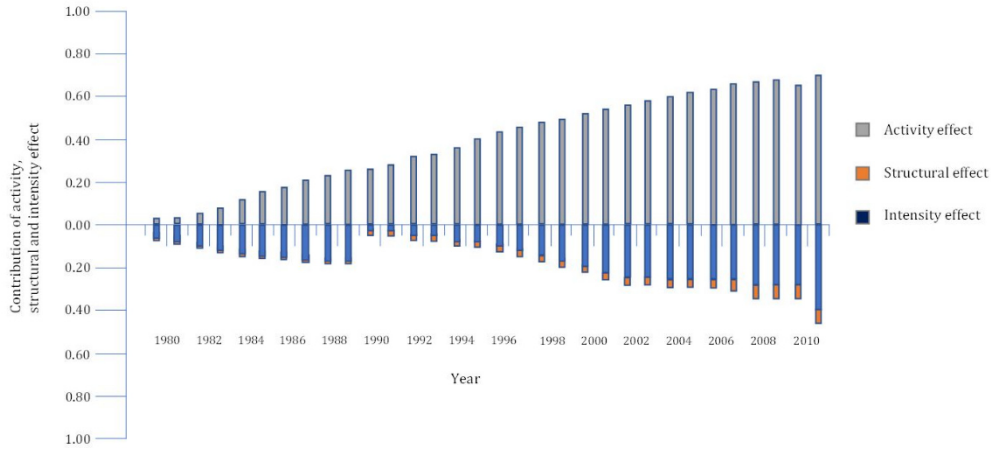


Figure 9: Decomposition of increase in total energy use in the world own figure, source: modified and derived from (Goldthau, 2017)

However, Figure 9 shows that energy consumption is constantly increasing, considering various factors such as technological development and behavioural aspects. According to the author Goldthau, activity growth increases energy consumption by 3.5 percent under exclusion of technology and behaviour. However, technological progress (energy intensity) reduces energy consumption by 2.4 percent, and structural changes reduce consumption by 0.13 percent (Goldthau, 2017). From this perspective, which does not initially consider the rebound effect, both technological progress and structural changes in society have a positive impact on energy consumption.Table 6 shows a composition of estimated rebound effects from several studies collected and analysed by the authors (Sorrell et al., 2018) for different areas and metrics. The studies use income and price elasticities to estimate how households allocate the cost savings from efficiency gains to different resources, and they use expenditure intensities to estimate the corresponding energy usage and related emissions.

Table 6: Studies to estimate combined direct and indirect rebound effects for households (income effects only)

Author	Region	No. expenditure categories	Measure	Area	Rebound measure	Estimated rebound effect (%)
Lenzen & Day	Australia	150	Effiency	Food & heating	Energy & GHGs	45 - 123
Alfredsson	Sweden	300	Suff-iciency	Transport, electricity, heating, food	CO_2	7 - 300
Thomas & Azevedo	US	428	Effiency	Transport, electricity, heating	Energy & GHGs	15 - 27
Murray	Australia	36	Effiency & Suff-iciency	Transport & lightning	GHGs	4 - 24
Chitnis et al	UK	17	Effiency	Electricity & heating	GHGs	5 - 15
Freire-Gonzalez	EU-27	163	Effiency	Transport, electricity, heating	Energy	30 -300
Bjelle et al.	Norway	12	Effiency	Transport, electricity, heating, food, waste, other	GHGs	40 - 58

Source: own table derived with data from (Sorrell et al., 2018)

Similar to Table 6, Table 7 shows a number of studies on the rebound effect. However, unlike Table 6, this table integrates both income and substitution effects of households.

Table 7: Studies estimating combined direct and indirect rebound effects for households (income and substitution effects)

Author	Region	No. of resources categories	Measure	Area	Rebound Metric	Estimated rebound effect (in %)
Brannlund et al	Sweden	13	Efficiency	Transport; utilities	CO_2	120
Mizobuchi	Japan	13	Efficiency	Transport; utilities	CO_2	12
Lin & Liu	China	10	Efficiency	Transport; utilities	CO_2	37
Kratena & Wuger	Austria	6	Efficiency	Transport; heating, electricity	Energy	37 - 86
Chitnis & Sorrell	UK	12	Efficiency	Transport; heating, electricity	GHGs	41 - 78

Source: own table derived with data from (Sorrell et al., 2018)

The authors of the study Sorell, Gatersleben and Druckman come to the following conclusion when evaluating the available studies in the tables shown:

It is difficult to draw concrete conclusions from the available data, as both the methodological limitations and unknown factors not considered may have an influence on the determined rebound effect.

If, however, the evaluation is limited to the available figures, the following summary and evaluation can be made: The Jevons paradox (rebound effects above 100 percent) is visible and obvious in the available data; furthermore, it is obvious that the indirect rebound effect is inversely proportional to the direct effect. Moreover, the direct and indirect effects appear to be greater for measures affecting road transport than for measures concerning electricity or heating oil. This could possibly be explained by the fact that road transport fuels tend to be taxed more heavily and thus have a greater impact

on the range and intensity of the rebound effect. Finally, the rebound effects within a country tend to be greater for low-income groups in that country.

-3.- Result of Research Question II

The multifaceted research question has determined the search strategy and leads to a separation into a manual and automated search. The manual search is limited to leading journals related to sustainability, while the automated search string is more widespread and is performed by Scopus (Scopus, 2019a). The aim is to identify limitations and gaps in the literature on the rebound effect. In addition, research papers, studies, and researchers dealing with the rebound effect are analysed and evaluated. Building on this, this should be possible to systematically integrate the theory of the rebound effect into current affairs.

Research Question 2: What are the limitations and gaps in current research on the rebound effect?

A selection of the journals chosen for manual research is shown in Table 8.

Table 8: Reporting overview

Author	Title	Citations	Year
Lorna Greening, David L. Greene & Carmen Difiglio (Greening, Greene & Difiglio, 2000)	Energy efficiency and consumption: The rebound effect – A survey	915	2000
Steve Sorrell, John Dimitropoulos & Matt Sommerville (Sorrell, Dimitropoulos & Sommerville, 2009)	Empirical estimates of the direct rebound effect: A review	421	2009
Peter H. G. Berkhout, Jos C. Muskens & Jan W. Velthuijsen (Berkhout, Muskens & Velthuijsen, 2000)	Defining the rebound effect	390	2000

Author	Title	Citations	Year
Kenneth Small, Kurt Van Dender (Small & Van Dender, 2007)	Fuel efficiency and motor vehicle travel: The declining rebound effect	386	2007
Steve Sorrell & John Dimitropoulos (Sorrell & Dimitropoulos, 636-649, 2008)	The rebound effect: Microeconomic definitions, limitations and extensions	367	2008
Mathias Binswanger (Binswanger, 2001)	Technological progress and sustainable development: What about the rebound effect?	354	2001
Edgar G. Hertwich (Hertwich, 2005)	Consumption and the rebound effect: An industrial ecology perspective	308	2005

Source: own table

The selected keywords for the automated Scopus search are listed in Table 9.

Table 9: Reporting overview for selected Keywords

Rebound effect	Energy efficiency
Sustainability	Energy
Economy-wide rebound effect	Efficiency side effects
Energy paradox	Energy consumption

Source: own table

The identified studies must then be combined and form the basis for more detailed analyses. By matching inclusion and exclusion factors with the combined studies, the relevant unity for the following quality assessment is defined.

Therefore, the factors defined in this study are listed in Table 10.

Table 10: Inclusion and exclusion criteria for defining relative unity

Inclusion criteria	Exclusion criteria
Publication date between 2000 and 2019	Publication earlier than 2000
Link to the research question	Irrelevant for the research question
Written in English	Written in a language other than English
Full text	Not peer-reviewed
Published in the selected database	Articles outside inclusion criteria

Source: own table

In addition to the general inclusion/exclusion criteria, a quality assessment is carried out:

- To have a secondary quality level according to inclusion/exclusion criteria,
- To reveal whether differences in quality lead to differences in study results,
- To weigh up the significance of individual studies in the synthesis of results,
- To guide recommendations for further research.

Once an article has passed the listed criteria and been identified as acceptable, it is included in the systematic review.

-3.1- Data extraction and synthesis

Based on Scopus (Scopus, 2019d), 686 papers are identified in the period from 1957 to 2019 that deal with the rebound effect and can be seen in Figure 10.

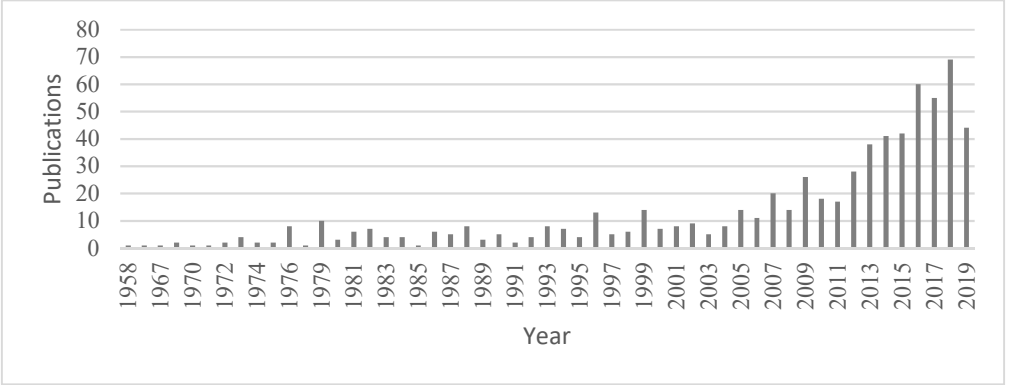


Figure 10: Total number of rebound effect papers from 1957 to 2019
Source: own figure, data source: (Scopus, 2019d)

3.2 Overview of publication sources

A total of 387 journals and 5 conference papers are selected for analysis. This literature review focuses on the database Scopus (Scopus, 2019a) and excludes a small number of publications before 2000 on the rebound effect. Using the Scopus database and omitting these papers does not mean that there is no multidisciplinary view of the rebound effect. The scientific work is given by a large number of papers to minimize distortion. The inclusion of a small number of related papers published before 2000 would not have changed the overview of the literature on the rebound effect.

Table 11: Dissemination of the rebound effect

Year	Number of Journal papers	Number of conference papers	Total
2000	6	-	6
2001	3	-	3
2002	2	-	2
2003	2	-	2
2004	5	-	5
2005	6	-	6
2006	7	-	7
2007	14	-	14

Year	Number of Journal papers	Number of conference papers	Total
2008	10	-	10
2009	13	-	14
2010	11	1	12
2011	14	-	14
2012	24	-	24
2013	26	1	27
2014	31	-	31
2015	29	-	29
2016	48	1	49
2017	42	1	43
2018	57	1	58
2019	37	-	37
Total	***387***	***5***	**392**

Source: own table; data source: (Scopus, 2019d)

-3.2.1- Temporal view of the publications

Table 11 shows that a total of 392 journal and conference papers were published in the last 19 years. In the years 2013 to 2018, the publication figures were highest. However, as only half of 2019 has passed, further publications may follow. It is therefore not entirely clear whether there will be a positive or negative trend in publication figures on the subject of the 'rebound effect' in the following years. However, it is clear that almost exclusively journal papers and hardly any conference papers were published. This has also been observed in many other areas in recent years. The reasons for this would have to be examined separately.

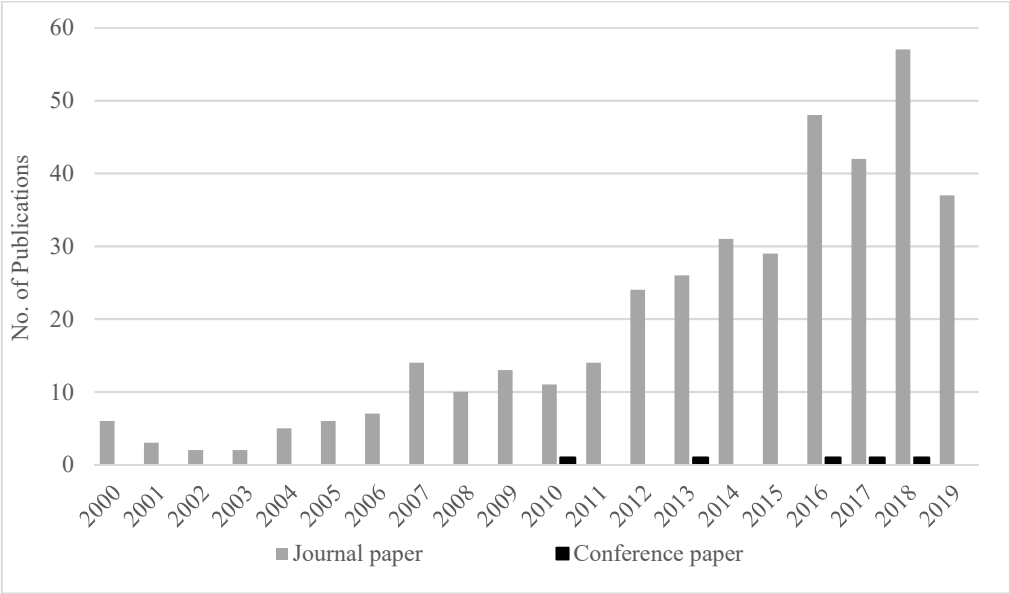
The first objective was to develop a system for accurate data processing. Second, a total of 392 publications were reviewed, and data were extracted using Microsoft Excel. The following lines have therefore been selected: Authors, Title, Year, cited by, Source title, DOI and Link. See Table 12.

Table 12: Selection of Journals by Inclusion Criteria

Extracted Data	Description
Authors	Names of all the authors
Title	The name of the paper which appeared in the searching stage
Year	Year of publishing the paper (2000–2019)
Cited by	The number of citations for that study obtained from Scopus
Source title	For instance: journal, conference proceedings
DOI	Digital object identifier
Link	The link to Scopus platform

Source: own table

Table 13: Number of published conference and journal papers of the Re-bound Effect from 2000 - 2019



Source: own table, data source: (Scopus, 2019d)

-3.3- Citation status

To assess quality and impact, a citation-statistical review was carried out, which was visualized in Figure 11. The corresponding statistics were compiled by Scopus and are intended to identify publications with high impact and reach.

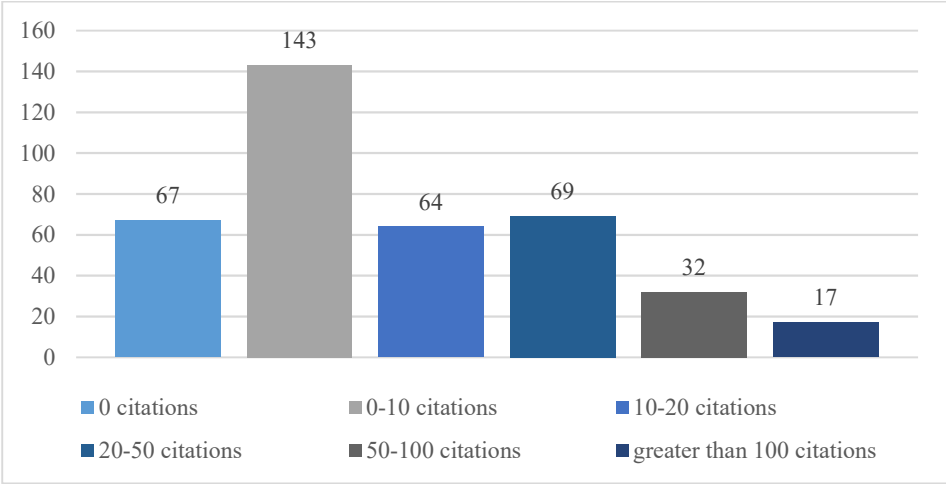


Figure 11: Number of citations from 2000 to 2019, own figure, data source: (Scopus, 2019d)

About 49 selected publications have more than 50 citations. 69 of the publications were cited between 20 and 50 times, while 64 were cited between 10 and 20 times. In addition, 210 publications were cited less than 10 times. However, as some publication have only recently been published, the citation rate cannot be used exclusively for quality assessments.

A central theme to be investigated in research papers is a research topic (Liang & Turban, 2011). In the following, the literature reviews are divided into three research topics: Definitions & benefits, Adoption, and Approaches & strategies for the rebound effect. Table 14 illustrates the research topics and the description of the papers on the rebound effect.

Table 14: Rebound effect research topics and descriptions

Research Themes	Description
Definitions & benefits	Papers focusing on the definition and benefits of applying the rebound effect, e.g. energy efficiency or cost savings
Adoption	Papers focusing on the processes for avoiding the rebound effect and on factors that motivate and influence individuals to avoid rebound effects, such as policies and taxes
Approaches & strategies	Papers that offer different approaches to avoid and manage rebound effects without government regulations

Source: own table

The following selection focuses on the second research question and examines the literature on possible research gaps. In a secondary systematic, abstract overview, the basis of 392 publications was analysed with regard to content aspects to avoid the rebound effect.

-3.4- Definitions & Benefits

The majority of the 275 (70 percent) publications in this paper focused on the definition and the potential benefits of the rebound effect. Nevertheless, the choice of definitions varies from author to author. Greening et al. provide "definitions and […] sources including direct, secondary, and economy-wide sources" (A. Greening et al., 2000). Sorrell et al. focus on the "overview of the theoretical and methodological issues relevant to estimating the direct rebound effect" (Sorrell et al., 2009), while Berkhout et al. describe "the state of the art of empirical estimation of the rebound effect" (Berkhout et al., 2000). The paper by Small & Van Dender develops a "model [that] accounts for endogenous changes in fuel efficiency" (Small & van Dender, 2007). Sorrell analyses the "theoretical work to provide a rigorous definition of the rebound effect" (Sorrell & Dimitropoulos, 2008).

Binswanger shows “the potential relevance of the rebound effect to ecological economics” (Binswanger, 2001). The paper by Hertwich points out “[…] that the current focus on the rebound effect is too narrow and needs to be extended to cover co-benefits, negative side effects, and spillover effects” (Hertwich, 2005).

-3.4.1- Adoption

The second category constitutes of 115 (29 percent) publications, focusing on the avoidance of the rebound effect through the implementation of restrictions and individual boundaries, consolidated as policies and taxes as a subsequent strategy to avoid the rebound effect. This approach is widespread among many authors and is based on the theory that individual or collective savings generated by technological progress are reinvested in increased usage (Birol & Keppler, 2000). Accordingly, some earlier savings are eaten up, and a rebound effect is created. Some authors such as Herring and Roy go even further by stating that energy reduction at the microeconomic level will ultimately lead to increased energy consumption at the macroeconomic level (Herring & Roy, 2007). Therefore, according to Santarius, a distinction must be made in policy-making between individual consumers, commercial consumers, and governmental agencies in order to reduce the rebound effect (Santarius, 2015).

Another area of research identified is the impact of policies on actual energy consumption and the rebound effect. Leading authors include Gillingham, Rapson, and Wagner, who have critically examined the effects on overall energy consumption (Gillingham et al., 2015). While different policy approaches are discussed by various authors, the main idea is to invent or extend a tax related to energy consumption (Herring & Roy, 2007).

-3.4.2- Approaches and Strategies

Only two studies (1 percent) provided a solution on how to avoid the rebound effect without governmental regulations. For example, Johannes Buhl speaks of shortening working hours in order to reduce the rebound effect. “The results show that time savings due to a reduction in working time trigger relevant rebound effects in terms of resource use” (Buhl & Acosta, 2016), while Jørgen S. Nørgård pointed out that the problem with the rebound effect is not the increase in energy efficiency that results from the reduced consumption of resources, but the economy that recoups the savings by consuming the saved resources. His proposal to avoid the consumption of resources savings is a steady-state economy (Nørgård, 2009), which means 3.5percent annual GDP growth and requires an improvement eco-efficiency by a factor of 80 in 2060 compared to 2000. At an annual GDP growth rate of 2 percent, the factor would be 35. In a steady-state economy, GDP is a constant 1 percent, and the factor is 10 (Schmidt-Bleek, 2014).

On the basis of the systematic literature research, the authors have concluded that the rebound effect and its impact on versatility have been clarified. Nevertheless, a significant gap was identified in terms of avoiding the rebound effect. The main research approach concentrates on the course and effects of the rebound effect, while avoidance is rarely targeted. It was found that only two studies (1 percent) had a relationship to avoidance. In-depth research has shown that the majority of authors have geared their avoidance theory towards the implementation of higher taxes and stricter policies. Although the fiscal and policy approach will avoid the repercussions of the rebound effect, it is not directly related to the elevated course indicated in RQ1. Therefore, further research has been conducted, focusing on the identification of alternative approaches to avoid rebound effects.

A limitation of these SLRs is that probably not all relevant assessments of the rebound effect that exist in literature are identified or have been biased by personal background and opinions when studies are manually included or excluded. These are limitations to which SLRs are generally subject. The risk of biased results was minimized by deriving only robust results. Like Mallet et al. defined, SLRs should be seen as "helping to get a robust and sensible answer to a focused research question" (Mallett et al., 2012).

-4.- Conclusion

In summary, a hybrid system of literature analysis and general description and derivation of the rebound effect was applied. This has the advantage that the procedures, methods, and findings elaborated in the reviewed literature can be placed directly in a scientific context and evaluated within the set limits and conditions.

In mathematical terms, the rebound effect can be simply understood as a gap between possible energy savings through increased energy efficiency through technological progress and the actual energy savings influenced by consumer behaviour. In the general analysis of the rebound effect, it was found that various gradations, derivations, and applications of the rebound effect have been used and developed in the literature. In addition to the mathematical subdivision, the comprehensibility of the rebound effect was clarified on the basis of the gradations made by Saunders and Sorell. Starting with a negative rebound effect ($X < 0$), the maximum expansion level culminates in the Jevons Paradox ($X > 1$).

Due to its conception and the close interdependence with technology and technological developments, the rebound effect is also dynamic in its field

of application and effect. From the diagrams and values shown, in particular from the Goldthau breakdown, it is clear that consumer behaviour leads to increased consumption as opposed to technological resource savings. Therefore, in the current economic system, a reduction in resource consumption is not reconcilable with economic growth.

Finally, RQ2 provided an overview of recent research on the rebound effect within the previously developed and defined scientific framework. A systematic review approach was chosen to answer RQ2 in order to investigate rebound effects.

The research questions place scientific papers published between 2000 and 2019 on the rebound effect in the context of a holistic view of the state of research. After carrying out various systematic processes, 392 papers were selected with a focus on the rebound effect. The remaining studies were not included in this review because they could not meet the eligibility criteria and were therefore considered irrelevant or scientifically value-bearing. After data analysis, the selected studies were clustered into three research topics: Definitions & benefits, Adoption, and Approaches & strategies. The results of this review showed that the 'Definitions & benefits' cluster was the most pronounced (70 percent), followed by 'Adoption' (29percent).

Finally, for the paper as a whole, it should be noted that research on the rebound effect is not yet comprehensive enough and focuses mainly on the effect itself rather than on solutions to avoid it. The main deviation, and thus the limitations, is that not much research has been published on the actual avoidance of the rebound effect. This is a significant limitation for practical application by decision-makers and policymakers.

Paper 3: An Evaluation of Corporate Sustainability in Context of the Jevons Paradox

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Keywords: corporate sustainability, jevons paradox, efficiency side-effects, grey energy, rebound-effect.

JEL Classification: O13

Abstract: The successful implementation and continuous development of sustainable corporate-level solutions is a challenge. These are endeavours in which social, environmental, and financial aspects must be weighed against each other. They can prove difficult to handle and, in some cases, almost unrealistic. Concepts such as green controlling, IT, and manufacturing look promising and are constantly evolving. This paper aims to achieve a better understanding of the field of corporate sustainability (CS). It will evaluate the hypothesis by which Corporate Sustainability thrives, via being efficient, increasing the performance, and raising the value of the input of the enterprises to the resources used. In fact, Corporate Sustainability on the surface could seem to contradict the idea, which supports the understanding that it encourages the reduction of the heavy reliance on the use of natural resources, the overall environmental impact, and above all, their protection. To

[6] Lead Author

understand how the contradictory notion of CS came about, in this part of the paper, the emphasis is placed on providing useful insight to this regard. The first part of this paper summarizes various definitions, organizational theories, and measures used for CS and its derivatives like green controlling, IT, and manufacturing. Second, a case study is given that combines the aforementioned sustainability models. In addition to evaluating the hypothesis, the overarching objective of this paper is to demonstrate the use of green controlling, IT, and manufacturing in the corporate sector. Furthermore, this paper outlines the current challenges and possible directions for CS in the future.

-1.- Introduction

The subsequent chapter should provide an overview of the relevant research topics that the authors are dealing with. The hypothesis is also duly discussed: Corporate Sustainability thrives on being efficient, increasing the output generated and raising the value of the input of the enterprises to the resources used (Jevons Paradox). The term sustainability refers to using a regenerative system in such a way that the essential properties of the system are maintained and its continued existence is ensured by natural means of regeneration (Herring & Sorrell, 2009). Due to the increased demand for sustainable solutions in almost all industries and economies, concepts such as sustainability management or green controlling, green IT and green production offer opportunities for operational optimization (Hahn & Scheermesser, 2006). In addition, new customers can be reached and old product portfolios can be updated through promotions and certifications in the required area (Schaltegger et al., 2012). Inherent benefits include increasing brand awareness, strengthening customer loyalty, improving image and increasing busi-

ness volume. Equally important is the finding that the application of sustainable industrial solutions does indeed lead to a stabilisation of development and social parameters. This should be considered independently of business objectives, as in the case of the economic and social development of a country or state. This is an important core aspect, especially when considering developing countries, which must be taken into account when planning and improving the quality of life (Baumgartner & Ebner, 2010).

Global impacts such as climate change tend to affect poor countries more, as they are unable to offset the negative effects of global warming or secondary effects of climate change as effectively as industrialised nations through countermeasures. This in turn affects social development and creates a tense political atmosphere. It can then be argued that social stability, including other forms of democratic perspectives, can be undermined by radical politicians or radical party politicians at the mercy of those who offer the so-called "simple" solution to quite complex problems, thereby hindering the improvement of human development. Seen in this light, this demand is primarily extrinsically triggered by legal requirements or an adaptation of one's own position to current social trends.

Therefore, no trend reversal or reduction in the demand for corporate and economic sustainability is to be expected in the foreseeable future. This is due to the nature of sustainability management. Problems such as environmental pollution, nature conservation and resource-efficient management will remain crucial in the long run to preserve a viable planet for future generations (Vlek & Steg, 2007).

-1.1- Material and Methods

A deductive approach by hypothesis has been used to realise this paper as it seems to fit best in this particular case. Qualitative analysis methods are intended to be used by collecting and analysing secondary data. Secondary data have been collected from relevant literature sources such as journals, reports, books, relevant, and credible newspapers. Furthermore, online research can be used as a data collection method. The data collected has been checked for consistency and reliability by applying a framework that continuously monitors possible biases and errors in the research and hypothesis (M. Saunders et al., 2009).

The information gathered should, therefore, allow further research to build on this work. This is supported by a clear, scientific definition of each source used. A qualitative analysis of relevant literature, indices, and theoretical concepts should support or neglect the hypothesis from a different point of view.

Investigating the impact of corporate sustainability has become an increasingly important topic amongst experts in the industry, researchers and some members of the general public. The first efforts to summarise the issues, challenges, and problems of sustainable global development were launched by the United Nations in 1987 with the publication of the so-called "Brundtland Report" under the official title of "Our Common Future" (United-Nations, 1987).

New technologies and a constant change in public awareness, especially with regard to environmental pollution and sustainable solutions have influenced

the industry, its processes, and product development (Montiel & Delgado-Ceballos, 2014). In addition, the global interest of academic researchers in issues of sustainable development and solutions, as well as corporate social responsibility, has increased significantly over the past decades (Salzmann et al., 2005). The aim and scope of this study is, therefore, to attempt to provide an overview of the subject matter and demonstrate the application of CS using examples. This will illustrate further the current state and implementation of CS in today's industry.

-1.2- Aim and Objectives

This working paper aims to review the relevant and thematic literature in the area of interest, to study the current state of affairs, knowledge of terminology, and conceptual frameworks for the development of green controlling, IT, and manufacturing with a view to possible integration into current industry applications. The focus should also, but not exclusively, be on the following objectives:

- to give examples of an industry standard for all three sub-areas in a case study,
- to present the Jevons Paradox in the context of corporate sustainability, and
- to offer a solution on how to diminish the Jevons paradox.

In order to step into the topic of corporate sustainability, including testing the relevance for potential users, the authors have developed a scientific survey, which has been digitally shared among business professionals using 28 personal interviews for verification of the questionnaire.

A total of 62 questionnaires were validated and analyzed to highlight the relevance of this topic (figure 10 and figure 11).

By reviewing the results, it can be stated that corporate sustainability is a very relevant topic for business professionals, which unfortunately has not yet been sufficiently considered by many companies.
Furthermore, stakeholders seem to have a growing interest in the concept of corporate sustainability, while practical applications are not widely known.

Figure 12 shows that 100 percent of the participants considered sustainability to be useful but are unfamiliar with specific terms of the research field as seen in Figure 13. Also, 67.74 percent of the participants already deal with sustainability in their day-to-day business.

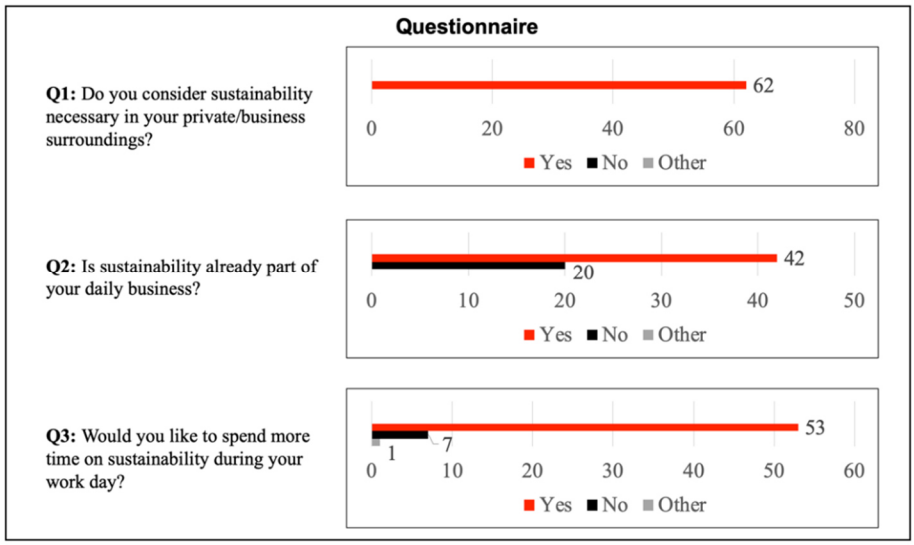


Figure 12: Survey Outcome 1; own figure, data source: (Staff of CGI Consulting & Hamburg Süd, 2019)

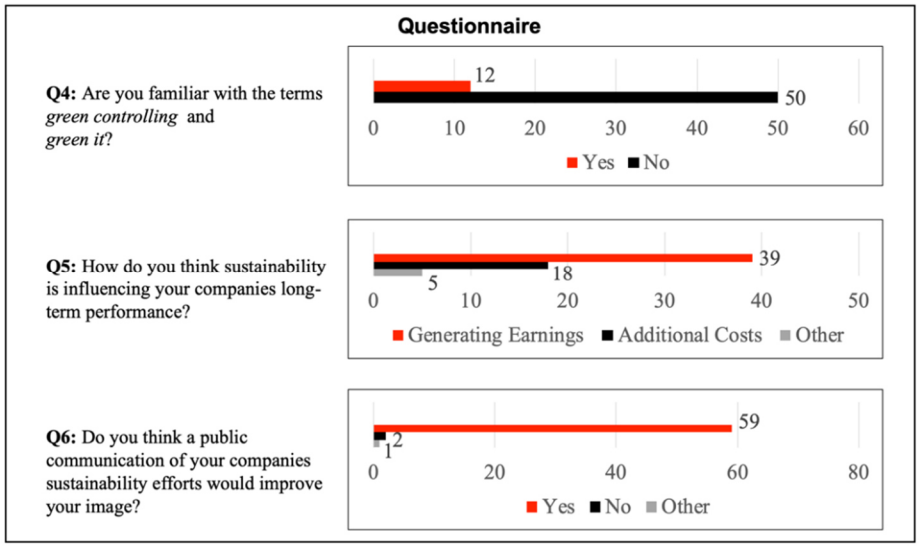


Figure 13: Survey Outcome 2; own figure, data source: (Staff of CGI Consulting & Hamburg Süd, 2019).

In line with these results, Question 3 (Figure 12) with a result of 53 to 7 shows that professionals would like to deal with the topic of sustainability much more frequently and intensively.

In contrast, most of the survey participants show a lack of specific knowledge in the field of corporate sustainability. Relatively new systems and models like green IT and controlling were unknown to 83.87 percent of the participants, which shows that much more information must be delivered and disseminated within the industry. Sustainability as a corporate system is seen first and foremost as an income-generating system (62.90 percent), even though 29 percent of the participants believe sustainability will cost money rather than generate income.

Finally, it should be noted that the term sustainability is readily well accepted. Companies like to present themselves with an expression such as "sustainable" (95.16 percent), as this affects the psyche of the general public.

The ambitious climate protection and emission reduction targets of most nations will in most cases have an increasing impact on private business sectors as well as governmental projects. This prospect once again underlines the importance of this topic (D. Dornfeld et al., 2013).

The chart in Figure 14 “Accumulated publications of Corporate Sustainability” is a representation of the ongoing scientific research in the field of CS by showing the accumulated publications from 2007 until 2019 to demonstrate the relevance of the research field.

Figure 14: Accumulated publications of Corporate Sustainability; own figure, data source: (Scopus, 2019a)

-2.- The Jevons Paradox in Context of Corporate Sustainability

The almost complete dependence on the use of natural resources in industrial production processes has increased remarkably since the Industrial Revolution (Statista, 2019). Despite the most efficient technological advances, the Jevons paradox has the ability to uncover substantial evidence for the argument that mankind must shape its industrial future to protect and preserve the environment in its present state (Buluş & Topalli, 2011). This correlation

between increased consumption of natural resources and increased efficiency is known as the Jevons Paradox (Alcott, 2005). The use or consumption of natural resources to provide energy and other consumer goods is often an irreversible process that both reduces the number of resources globally available and increases global environmental pollution (Polimeni & Polimeni, 2006).

The deterioration of habitats of various species, a direct consequence of environmental impacts, leads to the rapid extinction of unfortunate species by the use of natural resources (see coal deposits and air quality in Germany between 1950 and 1980) (German-Federal-Statistical-Office, 2019). The hypothesis that industrial progress will in principle lead to a generally better life for humanity must, therefore, be challenged. Due to global political developments in environmental education, sustainable development, and ecologically sustainable outlook, which are often a subject of conflicting interest, especially due to economic implications, it is strongly recommended to include the Jevons Paradox both socially and scientifically (Hahn & Scheermesser, 2006; Hopkins, 2004).

In order to develop environmentally sound strategies, it is necessary to understand the impacts of economic activities, resource use, and improved efficiency (Polimeni & Polimeni, 2006).
The 20th-century theory of "economic growth" sees technological change as the main cause of increased production and consumption (Lewis, 2006). In contrast, some ecologically oriented economists and virtually all governments, green political parties, and NGOs believe that efficiency leads to lower consumption and positive environmental impacts. Others doubt this

"efficiency strategy towards sustainability" because they assume that the efficiency gains in pursuing this goal will "decline" or even "backfire", leading to higher production and consumption (M. A. Camilleri, 2017; Dyllick & Hockerts, 2002). As several environmental problems require rapid and clear policy recommendations, this issue deserves high priority in the environmental economy and political decision-making process. If Jevons is right, efficiency policies are counterproductive.

Jevons recommended that efficiency gains must be offset by physical ceilings such as quotas or rationing, which would be in contrast to the liberal economic theories promoted over the last decades (Alcott, 2005). Figure 15 shows an example of the Jevons Paradox. It is assumed that the travel cost will fall due to efficiency gains in fuel consumption with elastic demand. This leads to the Jevons Paradox, which accounts for an increase in the number of kilometres travelled by car owners that exceeds the overall savings achieved through increased efficiency improvements.

Fuel consumption decreases by 20 percent, which corresponds to 20 percent lower travel costs.

Meanwhile, the number of kilometres travelled increases by 40 percent, so that in the end, the overall consumption of fuel will rise by 20 percent. William Stanley Jevons claimed that the technological efficiency gains – especially the "more economical" use of coal in engines which perform mechanical work – actually increased the overall consumption of coal, iron and other resources rather than "reducing" them (Jevons, 2016b).

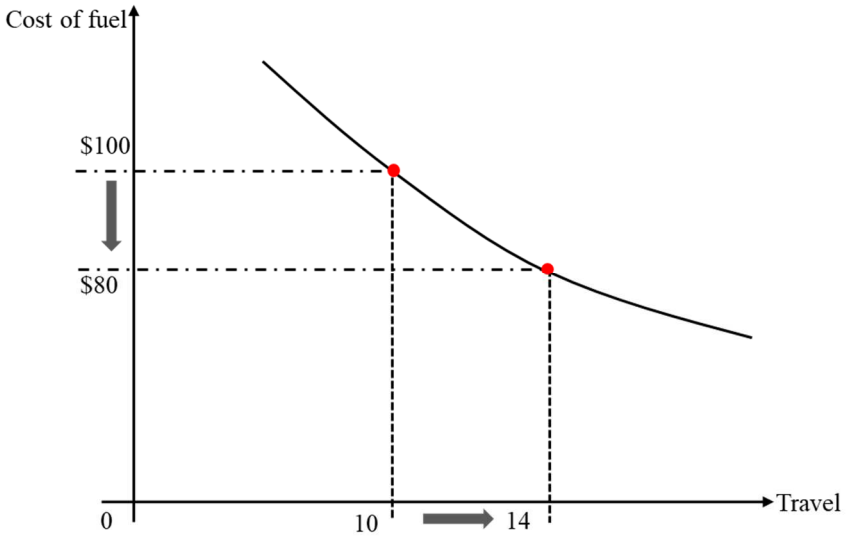


Figure 15: Example of the Jevons Paradox in case of price elasticity of demand; own figure, data source: (York & McGee, 2016)

-2.1- Corporate Sustainability

Corporate Sustainability is concerned with treating the stakeholders of the company ethically or in a responsible manner. "Ethically or responsible" means treating stakeholders in a way that is considered acceptable in civilized societies, including economic responsibility (M. A. Camilleri, 2017). Stakeholders exist both within and outside a company. The natural environment is a stakeholder. The wider aim of social responsibility is to create a high standard of living while maintaining the profitability of the company for people both within and outside the company (Hopkins, 2004). There are several ways to define sustainable development, but the most frequently quoted is the Brundtland Report 1987 known as "Our Common Future" (Kopfmüller et al., 2007). The central contribution of this report is to link human development and actions with environmental responsibility (M. Camilleri, 2014).

Businesses and governments are changing their position on sustainability and focusing on sustainable principles and regulatory guidelines (e.g., Global Reporting Initiative's Sustainability Reporting Guidelines, UN Global Compact and the Sustainable Development Goals, etc.) (United-Nations, 1987). Companies are therefore redesigning their standards, corporate programs, codes of conduct, and green policies (Kopfmüller et al., 2007). Corporate sustainability is also linked to economic, social, and ecological systems, which are all interrelated (M. A. Camilleri, 2017). Dyllick and Hockerts define eco-efficiency, socio-efficiency, eco-effectiveness, socio-effectiveness and sufficiency, and ecological equity as core criteria for corporate sustainability (Dyllick & Hockerts, 2002). Altogether, 144 journals and 11 conference papers have been selected for this analysis. This literature review focuses on the database Scopus (Scopus, 2019a) and excludes a small number of corporate sustainability publications before 2000. Using the database Scopus and omitting these papers does not mean that there is no multidisciplinary view of corporate sustainability. The scientific work is presented through a large number of papers to minimize distortion. The inclusion of a small number of related papers published before 2007 would not have changed the overview of corporate sustainability literature. Table 15 demonstrates the constant interest in corporate sustainability from 2007 to 2019.

The analysis of the 155 papers (Scopus, 2019a) has shown that corporate sustainability definitions differ across the same discipline. "The social responsibility of business is to increase its profit only to the extent that it contributes to the aim of business, which is the creation of long-term value for the owners of the business" (van Marrewijk, 2003b). Marrewijk and Were link "Corporate Sustainability, and also CSR, refers to a company's activities voluntary by definition – demonstrating the inclusion of social and environ-

mental concerns in business operations and in interactions with stakeholders." (van Marrewijk, 2003a). Schrave mentions that "there is no standard recipe: corporate sustainability is a custom-made process" (van Marrewijk, 2003b). Further definitions of corporate sustainability in literature can be found in articles by Dyllick & Hockerts and M. Camilleri. In summary, one could say that the majority generally agree that "Corporate sustainability creates higher and higher standards of living while preserving the profitability of the corporation, for peoples both within and outside the corporation" (Hopkins, 2004).

Table 15: Dissemination of Corporate Sustainability

Year	Number of journal-papers	Number of conference papers	Total
2007	10	1	11
2008	12	1	13
2009	11	1	12
2010	8	2	10
2011	15	1	16
2012	9	3	12
2013	5	2	7
2014	11	-	11
2015	13	-	13
2016	13	-	13
2017	12	-	12
2018	16	-	16
2019	9	-	9
Total	*144*	*11*	**155**

Source: (Scopus, 2019a)

-2.2- Review of Green IT

Murugesan mentioned that "Green IT includes the dimensions of environmental sustainability, the economics of energy efficiency, and the total cost of ownership, which includes the cost of disposal and recycling" (Murugesan, 2008). According to that, Green IT comprises a number of areas and activities.

1. Design for environmental sustainability,
2. Energy-efficient computing,
3. Responsible disposal and recycling,
4. Green metrics, assessment tools and methodology,
5. Environment-related risk mitigation, and
6. Use of renewable energy sources.

Green IT uses IT equipment that is energy-efficient and reduces energy consumption for the operation of information technologies (Schmermbeck, 2019). Brooks et al. found that the term Green IT appeared in CIO magazine in 2007 (Brooks et al., 2010). Starting from 2007, Elliot, Etzion, Feng and Cameron and Vlek and Steg mentioned Green IT (Etzion, 2007; Feng & Cameron, 2007; Vlek & Steg, 2007). For this reason, the analysis of this paper begins from January 2007 and finishes in April 2019. Altogether, 181 journals and 121 conference papers have been selected for the analysis. This literature review focuses on the database Scopus (Scopus, 2019b) and excludes a small number of Green IT publications prior to 2000. Using the database Scopus and omitting these papers does not mean that there is no multidisciplinary view of Green IT. Therefore, the leading IT and management journals and conference papers were selected by searching for papers containing the term 'Green IT'. The scientific work is giving a large number of papers to minimize distortion. Furthermore, most of the literature was written after the coining of the term Green IT in 2007. The inclusion of a small number of related papers published before 2007 would not have changed the overview of Green IT literature. The analysis of the 302 papers (Scopus, 2019b) in Table 16 has shown that the definitions of Green IT differ across the same discipline.

Table 16: Dissemination of Green IT Publications

Year	Number of journal-papers	Number of conference papers	Total
2007	3	1	4
2008	7	2	9
2009	9	16	27
2010	12	20	32
2011	21	16	37
2012	19	18	37
2013	14	16	30
2014	15	15	30
2015	22	8	30
2016	8	2	10
2017	23	4	27
2018	18	3	21
2019	10	0	10
Total	*181*	*121*	***302***

Source: (Scopus, 2019b)

Erek et al. defined "Green IT [as] the systematic application of practices that enable the minimization of the environmental impact of IT, maximize efficiency and allow for company-wide emission reductions based on technology innovations" (Erek et al., 2011). There are a number of definitions of Green IT in the literature (Elliot, 2007; Molla et al., 2009). In this paper, Green IT refers to the use of IT equipment that is energy-efficient in order to reduce the energy consumption for IT operations (Schmermbeck, 2019).

Further, Sayeed and Gill identified that "Green IT initiatives are organizational activities that aim to engender environmentally sustainable consequences in the conduct of information processing tasks of an enterprise" (Sayeed & Gill, 2009). Molla et al. describe "Green IT [as] an organization's ability to systematically apply environmental sustainability criteria (such as pollution prevention, […] use of clean technologies) to the design, production, sourcing, use and disposal of the IT technical […]" (Molla et al., 2009).

-2.3- Review of Green Controlling

Green controlling is a form of controlling that supports sustainable corporate development. Green controlling extends the economic part of the pilot function in controlling beyond the ecological aspect. In addition to classic controlling, green controlling should refer to the following aspects (Horváth et al., 2011):

Economic: Provide a sustainable basis for acquisition and prosperity in the long term
Ecological: Nature and environment should be preserved for future generations
Social: A society that is worth living in the long run must be achieved
Cultural: The culture in which people live in their everyday lives must be aligned with the guiding principle of sustainability

Table 3 focuses on the Scopus database and excludes a small number of Green Controlling publications prior to 2000 (Scopus, 2019e). The concept and terminology "Green Controlling" (GC) started to appear in Germany in the early 2000s, and the definitions and implementations have continued to develop ever since. As seen in Table 17, there are only very few publications in journals on the subject of Green Controlling. This shows that Green Controlling has not yet obtained the necessary awareness and interest in the field of academic research. So far, most of the authors who have been writing about Green Controlling refer to (Kramer, 2010).

Table 17: Dissemination of Green Controlling publications

Year	Number of journal-papers	Number of conference papers	Total
2007	-	-	-
2008	-	-	-
2009	-	-	-
2010	-	-	-
2011	-	-	-
2012	-	-	-
2013	-	-	-
2014	-	-	-
2015	1	-	-
2016	-	-	-
2017	1	-	-
2018	1	-	-
2019	3	-	-
Total	***6***	**-**	***6***

Source: (Scopus, 2019e)

Controllers play an active role in supporting the green transformation of their company, which is not only limited to the proof of economic efficiency or the collection of key figures but also includes the sensitization, consulting, and motivation of management and other actors by constantly questioning ecological and economic interrelationships (Romeo, 2011).

With regard to the perception of the tasks of Green Controlling, the majority of those surveyed in the study published in 2011 by the "International Controller Association e.V.", assume that green aspects will be integrated into corporate controlling. A separate and isolated Green Controlling by the actors of environmental management is thereby to be avoided. If the strategic importance of greening is low, this position is less clear. The controlling tasks resulting from the increasing strategic importance of greening are not fundamentally new controlling tasks, but rather an extension of the core tasks of controlling to new green goals and information (Horváth et al., 2011).

For companies, this results in the task of adapting their existing controlling instruments accordingly and setting up a so-called "Green Controlling Toolbox". Within the framework of strategic planning, instruments such as stakeholder analyses, portfolio techniques for market potential analysis, scenario techniques, or a Sustainability Balanced Scorecard (SBSC) are conceivable. In cost, performance, profit and loss accounting, for example, the task is to map environmental costs in the context of environmental cost accounting. In project and investment controlling, for example, ecological considerations can increasingly be integrated into lifecycle assessments or green target costing (Romeo, 2011).

-2.4- Review of Green Manufacturing

This review focuses on the Scopus database (Scopus, 2019e) and excludes a small number of Green Manufacturing publications prior to 2000 (Table 18).

Table 18: Dissemination of Green Manufacturing Publications

Year	Number of journal-papers	Number of conference papers	Total
2007	10	4	14
2008	9	2	11
2009	7	8	15
2010	14	14	28
2011	17	9	26
2012	25	5	30
2013	39	7	46
2014	31	1	32
2015	25	3	28
2016	25	4	29
2017	20	5	25
2018	31	5	36
2019	4	1	5
Total	*257*	*68*	***325***

Source: (Scopus, 2019c)

The presented Table 18 shows an increasing interest in the field of green manufacturing from 2010, which has existed ever since. The concept and terminology "Green Manufacturing" first appeared in Germany in the late 1980s and since then has evolved technology-wise as well as in meaning and understanding. Until now, no mutually exclusive definition has been adopted in the literature (Rehman & Shrivastava, 2013). Therefore, it is necessary to look at the topic from different perspectives and sort out a common understanding for this paper. Our review of GM is part of the wider field of corporate social responsibility.

From a linguistic point of view, "green" and "manufacturing" can be separated. In the context of corporate social responsibility, "green" stands for ecological sustainability and encompasses several different concerns including, but not limited to, water, air and soil pollution, energy consumption, and waste generation and recycling. For the context of this work, "green" may be summarised as follows: "Concerned with or supporting environmentalism and tending to preserve environmental quality" (D. A. Dornfeld, 2013; D. Dornfeld et al., 2013).

Manufacturing is a series of processes that include: the selection of raw materials, production or manufacture of an object or objects, building or constructing, assembling the parts, inspection or examination, and finally dispatching. The overarching goal of Green Manufacturing (GM) is the reduction and conservation of resources by designing the manufacturing process for minimal or non-existent negative impact on the environment (D. Dornfeld et al., 2013; Swathi & Srikanth, 2014). Another key element is the product design itself, which should focus on recyclable and reusable materials (Mathu, 2019, 2019). Furthermore, GM also includes socially responsible manufacturing that focuses on employee safety precautions and risk protection for humans and nature (Niehoff et al., 2011). If the greening ambition

is including the multidimensional procedure of supply and distribution, the literature refers to Green Supply Chain Management (GSCM) (Mathu, 2019).

Two key figures to measure the environmental impact of a factory are the virtual water and grey energy consumption. Virtual water was introduced by Allan in 1993 and calculates the amount of water required for the entire production process of one product (Lillywhite, 2010). This calculation includes neglected and hidden components of water consumption from start to finish (Boland, 2014). Similar to virtual water, grey energy combines the entire energy consumption necessary to manufacture a product throughout its whole production process. The term grey indicates that not all the energy-consuming parts are known (Pao et al., 2012). In both cases, it is nearly impossible to derive an exhaustive precise number because of the complexity of manufacturing and the supply chains involved. Nonetheless, both figures are of great importance to review the ecological impact of a product and its predicted resource consumption (Pao et al., 2012).

-3.- Case Study – Corporate Sustainability in an Industrial Context

Environmental sustainability measures such as the reduction of Carbon Dioxide (CO2), grey energy, and virtual water conservation in the automotive industry create unfavourable conditions for production costs, and inventories are essential to reduce the ecological footprint (Abduaziz et al., 2015).

This transformation can only be achieved by rapidly reducing the resource- and energy intensity in the manufacturing of existing goods by investigating the options for a thorough redesign of the industrial system and by radically rethinking business models (Tonelli et al., 2013). The following case study

is based on three real-world examples that have been anonymised, summarised into one use case, and placed in the context of the Jevons Paradox. The authors decided to process the following three sub-genres of Corporate Sustainability (Schrader & Vollmar, 2013):

- Green Controlling
- Green IT
- Green Manufacturing

The case study aims to demonstrate both the current possibilities for applied corporate sustainability and its side effects regarding the Jevons Paradox. Particularly hard-hit countries are high-tech ones, such as Japan, the USA, or Germany, which tend to replace workers with machines, as productivity gains are often achieved by efficiency gains through automation and digitization (Abolhassan & Kellermann, 2016). It is therefore intended to combine scientific research with today's industrial reality to visualize how e.g., economies need to adjust and politicians need to take previously unrecognized side effects into account when planning efficiency strategies.

-3.1- B³ Engineering Systems – Applied Science

B³ Engineering Systems is a fictional medium-sized company based in Southern Germany. The company is a manufacturer of innovative electric buses and currently employs around 2,000 people. B³ Engineering Systems operates mainly in the national markets of DACH (Germany, Austria and Switzerland). In its strategic plan S2020, the company management aims to increase productivity through gains in efficiency. Since classical measures have not had the desired effect yet, the new Corporate Sustainability department is being set up on behalf of the company management. B³ Engineering Systems will introduce CS at the beginning of the fiscal year and would like

to have a company analysis carried out in advance by the newly established department in order to uncover optimization potential with regard to productivity and efficiency increases. It is important for the management that this increase in productivity is not at the expense of the environment. The aim is, therefore, to make existing processes more sustainable or, if applicable, to create new processes that are profitable from both an entrepreneurial and an ecological point of view.

The Corporate Sustainability department consists of the subdivisions of Green Controlling, Green IT, and Green Manufacturing. The sub-divisions work together to develop a company-wide concept (Figure 16).

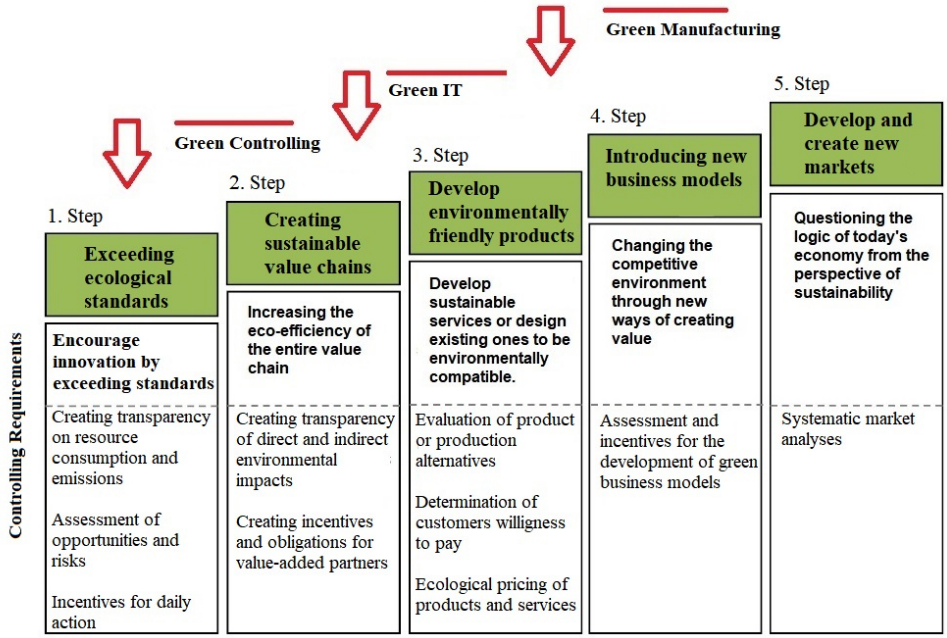


Figure 16: Strategy Plan of the Department of Corporate Sustainability; source: graphic was derived and modified from (Schrader & Vollmar, 2013).

-3.1.1- Green Controlling

The aim of the GC subdivision is to set goals, plan, and manage ecological sustainability, which can be implemented downstream by the Green IT and Green Manufacturing subdivisions.

From the point of view of Green Controlling, a key figure analysis must first be carried out, followed by the creation of an action plan, which will be executed by the Green IT and Green Manufacturing subdivisions. The GC department, therefore, creates Sustainability Balanced Scorecards as seen in Table 19 & Table 20.

Table 19: B³ Engineering Systems – Sustainability Balanced Scorecard – Financial Perspective

Strategic Goal	Measured Values	Target Values
Increase Profitability	6%	7%
Increase Liquidity	118%	120%
Decrease Environmental-Costs[7]	0.05€/ working hour	0.03€/ working hour

Own table, data source: modified and derived from (Schrader & Vollmar, 2013).

[7] Environmental-Costs include environmental relevant costs like waste, energy consumption, freshwater usage and Co2 emissions

Table 20: B³ Engineering Systems – Sustainability Balanced Scorecard- Environmental Perspective

Strategic Goal	Measured Values	Target Values
Decrease Grey Energy[8] Usage	50,000 kWh	40,000 kWh
Decrease Co2 Emissions	15 tons	12 tons
Decrease Virtual Water[9]	300,000 litres	240,000 litres

Own table, data source: modified and derived from (Schrader & Vollmar, 2013).

-3.1.2- Green IT

B³ Engineering Systems uses Green IT technologies for processing simulation, validation, and verification techniques based on digital models. The following example from the B³ Engineering System shows the quantitative effects of Green IT in the product development process. Figure 17 shows much higher resource consumption for Green IT (Y1 Peak usage GI & X1 peak GI) compared to conventional development (Y0 Peak usage CD & X0 peak CD). However, if you compare CD (Y2 usage CD & X2 cost) and GI (Y3 usage GI & X3 cost), the cost over the entire product development process for the CD is higher because late changes are costlier than at an earlier point in time. Therefore, higher resource consumption is compensated by the lower cost of GI throughout the entire product development process. The biggest advantage of using GI technologies is the former final maturity of the series (X5 final series maturity GI vs. X4 final series maturity CD).

[8] Grey Energy: the amount of energy required to manufacture, transport, store, sell and dispose a product.
[9] Virtual Water: refers to the quantity of water actually used for the manufacture of a product

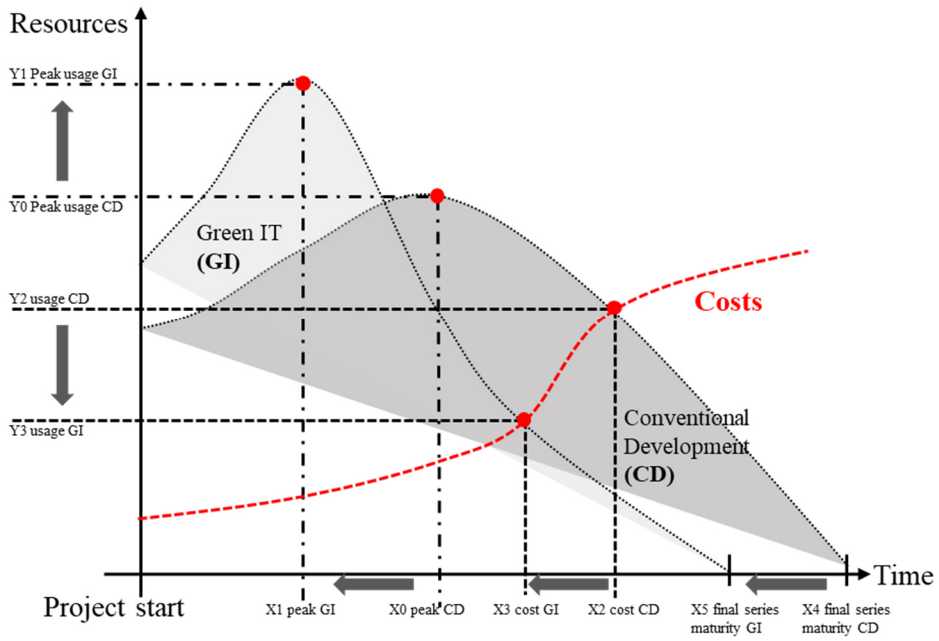


Figure 17: Added value of virtual engineering; own figure, data source: modified and derived from (Eigner & Stelzer, 2013)

The controlling department of B³ Engineering Systems therefore listed a number of more or less concrete or quantifiable data. The data collected from the controlling department allowed B³ Engineering Systems to identify the benefits by applying a virtual simulation. The controlling numbers are based on simulation test reports, physical test reports, and simulation methodologies. To simplify the model, all data values from Figure 17 are normally distributed and differently proportioned. For the calculation in Table 21, test procedures were applied, in which one bus is used. The basis for calculation is the numbers of the controlling department: 10,000 kilowatt hours of grey energy, 3,000 kilograms of carbon dioxide, and 60,000 litres.

Table 21: Physical prototype and simulation comparison

Test	Physical prototype %	Grey energy	Carbon dioxide (CO_2)	Virtual water	Virtual simulation %	Grey energy	Carbon dioxide (CO_2)	Virtual water
Body temperature	40%	4,000 kWh	1,200 kg	24,000 l	20%	2,000 kWh	600 kg	12,000 l
Roof crush	90%	9,000 kWh	2,700 kg	54,000 l	50%	5,000 kWh	1,500 kg	30,000 l
Side crash	100%	10,000 kWh	3,000 kg	60,000 l	60%	6,000 kWh	1,800 kg	36,000 l
Total		23,000 kWh	6,900 kg	138,000 l		13,000 kWh	3,900 kg	78,000 l
Resource Savings		**-**	**-**	**-**		**10,000 kWh**	**3,000 kg**	**60,000 l**

Own table, data source: modified and derived from (Chan, 2003)

As a result, all four tests have the potential to reduce one physical prototype, with 10,000 kWh grey energy, 3,000 kg carbon dioxide (CO2) and 60,000 litres virtual water using virtual engineering. Consequently, the virtual simulation test does not eliminate the physical prototype due to legal requirements, limitations of simulation methods, or correlations with physical prototypes. Using figure 19 for the interpretation of the calculated values in Table 16, it can be seen that the resource consumption initially increases through the use of virtual engineering technologies. Nevertheless, virtual engineering technologies save 35 percent (Figure 18) of the whole product development time but provide a higher level of maturity of competence at an earlier stage of the product development process. This is because virtual engineering technologies can be redone as often as needed with stable costs, whereas physical prototypes are very much time and resource consuming as well as very costly in later stages of their product development.

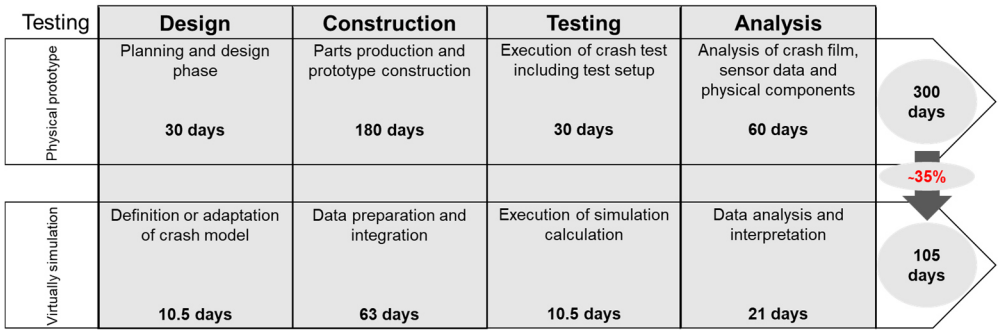
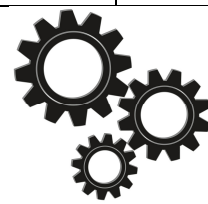


Figure 18: Product development testing time; own figure, data source: modified and derived from (Westkämper et al., 2013)

-3.1.3- Green Manufacturing

As new resources have been released through the implementation of Green IT systems, the Green Manufacturing subdivision can leverage these resources to work towards implementing a sustainable manufacturing program based on strategic corporate sustainability goals: to gradually develop and construct a minibus that uses recycled plastic parts and which is therefore believed to have a better ecological footprint. Research needs to be carried out, and the interior components manufacturing facility needs to be updated. The interior of the minibus is currently manufactured of one-way, disposable plastic. By using the new digital Green IT-based design and test facilities, it is possible to develop and simultaneously test new recyclable materials without wasting capital goods. Due to the 35 percent more effective testing department, it is possible to reallocate research resources. Testing shows that 80 percent of the interior can be manufactured using recycled materials. In order to integrate new materials, it is necessary to reconstruct the interior manufacturing process. The combined repercussions on the environmental footprint can be seen in Table 22.

Table 22: Environmental impact of Green IT & Green Manufacturing

Virtual Water			CO2 Emissions		Grey Energy		
GI Savings		3.000.000 l	GI Savings	100 t/CO2	GI Savings		500.000 kWh
GM Investment	R & D	- 200.000 l	GM Investment	- 85 t/CO2	GM Investment	R & D	- 110.000 kWh
	Manufacturing	- 1.400.000 l	After Investing =	15 t/CO2		Manufacturing	- 175.000 kWh
	Transportation	- 750.000 l	GM Savings	+ 75 t/CO2		Transportation	- 65.000 kWh
	Setup	- 250.000 l	Total =	90 t/CO2		Setup	- 50.000 kWh
After Investing =		400.000 l			After Investing =		100.000 kWh
GM Savings		+ 1.050.000 l			GM Savings		190.000 kWh
Total =		1.450.000 l			Total =		290.000 kWh

Green Manufacturing savings per Minibus					Total (50)
One-Way Plastic	1400 kg	Recycled Plastic	1400 kg	Savings	Total Savings
Grey Energy 17 kWh/kg	23.800 kWh	Grey Energy 10 kWh/kg	20.000 kWh	3.800 kWh	190.000 kWh
Carbon Dioxide 10,71 CO2/kg	15 t	Carbon Dioxide (CO2) 9,64 CO2/kg	13,5 t	0,3 t	15 t
Virtual Water 215 l pro kg	301.000 l	Virtual Water 205 Liter pro kg	287.000 Liter	14.000 l	700.000 l

Own table, data source: modified and derived from (Chan, 2003)

The implementation of GI has saved resources that have now been partially consumed again by investing in GM. In particular, 87 percent of the virtual water saved was reinvested, but the new technology used from now on saves an additional 23,800 litres per bus, which is a total savings of 1,050,000 litres for 50 buses. In addition, 85 percent of CO_2 emissions saved by GI have been reinvested, leading to a decrease of 1.5 tonnes of CO_2 per bus and overall GM savings of 75 tonnes of CO_2 saved on the whole production. Grey energy has been reduced by 500,000 kWh, of which 84 percent was reinvested in GM. This led to a reduction in the manufacturing-based grey energy consumption of 3,800 kWh per bus and 190,000 kWh for 50 buses. Both measures combined result in a positive environmental saving of 1,450,000 litres of virtual water, 90 tonnes/ CO_2 and 290,000 kWh if 50 buses are produced. To measure the monetary impact of using recycled plastic parts, a cost analysis is needed, as shown in Table 23.

Table 23: Cost Structure Minibus

Old Cost Structure		**Cost**		**New Cost Structure**	
List Price incl. VAT	150.000,00 €	Engine -30%		List Price incl. VAT	140.000,00 €
VAT (19%)	23.949,58 €			VAT (19%)	22.352,94 €
List Price Net	126.050,42 €	Exterior -20%		List Price Net	117.647,06 €
Distribution (14,7%)	18.534,08 €			Distribution (15,75%)	18.534,08 €
Labour (10,37%)	13.071,90 €	Interior = -40%	Non-Recyclable -40%	Labour (11,11%)	13.071,90 €
Material (32,70%)	41.223,15 €			Material (24,33%)	28.618,11 €
Depreciation (6,7%)	8.450,05 €		Recyclable -60%	Depreciation (7,18%)	8.450,05 €
R & D (7,70%)	9.710,55 €			R & D (8,25%)	9.710,55 €
Advertising (5,37%)	6.769,37 €	Recycled plastic can be purchased 51% cheaper than one-way plastic leading to 12.605,04 € (31%) lower material cost which now account for 24,33% of the total cost.		Advertising (5,75%)	6.769,37 €
Warranties (5,04%)	6.349,21 €			Warranties (5,4%)	6.349,21 €
Admin (10,04%)	12.651,73 €			Admin (10,75%)	12.651,73 €
Profit (7,37 %)	9.290,38 €	**+ 4.201,68 € more Profit**		Profit (11,47 %)	13.492,06 €

Own table, data source: own calculation based on model

The cost of materials is the largest component at 32.7 percent, which can be further divided into exterior and interior ones. 40 percent of the material costs are attributable to the interior, of which 60 percent can be replaced by recycled plastics. Further research shows that recycled plastic can be purchased 51 percent cheaper than one-way disposable materials. This means that due to green manufacturing, research, and change of materials, the cost of production per minibus can be reduced by € 12,605.04. Following the change in cost, a new calculation has been made, aiming to lower the gross price per minibus to € 140,000 (6.67 percent) in order to increase the overall sales. Given the new net price target of € 117,647.06 instead of € 126,050.26 and

material cost savings of € 12,605.04, the margin has been increased from € 9,290.38 (7.37 percent) to € 13,492.06 to 11.47 percent per bus.

-3.1.4- The Jevons Paradox at B³ Engineering Systems

The greening process at B³ Engineering Systems has impacted the environmental factors as well as the production cost and pricing strategy. Part of the saved cost will be used to push sales and demand by reducing the list price. Meanwhile, the overall ecological impact will not exceed the initial figures. Therefore, it is necessary to research the new maximum output and the price elasticity to predict the demand. Table 24 shows how resource consumption is affected by the greening program.

The innovations have individually lowered the level of grey energy, CO_2 emission, and virtual water consumption. Therefore, each figure must be individually reviewed to describe the maximum number of buses which can be produced without exceeding the initial level of resource consumption.

Table 24: Resource consumption and savings

Initial Total Consumption (50 Buses)		
Grey Energy (50.000 kWh per Bus)	CO2 Emission (50t per Bus)	Virtual Water (300.000 l per Bus)
2.500.000 kWh	750t CO2	15.000.000 l
New Total Consumption (50 Buses)		
Grey Energy (44.200 kWh per Bus)	CO2 Emission (13,2t per Bus)	Virtual Water (271.000 l per Bus)
2.210.000 kWh	670t CO2	13.550.000 l
Savings		
Grey Energy	CO2 Emission	Virtual Water
290.000 kWh	90t CO2	1.450.000 l
Possible Production without more Emissions		
2.500.000 kWh / 46.200 kWh	750t CO2 / 13,5t CO2	15.000.000 l / 277.200 l
= 54,11 Buses	= 55,55 Buses	= 54,11 Buses

Own table, data source: own calculation based on model

After implementing the greening process, 54 minibuses can be produced without exceeding the resource consumption of the initial production of 50, which equates to 8 percent more output. Second, price elasticity is examined to determine how changes in the asking price will affect the demand. The elasticity equation is shown in Equation 1.

$$E = \frac{(\frac{(50-67)}{67} * 100)}{(\frac{150.000-140.000}{140.000} * 100)} = \frac{-25.37\%}{7.14\%} = (-3.5532\%) = 3.5532\% \quad \textbf{(1)}$$

Equation 1: Applied formula of demand elasticity

The elasticity and the potential to lower the price by 6.67 percent would lead to a demand of 67 minibuses. Table 25 shows the theoretical environmental impact.

Table 25: Environmental impact calculation

Initial Total Consumption: Output 50 Buses		
Grey Energy (50.000 kWh per Bus)	CO2 Emission (15t per Bus)	Virtual Water (300.000 l per Bus)
2.500.000 kWh	750t CO2	15.000.000 l
Theoretical Total Consumption: Output 67 Buses		
Grey Energy (46.200 kWh per Bus)	CO2 Emission (13,5t per Bus)	Virtual Water (277.200 l per Bus)
3.095.400 kWh	904,5t CO2	18.572.400 l
Theoretical Additional Resource Consumption		
595.400 kWh	154,5t CO2	3.572.400
New Manufacturing Plan: Output 54 Buses		
Grey Energy (46.200 kWh per Bus)	CO2 Emission (13,5t per Bus)	Virtual Water (277.200 l per Bus)
= 2.494.800 kWh	= 729t CO2	= 14.968.800 l
Saved Resources		
5.200 kWh	21t CO2	31.200l

Own table, data source: own calculation based on model

This new output calculation would lead to the Jevons Paradox. Greener production is implemented, and the environmental impact per bus has decreased, but the savings in manufacturing cost allow for a lower asking price, which

would increase the overall demand. This would ultimately lead to the increased overall consumption of resources. At B³ Engineering Systems, the Green Controlling department has decided that the overall resource consumption will not be exceeded. The management agrees, under the condition that revenue must be increased as much as possible. Therefore, the optimal price per bus is calculated, which allows selling 54 buses at the maximum price. By doing so, the maximum revenue is achieved while the Jevons Paradox does not apply. Figure 19 shows the optimal price.

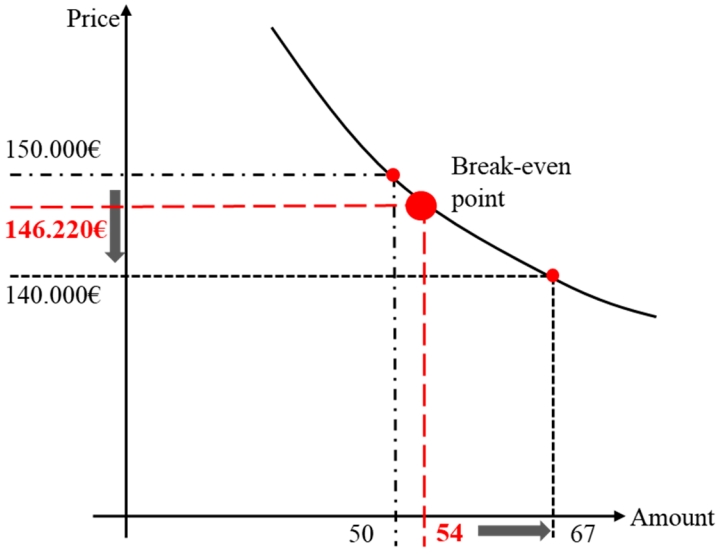


Figure 19: Neutralization of the Jevons Paradox by price adjustment under consideration of the raw resource usage; own figure, data source: usage of (York & McGee, 2016)

The adjusted price and output increase the overall revenue of B³ Engineering Systems, which is shown in Table 26.

Table 26: Revenue B³ Engineering Systems

B³ Engineering Systems -Minibus Standard Model			
Manufactory	Output	Price	Revenue
Standard	50	150.000,00€	7.500.000,00€
Green	54	146.220,00€	7.895.880,00€
Maximum	67	140.000,00€	9.380.000,00€

Source: (Biewendt, Böhnert, & Blaschke (b), 2019)

Although the price per bus is lower by € 3,780, the overall revenue increases by 395,880 (5.28 percent). By implementing this adjustment, the specifications of the Green Controlling department can be met while satisfying the constraint of the management.

-4.- Conclusion

In fact, the Jevons Paradox does not describe a paradox in its own sense, but only a lack of information for the evaluation and classification of future events. In the authors example, it is assumed that based on current knowledge and logic, the total consumption of resources must decrease, as long as the resource consumption for the manufacture of products is reduced by efficiency gains. In a model without further environmental impacts, this assumption would be correct.
However, extending the model to the classic supply-demand function shows that a reduction in resource use correlates with a reduction in production costs. This also directly and indirectly influences the price of the product, which, when it decreases, has an impact on consumer demand.

A reduction in the product price thus increases demand, and thus the supply if the market is not saturated and the supplier has sufficient capacity. Hence,

considering the knowledge of environmental influences, an increase in resource consumption as a whole is not paradoxical but a logical consequence of market mechanisms. In the example of B³ Engineering Systems shown here, this effect takes place. The original concept, developed by the Green Controlling subdivision, was to reduce the usage, consumption, and emission of the resource's grey energy, virtual water and CO_2. The first step to achieve this was realized through a new product development system of the Green IT sub-division. The resources that have now been freed up were then thus used by the Green Manufacturing subdivision to establish a new production process that also reduces environmental costs and thus the company's overall cost structure. The management has decided to pass on this cost reduction to the customers through a reduced product price.

As a result of the higher production figures due to increased demand, saving resources became absurd from an ecological point of view as overall consumption of resources increased in the first place. Therefore, the authors of this study must confirm zero hypotheses.

The use of corporate sustainability results in increased overall output generated and resource consumption of companies through efficiency gains, which precisely describes the Jevons Paradox.

Nevertheless, the use case designed by the authors for this paper shows a newly developed concept and perspective on how to neutralize the Jevons paradox while still enabling the company to increase its sales. This approach fits better with a liberal market economy as it is found today in most industrialized countries. In contrast to Jevon's socialist approach, the approach of this paper combines the benefits of efficiency gains through the use of corporate sustainability with the management of total resource consumption through the selling price of the product and consideration of demand elasticity.

CHAPTER 3

GENERAL DISCUSSION OF THE RESEARCH

3. General Discussion

The aim of this thesis was to identify the socio-economic challenges that exist with regard to resource and sustainability management. This was substantiated by the three hypotheses:

H1 The share of resource revenues in GDP has no influence on the HDI value and thus, on the socio-economic development of a country classified as a rentier state.

H2 Integration of corporate sustainability measures results in increased overall resource output and resource consumption through efficiency gains.

H3 Demand elasticity and consumer behaviour has a positive impact on the effectiveness of sustainability measures in companies

3.1 Discussion of Macroeconomic Perspectives

Paper 1 discussed the macroeconomic perspective of the research, regarding socio-economic challenge in context of resource management. To conduct research, the HDI Index was selected as the lead index due to its nature and structure. In particular, because this index lists the parameters that are important for the author's research, including life expectancy at birth, average length of schooling, expected length of schooling and gross national income per capita. All these parameters are directly or implicitly indicative of the state's motivation to invest in infrastructure and population and are therefore suitable for socio-economic analysis.

Hence, the literature review has revealed that there are different theoretical frameworks and approaches to resource management in previous and current research in the broader context of socio-economics. Beneath others,

the presented approaches of (Jevons, 2016a), (Szirmai, 2015) and (Haq, 1995) as well as (Yates, 1996) illustrated the general influence of resource wealth on the ecological and social behaviour of a country in a theoretical approach. Especially, the concept of the rentier state, which is predicated on the wealth of natural resources, set the stage for a scientific discussion of the problem posed (Rahman et al., 2014).
The literature review conducted and the qualitative analyses revealed that resource wealth tends to have a negative impact on a country's socio-economic prospects. The imbalance caused by resource wealth in terms of dependency between the state and citizens was particularly debatable in this view. Basically, the rents generated by oil, for example, decouple the principle of interdependence, as the state no longer relies on the tax revenues of its citizens and thus stops investing in them.

This is underlined by the fact that human rights and democracy are interwoven with a negative correlation as well (Besson, 2011). The consequence of this is that, due to the lack of investment, citizens no longer seek to trust the state and look for (sometimes criminal or illegal) substitutes. When these alternatives are found, there is no longer any interdependence between the citizen and the state. To investigate these findings further, a quantitative analysis was conducted. For this purpose, data from the World Bank on the share of resource rents in GDP was collected and put into an analysable standard. In addition, the corresponding data of the HDI index were obtained for the same period.
In a statistical analysis, an endeavour was made to interlink these two data sets and to determine whether a (statistical) correlation could be estab-

lished. In its findings, the analysis was able to show that the share of resource revenues in GDP has a negative influence on the HDI value and thus on the overall socio-economic development in the countries studied.
Considering the statistical uncertainty and also considering that the models used only partially reflect reality, a higher share of resource sales in GDP leads to a lower HDI value. It also leads to a slower or less favourable development of the respective country due to a negative correlation between thus two variables. From this analysis it can be deduced that the null hypothesis of this thesis can be rejected, since based on the present results there is an influence of the share of resources in GDP on socio-economic aspects.
However, it must be noted that the results from the statistical analysis are only valid for the selected period and the selected countries. If one look at the variables in a smaller or larger time period, the results may change. Overall, however, the trend is similar to the selected period of observation even with a larger period of observation.

3.2 Discussion of Microeconomic Perspectives

With paper 2 and paper 3 discussed the microeconomic perspective of the research, in the same cluster of socio-economic challenges in context of resource management. Evaluating the results of both papers, the author was able to understand the microeconomic effects when developing his own research and use case, which created a model of a company that wanted to reduce its environmental impact by optimising resources through sustainability management. The initial draft envisaged that the Green Controlling department of the fictitious company would elaborate a policy for this.
For this the use and consumption as well as the emission of the resource's grey energy, virtual water and CO2 should be diminished. This would also

be in line with the latest state of the technology in measures to act more sustainably as a company in a whole. In a preliminary effort, a new product design system was put in place in collaboration with the "Green IT" department.
The resources freed up by this system were then used by the "Green Manufacturing" sub-division to establish a new and more resource-efficient production process, which also reduces the environmental costs and thus the overall cost structure of the company. Up to this point, it was clear that the technological and conceptual changes within the company would lead to the consumption of fewer resources.
Executive management, nevertheless, then decided to pass on this cost reduction achieved through more efficient resource use to customers through a lower price of the product.
In line with the presumed elastic demand for the company's product, the associated increase in demand from the price lowering was so significant that the economies of scale offset the resource savings gained from the implemented environmentally friendly measures. This way, the total resource consumption could be significantly higher than before the optimisations due to the higher sales. This highlighted the importance of an interdisciplinary and holistic perspective when planning and implementing resource savings technologies. Thus, the management must decide whether to choose the maximum saleable quantity or a sales quantity that considers the total resource consumption and is adjusted accordingly.

This results in a margin of environmental protection and profit maximisation, which must be decided individually on the basis of one's own moral

concepts. Although state regulation can be considered, a system of incentives in the context of a (social) capitalist market economy would, in the author's opinion, be more expedient.

This would, at least in theory, reconcile both the company's need to make greater profits and environmental protection. Through these conclusions, it was possible to show that the integration of corporate sustainability measures results in increased overall resource output and resource consumption through efficiency gains. Further it was shown that considering demand elasticity and consumer behaviour enhances effectiveness of corporate sustainability measures, thus benefiting socio-economic development.

3.3 Discussion of the Outcomes

In particular, the findings from the macroeconomic analysis "Sustainable Development: A Quantitative Analysis Regarding the Impact of Resource Rents on State Welfare from 2002 to 2017" and the qualitative microeconomic analysis "An Evaluation of Corporate Sustainability in Context of the Jevons Paradox" support the statement that both resource and sustainability management have a significant impact and interrelations on and with socio-economic factors. The field of socio-economics deals with economic activity in its social context. Thus, the interdependence of resource management and socio-economic impact in the two analysed and rentier state classified countries was shown. Further, the impact of integrating sustainability management on economic and social factors was shown as well.

CHAPTER 4

CONCLUSION OF THE DISSERTATION

4. Conclusion of the Dissertation

A country's socio-economic development is influenced in a macro-economic view in particular by the indicators of the Human Development Index. The index, in adding its own explicit data such as life expectancy at birth and the average number of years of schooling completed and expected, includes economic well-being in the form of gross national income per capita to assess a country's level of advancement. In the particular subsectors, other metrics are important that consider both economic and sociological gauges. These are gender equality, job security, the ratio of imports to exports and a host of other socio-economic markers.

The HDI was the leading index in the process of the macro-economic research. It was serving as a benchmark for any further analyses and observations. In addition, data from the World Bank as well as secondary data from recent literature revealed that resource wealth in specific does have a tendential negative impact on a country's socio-economic progression.

This is likely to be due, in combination with unstable political conditions, to the prevailing imbalance of dependencies between the state and its citizens, among other causes. This imbalance arises in particular when the state does not generate a significant part of its revenue from taxation. If the state's sources of revenue are largely detached and independent of the financial resources provided by the citizen in the form of taxes, the dependence of the state on its citizens decreases, according to the literature examined, which can lead to the situation that the state reduces its investments in the citizen as a result.

In particular, revenues from resource extraction and sales play an important role in this problem in emerging and developing countries. The data analysis found a negative correlation between the HDI ranking and the share of the resource economy in GDP for the period studied. However, the correct administration and handling of state resources is not only important in developing and emerging countries.

Research has further found that resource management and it's sustainable use play an important role in the microeconomic analysis. In particular, the rebound effect has been studied and especially its extreme form called the Jevons paradox. Thus, especially in industrialised nations, where technological progress is particularly strong and fast, the goal of sustainable use of resources can be contrasted by the rebound effect. Despite the fact that an intensified literature research has demonstrated that the rebound effect as such is very well researched already, it became apparent that abatement measures for the rebound effect are scarcely or not at all available. Just as there is practically no discussion of this problem in the general public debate, which results in the making of wrong decisions with reference to sustainability management.

The reason for ignoring the negative effects of technological progress on the sustainable use of resources, apart from the complexity of the matter, is the lack of precise information. For instance, when some technologies are introduced, it is often not possible to assess what socio-economic effect they will have in terms of resource consumption. The need for a redesign of the impact analysis with regard to technological innovation and its influence on the consumption of resources has become clear on the basis of the present research. Otherwise, efforts to establish a more sustainable economy through resource-saving technologies will turn into the opposite, as

market effects (including the principle of supply and demand) will prevent implementation.

Emerging and developing countries in particular, which in the foreseeable future will be confronted with the issues of efficiency increases through technology, should be confronted with these problems as early as possible. In this way, a social, governmental and economic framework can be created, which channels the challenges of resource and sustainability management relevant to society as a whole as effectively as possible.

CHAPTER 5

NEW SCIENTIFIC RESULTS

5. New scientific results

5.1 Macro-Economic Results

1. For the sample examined (Norway and Nigeria) it was shown that the share of resource revenues in GDP is influencing the HDI value negatively and thus impacts also the overall socio-economic development negatively of the countries.

2. Research has shown that there is a negative interaction between the share of resources in GDP and the HDI value of a country, which translates into a more gradual or adverse socio-economic evolution of the country in question. Reasons are found for this in particular in the decoupling of state and citizen

3. Research conducted has shown that negative correlation holds true for both Nigeria and Norway for the monitored time period, even though the national culture and society are very much apart.[10]

[10] it should be noted that a rather simplified model of reality was utilized in the course of the analysis, which therefore does not include all the influential drivers of the "real" world in this analysis. Moreover, the period of observation was restricted to 15 years.

5.2 Micro-Economic Results

1. Research conducted show that technological progress leads to increased resource consumption through increased consumer demand when the demand modified by technological progress exceeds the resource savings from the newly established technology.

2. It was shown that reduction, consumption and emission of grey energy, virtual water and CO2 is thwarted by effects of technological improvements, economic supply-demand function and the rebound effect in context of sustainability measures.

3. However, research conducted has also shown that the benefits of increasing efficiency through the use of new and resource-saving technologies do not necessarily have to lead to a rebound effect. Provided that the side effects are known to the companies and are considered in the planning.

4. Research has shown, that the rebound effect can be independently neutralized or alleviated by companies and at the same time an increase in the profitability of the company is still possible.

5.3 Testing of Hypothesises

H1 The share of resource revenues in GDP has no influence on the HDI value and thus, on the socio-economic development of a country classified as a rentier state.

Result: The hypothesis was rejected.

H2 Integration of corporate sustainability measures results in increased overall resource output and resource consumption through efficiency gains.

Result: The hypothesis was confirmed.

H3 Considering demand elasticity and consumer behaviour enhances effectiveness of corporate sustainability measures, thus benefiting socio-economic development.

Result: The hypothesis was confirmed.

CHAPTER 6

SUMMARY OF THE DISSERTATION

6. Summary

In summary, it can be deducted from the studies and research carried out that the provision and analysis of information in the context of socio-economic challenges is an important aspect in ensuring sustainable, environmentally friendly social development. From both a macroeconomic and a microeconomic perspective, it is crucial that states and companies establish reliable and valid control mechanisms in order to counteract undesirable effects such as the rentier state or the rebound effect. Transparent and scientifically sound models can make an important contribution to this by revealing previously unknown consequences and enabling decision-makers to weigh up their actions.

Considering the revealed side effects of resource abundance and the introduction of new technologies, states, confederations of states as well as companies can make the decision to weigh their profit motives against environmental protection. Accordingly, consistent sustainability and resource management can lead to positive and ecologically and economically sustainable development for both the economy and the environment in all aspects of socio-economics examined.

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Publications related to the topic of the dissertation

1. **Sustainable Development: A Quantitative Analysis Regarding the Impact of Resource Rents on State Welfare from 2002 to 2017**
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2. **The Rebound Effect – A Systematic Review of the Current State of Affairs**
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Conducted Conference Presentations

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Academic Experience

2018-22	**Hungarian University of Agriculture and Life Sciences, Campus Kaposvár, Hungary** Doctor of Philosophy in Management & Organisational Sciences (Ph.D.) Majors: Socio-Economics, Resource Management
2018	**Edinburgh Napier University, Scotland** Master of Science in Flexible Management (M.Sc.) Majors: Leadership, Strategy, Innovation
2017-18	**University of Applied Sciences Aachen, Germany** Master of Arts in International Business Management (M.A.) Majors: Customer- and Service Management
2013-14	**Polytechnic University Tomsk, Russia** Academic Semester Abroad Majors: General Management
2010-15	**University of Applied Sciences Aachen, Germany** Bachelor of Science in Business Studies (B.Sc.) Majors: Law, Marketing, Organisations Management

Work Experience

Apr. 2020 – today	**Chief Operations Officer (COO)** **Scientific Institute for Digitization, Aachen** Business Development, Organisational Management and Supervision of Scientific-Projects & Project-Teams, Scientific Research
March 2020 – today	**Chief Executive Officer / Founder** **Deep Gaming Industries GmbH, Aachen** Founder & CEO, Organisational Process Optimization, Organisational Management, Business Development
May 2019 – Feb. 2020	**IT & Management Consultant** **Tallence AG, Hamburg** Agile and classic project management, stakeholder management and work as a scrum master, agile coach and project manager
Oct. 2018 – Apr. 2019	**IT-Consultant** **CGI Consulting. Hamburg** International project in a shipping company, requirements engineering, stakeholder management as well as digital transformation
Nov. 2016 – Sept. 2018	**Business Development Manager –** **Biewendt GmbH, Würselen** Business development, strategy in various medium-sized projects of the parents' company in Aachen
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Others

Certificates	HP ALM Expert, ISTQB Certified Tester, ITIL 2011 Foundation Expert, Prince 2 FL Expert, Professional Scrum Master, Tricentis Automation Specialist
Languages	German (mother tongue), English (business fluent); Dutch, French, Russian (basic knowledge)
Academic	Tutor for commercial and private law (2013-15), guest lecturer for macroeconomics and economic policy at the Aachen University of Applied Sciences
Leisure activities	Swimming and technical diving, history literature, science-fiction and adventure novels