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The Relevance of Governance Quality for Sustainable Resource Use. Greece as a Case Study

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The Relevance of Governance Quality for Sustainable Resource Use.

Greece as a Case Study*

von

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I am grateful to the admirable women in my surrounding
who inspire and encourage me.

Abstract

The aim of this study was to investigate the social metabolism of Greece with a particular focus on the interaction of resource use and governance quality. This was achieved by conducting a material flow analysis (MFA) for the period between 1970 and 2012. Results of the MFA reveal a transition from a biomass-based, agricultural to a minerals-based, industrial society in Greece. In 1970, Greek metabolism was dominated by biomass and construction materials. In 2012, fossil energy carriers and construction minerals are by far the most important materials used. Greek domestic material consumption increased in total from 89 million tons in 1970 to 250 million tons in 2006, indicating a growth rate of 180%. Between 2006 and 2012, DMC declined by 25%, which was a consequence of the economic crisis of 2008. The economic crisis and the resulting austerity measures had not only a massive impact on Greek national budget but also on the country's biophysical economy. In order to contextualize the country's material flows, the socioeconomic development and Greek recent political history were investigated, too. Developments in the European political landscape and the industrial transition were identified as relevant determinants for the actual prevailing biophysical characteristics of Greece. Governance quality is regarded as playing an important role for socioeconomic development, thus it was considered as a possible determinant for biophysical development, too. The relationship between resource use and governance quality was investigated by applying a correlation analysis. The scope of the study was extended and EU-wide data was taken into account. A statistically significant relationship between resource use and governance quality variables could be identified. The most significant relationship exists between governance quality and resource productivity. This indicates the close interaction between governance quality, resource use and economic development. Several dimensions where governance quality and resource use may interact are discussed, such as the construction sector and the external trade structures. Results of the correlation analysis provided us with relevant information about European development, in particular about structurally similar countries, such as Spain, Italy and Portugal. This was useful for contextualizing Greece within the European Union. The transition from an agrarian to an industrial economy was finally discussed as possible dimension for explaining the relationship between resource productivity and governance quality.

Table of contents

1. Introduction 11
   1.1. Aim of the Thesis and Research Questions 12
   1.2. Structure of the Thesis 12
2. Concepts 13
   2.1. The Concept of Social Metabolism 13
      2.1.1. Material Use Determinants 14
      2.1.2. Resource Productivity 15
   2.2. Governance and Governance Quality 17
      2.2.1. Quantifying what is not Quantifiable (?) 18
      2.2.2. Corruption 18
      2.2.3. Governance Quality and Sustainability Development 19
3. Methods and Data 20
   3.1. Material Flow Accounting and Analysis 20
      3.1.1. Data and Sources 22
      3.1.2. Comparison of Sources 24
   3.2. Governance Indicators 25
      3.2.1. World Governance Indicators 26
      3.2.2. Corruption Perceptions Index 27
   3.3. Correlation Analysis 28
      3.3.1. Data and Sources 29
4. Socioeconomic Development and Governance Quality in Greece 30
   4.1. Process of Europeanization and the Way into Crisis 33
   4.2. Governance Quality in Greece 35
5. Results 38
   5.1. Greek Metabolic Profile 38
      5.1.1. Domestic Extraction 38
      5.1.2. Domestic Material Consumption 40
      5.1.3. Trade 43
      5.1.4. Description and Analysis of main Materials 45
      5.1.5. Metabolic Rates and EU-Comparison 56
      5.1.6. Resource Productivity 59
   5.2. Resource Use and Governance Quality. Correlation Analysis of the EU-countries 60
      5.2.1. Relations between Resource Use and Governance Quality 61
      5.2.2. Graphical Examination of the Relationship between Resource Use and Governance Quality 63
6. Integrated Results Discussion 66
   6.1. An Industrial Transformation: Greek Material Consumption and the Role of Europeanization 66
   6.2. Greek Consumption of Construction Minerals and the Role of Corruption 67
   6.3. Greek External Trade Structure 67
   6.4. Greece in the European Context 69
7. Conclusions 71
8. Bibliography 73

List of Acronyms

VV	Voice and Accountability (VA)
BGS	British Geological Survey
CC	Control of Corruption
CEMBUREAU	The European Cement Association
CPI	Corruption Perceptions Index
DE	Domestic Extraction
DMC	Domestic Material Consumption
DMI	Direct Material Input
EMU	Economic and Monetary Union
EU	European Union
EUR	Euro
EUROSTAT	The statistical office of the European Union
EW-MFA	Economy-wide Material Flow Analysis
FAO	Food and Agriculture Organization of the United Nations
FAOSTAT	Statistics Division of the FAO
GDP	Gross Domestic Production
GE	Government Effectiveness
IEA	International Energy Agency
IFEU	Institute for Energy and Environmental Research
MFA	Material Flow Accounting
MTB	Monetary Trade Balance
OECD	Organization for Economic Co-operation and Development
PTB	Physical Trade Balance
PV	Political Stability and Absence of Violence/Terrorism
RL	Rule of Law
RME	Raw Material Equivalents
RP	Resource Productivity
RQ	Regulatory Quality
SERI	Sustainable Europe Research Institute
UN COMTRADE	United Nations Commodity Trade Statistics Database
UNICPS	United Nations Industrial Commodity Production Statistics
UNSTATS	National Accounts Section of the United Nations Statistics Division
USGS	United States Geological Survey
WGI	World Governance Indicators
WU	Vienna University of Economics and Business

List of Figures

Figure 1 Concept 'Double Decoupling' 16
Figure 2 Scope of economy-wide MFA. 21
Figure 3 Comparison DE of individual material groups 25
Figure 4 Timeline of Greek history 31
Figure 5 Comparison World Governance Indicators for Greece and EU27 countries 36
Figure 6 World Governance Indicator dimensions for Greece 37
Figure 7 Comparison Corruption Perceptions Index Greece - EU27 37
Figure 8 DE in million tonnes 38
Figure 9 Comparison of DE growth rates for EU27 39
Figure 10 DMC in million tons 40
Figure 11 Final electricity consumption in sectors in GWh 41
Figure 12 Sources of electricity production in GWh 41
Figure 13 DMC in four material categories in million tons 41
Figure 14 Imports in million tons 43
Figure 15 Exports in million tons 43
Figure 16 Physical Trade Balance PTB in million tons 43
Figure 17 Monetary Trade Balance MTB in billion Euro (chain-linked volume) 44
Figure 18 DE of biomass materials in million tons 45
Figure 19 DMC of biomass materials in million tons 45
Figure 20 Imports of biomass materials in million tons 46
Figure 21 Exports of biomass materials in million tons 46
Figure 22 DE of fossil energy carriers in million tons 48
Figure 23 DMC of fossil energy carriers in million tons 48
Figure 24 Imports of fossil energy carriers in million tons 48
Figure 25 Exports of fossil energy carriers in million tons 49
Figure 26 Final consumption of oil in Greece, in kt 50
Figure 27 DE of metal ores in million tons 51
Figure 28 DMC of metal ores in million tons 52
Figure 29 Imports of metal ores in million tons 52
Figure 30 Exports of metal ores in million tons 52
Figure 31 DE of non-metallic minerals in million tons 54
Figure 32 DMC of non-metallic minerals in million tons 54
Figure 33 Imports of non-metallic minerals in million tons 54
Figure 34 Exports of non-metallic minerals in million tons 55
Figure 35 Metabolic rates in t/cap/yr 56
Figure 36 Change in material consumption in t/cap 57
Figure 37 Comparison of metabolic rates and income for EU27 countries 58
Figure 38 Development of resource productivity in Greece 59
Figure 39 Correlation domestic material consumption (in t/cap) and the Corruption Perceptions Index CPI 63
Figure 40 Resource productivity (in EUR/ton) plotted against the Corruption Perceptions Index 65

List of Tables

Table 1 Variables and corresponding sources included in the correlation analysis 29
Table 2 Heat values/Gross calorific value for comparison 49
Table 3 DE of iron ore and bauxite in million tons 53
Table 4 Correlations for the years 2000, 2005 and 2010 61

1. Introduction

The interdisciplinary research field of social ecology, in particular as it is understood at the Institute of Social Ecology in Vienna, is deeply concerned with the interaction between social and natural systems. This perspective implies not only the interaction of the systems but their co-evolution over time and their "substantial impact upon one another" (Fischer-Kowalski and Weisz 2014:1). The key link between the natural and the social system is framed as the concept of social metabolism. In order to reproduce the biophysical structures of society a "continuous flow of energy and materials" (Fischer-Kowalski and Weisz 2014:15), also referred to as natural resources, is required. This in turn is needed to be extracted from and at some point eventually released to the environment (Ayres and Kneese 1969). The socially organized extraction and consumption of resources is of interest to me, while I am particular concerned with the factors that shape resource use. I therefore decided to scientifically explore the determinants of resource use applying the method of Material Flow Accounting and Analysis and taking into account specific aspects of socio-economic and political developments.

My research interest relates to the relationship between socio-economic and biophysical systems and how their interaction is shaped. At the heart of my study lies Greece, a country geographically located at the south-eastern border of Europe and member of the European Union since 1981. The country was recently clearly not at the periphery but at the center of political and the media's attention regarding future political and financial development – not only concerning Greece but the future of the European Union. When choosing Greece as a research field, one must eventually deal with the Greek fiscal crisis, the country's struggle to recover and the political and socioeconomic implications of the crisis. Events of this quality and magnitude also have significant influence on resource use and material flows (Krausmann 2011:29). When dealing with the factors that led the country into crisis, one aspect, namely governance quality, is of particular relevance. Acknowledging that governance quality plays an important role for socioeconomic development (Graham, Amos, and Plumptre 2003; Rothstein and Teorell 2008), it seems worth considering governance quality as a possible determinant for biophysical development, too. Therefore the question will be raised if governance quality, amongst other resource use determinants, is a relevant variable influencing resource use.

1.1. Aim of the Thesis and Research Questions

The aim of the thesis is to investigate the Greek social metabolism with a particular focus on the interaction of resource use and governance quality. This leads to the following research questions:

1. What are the characteristics of the Greek social metabolism?

2. What determines the biophysical development of Greece and in particular Greek resource use?

3. Does the integration into the European Union influence the biophysical and socioeconomic development of Greece?

4. Can a statistically significant relationship between governance quality and resource use be observed when including corresponding data for the current EU member states?

5. What are the channels through which governance quality influences resource use in Greece?

1.2. Structure of the Thesis

In order to investigate the research questions raised above, I focused on the following three dimensions:

1. I regard Greece as a biophysical system which is built up, maintained and reproduced by the continuous input of energy and material (following the logic of the concept of social metabolism). In order to be able to describe and analyze the metabolic profile of Greece, the method of economy-wide material flow analysis and accounting (in short MFA) is applied. I compiled Greek material flows for the period between 1970 and 2012.
2. The Greek socioeconomic development is acknowledged and thus described in depth, taking into account relevant scientific literature. Governance quality is an important feature of the socioeconomic system. Literature reviewing Greek governance quality is taken into account in order to assess particularities of Greek governance quality. The topic is furthermore assessed in a quantitative manner by including relevant governance indicators.
3. In a correlation analysis, I tested the relationship between governance quality and resource use. In this particular analysis, the geographical scope of the thesis is extended and provides information about governance quality, resource use and economic development for current EU member states. Scatter plots are used for illustrating the development of included EU countries.[1]

The thesis rests upon two conceptual pillars, namely the concepts of social metabolism and governance quality. Section 2 provides information about the state of the art of these concepts. All relevant indicators are described in Section 2, too.

[1] Data sheets containing figures of the material flow analysis and the correlation analysis are provided in a separate appendix. Download: http://www.uni-klu.ac.at/socec/inhalt/1818.htm, July 2016

In Section 3, methods and data are described. Information about the data and sources I used to compile Greek material flows are provided and corresponding methodological considerations are outlined. In this section, I also deal with data and sources of governance quality indicators. The correlation analysis applied to investigate the relationship between governance quality and resource use, as well as the data taken into account, is also described in this section. The MFA and the governance quality data used in the analysis have been well-established during recent decades (Fischer-Kowalski et al. 2011; Kaufmann and Kraay 2007). It is expected that sound information about the topic can be provided.

In Section 4, I deal with the socioeconomic and political development in recent decades in Greece. This information is important for contextualizing Greek biophysical developments. Information about Greek governance quality is provided in this section, too.

In Section 5, I present the results of the material flow analysis and the correlation analysis. By taking into account socioeconomic information, a thorough understanding of Greek social metabolism and resource use determinants becomes possible. Information about EU-wide development helps contextualizing Greek development within the European landscape.

The aim of section 6 is to contextualize, interpret and discuss results, while taking into account relevant conceptual considerations. The results presented in Section 5 are discussed in an integrated manner aiming at answering the initial questions concerning Greek biophysical characteristics.

Section 7 presents an overview of the main results, deals with the feasibility of the approach and provides a brief outlook of possible future research questions.

2. Concepts

In this section, I provide information about the state of the art of the applied concepts. The concept of social metabolism is outlined first. In the second part, I describe the concepts of governance and governance quality. Issues of governance quality are assessed in a quantitative way too. The linkage of biophysical with governance quality dimensions in a quantitative manner opens up new vistas for gaining insights into the topic. This is nevertheless a delicate matter, which is why I also outline the limitations of this approach.

2.1. The Concept of Social Metabolism

The concept of social metabolism is based on works by Ayres and Kneese (1969), a physicist and an economist, who had been concerned with the question of required material input and the "disposal of residuals resulting from the consumption and production process[es]" of societies (1969:282). Ayres and Kneese proposed to view environmental problems, namely pollution, and "its control as a materials balance problem for the entire economy" (1969:284). This approach prepared the ground for the concept of social metabolism, which was elaborated by Marina Fischer-Kowalski and colleagues from the "island of the Vienna School of Social Ecology" (Fischer-Kowalski and Weisz 2014:13). The concept is used as a framework to provide a thorough understanding of society-nature interactions. Within this approach, social and natural systems are regarded as "dichotomous": society is understood as being capable of influencing natural systems and vice versa. Human society, or rather the biophysical structures of human society, lies at the interface of these two realms, as a so-called "hybrid" (Fischer-Kowalski and Haberl 2007:12f; Fischer-Kowalski and Weisz 1999:240). The dynamic of this interface is determined by both the "system of social regulations functioning by way of

communication (cultural exchange) and the system of biophysical regulations functioning by way of flows of material and energy (natural exchange)" (Fischer-Kowalski and Weisz 1999:240). In order to approach these dynamics, the concept of social metabolism was elaborated. It is the key link between society and the natural environment (Fischer-Kowalski and Weisz 2014:15). This implies that a continuous input of energy and material is required in order to build up, maintain and reproduce the biophysical structures of society.

Social metabolism comprises "the material input, processing and releases of societies and the corresponding energy" (Fischer-Kowalski and Haberl 1998:574). The aspiration of the concept thus goes somewhat further, aiming at bridging over the "'great divide' between the natural sciences, on the one hand, and the social sciences and the humanities, on the other"(Fischer-Kowalski 1998:62). This is also expressed through the application of the biological concept of metabolism, which actually refers to the "internal processes of a living organism" to human societies (Fischer-Kowalski and Haberl 1998:574; Fischer-Kowalski 1998:62). Similar to the necessary exchange of material and energies of an organism in order to maintain its existence, the social system converts in an analogous way raw materials into required goods or services and finally into waste (Fischer-Kowalski and Haberl 1998:574). Looking at societies by investigating their social metabolism allows to "distinguish cultures, societies or regions according to their characteristic exchange relations with nature." (Fischer-Kowalski and Haberl 1998:574)

Measuring these socially organized exchanges with nature is a relevant topic within the field of quantitative environmental research. Material and energy flows are at the focus of this research field, aiming at quantifying the use of natural resources by modern societies. Natural resources are understood as "natural assets deliberately extracted and/or modified by human activity for their utility to create economic value. They can be measured both in physical units (such as tons, joules or area), and in monetary terms expressing their economic value" (Krausmann et al. 2011:4–5).

2.1.1. Material Use Determinants

The rapidly growing material extraction and consumption is considered as one of the major drivers for the global environmental change. This perspective also includes the environmental problems, which occur during extraction, processing and disposal of raw materials (Krausmann et al. 2009). Giljum et al (2014:334) who assess world-wide patterns of material use (extraction, trade, consumption and productivity) show that it has grown by 94% in recent decades. The highest growth rates can be observed in Asian countries, while material extraction in Europe and North America decreased below global average in recent years.

Besides bio-geographical factors such as climatic conditions, natural productivity of land, resource endowment or population density, socio-economic factors, in particular stage of economic development, standard of living, macro-economic and trade structures as well as the structure of the energy system were identified as determinants of material consumption and its variations across countries (Weisz et al. 2006:694). In Steinberger et al (2010:1157) authors show that material flows correlate most significantly with national income, population and land area. The authors furthermore find that variations in material consumption around the globe are first and foremost due to income variations. Steger and Bleischwitz (2011) demonstrate that factors such as final energy consumption, the construction sector and its industries, population density as well as the share of imports in GDP are of high significance for national resource consumption.

2.1.2. Resource Productivity

Within the framework of sustainable development, the growing use of natural resources is regarded as a main driver for environmental change (Krausmann et al. 2009). Taking this into account, the question of efficiency arises: how can societal development be maintained, considering challenges such as population and economic growth, whilst using less materials? In order to address this question, national material use and economic performance are related. The indicator material efficiency is calculated as the ratio between material use and economic growth: higher resource productivity indicates that more wealth is produced per unit of resource use. Resource productivity, which is synonymously used for material efficiency, was chosen as the lead indicator in the EU flagship initiative "Resource Efficient Europe" (European Comission 2011). The indicator provides guidance for the political goal of increasing economic output while reducing material input. It is well established, and profound data is available for European countries (Eurostat. 2015b).

In Europe, a general trend of improving resource productivity can be observed (Bleischwitz 2010; Giljum et al. 2014). Besides economic growth and national income as central factors for improving resource productivity, technical factors and competitiveness are discussed within the debate. Krausmann et al (2011), however, state that material productivity (which serves as proxy for resource productivity) is highly correlated with national income in EU countries but only weakly correlated to competitiveness. According to this, more resource-productive countries benefit from being richer economies rather than being more environmentally efficient. Authors also illustrate that wealthier economies with a smaller share of agriculture, extraction and material-intensive industries with a focus on service sectors (which are usually not material-intensive) have a higher resource productivity (Krausmann et al. 2011). The shift from material-intensive industries to material-extensive sectors might have contributed to the increasing resource productivity, which is in most cases also accompanied by the effect of burden shifting. This means that economies that focus on less material-intensive industries exhibit increasing trade activities and import goods with material-intensive production chains (UNEP 2011). Until recently, these so called upstream-flows were due to the lacking availability of data not taken into account when calculating resource productivity. Authors of recent studies however find that countries use manifold "non-domestic" resources because of trade activities. This leads to a shift of resource use and associated environmental pressures among countries. (Wiedmann et al. 2015) For this thesis, I calculated the indicator resource productivity as the ratio between resource use and economic growth, which does not include the potential shift of resource burden (European Comission 2011:20). The indicator furthermore only deals indirectly with other resources, such as water or air (European Comission 2011:20).

The simplicity of the indicator resource productivity, expressing the ratio between economic output (GDP) per resource use , makes it an appealing indicator measuring environmental sustainability (Steinberger and Krausmann 2011). The concept of decoupling is central when it comes to environmental sustainability. The "Environmental Strategy for the First Decade of the 21st Century" by the OECD adopted the concept and regards resource decoupling as one of the main policy objectives. (OECD 2001) The "Roadmap to a Resource Efficient Europe" and the corresponding political strategy "Thematic Strategy on the Sustainable Use of Resources" also refer to the concept of decoupling (Commission of the European Communities 2005; European Comission 2011; Krausmann et al. 2011).

When comprising the decoupling of resource use from economic growth on the one hand and from environmental impacts on the other, it is furthermore referred to the concept of "double decoupling" (Bleischwitz 2010:230). It provides a comprehensive understanding of the relationship between resource use, economic growth and environmental impacts. Figure 1 shows a schematic representation of the concept, which was obtained from the corresponding report commissioned by the United Nations Environment Program (UNEP 2011).

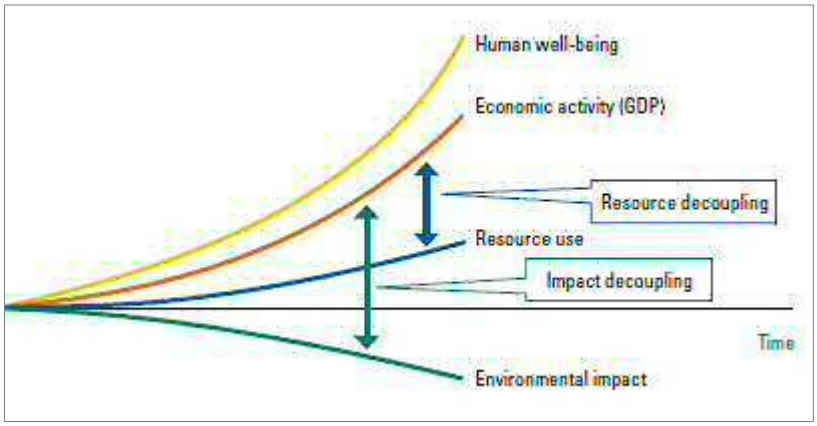

Figure 1 Concept 'Double Decoupling', Source: Fischer-Kowalski et al 2011.

In this thesis, I refer first and foremost to the concept of resource decoupling which means reducing resource use per unit of economic activity.

In Europe, as mentioned above, a trend of increasing resource productivity can be observed. This, however, resulted not in an absolute but relative decoupling. Relative decoupling means that the growth rate of resource use (or any other environmentally relevant indicator) is lower than the growth rate of an economic indicator, such as GDP. On the other hand, absolute decoupling refers to a declining resource use whilst economy is growing. (UNEP 2011) Steinberger et al (2013) investigate the potential for decoupling economic activities from environmental resources. The authors state that countries which are economically mature, such as industrialized countries, have a lower material coupling than developing countries They found absolute decoupling (declining resource use whilst growing GDP) in Germany, the Netherlands and the UK. Authors emphasize that decoupling has diverse reasons: UK and Germany are an example of dematerialization because of the declining and offshoring of manufacturing and construction sectors as well as material-intensive heavy industry. They find different types of materials to be coupled to a varying extent with economic growth. Minerals and fossil energy carriers have the strongest coupling with economic growth and hence play the most important role in economic development. Krausmann et al (2011) describe the development of relative dematerialization (which is used synonymously for decoupling) for different EU member states, but state in general that overall "periods of declining DMC (…) occurred only in conjunction with recession or very slow economic growth" (Krausmann et al. 2011:28). Highly resource-productive countries cannot *per se* be regarded as role models for countries with lower resource productivity levels. Reasons for high or low levels of resource productivity must be interpreted very carefully since they often are based on very individual, nation-specific developments.

2.2. Governance and Governance Quality

The governance concept is regarded as a new approach that describes and analyzes social interaction (Schimank et al. 2007). The complexity of the concept becomes apparent when considering that no consistent definition of governance exists (Kaufmann, Kraay, and Mastruzzi 2011; Rothstein and Teorell 2008). Governance is a highly contested concept which was previously used synonymously with 'government'. The current application as a concept in the social sciences encompasses broader contexts with multiple meanings and implications. When using the concept governance, authors refer to distinct discussions, i.e. 'good governance' as a policy condition, governance as a management tool, corporate governance or governance as self-organizing policy networks (Hezri and Dovers 2006). Since the early 2000s, the concept of governance has more and more been used as an analytical tool to describe causal links between the structure of institutions, interests and the interaction of different actors (Schimank et al. 2007:14). Contrary to its previous synonymous meaning with government, it is now rather interpreted as how governments and other social organizations interact, how they relate to citizens and how decisions are taken and implemented.

Defining the *quality* of governance is as complex and widely discussed as the concept of governance itself (Ott 2010; Rothstein and Teorell 2008). In 1997, the United Nations Development Program formulated a set of "good governance principles", which received great response in the literature (Graham et al. 2003:3). These principles include legitimacy and voice, direction, performance, accountability and fairness and illustrate how power is exercised. Rothstein and Teorell (2008) regard democracy as the access to power and impartiality in the exercise of power as the necessary features of governance quality (2008:180). Bovaird and Löffler list ten characteristics of good governance which occur frequently in literature and in political and practitioner debates. These are: "citizen engagement, transparency, accountability, the equalities agenda and social inclusion (gender, ethnicity, age, religion, etc.), ethical and honest behaviour [sic], equity (fair procedures and due process), ability to compete in a global environment, ability to work effectively in partnership, sustainability, respect for the rule of law"(2003:322–323). The authors however emphasize that the importance of the listed features can vary between contexts and over time. Different countries have different views on what the specific features mean in practice and how important they are (Bovaird and Löffler 2003).

When operationalizing my research question, I was challenged by finding a working definition of governance quality. Against the backdrop of my research question, I use governance quality as a normative term which describes the quality of governments and administrative systems. The norms considered are, among others, rule of law, transparency, democracy and political impartiality (Schimank et al. 2007:15). Dealing empirically with questions of governance or governance quality requires the application of indicators providing quantitative information. This approach was pursued in most other studies I refer to in my thesis: Common indicators are the World Governance Indicators WGI or the Corruption Perceptions Index CPI. The quantitative assessment of governance quality however had triggered a broad discussion. The crucial question is if something complex as governance quality can be measured accurately at all. In the following section I will briefly outline the ongoing debate.

2.2.1. Quantifying what is not Quantifiable (?)[2]

Each indicator used within quantitative research features advantages as well as limitations. The difficulty of quantifying governance is discussed broadly in the governance literature. Most widely used governance indicators are aggregate perception-based indicators, which means an amalgamation and thus sometimes a simplification of a wide range of data and information. The reduction of a complex concept such as governance quality to a single number, as it is practice for indicators such as the World Governance Indicators (in short WGI) or the Corruption Perceptions Index (CPI), is regarded as a weakness, thus transparency regarding data aggregation is very important. Oman and Arndt (2013) stress the fact that perception-based indicator sets do not make entirely clear whose perception is taken into account and to what extent. They question how different sources are weighted, and emphasize that household surveys are not weighted as important as expert surveys which very often represent the views of business people (Oman and Arndt 2013:4;14). Authors warn against overestimating the precision of the country's governance scores, because users tend to apply indicators as if they were accurate to a degree they are not. Another aspect is the question of a conceptual framework. Indicators do not reflect any definition of "good" or "bad" governance quality. Arndt and Oman (2013:12) emphasize the difficulty to judge what governance quality is and that it is impossible to assess governance quality while lacking an existing underlying concept. In order to meet the challenges stated above, the conclusions I can draw in my thesis are not exclusively based on quantitative information provided by indicators. I also include theoretical considerations and findings from analyzing the relevant literature. When dealing with governance quality in Greece, indicators are contextualized within Greek national particularities.

2.2.2. Corruption

Corruption, a crucial feature of governance quality and a prevalent issue in Greece, deserves particular attention within the context of my thesis (Rothstein and Teorell 2008:169). The clientelistic, non-transparent political system is a topical issue and dealt with in much of the literature I considered about Greece. Corruption also serves as a proxy for assessing governance quality. I want to approach the topic by asking why corruption is a more current issue in some states than in others and what the causes and consequences of corruption are. Most of the studies I considered deal with the topic in a quantitative way, by investigating statistical relations. Others however stress that it has to be acknowledged that corruption is difficult to study empirically because it is often characterized by determinants that are "interrelated in complicated ways" (Treisman 2000:437).

Corruption is a phenomenon that affects societies of different socioeconomic status at different times. Cases of corruption can be found in countries at different levels of development, but the extent of corruption still differs remarkably between countries (Pellegrini 2011). Treismann (2000, 2007) stresses that very little is known for sure about causes of corruption and about the consequences which result thereof for individual countries. Structural reasons seem to be worth considering, such as the effectiveness of a country's legal system. The probability of getting caught and punished as well as the risk of being exposed are obvious reasons to misuse public office, too. Treismann (2000, 2007) includes global data in his empirical analysis, which covers countries with very different levels of development. Within this global context, manifold reasons were identified for causing

[2] (Bovaird and Löffler 2003:316)

corruption, including aspects such as colonial heritage, the status of development as well as the availability of natural resources and the degree of openness to trade.

What seems intuitively reasonable is that democracy plays an important role when explaining the degree of corruption. Treismann (2000, 2007) finds that the long-term implementation of a democratic system is more important than current politics. When comparing individual countries, he finds that the "distant past appears as important, or even more important, than current policy" (Treisman 2000:401). Democracies have to be long established thus the longer democratic structures exist without interruption, the less corrupt is a country. In his very detailed literature review, dealing with causes and consequences of corruption, Lambsdorff (2006) cites studies that detect that the grade of democratization is not relevant when income is included. This supports Treisman's finding that rather the duration of democratic structures than the current political status is the most relevant dimension. He provides the illustrative example that if Portugal had been a democracy since 1950, it would have been as non-corrupt in 1998 as Germany. The country's cultural and institutional traditions also seem to affect the level of corruption. This might as well apply to the Greek governance system, considering its clientelistic features with almost clan-like structures. Treisman (2000, 2007) describes a very robust relationship between economic development and the level of corruption. This can be found in most of the literature and it can be concluded that corruption goes along with lower GDP levels (Lambsdorff 2006; Mauro 1995; Treisman 2000, 2007). Yet, if any causalities (direct or indirect) exist, the direction of causation can hardly be identified. There are some interpretations about the influence of investment and the unequal distribution of income, but it can only be said with certainty that complex interdependencies exist. The development from a corrupt to a less corrupt country apparently goes slowly and depends on country specific structures. Within the European Union, the structural differences between the member states clearly have to be considered when it comes to individual levels of corruption. Lambsdorff (2006) describes a wide range of consequences of corruption. There exists strong evidence that corruption affects government expenditure and it seems very likely that corruption leads to a quality reduction of a wide range of government services, including public investment, health care, tax revenue and environmental control. The latter is of particular interest to me and will be dealt with in the next section.

2.2.3. Governance Quality and Sustainability Development

Within the research field of environmental and development economics, scholars provide a perspective on sustainable development that combines aspects of governance quality with dimensions of environmental sustainability. Most of these studies either use the World Governance Indicators to provide information about governance quality, or the Corruption Perceptions Index, since corruption is regarded as being representative for governance quality. The studies I considered deal with aspects such as environmental sustainability or sustainable development (Lambert 2014; Morse 2006), resource management (Robbins 2000), pollution levels (Welsch 2004) or the effects of corruption on environmental policies (Pellegrini and Reyer 2006). Morse (2006), who investigates the question if corruption is "bad" for environmental sustainability, stresses the fact that there are many assumed relationships but only few empirical analyses. He correlates the Environmental Sustainability Index provided by the World Economic Forum with the Corruption Perceptions Index and stresses that results need to be interpreted very carefully. Still, he finds a statistically significant relationship between corruption and environmental sustainability (Morse 2006:18). Robbins (2000) offers an outline of a theory of "natural resource corruption" (Robbins 2000:424) and investigates

the “enforcement of protection for a nature reserve” (Pellegrini 2011:79) in India. He concludes that a lack of law enforcement results from corrupt practices and that corruption is ecologically unsustainable, because it leads to habitat destruction. Welsch (2004) examines the relationship between corruption and pollution levels and finds that fighting corruption may reduce pollution particularly in low-income countries with high corruption rates (Welsch 2004:684). Pellegrini and Reyer (2006) focus on political commitment to the environment and on effects of democracy. They regard the poor environmental performance of autocratic systems, for instance in Asia, Latin-America or Eastern Europe, as evidence for the positive influence of democratic structures on environmental quality. Pellegrini (2011), who offers a good overview of studies that deal with the relation between democratic structure and the environment, concludes that a positive effect of democracy on environmental policy stringency can be found in most of the literature.

Another study conducted by Pellegrini (2011) investigates the implications of EU environmental policies and their implementation in EU member states. He focuses on new EU members which have lower environmental standards. He includes data about the EU Environmental Policy Stringency and finds that the corruption level across EU member states is the most important reason for the variance in differing environmental standards. He furthermore finds that countries with low income and high corruption levels have the least stringent environmental policies, which is mainly applicable for East and South European countries. He applies a regression analysis including the Environmental Regulatory Regime Index and the Corruption Perceptions Index and finds that if highly corrupt countries would improve their corruption level, it would also improve its performance with regard to environmental policy significantly (Pellegrini 2011:113–115).

3. Methods and Data

3.1. Material Flow Accounting and Analysis

Economy-wide material flow analysis and accounting (in short EW-MFA or MFA) aims at describing the interaction of the national economy with its natural environment and the rest-of-the-world economy. Its beginning was decisively influenced by two major publications by the World Resources Institute in the 1990s which contributed significantly to the awareness of this method (Adriaanse et al. 1997; Matthews et al. 2000). Material flow analysis and accounting is today regarded as one of the key methods within the field of quantitative environmental research, although being perceived as a fairly young discipline (Behrens et al. 2007; Fischer-Kowalski et al. 2011; Hinterberger, Giljum, and Hammer 2003). Standardization for economy-wide material flow accounting was for the first time achieved and published in a methodological guidebook by Eurostat, the European Statistical Office, in 2001. (Hinterberger et al. 2003) The Organization for Economic Cooperation and Development (OECD) also published a series of guidance documents on measuring material flows, the development of material flow accounts and related indicators (OECD 2008b). Eurostat updates its compilation guides on a regular basis. When calculating Greek material flows; I relied on the Eurostat’s “Economy Wide Material Flow Accounts: Compilation Guidelines” from 2013, which is a systematic and comprehensive conceptual framework that consists of accounting rules, definitions, and classifications (Eurostat 2013). MFA is based on the material balance principle, which means that the material input in a system, in my case the socioeconomic system of Greece, must equal outputs (in form of wastes and emissions) and net accumulation of materials. The latter refers to the system’s material compartments (stocks), which are built up and maintained by input flows. MFA is consistent with the principle and system boundaries of

national accounting. It accounts for material flows associated with the activities of all residents of a national economy (Eurostat 2013; Fischer-Kowalski and Hüttler 1999:115; Fischer-Kowalski et al. 2011:859; Hinterberger et al. 2003; Krausmann et al. 2015; OECD 2008b). Two types of material flows across system boundaries are relevant (see Figure 2): material flows between the national economy and the natural environment which consist of the extraction of primary material from and the disposal of materials to the natural environment. Material flows between a national economy and the rest-of-the-world-economy are considered, too, and encompass import and export flows (Eurostat 2013; Krausmann et al. 2015). Material inputs from the natural environment to the economy are called domestic extraction (DE). This refers to the extraction process that moves materials by humans or human-controlled means of technology and which are intended to be used in the economy.

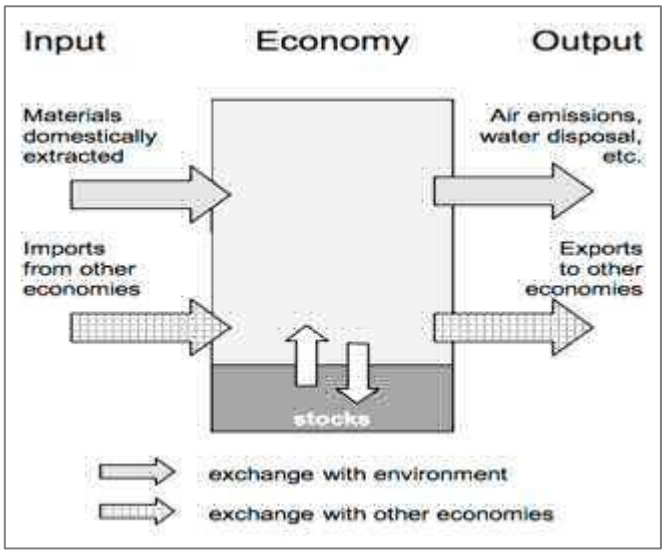

Figure 2 Scope of economy-wide MFA, Source: Krausmann et al 2015.

The MFA framework distinguishes between used and unused extraction. Used materials are defined as the amount of extracted resources entering the economic system for further processing or consumption (Eurostat 2013; Fischer-Kowalski et al. 2011:861). The term “used” refers to acquiring value within the economic system (Eurostat 2012:9; Krausmann et al. 2015). Air and water are excluded from the standard MFA indicators since they by far exceed all other flows by magnitude (Fischer-Kowalski et al. 2011:859). MFA focuses on flows of solid materials and thus compiles data on the following categories: biomass, metal ores, non-metallic minerals and fossil energy carriers. Material flows within the economy are considered as internal flow and not shown in MFA indicators. (Eurostat 2013; OECD 2008a)

Indicators representing environmental pressure traditionally focus on outflows. In contrast to that, material flow indicators have a stronger focus on input indicators, for which methods are further developed and empirical data are broadly available. In consistency with MFA principle, output flows are calculated too, namely material exports to other economies and outputs into the environment. Due to statistical reasons, exports can be calculated easily and they are complete and consistent. Outputs into the natural environment are included in terms of waste and emissions, but, in contrast to exports, statistical data is rarely complete in terms of mass balance (Fischer-Kowalski et al. 2011:861; Krausmann et al. 2015:12).

Commonly, MFA indicators focus on direct flows of used materials that is DE, imports and exports. Thereof derived indicators for representing the metabolic scale of a national

economy are domestic material consumption (DMC, calculated as DE + Imports – Exports), direct material input (DMI, calculated as DE + Imports), and physical trade balance (PTB, imports-exports). For international comparison, it is common to express annual national material flows in relation to the population size (DMC/cap*year). This indicator is known as metabolic rate, "the average amount of material associated with sustaining one individual during a year" (Fischer-Kowalski et al. 2011:861). Physical trade balances (PTBs) aim at explaining "the extent to which domestic material consumption is based on domestic resource extraction or depends on imports" (Fischer-Kowalski et al. 2011:861). Import and export data used in traditional MFA compilations do not consider so-called "hidden flows" or indirect flows, which refer to all materials required along a production chain to manufacture a product. Taking into account upstream material requirements (also termed raw material equivalents, RME) would make a significant difference when comparing results with traditional MFA indicators (Schaffartzik et al. 2013).

MFA indicators are derived from more detailed data sets and highly aggregated. They can be distinguished between extensive and intensive indicators: *Extensive* refers to the absolute value of a material flow. With intensive indicators information in relation to another quantity is provided (Krausmann et al. 2015:115–116). Material efficiency of an economy is an intensive indicator, relating DMC to economic data, usually gross domestic product (GDP). GDP per DMC is referred to as material productivity, the inverse of it is material intensity, defined as DMC to GDP (Krausmann et al. 2015:116).

3.1.1. Data and Sources

For data compilation, I followed the methodological procedure as it is recommended in the Eurostat EW-MFA compilation guide (Eurostat, 2013). For practical application, the guide provided by the Institute of Social Ecology in Vienna was consulted, too (Krausmann et al. 2015). For the material flow analysis of Greece I compiled the flows described in Section 3.1., that is domestic extraction used (DE), imports, exports, and calculated standard MFA indicators derived thereof (Eurostat, 2012). The unit of measurement is metric tonnes per year. Domestic extraction (DE) is aggregated to 42 categories on a detailed level and further aggregated to four main raw material categories: biomass, fossil energy carriers, metal ores, and non-metallic minerals.

Biomass comprises organic, non-fossil material of biological origin. Its DE includes all biomass of vegetable origin, extracted by humans and their livestock, fish capture, and the biomass of hunted animals (Eurostat 2012; Krausmann et al. 2015). The data used for the DE of biomass is taken from the Food and Agriculture Organization of the United Nations (FAO 2014). Total biomass extraction includes the amount of harvested primary crops, used fraction of crop residues, harvest of fodder crops, grazed biomass, wood extraction, fish capture and the amount resulting from hunting and gathering. Country specific harvest factors and recovery rates were used to estimate used crop residues (Krausmann et al. 2015:4). Detailed information about harvest factors and recovery rates are presented in the appendix (Table A1, A2). Data on grazed biomass is usually not reported in agricultural statistics which is why these numbers were estimated on the basis of livestock numbers and daily roughage requirements of different livestock species (Krausmann et al., 2009, p. 4, see also appendix Table A3).

Data on the extraction of fossil energy carriers were retrieved from the energy statistics provided by the International Energy Agency (IEA 2014a). IEA provides high-quality data which is usually very reliable (WU, SERI, and Dittrich 2014). I additionally consulted the United States

Geological Survey (USGS 2015) and the United Nations Industrial Commodity Production Statistics Database (UNICPS 2015). The data matched data reported by the IEA. Material flow accounts distinguish between brown coal, hard coal, petroleum, natural gas and peat. Extraction data about fossil energy carriers are provided in metric tonnes, with the exception of natural gas. Natural gas is reported in energy content (Joules) and had to be converted to metric tonnes by applying a general conversion factor. The factor applied is presented in the appendix (Table A4, Eurostat 2012:54).

Metal ores are distinguished in two sub-categories: iron ores and non-ferrous base metals. The latter is an aggregate of 9 sub-groups. Data for the calculation of the DE of metals was taken from the compilation of the Unites States Geological Survey (USGS 2015). MFA conventions require metals to be included in terms of their gross ore. This refers to the run-of-mine production. Run-of-mine production means that the total amount of extracted crude mineral that is submitted to the first processing step is counted (Eurostat 2012:33). Mining surveys mostly report metal production in metal content. In order to arrive at the amount of gross ore, ore grades were applied. Ore grades differ from country to country and from mining site to mining site. I derived information on ore grades from Greek mining companies and from the USGS minerals yearbook (2006). Specific ore grades and corresponding sources can be found in the appendix (Table A5). In the aggregation, it is furthermore considered that one ore (=the metal containing material) can contain more than one metal. Several metals might be located in and extracted from the same deposit. This so-called coupled production was considered when calculating the DE of metal ores.

In the material category non-metallic minerals, the DE of construction and industrial minerals were aggregated. Materials mainly used for construction activity are usually insufficiently represented in statistical sources, such as the United States Geological Survey (USGS 2014), the British Geological Survey (BGS 2014) and the United Nations Industrial Commodity Production Statistics Database (UNICPS 2014). Therefore, estimations were required: On the one hand, I estimated the extraction of construction minerals, such as sand and gravel, based on the apparent annual consumption of cement. On the other hand, the consumption of bitumen (used for asphalt production, IEA 2014b) was estimated by applying appropriate coefficients. The extraction of limestone was estimated based on the annual production of cement in Greece (see also appendix Table A6).

To capture Greek physical trade flows, I first and foremost used data from the United Nations Commodity Trade database (UN COMTRADE 2014). These were consistent with FAO data for trade with products from agriculture and forestry (FAO 2014) and with IEA data for trade with fossil energy carriers and derived products (IEA 2014a). Trade with metal ores and non-metallic minerals and products thereof was compiled from the UN COMTRADE database (2014). Additional data was provided by Comext (2014). For some years and commodities, no physical trade data was available. When monetary data was available for corresponding years, physical values were estimated via average prices of adjacent years (see also appendix Table A8, A9).

With domestic extraction (DE), physical imports and exports, I could calculate the indicators domestic material consumption (DMC) and physical trade balance (PTB). DMC is the domestic extraction plus physical imports minus physical exports and is also termed material use in the text. PTB is calculated as physical imports minus physical exports and provides information whether Greece is a net-importer or a net-exporter of materials and goods.

I used population data by Eurostat (2015a) to calculate metabolic rates, which is the amount of materials used per capita and year (Krausmann et al. 2009, 12). Metabolic rates are the most common way to compare material consumption between different countries. Population data is presented in the appendix (Table A25).

I furthermore used economic data (gross domestic product, GDP measured in 2005 chain-linked volumes), provided by Eurostat for the years 1995 until 2012 (2015b) and the National Accounts Section of the United Nations Statistics Division for the year 1970 until 1994 (UNSTATS 2015), to calculate material productivity (GDP per unit of DMC). GDP data can also be found in the appendix (Table A26).

3.1.2. Comparison of Sources

Material flow analysis and accounting is a well-established method. A study analyzing the state of the art of MFA and the reliability across different sources conducted by Fischer-Kowalski et al (2011) show that, apart from some uncertainties, global MFA data can be regarded as reliable. As mentioned above, I first and foremost relied on the Eurostat EW-MFA compilation guide (Eurostat, 2013). For practical application, I also consulted the guide provided by the Institute of Social Ecology in Vienna (Krausmann et al. 2015). I compiled Greek material flows for the years 1970 to 2012. With my data compilation I add to the existing MFA material which is available only for shorter periods of time. MFA data by Eurostat (Eurostat 2015c) is publicly available for the period between 2000 and 2012. For contextualizing my own calculation and the data provided by Eurostat, I included another MFA database, namely the global material flow database, which provides MFA data for the years 1980 to 2011. Authors of the global material flow database are the Sustainable European Research Institute (SERI) in Vienna and the Vienna University of Economics and Business (WU), in cooperation with the Institute for Energy and Environmental Research (IFEU) in Heidelberg, the Wuppertal Institute and the Austrian Ministry for the Environment (WU, Dittrich and SERI 2014). The global material flow database follows the standards of economy-wide material flow accounting as provided by Eurostat and the OECD (WU et al. 2014).

A comparison of the different data compilations reveals differing results for Greece. . Figure 3 shows DE derived from the different sources, disaggregated into four main material categories. Having a closer look at the data, the following differences occur: DE of fossil energy carriers shows the most consistent trajectory as well as similar quantities in all three compilations. The IEA database (from which data for the compilation of fossil energy carriers was extracted) is considered being the most comprehensive and high quality data source (WU et al. 2014). When comparing my own calculation with data from the global material flow database and Eurostat data, the material categories ores and biomass show a similar trajectory. In both material categories, however, Eurostat data deviates in terms of quantity. DE of metal ores provided by the Eurostat database exceeds my own calculation. The most significant difference can be observed for the material category non-metallic minerals. Here, data uncertainties are usually highest because data of very different quality are used (Weisz et al. 2006:688; WU et al. 2014:19). Differences in terms of quantities and regarding the trajectory are mainly due to the material category sand and gravel. In statistics, sand and gravel are often either not adequately reported or underestimated. Therefore, sand and gravel had to be estimated in order to be included in the MFA compilation. The procedure I conducted required the estimation of the sand and gravel used for the concrete production as well as the sand and gravel used in asphalt production. These uses make up for most of the sand and gravel used. For estimating sand and gravel required for concrete production, a

coefficient provided by the Portland Cement Association (Krausmann et al. 2015, 58) was included. Data about cement consumption was derived from the European Cement Association (Krausmann et al. 2015, 58). Asphalt production is crucial for any infrastructure projects and construction activities, thus information about sand and gravel used in these activities is important, too. Data about bitumen consumption was derived from the IEA database (IEA 2014).

Although the methodological procedure in the three data compilations is consistent, the use of different primary databases and in particular the inclusion of data provided by CEMBUREAU (1998) is decisive for the deviating MFA results. Data used in the comparison of sources is included in the appendix (see Table A19).

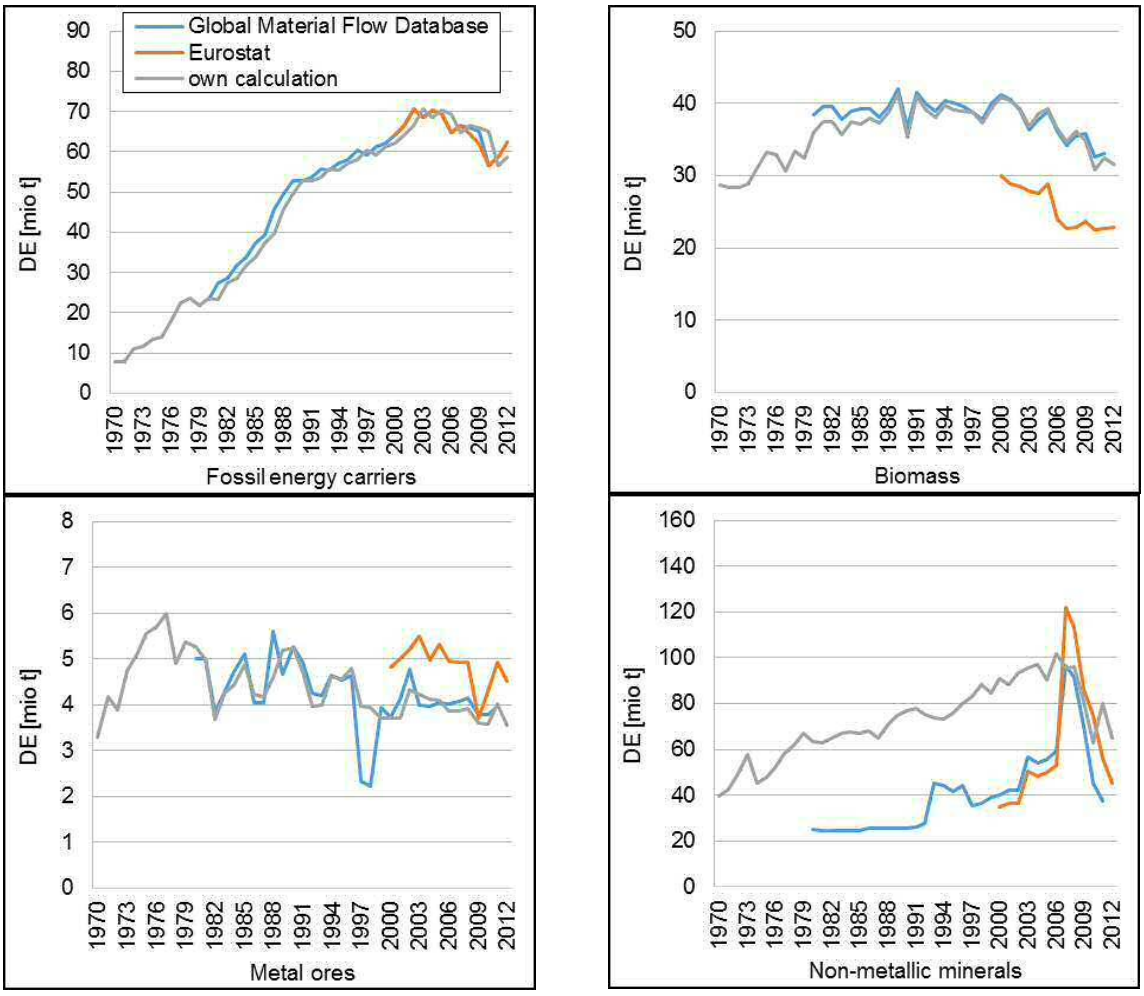

Figure 3 Comparison DE of individual material groups 1970-2012; Source: Eurostat 2015, WU, Dittrich and SERI (2014), own calculation

3.2. Governance Indicators

The following section describes the data used to assess Greek governance quality. The datasets I relied on represent different aspects of governance quality. The databases have more or less been long established and discussed lively within the scientific community, pointing out their potential uses and limitations (Bovaird and Löffler 2003; Kaufmann and Kraay 2007). The indicators were selected because they are easily accessible and they are available in time series. Governance quality data are also included in the appendix (Table A27, A28).

3.2.1. World Governance Indicators

The World Governance Indicators (WGI) are a well-known dataset that was launched by the World Bank Development Research Group in 1996 (Kaufmann et al. 2011; Kaufmann and Kraay 2007; Kaufmann 2009). Authors define governance as

> *"the traditions and institutions by which authority in a country is exercised. This includes (a) the process by which governments are selected, monitored and replaced; (b) the capacity of the government to effectively formulate and implement sound policies; and (c) the respect of citizens and the state for the institutions that govern economic and social interactions among them"* (Kaufmann et al. 2011:4).

Authors emphasize that there is no single definition of governance and hence no strong consensus about institutional quality (Kaufmann et al. 2011:3). They also point out limitations of the indicators as they naturally reflect the difficulty of measuring something as complicated and multifaceted as governance. They argue, however, that appropriate considerations of margins of error make it feasible to measure and compare governance across countries and over time (Kaufmann 2009:24). Changes in governance performance have to be taken into account carefully, since this might also be due to the number of underlying sources and hence be a statistical phenomenon and not a real development. The WGI are based on perceptions-based measures of governance, taken from 31 different sources. The sources are surveys of households and firms as well as expert assessments produced by governmental and non-governmental organizations. The authors argue that perceptions-based data have a particular value in measuring governance. Certain dimensions of governance cannot be captured by purely objective measures, e.g. corruption. It is stressed that "agents base their decisions and activities on the perception they have from governance in a country" (Kaufmann et al. 2011:18). This is what makes perceptions-based data important. The weakness of perceptions-based data is that it can be imprecise because it represents a subjective view. This also includes that respondents differ in their perception of the same underlying reality, depending on the position they hold. An interesting aspect the authors mention is the "halo-effect", with which they refer to the subjective perception of governance that might be driven by other factors than governance itself. Respondents might conclude, for instance, that governance must be good when economy is growing fast or the country is rich. The authors refer to their own research and argue that this conclusion does not withstand empirical scrutiny (Kaufmann et al. 2011:18–19).

The aggregate WGI are reported in two ways: in the standard unit of the governance indicator, ranging from –2.5 to 2.5, and in percentile rank terms ranging from 0 (lowest) to 100 (highest). The latter is applied when countries are compared. Data is available from 1996 until 2013, covering more than 200 countries (Kaufmann et al. 2011; Kaufmann 2009). The definition the authors provide for governance already gives a clue about what dimensions aggregated indicators are supposed to cover. The authors distinguish between two measures for each of the above mentioned areas, resulting in six dimensions of governance:

1. *The process by which governments are selected, monitored, and replaced:*

Voice and Accountability (VA) – capturing perceptions of the extent to which a country's citizens are able to participate in selecting their government, as well as freedom of expression, freedom of association, and a free media.

Political Stability and Absence of Violence/Terrorism (PV) – capturing perceptions of the likelihood that the government will be destabilized or overthrown by unconstitutional or violent means, including politically-motivated violence and terrorism.

2. *The capacity of the government to effectively formulate and implement sound policies*

Government Effectiveness (GE) – capturing perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies.

Regulatory Quality (RQ) – capturing perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development.

3. *The respect of citizens and the state for the institutions that govern economic and social interactions among them*

Rule of Law (RL) – capturing perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence.

Control of Corruption (CC) – capturing perceptions of the extent to which public power is exercised for private gain, including all forms of corruption, as well as "capture" of the state by elites and private interests. (Kaufmann et al. 2011:4)

3.2.2. Corruption Perceptions Index

What is meant by corruption ranges from very narrow definitions to the notion, that the meaning of corruption is widely understood and doesn't require further explanation (Wang and Rosenau 2001). I will follow Lambsdorff (1999), the lead author of the Transparency International Corruption Perceptions Index. Relying on different sources, this definition is relatively broad and captures corruption as "the misuse of public power for private benefits, e.g., bribing of public officials, kickbacks in public procurement, or embezzlement of public funds" (Lambsdorff 1999). He argues that corruption can come in different forms and degrees, and is perceived differently depending on the country. Regarding my research question and because I will rely on the Transparency International data for corruption, I consider this broad definition as useful. Corruption however remains a complex human behavior that is notoriously difficult to measure because its very nature makes it opaque (Morse 2006). The Corruption Perceptions Index (CPI) by Transparency International is the most widely known governance index (Bovaird and Löffler 2003:323). It is an aggregate indicator that ranks countries in term of the degree to which corruption is perceived to exist among public officials

and politicians. It is a composite index relying on data from different institutions. Authors argue that using an aggregate index based on a variety of sources, increases its reliability (Transparency International 2010). CPI data is based on two different types of sources: business people opinion surveys and assessments of a country's performance provided by a group of analysts. All sources intend to measure the misuse of public power for private benefit. Data provided from the sources are averaged by country and standardized, before entering CPI. Only countries assessed by three or more sources are included in the CPI and confidence intervals are provided to indicate the reliability of the CPI scores. The data is reported in two ways: first a score indicates the perceived level of public sector corruption on a scale of 0-1 (0=highly corrupt, 1=very clean); second a country's rank indicates its position relative to other countries included in the index. The country with the lowest score is the one where public sector corruption is perceived to be greatest among those included in the list (Transparency International 2010).

3.3. Correlation Analysis

The correlation analysis was chosen to assess the research questions in a quantitative manner. This also required a sufficiently large data sample which is why I extended the data scope and took EU wide data into account, aiming for uncovering patterns regarding the relationship between resource use and governance quality on EU level. It is acknowledged that each individual country within the EU has its own specific history, socioeconomic system and resource endowment. Still, since countries are situated in a similar political framework with rules applying more or less equally across them, the inclusion of this data enables a contextualization and sound interpretation of Greek results.

A correlation analysis is a commonly used method to investigate a linear relationship between two quantitative, continuous variables. (Bortz 2005; Krämer 1998). I included data about governance quality, data from the biophysical system, and data about the socioeconomic system. **Fehler! Verweisquelle konnte nicht gefunden werden.** in section 3.3.1. gives an overview of the variables included in the analysis and the corresponding sources.

3.3.1. Data and Sources

Fehler! Verweisquelle konnte nicht gefunden werden. shows the included variables and the corresponding data base. The descriptive statistics of the correlation analysis are included in the appendix (Table A29).

Table 1 Variables and corresponding sources included in the correlation analysis

Variables representing Resource Use	Source	Variables representing Governance Quality	Source	Economic Variables	Source
Resource productivity (measured as GDP/DMC in EUR/tons)	GDP: Eurostat, 2015b, DMC: WU, Dittrich and SERI, 2014. Global Material Flows Database, Greece: own calculation	Aggregate of World Governance Indicators representing "the process by which governments are selected, monitored, and replaced" = WGI1 governance dimensions: Voice and Accountability and Political Stability and Absence of Violence/Terrorism	The World Bank Group, 2015	National income measured as Gross domestic product per capita (GDP per capita in EUR/cap)	GDP: Eurostat, 2015b, Population: Eurostat, 2015a
Domestic material consumption per capita (DMC/cap in tons/cap)	DMC: WU, Dittrich and SERI, 2014. Global Material Flows Database, Greece: own calculation, Eurostat, 2015a	Aggregate of World Governance Indicators representing the "capacity of the government to effectively formulate and implement sound policies" = WGI2 governance dimensions: Government Effectiveness and Regulatory Quality	The World Bank Group, 2015		
		Aggregate of World Governance Indicators representing the "respect of citizens and the state for the institutions that govern economic and social interactions among them" = WGI3 governance dimensions: Rule of Law and Control of Corruption	The World Bank Group, 2015		
		Corruption Perceptions Index	Transparency International, 2015a		

4. Socioeconomic Development and Governance Quality in Greece

In the light of the concept of social metabolism it is of decisive importance to understand the interactions between society and its material environment (Fischer-Kowalski and Haberl 2007). Before immersing deeply into Greek material characteristics, it is imperative to understand Greek socioeconomic development, its political history as well as its particularities. The following section is therefore first concerned with Greek recent history. In the second part of the chapter, Greek governance quality is described in depth. Figure 4 provides an overview of Greek history since the early 19th century, beginning with the Greek War of Independence from the Ottoman Empire in 1821. In the following section I will then focus on Greek development during the second half of the twentieth century.

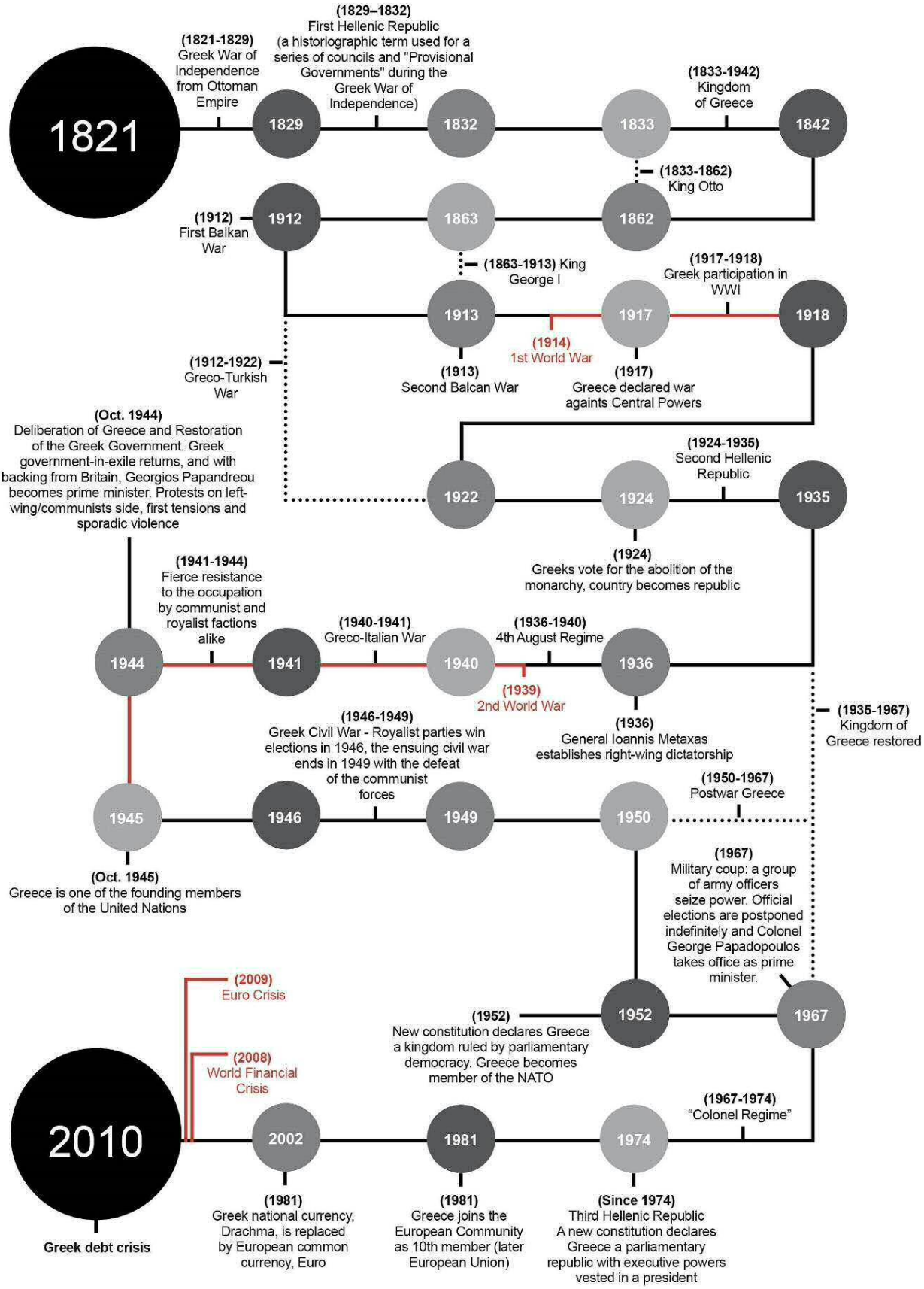

Figure 4 Timeline of Greek history, 1821-2010

As most European countries, Greece has experienced different regimes of governments since the early 19th century. After a back and forth between monarchy, two periods of democratic regimes, as well as autocratic regimes, Greece has established a liberal and pluralistic democracy system with fully inclusive institutions in 1974 (Pappas 2013:31). This happened after the breakdown of the so-called "colonel regime", a military dictatorship that lasted from 1967 until 1974. Since 1974, the Greek political leadership has aimed for a full membership in the European Community. The membership was regarded as a lasting measure to protect the country's re-established democratic institutions and as stimulus for economic development (Karamouzi 2013:19). The then Prime Minister Konstantin Karamanlis was ambitious to reinforce international relations with Western Europe, also because of Greece's conflictual situation with its neighboring country Turkey (Clogg 2013:174). Since signing the Athens Agreement in 1961, Greece has enjoyed a status as Associate Member of the European Community. This however was suspended after the military coup of 1967 that heralded the above mentioned colonel regime, a period of diplomatic isolation. After the dictatorship was overthrown in 1974, Greece was readmitted to the Council of Europe with the opportunity to participate the European Community in 1984. (Clogg 2013; CVCE 2011) Karamanlis however was determined to speed up the process. Under his political guidance, Greece succeeded in becoming a member of the EU only shortly after the establishment of the Greek republic. The European Commission in Brussels, although aware of the political significance of this enlargement, was hesitating regarding the country's economic stability and its ability to withstand the competition of the European market, considering Greece's lagging-behind in economy compared with the nine more industrialized nations that then made up the European Economic Community. Greece's application for accession was examined critically. Karamanlis yet convinced the European Council and the treaty of full membership was signed on January 1st in 1981 (Clogg 2013:174). Greek government as well as EU leadership hoped that the country would benefit economically from the integration and rapidly improve in its economic performance. The EU membership was regarded as an external stimulus needed for advancing economic, social and political modernization (Ioakimidis 2000:74). For the first decade, however, these expectations could not be fully achieved. The early 1980s financial crisis, the 2nd oil crisis and the ongoing conflictual situation with its neighboring country Turkey damped economic development in Greece. These difficulties become empirically apparent when consulting the indicator Gross Domestic Product (GDP) which is commonly used to represent economic development: GDP increased only slowly in the first decade of EU membership. These years are also characterized by periods of economic recession. GDP amounts to 117 billion EUR in 1981 increasing to 121 billion EUR in 1989, indicating a growth rate of 3.2%. (Eurostat 2015b) By the time of EU accession one salient feature of Greece was the gigantic size of the state apparatus and the "over-centralized nature of the state and the political system in general" (Ioakimidis 2000:76). The Greek state occupied a hegemonic position in every aspect of society and the country was governed by a clientelistic political elite. Ioakimidis (2000:76) names characteristics of the Greek state by 1981 such as the overemployment in the public sector or the high amount of public expenditure. The state was intensively involved in most areas of Greek society and a tight controller of the Greek economic activity. In the beginning of the 1980s, the state was regarded as the greatest entrepreneur and employer which was a result of a huge state expansion process during the 1970s. The Greek state controlled an unspecified number of businesses in practically all areas of economic activity (Ioakimidis 2000:78). These peculiarities of the Greek political culture also can be found in other South-European countries such as Spain, Italy or Portugal. In literature different possible explanations are offered: Sotiropoulos (2007) describes one characteristic

of a modern state as the engagement of state authorities only in those actions in society which are set out in law. In clientelistic states he detects that this leads to an over-production of laws and regulations to maintain the states scope of action. According to Sotiropoulos (2007:414–415), this could be observed in all South-European countries in recent decades. The result is a vast and inflexible legal framework, thus a bureaucratic apparatus characterized by inefficient and cumbersome administrative processes. The regulations imposed on Greece after EU accession in 1981 included requirements regarding the state's size and the associated public expenditures. Until at least the mid-1980s, Greece did not meet these conditions and also economic expectations could not be fulfilled entirely. This resulted in uncontrollable public deficits, rapidly rising public debt and a bloated public administration with a steadily increasing number of employees in the public sector. After 1985, Greece was asking for EU assistance in order to get a grip on these issues. Political and economic stability hence could be fostered by a tough reform program. The program involved a drastic reduction in public deficits, expenditure and employment as well as the curtailment of the gigantic size of the Greek state (Ioakimidis 2000:81).

4.1. Process of Europeanization and the Way into Crisis

The process of Europeanization plays a crucial role within Greek development. Europeanization can be described as the process of how EU membership or prospective membership influences the society, the economy and the political systems in general (Ioakimidis 2000). It demands opening up the structures of the traditional nation state towards rules originating from the supranational EU-level. Paraskevopoulos describes Europeanization as an "independent variable that crucially affects and challenges well-established structures within the domestic systems of governance and plays an important role in the administrative restructuring and devolution processes" (Paraskevopoulos 2005:446) of prospective member states. It is experienced differently by each country depending on factors such as the specific state formation, the patterns of policy-making, the political culture, as well as the balance of power between state and society. It is often associated with modernization, but meanings are differing and the concept actually refers to a wide variety of processes. (Paraskevopoulos 2005) In Greece, the process of Europeanization had a particular intense impact (Ioakimidis 2000:73): In terms of political development, it first and foremost meant the development of a dynamic process of rebalancing relations between the Greek state and society in favor of the latter. The boundary between state and society has been changing in the direction of limiting the scope of the state and widening that of the society (Ioakimidis 2000:79). In terms of economic development, the structural and cohesion policy and fund which were inaugurated in 1985 was an important component of EU's integration process. Greece was the major beneficiary of this funding (Featherstone, Kazamias, and Papadimitriou 2000:406). The cohesion and structural policy had two basic parts, one with development priorities on a national level (big infrastructure projects financed by the cohesion fund) and one composed of 13 regional development programs specifically tailored for the regions' needs (Ioakimidis 2000:87–90). This has entailed a very substantial financial dependency of the Greek state on EU aid schemes as these are crucial to all new large-scale infrastructural projects. Another drastic intervention in the Greek political and economic situation came in 1994 with the Maastricht treaty and the "convergence criteria". The key aim of the "Treaty on European Union", also known as the Maastricht Treaty, was to create the European single market, strengthen economic and social cohesion and establish the economic and monetary union (EMU) (European Comission 1992:Article B). The convergence criteria were required to be met by member states that wanted to join the EMU. In Greece this required a reduction of public

deficits to 3 % of GDP, a reduction of inflation and a radical reform of the Greek public finances (Ioakimidis 2000:80). The years ahead of the Maastricht Treaty were marked by reforms and austerity measures as the country was ambitious to meet convergence criteria and join the EMU (Featherstone 1998:26). Greece succeeded and started fostering its economic stability. In 1994, the time of the implementation of the Maastricht Treaty, Greece was one of the poorest nations in Europe (Clogg 2013:212). After signing the Maastricht Treaty, Greece finally entered a phase of economic growth. Greek political leadership managed to reduce public debt and expenditure which entailed a radical reduction in the size of the Greek state and a thorough redefinition of the state's economic role (Ioakimidis 2000:87–90). It also involved a shift of power away from the Greek state to market actors which was accompanied by deregulation mechanisms and privatization. The opening up of a "home market previously based on heavy-handed protection and control to the international market" led to a flooding of the Greek domestic market by international suppliers (Featherstone 1998:36–38). The interplay of these different developments during the 1980s and 1990s finally led the country on a pathway to the "inner core of the European Union" (Verney 2014:21). The integration in the Eurozone and the adaption of the new currency in 2002 supported Greece in its rise as a seemingly prosperous nation until 2008. Greece was nevertheless rated among chronic deficit-inducing countries, such as Portugal, Spain and Italy (Varoufakis 2011:196) and showed even a double deficit, namely a trade deficit, too. This means that Greek imports exceed its exports which leads to a negative trade balance. The mechanism to compensate for a trade deficit and to stabilize the national economy is a currency devaluation. The double deficit thus became a problem when Greece entered the Eurozone and adopted the new common European currency. The then missing mechanism of devaluation led to a debt explosion. With the adoption of the Euro a time of rising living standards and consumerism commenced, but it was accompanied by an expansion of cheap credits that financed these achievements (Ioakimidis 2000; Verney 2014): Consumerism exploded, but debt did too (Schrader and Laaser 2010:542). In 2008, when the financial crisis was shaking the global economy in its very foundations, the Greek growth trajectory was brought to a halt. The process of Europeanization, which was also regarded as a process of modernization and a driving force in Greek development, had in many dimensions been apparently rather cosmetic than structural. During the financial crisis, it became obvious that the distance between formal adaptation to EU rules and procedures on the one hand and informal practices on the other has been retained in Greece (Sotiropoulos 2007:418): The huge amount of debt, , an inefficient tax system, balance sheet frauds and an under-resourced and corrupt political system were crucial determinants for the downturn of the country's economy (Clogg 2013:251). In October 2009 the Greek government announced that the deficit was in excess of 12% of GDP rather than the projected 6.5%, which already exceeds twice the Maastricht limit of 3% (Varoufakis 2011:206). Against this backdrop, rating agencies downgraded Greece's status by the end of 2009 (Featherstone 2011:199–200). Debt accounted for almost 100% of Greece's GDP between 1992 and 2009 and increased to 145% in 2011 (European Commission/Eurobank cit. after Featherstone, 2011, p. 204). GDP declined from 201 billion EUR in 2008 to 167 billion EUR in 2012, indicating an aggregate negative growth rate of -20%. The Eurozone in general was hit hardly by the crisis of 2008 and Greece was the most vulnerable member state. Although Greece has been temporarily rescued from default by a series of massive European and IMF bail-outs, which included painful austerity measures, today it still struggles to recover from recession. This led to an unstable political environment which finally brought about government turnover. The incapability of the long-established system to deal with the crisis was followed by the erosion of social trust: the legitimation of the political system which

preceded the crisis was questioned. (Sotiropoulos 2015; Verney 2014) The "meltdown of the party system" (2014:19) in Greece, as it was described by Verney after the elections in 2010, and the inability to get grips on these issues suggest considering governance quality not only in Greece but also in the European Union. European economic policy and unequal conditions and measures to meet the crisis seem to have led to a hopeless situation with needs on different sides. Considering the focus of my research, I will not concentrate on the "EU side" but immerse into characteristics of Greek governance quality.

4.2. Governance Quality in Greece

Certain characteristics such as a lack of transparency, an inflated state apparatus, poor intra-governmental coordination, weak efficiency, lacking resources and clientelistic and corrupt practices had been stressed regarding Greek governance quality. (Featherstone 2011) These characteristics, but also the structural embedding in the Eurozone, were crucial determinants for the Greek downturn after the global financial crisis and the following Euro crisis. The years in which Greek had been in crisis revealed economic difficulties that went deeper than in any other European country. The Organization for Economic Development (OECD) observed that "difficulties have been brewing for years, so when the crisis came, Greece was significantly more exposed than others (…)" (OECD n.d.). The Greek economy has been growing during the last two decades and Greece seemed to be on a road to success since accessing the Eurozone in 2001, yet the country's prosperity was fragile and largely build on debt. The severity of the fiscal crisis in Greece exhibits the weakness of the Greek government and the poor governance quality. Featherstone (2011) detects an endemic weakness of the state and the incapability of reforming and restructuring its institutions. Successive governments, incapable of establishing reforms, failed to overcome problems which made the country highly prone to external forces. The debt crisis thus has also revealed a crisis of governance in Greece (Popescu 2012:345). Governance quality is a complex concept which characteristics differ in each country depending on national peculiarities. Greek developments seem shaped by the influence of a clientelistic political elite including issues of transparency and corruption. In recent years, there have been many attempts to measure governance quality. The indicators developed are diverse and it is lively discussed in which context their application is most reasonable. The discussion about the difficulty of quantifying governance quality and the application of the indicators was outlined in section 2.1.1. The following section will focus on indicators that provide information on governance quality in Greece.

Quantitative assessment of Greek Governance Quality

Greek governance quality was assessed by including the World Governance Indicators (WGI) of the World Bank Group and the Corruption Perceptions Index (CPI) of Transparency International.

World Governance Indicators for Greece

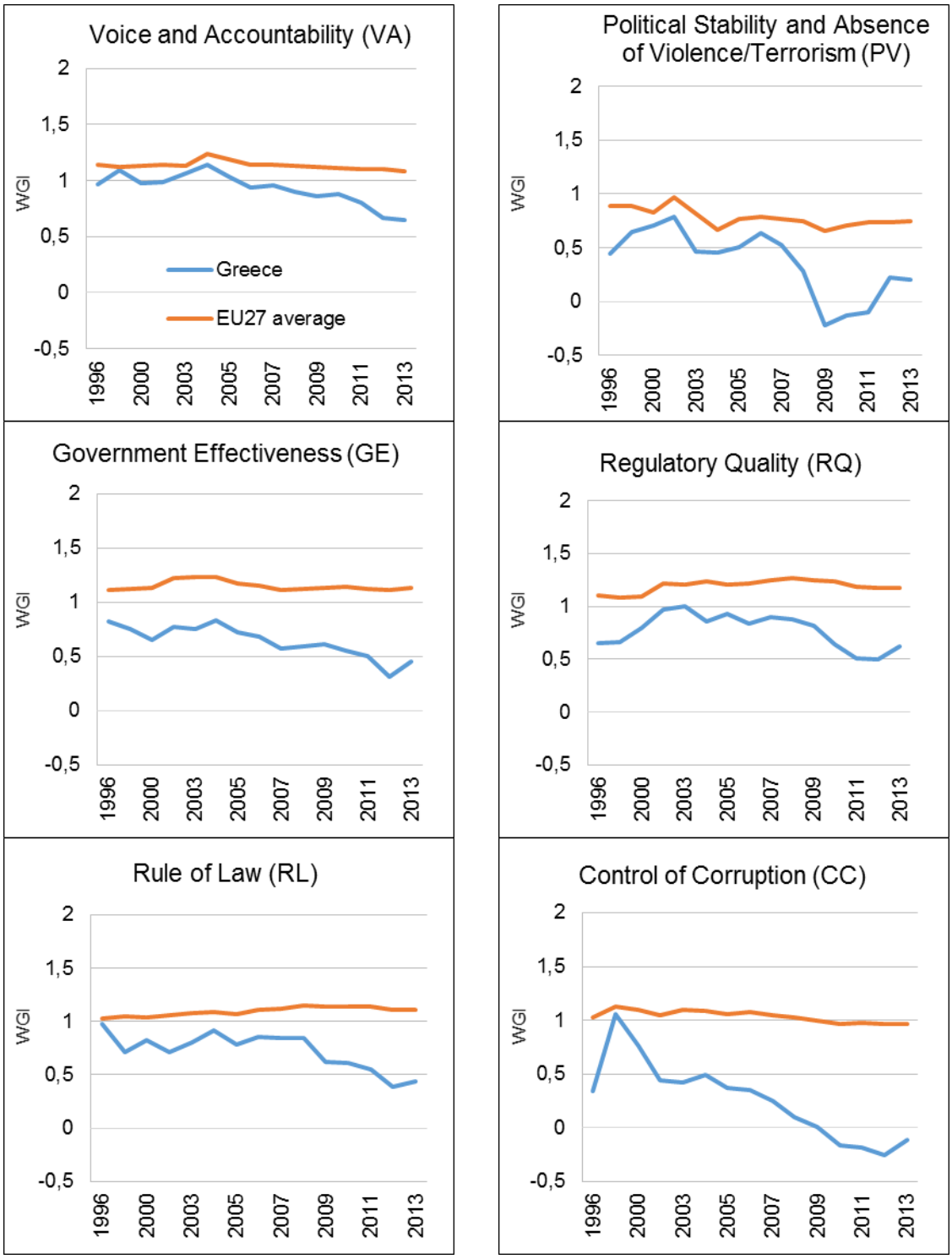

Figure 5 Comparison World Governance Indicators for Greece and EU27 countries. Source: The World Bank Group, 2015

WGI for Greece are available from 1995 to 2013 and are reported in the standard unit of the governance indicator, ranging from –2.5 to 2.5. In Figure 5, Greek WGI data is compared with EU-average. Data for the EU27 (excl. Luxemburg) countries are included. Authors of the dataset stress that changes in governance over short year-to-year periods are difficult to measure. In general, it can be observed that Greek governance quality lies significantly below EU-average in each category (see Figure 5).

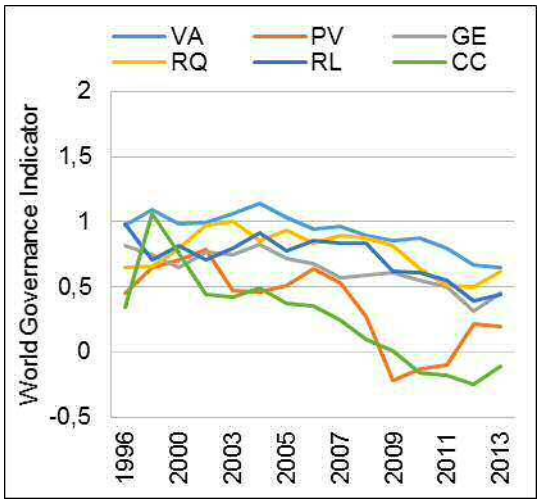

Figure 6 World Governance Indicator dimensions for Greece, Source: The World Bank Group, 2015

Figure 6 reveals that Greek governance dimensions follow a declining trend. It can be observed that all governance categories show a rather constant development between 1996 and 2007, apart from control of corruption (CC) which shows a more or less constant decline since 1998. After 2008 all categories start deteriorating, some more than others. Political stability (PV) and control of corruption (CC) show a significant drop after 2007 which can be associated with the overall economic and political situation as a consequence of the global financial crisis. Kaasa (2013), also relying on WGI data, analyzes governance quality in the EU-27 countries between 1996 and 2010. She finds that governance quality declined particularly in Spain, Greece and Italy, but not so much in Central- and Eastern Europe during the same period of time

Corruption Perceptions Index for Greece

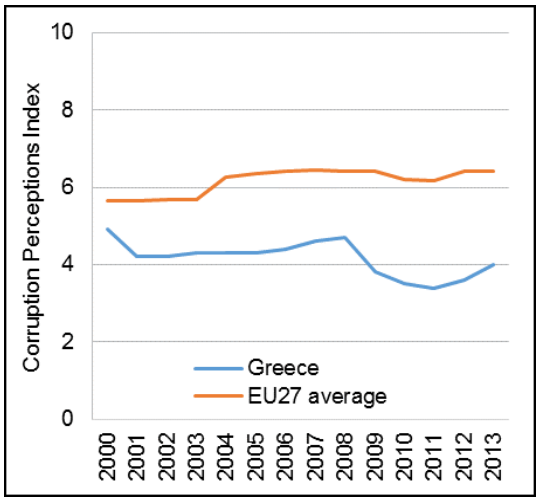

Figure 7 Comparison Corruption Perceptions Index Greece - EU27, Source: Transparency International, 2015a

The Corruption Perceptions Index published by Transparency International in 2015 (2015b) shows that the CPI in Greece is clearly below EU average (see Figure 7). . In cross-country comparison Greece ranks between score 35 (from 90 countries) in 2000 and score 94 (from 174 countries) in 2012. According to Transparency International, the main reason for the country's CPI scoring is the lack of transparency in the public sector. This includes in particular

bribery which occurs and tends to go unpunished, and missing transparency in public procurement. According to Transparency International, another explanation for the Greek CPI score is the prevalent tax control system, which enables bribery and tax evasion. The business sector's complex legal environment, excessive bureaucracy and frequent policy changes create also an atmosphere beneficial for corruption. Moreover, companies not listed at Athens Stock Exchange operate in a state of almost complete opacity and without reasonable corporate governance (Transparency International, 2015b). Since 2010 and after several scandals including the balance sheet fraud mentioned in the previous section (4.1.1.), national decisions are required to be published on a public database to increase transparency. Since 2011, an independent body reinforces tax authority's efficiency. CPI clearly indicates that Greek governance performance deteriorates right after 2008. One reason, amongst others, was the revelation that Greek fiscal data was not reported correctly to the EU. Governance quality improves after 2010 because reforms were established. Improvements especially in the field of corruption in recent years were also due to the Greek anti-corruption policy adopted in 2013 (Transparency International, 2015c).

5. Results

In this section, Greek metabolism is described and Greek resource use trends and corresponding determinants are identified. The complete data series for the results of the material flow analysis is included in the appendix (Table A10-A18). I first give an overview of Greek material extraction (DE) and consumption (DMC) on an aggregated level. In section 5.1.4 I describe the individual material categories in further detail. In the second part of this section, the results of the correlation analysis are presented. By correlating governance quality indicators, namely the World Governance Indicators and the Corruption Perceptions Index, with indicators providing information about biophysical and socioeconomic development, potential relationships can be identified.

5.1. Greek Metabolic Profile

5.1.1. Domestic Extraction

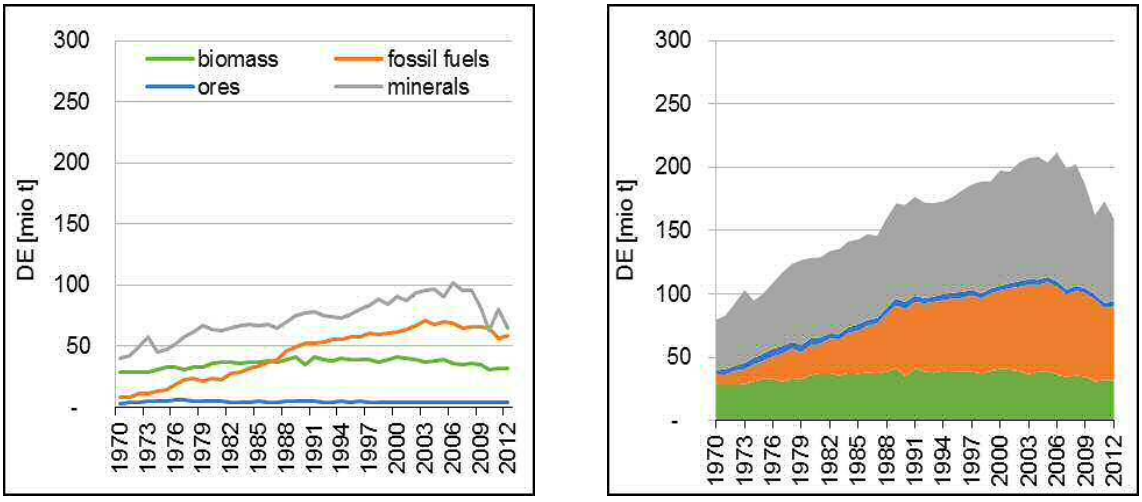

Figure 8 DE in million tonnes, 1970-2012, Source: own calculation

Figure 8 shows Greek material extraction which increased significantly over the observed period of time: from 80 million tons in 1970 to 212 million tons in 2006, before it declined again. This corresponds with a growth rate of 260% between 1970 and 2006. Biomass extraction shows the most constant development in comparison with other material

categories. The DE accounted for 29 million tons in 1970 and for 32 million tons in 2012. Fossil energy carriers are, besides non-metallic minerals, the most important material category and the one that grew the most. In 1970, 7.9 million tons of fossil energy carriers were extracted. The peak of extraction was reached in 2003 (71 million tons) and in 2012 it amounted in 58.8 million tons. Greek mining industry is small but significant, because of the country's vast mineral resources. Most important ores extracted are bauxite and iron ore. Extraction however peaked in 1977 and has been declining since then. Non-metallic minerals are the most important material flows by weight with gravel and sand to rank first, followed by limestone. The DE of non-metallic minerals increased from 39.7 million tons in 1970 to 65 million tons in 2012, but reached a peak of 101.7 million tons in 2006. After 2008, the DE dropped by almost a third within only four years. Individual material categories are described in further detail in chapter 5.1.4.

For contextualizing Greek growth in DE, I conducted a comparison with other EU member states (Figure 9). Data for the EU comparison is included in the appendix (Table A20). Data for comparison of countries was available from 1980 to 2010 (WU, Dittrich and SERI, 2014). The indexed presentation in Figure 9 allows a comparison of DE growth rates. It shows that Greece ranks among the countries with higher DE growth rates, only Spain and Portugal indicate a steeper increase. Apart from Spain, Portugal and Greece, Ireland and Denmark also rank among the EU countries with the highest growth rates. In the presentation, these countries are emphasized in color. Most of the European countries show a considerable decline of DE after 2008, which is a result of the global financial crisis. In Greece, after the economic crisis in 2008 and four years of economic recession, DE dropped by 80% and amounts at 160 million tons in 2012.

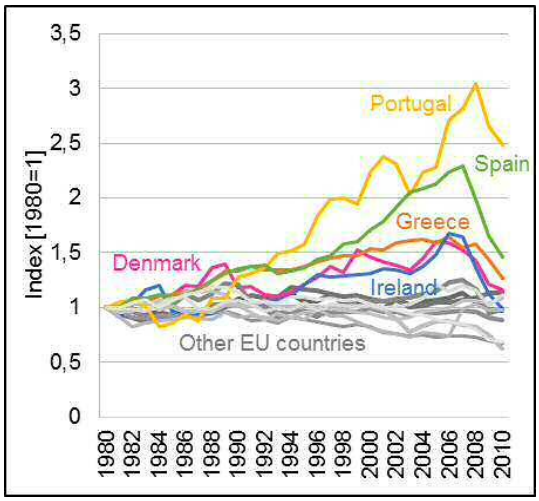

Figure 9 Comparison of DE growth rates for EU27, 1980=1, 1980-2010; Source: EU27 countries (except from Luxembourg and Greece): materialflows.net; Greece: own calculation

5.1.2. Domestic Material Consumption

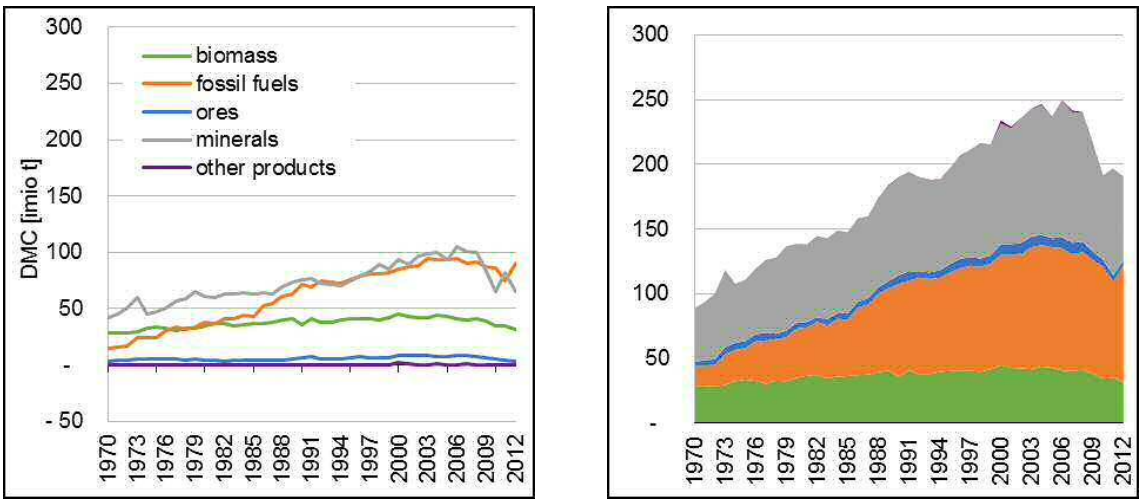

Figure 10 DMC in million tons, 1970-2012, Source: own calculation

The indicator DMC measures the annual amount of raw materials extracted from the domestic territory plus physical imports minus physical exports and represents the apparent material consumption in Greece. Greek DMC (Figure 10) increased from 89 million tons in 1970 to 250 million tons in 2006, indicating a growth of 180%. Between 2006 and 2012, DMC declined by 25%. Greek DMC is dominated by fossil energy carriers and non-metallic minerals. Fossil energy carriers register an average annual growth rate of 7%. Fossil energy use increased constantly, apart from a slight decline in the early 1980s due to the second oil crisis. In Greece, lignite is the most important fossil energy carrier in terms of extraction as well as consumption. It is almost exclusively used for electricity production. It can be observed that during the 1990s, other sources for electricity production became relevant too, such as gas, hydro or wind power (Figure 12). I included data about final electricity consumption in order to find out which sector uses most of Greek lignite resources. Data about final electricity consumption is provided by the IEA (IEA 2015a). Most important sectors are industry, residential and commercial and public services. In 2007 commercial and public services is the most important electricity consuming sector in Greece (Figure 11). This also includes tourism which is in terms of economic value the most important sector in Greece. Second most important electricity consuming sector is residential, which includes housing where electricity is mainly used for cooling during summer (Figure 11). Figure 12 shows that coal is the most important source to fulfil the electricity demand. Data for Greek electricity consumption is provided in the appendix (Table A22).

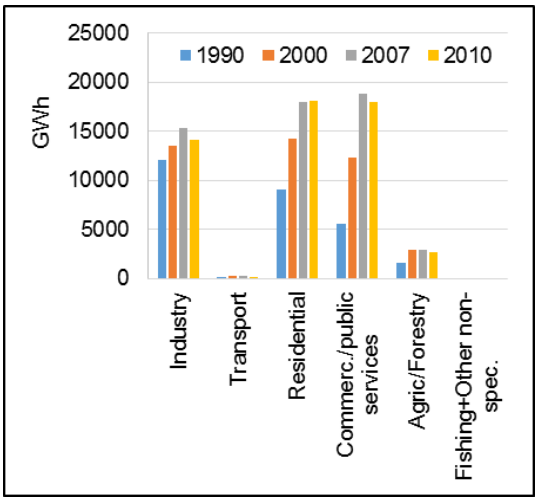

Figure 11 Final electricity consumption in sectors in GWh, 1990, 2000, 2007, 2010; Source: IEA 2015a

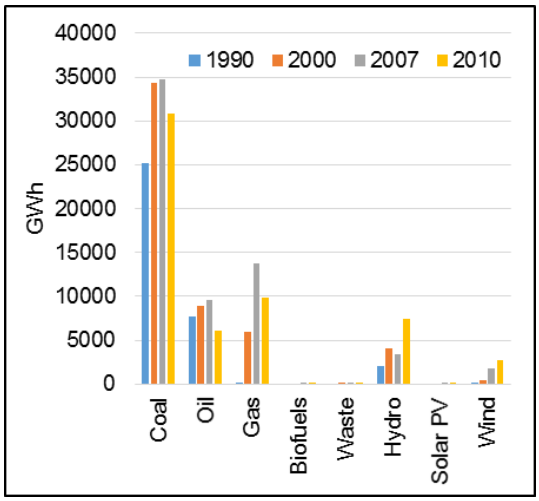

Figure 12 Sources of electricity production in GWh, 1990, 2000, 2007, 2010; Source: IEA 2015a

Apart from fossil energy carriers, Greek DMC is dominated by non-metallic minerals, in particular by construction minerals such as sand and gravel. This is mainly due to infrastructural investments which took place in order to stimulate economic growth during the 1990s. The Greek DMC of non-metallic minerals is however not unusually high or low. It was found that in western industrialized countries minerals required to build up, maintain, and use large infrastructure usually account for more than two thirds of DMC, with bulk minerals (e.g. sand and gravel) playing the dominant role. (Schaffartzik et al. 2014) In Greece, mineral consumption accounts for more than 40% of total DMC Periods of accelerated economic growth usually result in enhanced construction activities, because high amounts of construction minerals are required to build up stocks. During periods of 'average' growth or during recession investment in physical infrastructure declines, hence the use of construction minerals decreases, too (Weisz et al. 2006). In Greece, this can be observed, too. Furthermore, as presented in Figure 13, DMC of construction minerals follows the same trajectory as GDP better than any other material type.

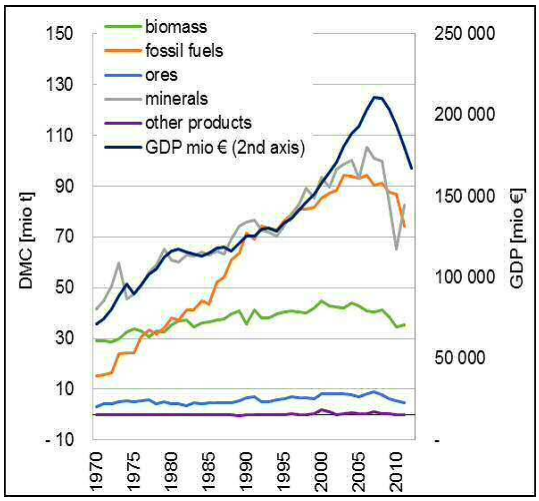

Figure 13 DMC in four material categories in million tons, 2nd axis: GDP in million EUR (chain-linked vol), 1970-2012; Source: DMC: own calculation, GDP: Eurostat 2015

Political and economic developments in Europe are highly interlinked. For instance, EU accession not only aims at strengthening political stability, but also at stimulating economic

growth. Greek economy, measured in GDP, increased between 1970 and 2008 by 195% (Eurostat 2014). After 1990, accelerated economic growth can be observed. This is mainly due to investments in infrastructure projects and thus in mineral intensive sectors that finally resulted in increasing mineral consumption. As a consequence of new infrastructure and the necessity to maintain it, the demand for electricity, and thereby fossil energy carriers, increased, too. Consumption of both fossil energy carriers and minerals are closely linked to the economic growth of the country. The domestic consumption of biomass and metals is deviating from this trend and stays more or less constant over the observed period of time, with the exception of the periods of economic recession after 2008.

After 2004, the construction boom came to a halt and between 2004 and 2005 as well as after 2008, DMC of construction minerals decreased. The consumption of construction minerals is closely bound to economic development, but what is interesting to observe is that GDP only declined after 2008. The question occurs what causes Greek decline in construction minerals already in 2004? One possible explanation might be the enlargement of the EU in 2004. Within this expansion not only Greece but also Portugal, Spain and Ireland lost their 'most-favored status' with respect to EU structural funding. The EU enlargement of 2004 led to a revision of the structural policy in favor of the new member states (Sabethai 2006:261). This restructuring in the European landscape can be regarded as having affected Greek infrastructural investments and thus construction activities. After 2008, the economic recession causes a decline in material use, but a slight decrease in Greek DMC can be observed already before the beginning of the crisis. According to Schaffartzik et al (2015:7), this pre-crisis dematerialization can be observed in other European countries too, in particular in Hungary, the United Kingdom and Italy.

Economic recession and the resulting austerity measures had not only a massive impact on the Greek national budget but also on the country's physical economy. DMC dropped by 21% between 2008 and 2012, GDP by 20% during the same period. The decrease in materials was mainly due to minerals, because this is the most important material category by weight and particularly sensitive to economic growth. Metal ores, and in particular metal products, declined most steeply. DMC of metal ores and products decreased by 55% from 2008-2012, which is mainly due to decreasing imports. Iron is the most important metal import commodity and declined from 4.2 to 1.5 million tons between 2008 and 2012. The MFA category metal products is also strongly affected by economic recession. It comprises metal products which are imported to Greece. Metal products are of particular importance in final consumption, which decreased significantly during the economic recession. For DMC of fossil fuels a decline of 18% between 2008 and 2011 can be observed. DMC of biomass declined by 23% between 2008 and 2012, mainly because of decreasing biomass imports with biomass products to be ranked first, followed by cereals. Details about Greek individual material flows are presented in chapter 5.1.4.

5.1.3. Trade

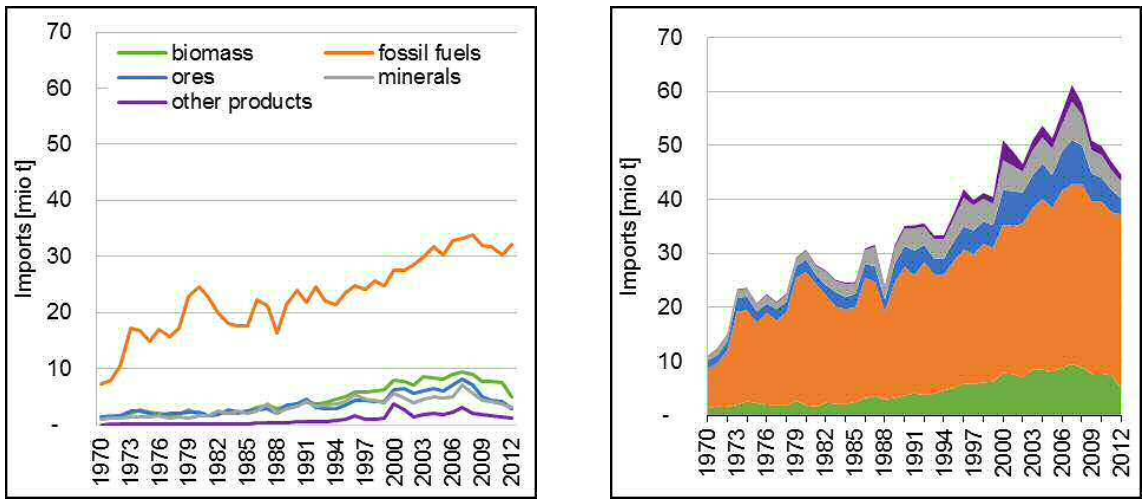

Figure 14 Imports in million tons, 1970-2012; Source: own calculation

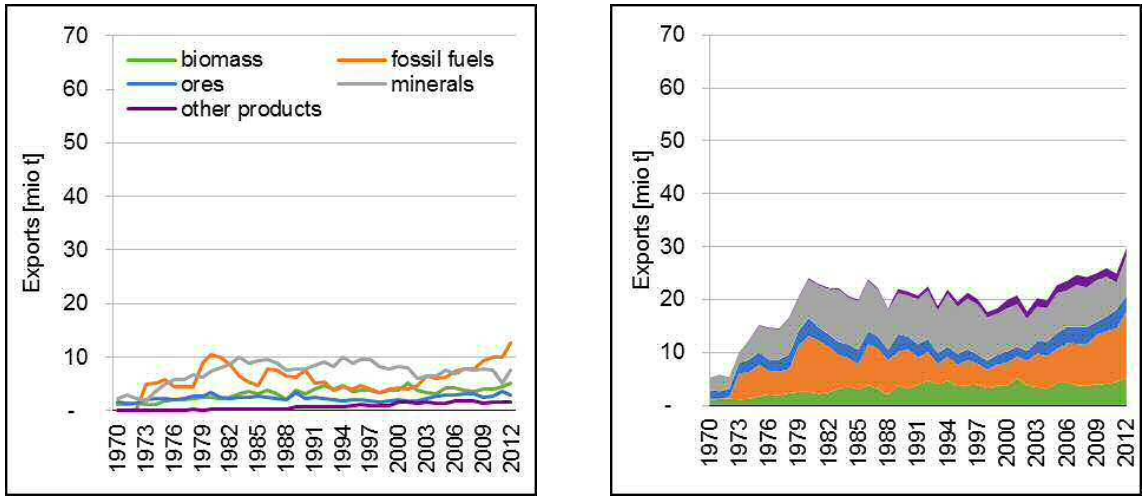

Figure 15 Exports in million tons, 1970-2012; Source: own calculation

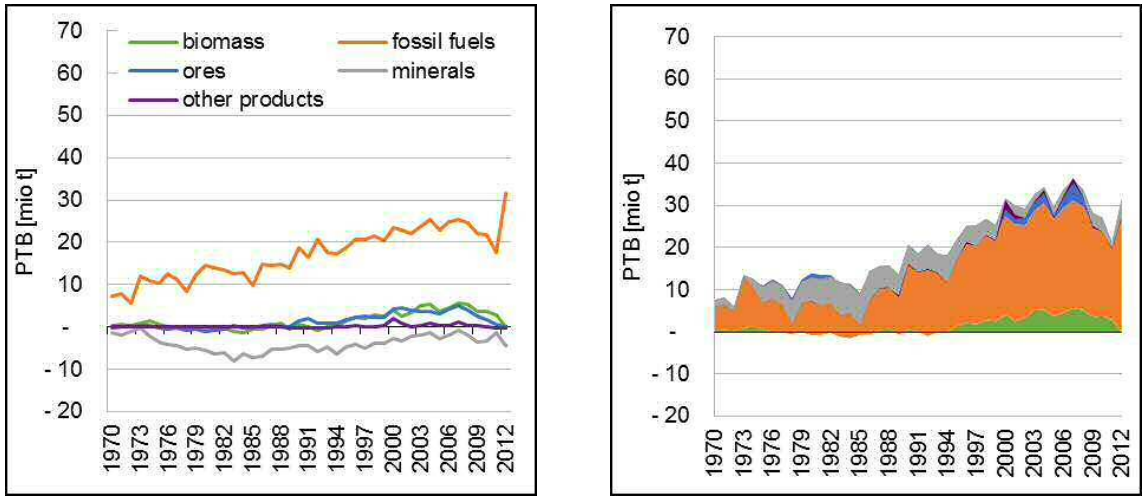

Figure 16 Physical Trade Balance PTB in million tons, 1970-2012; Source: own calculation

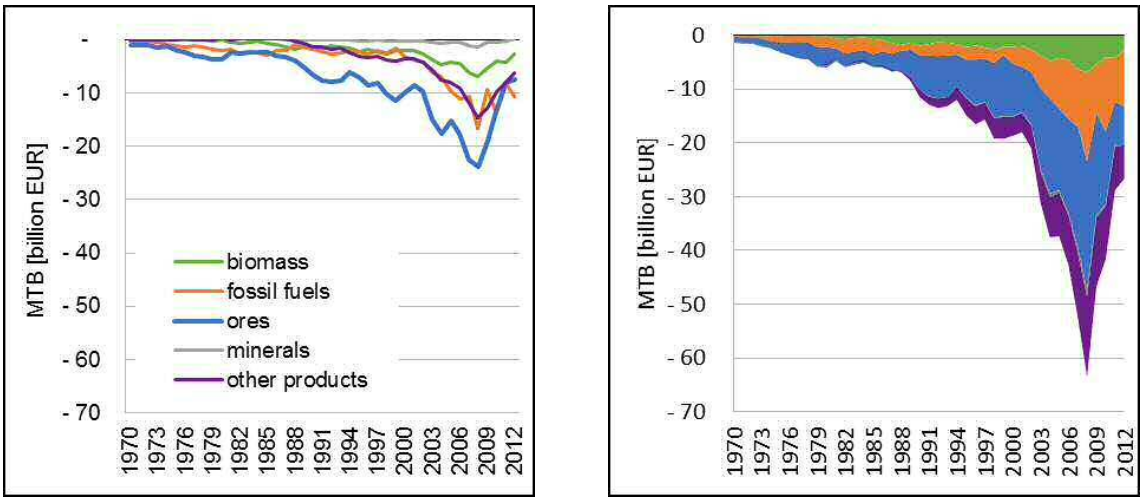

Figure 17 Monetary Trade Balance MTB in billion Euro (chain-linked volume), 1970-2012; Source: own calculation

Figure 14 shows Greek aggregated import flows. The import flows account for 11 million tons in 1970 and for 61 million tons in 2007 at its peak. The most important import commodity is crude oil, as it is found in most European countries (Krausmann et al. 2011). In the early 1970s, import of crude oil starts rising significantly and keeps growing over the observed period of time. Only during the second oil crisis in the early 1980s a slight decline in oil imports can be observed. Between 2007 and 2012 and as a consequence of the global financial crisis of 2008, oil imports declined by 27%. Apart from crude oil, imports of metal ores (mainly road vehicles) and biomass products as well as primary crops increased during the 1990s, too. Export of petroleum products started rising during the early 1970s, which was closely related to the opening of two new refineries in 1972 (IEA 2006:73). It is interesting to observe that exports decreased during the 1990s while the economy kept growing and imports were increasing. This suggests that crude oil imports were rather used domestically than being transformed into export commodities. After 2000, export of petroleum products increased again. Figure 16 shows the physical trade balance (PTB) and exhibits Greece as a massive net-importer. The positive physical trade balance indicates that Greek imports exceed exports. Apart from minerals, all material categories record a positive balance, thus indicating that Greece is highly dependent on resources extracted in other world regions. The negative trade balance with minerals reveals Greece as a net-exporter, in particular of cement. Even though the amount exported is declining, in 2008 it still accounts for a net export of 3.5 million tons.

Greek monetary trade flows are presented in Figure 17. The monetary trade balance is calculated as exports minus imports. Greek expenditures on imports thus exceed its export revenues. Lowered trade barriers after entering the European single market led to increasing imports after 1994 and to exploding export costs after adopting the Euro in 2001. The increasing imports (and thus high export costs) after 2001 were mainly debt financed (Schrader and Laaser 2010:543). Greece has the highest expenditures on metals imports, in particular on metal products. These are also considered as “capital goods” and Papazoglou (2007:413) concludes that the “increased need for capital goods” is a crucial consequence of infrastructure projects that were underway during the 1990s and early 2000s. The comparison between Greek physical and monetary trade flows reveals opposing trends in weight and monetary value. The imports of metal products play a minor role in physical trade due to their low weight when crossing the national border. Metal products are highly processed and thus high-prized goods, but low in weight. High metal imports measured in monetary units reveal

the importance of metal products for Greek metabolism. As described in Schrader and Laaser (2010:543), Greek exports are in contrast rather characterized by labor-intensive raw materials. Physical as well as monetary trade flows are very sensitive to economic development. When regarding Greek trade flows within the context of economic recession, a significant decline in all material categories can be observed since 2008.

5.1.4. Description and Analysis of main Materials

Biomass

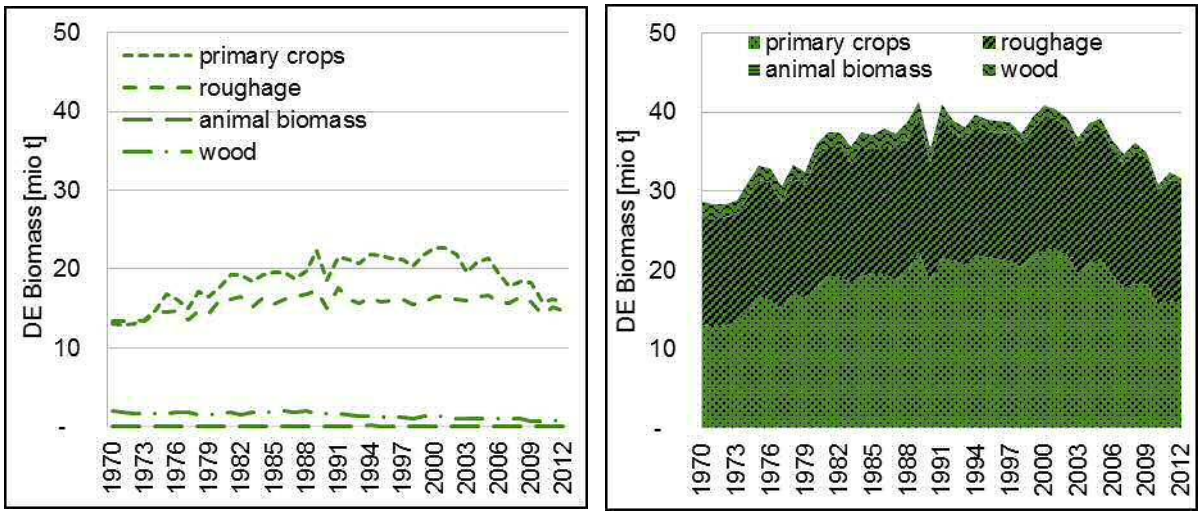

Figure 18 DE of biomass materials in million tons, 1970-2012; Source: own calculation

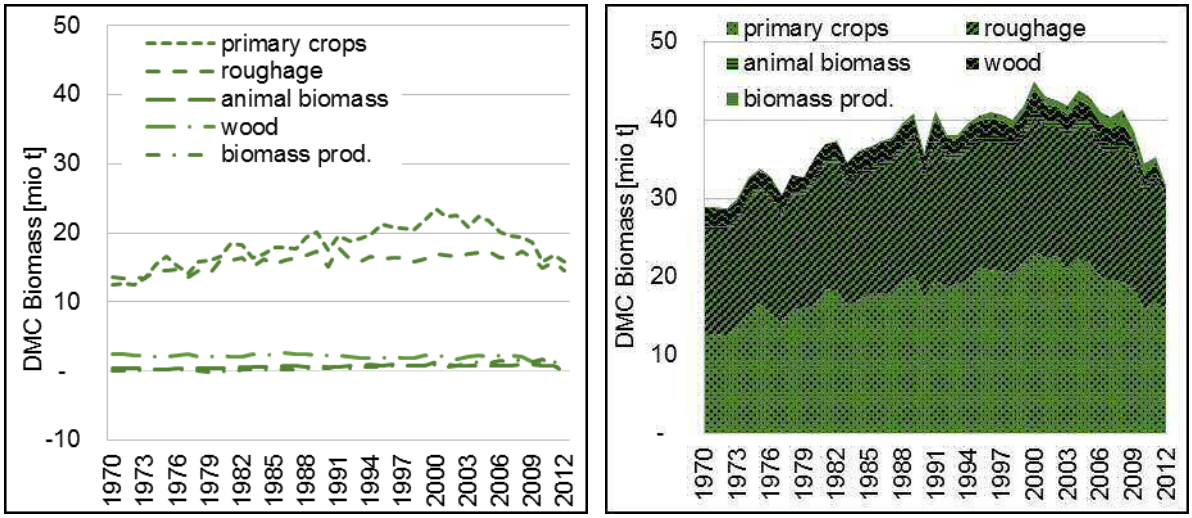

Figure 19 DMC of biomass materials in million tons, 1970-2012; Source: own calculation

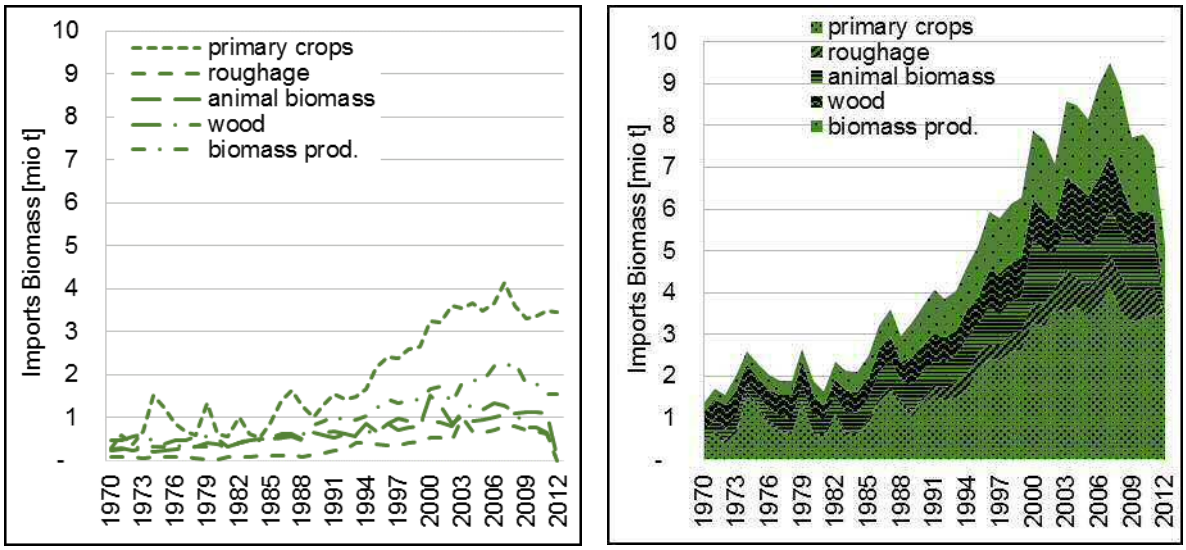

Figure 20 Imports of biomass materials in million tons, 1970-2012; Source: own calculation

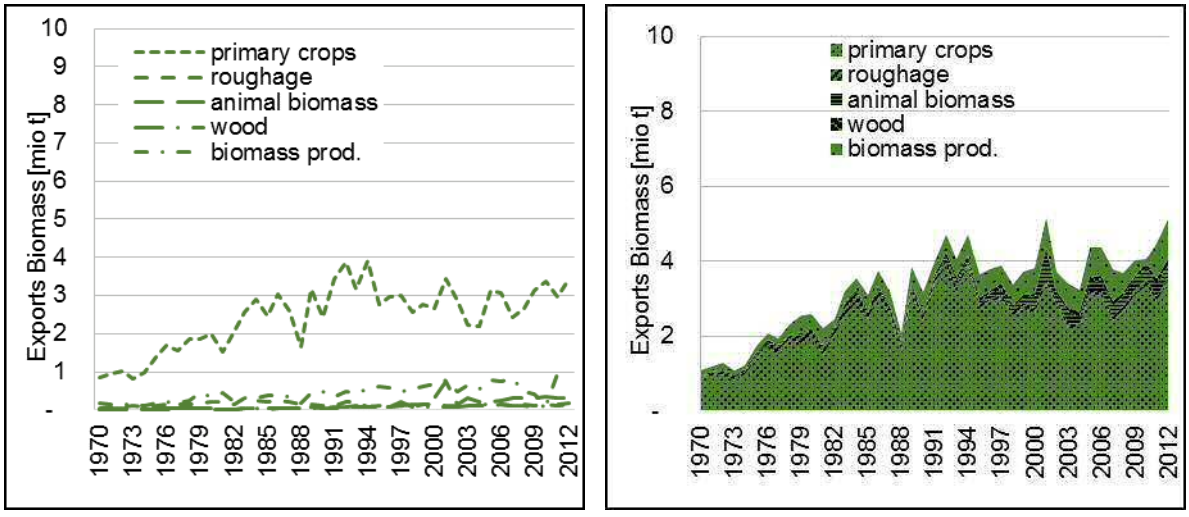

Figure 21 Exports of biomass materials in million tons, 1970-2012; Source: own calculation

At the beginning of the observation period, the Greek metabolism was dominated by biomass extraction which identifies Greece as agrarian country. The agrarian section deteriorated in the observed period of time and Greece became a major importer of biomass products but hardly an exporter (see Figure 18). Biomass shows the most constant development in comparison to other material categories. The DE accounted for 29 million tons in 1970 and for 32 million tons in 2012 (see Figure 18). Until the late 1980s, biomass as well as non-metallic minerals were in terms of extraction the dominant material category. In 1986, fossil energy carrier extraction surpasses extraction of biomass which indicates the shift of a biomass-based economy to a minerals-based economy. The importance of the agricultural sector has been decreasing since then. The declining employment in the sector is another indicator of this development, which can particularly be observed between 2000 and 2010. During that period, the agricultural labor force decreased by 15% (Pezaros 2004:1). Agriculture, however, is still very important in Greece: in 2010, 1.2 million people were working on Greek farms which indicated one of the largest agricultural labor forces within the EU-countries (Eurostat 2015d). The importance of the agricultural sector for Greek economy is yet declining: In 1970, the agricultural activities contributed to GDP by 10%, in 2012 agricultural activities contributed by

4%. The agricultural output in monetary terms stayed constant but due to the growing economy in absolute terms, the share declined.

The most important biomass category is primary crops. This comprises in Greece mainly cereals, fruits, vegetables and oil bearing crops, where the latter category mainly subsumes olives. Olive and olive oil production is an important economic activity and specialist olive farms made up the largest share (38%) of farms in Greece in 2010 (Eurostat 2015d). Biomass consumption (DMC, Figure 19) is dominated by primary crops, with cereals to rank first, followed by fruits, oil bearing crops and vegetables. In terms of domestic extraction and consumption, roughage is the second most important biomass category. Roughage includes fodder crops, biomass harvested from grassland and biomass directly grazed by livestock. Until the year 2000, the amount of roughage extracted and consumed stays rather constant as do the livestock numbers in Greece. After 2000, livestock numbers and consumption of roughage decrease by an average declining rate of 2.5% per year. Livestock numbers per person were declining from 1.5 animals per capita in 1970 to 1.3 in 2012. This is mainly due to an increasing Greek population and the decreasing economic significance of the agricultural sector. Dairy sheep and goats are the most important and most common livestock in Greece, followed by cattle as the second most important livestock (FAO 2014, Eurostat 2015d). Sheep and Goats are kept mainly extensively in agriculturally less favored areas and produce milk which is processed into cheese products (Hadjigeorgiou 1998). After 1994, it can be observed that the import of biomass products increases. This compensates for the declining domestic extraction occurring at that time. This trend cannot be observed for roughage and animal biomass such as straw or fodder crops which traditionally are not traded much. The structural changes in the political landscape of the EU at that time had significant influence on external trade in Greece. The European Monetary Union was established following the Treaty on European Union, also known as the Treaty of Maastricht, which led to the free movement of capital between 1990 and 1993, the convergence of the Member States' economic policies between 1994 and 1998 and the implementation of a single currency (Europäische Kommission 2015). Greece benefited from the financial support provided by EU funds, but in turn it had to abolish its import tariffs which protected domestic producers. This resulted in an overstock of the market and the massive import of mainly primary crops (Figure 20). The import of primary crops rose from 1.3 million tons in 1990 to 4.1 million tons in 2007 and decreased to 3.5 million tons in 2012. The most important import partners for primary crops are France, Germany, Netherlands and Italy (UN COMTRADE 2014). Biomass exports, in contrast to imports, stayed rather constant (Figure 21).

Fossil Energy Carriers

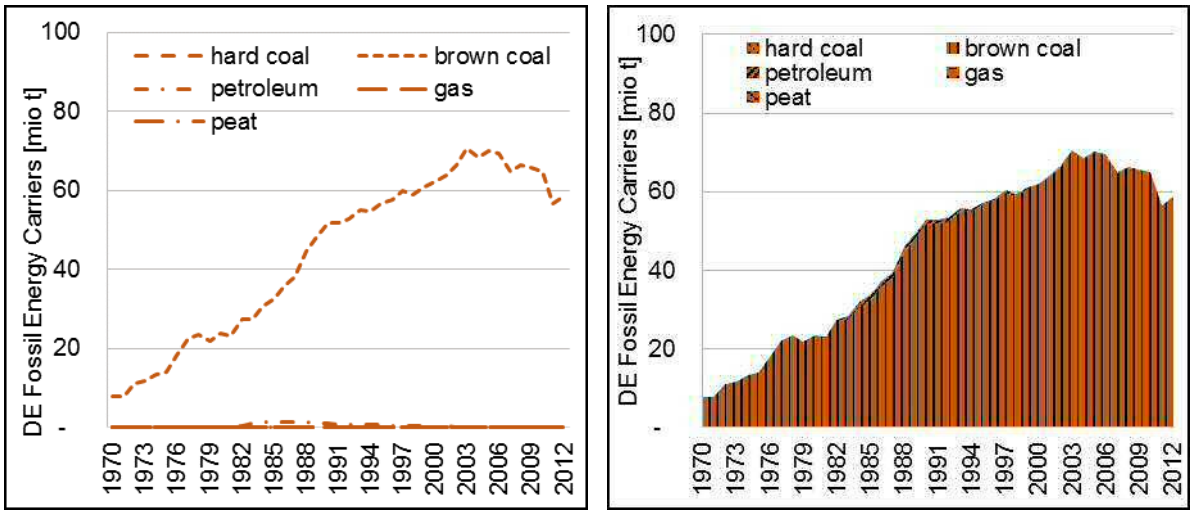

Figure 22 DE of fossil energy carriers in million tons, 1970-2012; Source: own calculation

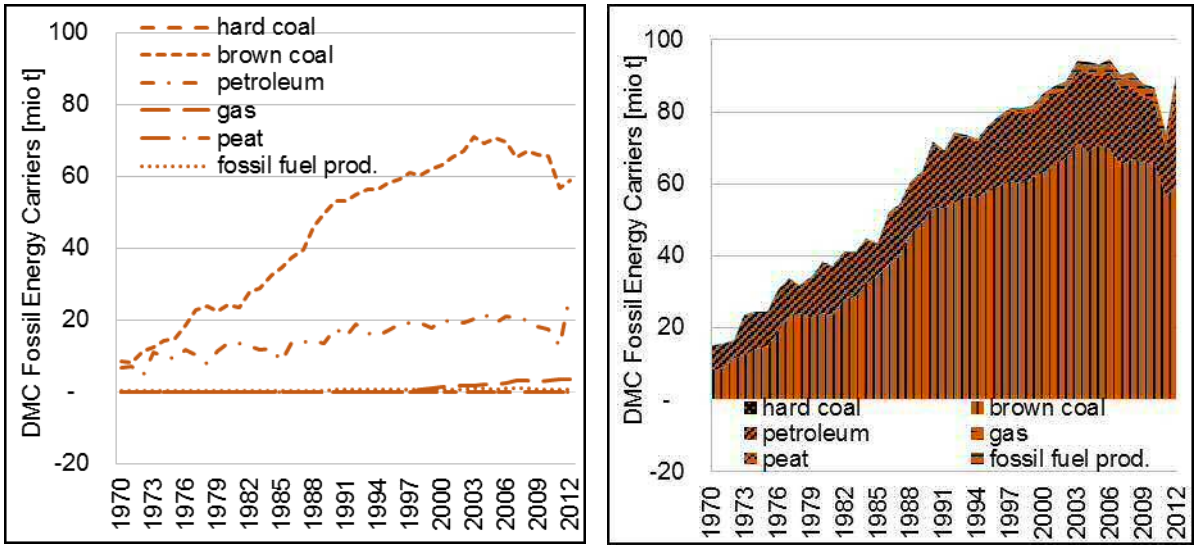

Figure 23 DMC of fossil energy carriers in million tons, 1970-2012; Source: own calculation

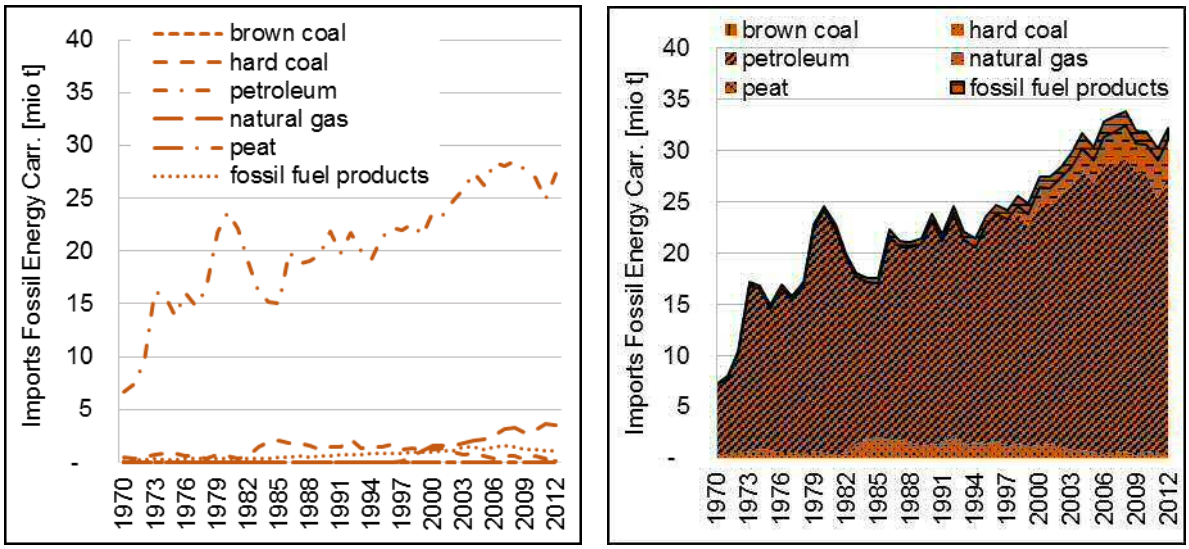

Figure 24 Imports of fossil energy carriers in million tons, 1970-2012; Source: own calculation

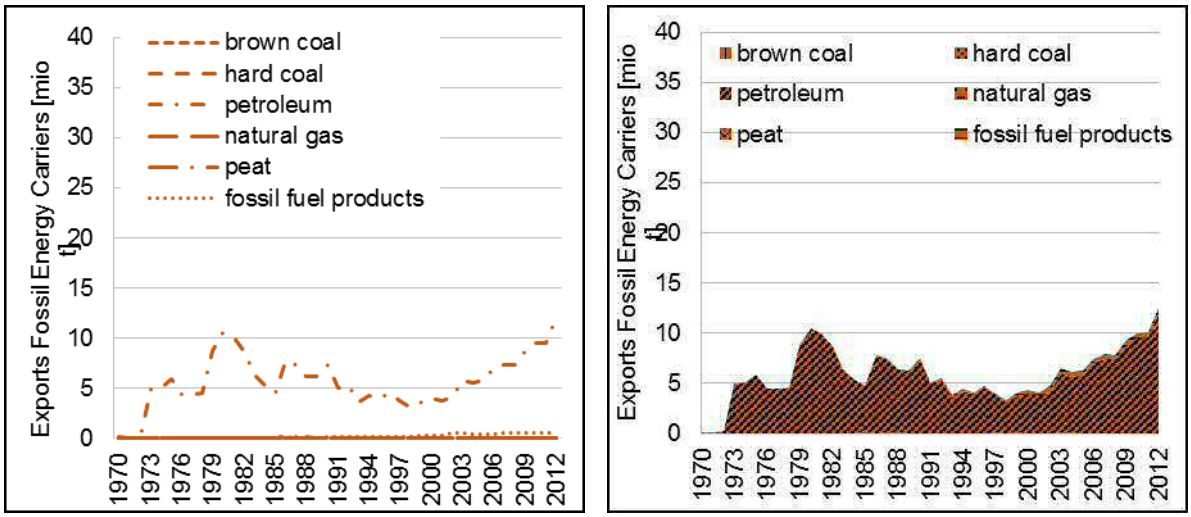

Figure 25 Exports of fossil energy carriers in million tons, 1970-2012; Source: own calculation

In the observation period, fossil fuel extraction and consumption in Greece increased significantly, which points at a transition from an agrarian to an industrial economy. In 1970, 7.9 million tons of fossil energy carriers were extracted (Figure 22). The peak of extraction was reached in 2003, when extraction amounted at 71 million tons, indicating a tenfold increase. Extraction stayed constant after 2003 and it was only after 2010 that extraction of fossil energy carriers decreased significantly. In 2012, it amounted in 58.8 million tons. Lignite, a low rank, non-agglomerating coal, is the most important domestic energy source in Greece. See Table 2 for comparison of heat values of different fossil energy carries.

Table 2 Heat values/Gross calorific value for comparison (Kavouridis 2008:1257)

petrol/gasoline	44-46 MJ/kg
Hard coal	> 23,9 MJ/kg
Lignite	< 17,4 MJ/kg

Lignite also dominates Greek DMC of fossil energy carriers and grew by 850% between 1970 and 2003 (see Figure 23). After 2003, the amount of fossil energy carriers consumed stayed more or less constant until 2007 and started decreasing afterwards:

1970: 8.4 million tons
2003: 71.2 million tons
2012: 58.8 million tons

Lignite accounts for more than 60% of Greek power generation. Until 2008, Greece was the second largest lignite producer in the EU and third in the world (Kavouridis 2008:1260; IEA, 2011, p. 85). In comparison with heat values of other fossil energy carriers and due to its high moisture content, lignite is regarded as of low quality when it comes to energy production (see heat values in Table 2, DERA 2009:154). Until 2003, the extraction rate of lignite grew more or less constantly, but shows a significant decline afterwards. This is interesting, since lignite is the most important domestic source for electricity production and is also closely bond to economic development. Economy, however, continued its growth trajectory until 2009 and demand for electricity had to be maintained. Electricity provision has changed in its composition and since 2003, gas has played a more important role in terms of electricity

production, as well as wind energy and hydro power. Nevertheless, lignite still is the most important source for electricity production. Another reason for the declining lignite extraction might have been the liberalization of the EU energy market in 2001, which affected all member states. The liberalization had an impact on the Greek energy market in general and on the lignite industry in particular. Developments such as intensified competition, increasing dependency on the import of fossil fuels, price fluctuations in energy resources due to geopolitical reasons as well as improving technologies raising the efficiency of lignite fired power plants became relevant (Kavouridis 2008:1260). In Greece, 97% of lignite is extracted by the extraction firm Public Power Corporation S.S. (PPC), whereof 51.1% is owned by the state (Kavouridis 2008:1261). PPC also owns around 60% of exploitable lignite reserves in Greece, is the main electricity provider and the owner of the national grid (Kavouridis 2008:1261). The main extraction sites are located in the northern part of Greece, were lignite with the nation-wide highest heating value is extracted. The industrial extraction and use of lignite was established in the 1950s. The by then already existing PPC merged in 1975 with the first large-scale extraction firm Lignite Mining Company LIPTOL. With this started in the wider area of Ptolemais basin one of the largest lignite extraction activities in the world.

Greek trade flows are dominated by the import of crude petroleum and export of petroleum products (Figure 24). The Greek refining industry imports massive amounts of crude oil due to a lack of domestic sources. 6.2 million tons of crude petroleum were imported in 1970 and 28.5 million tons in 2008. After 2008, import of crude petroleum decreased to 24.8 million tons in 2011. Rising taxes on diesel and gasoline resulted in declining domestic demand which also affected imports (IEA 2011:62). After 2011, a slight increase in imports can be observed. Greece has a rather weak export structure but within this, fossil fuel exports play an important role (Figure 25). Physical export flows are dominated by petroleum products such as petroleum coke and bitumen (Figure 25).

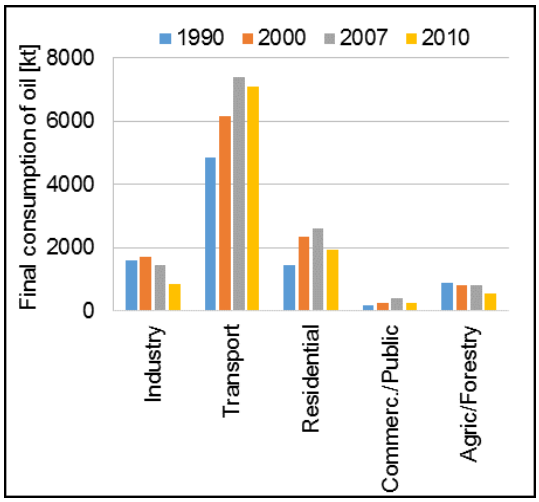

Figure 26 Final consumption of oil in Greece, in kt, for the years 1990, 2000, 2007, 2010 in different sectors; Source: IEA 2015b

Following the methodological standard in MFA, DMC only accounts for the country's apparent consumption. In order to understand Greek domestic demand for oil, data about the final consumption, provided by the International Energy Agency (IEA 2015b), was taken into account. Figure 26 shows that Greek final oil consumption increased from 1990 to 2009 by 42% (all different kinds of oil and refined oil produced were included). In 2009, the transport sector was the largest oil consuming sector in Greece, followed by the residential sector,

industry, the service and the agricultural sector (IEA 2015b).The oil consumed in the transport sector is almost entirely imported, mainly from Russia (UN COMTRADE 2014), and domestically refined (IEA 2011:38; IEA 2011:19–20). The inland transport of oil is managed by road transport and ship. In Greece, ten oil terminals exist, whereby six of them are constructed to import crude oil (IEA 2011:60). Figure 26 shows that in the transport sector final consumption of oil increased by 52% between 1990 and 2007. Data indicates that Greek petroleum consumption is mainly driven by domestic transport activities. This might be attributed to the following three factors: Regarding the Greek transport system, road largely dominates the modal split for both freight and passenger transport. Greece is among the ten most transport-intensive countries in Europe, measured in annual road freight transport in thousand tons per year (Eurostat 2015e). In recent decades the country aimed for completing the national transport system, focusing on Trans-European corridors to make Greece a major transport route node (OECD 2009). Another reason for the high energy consumption in the transport sector is the increasing individual passenger transport. From 1994 to 2004, ownership of passenger cars per 1 000 inhabitants increased by 102% (Eurostat 2015f). EU average increased by 30% during the same period of time (ECORYS 2013). The particular geological situation of Greece might be another reason for the high energy consumption in the transport sector: to connect the more than 2500 Greek islands, ferries are the most important means of transport. Ferries are not only transporting residents, but also a growing numbers of tourists who visit Greece every year. The shipping industry in Greece is an important pillar of the Greek economy and a relevant consumer of petroleum (Prandeka and Zarkos 2014).

Metals

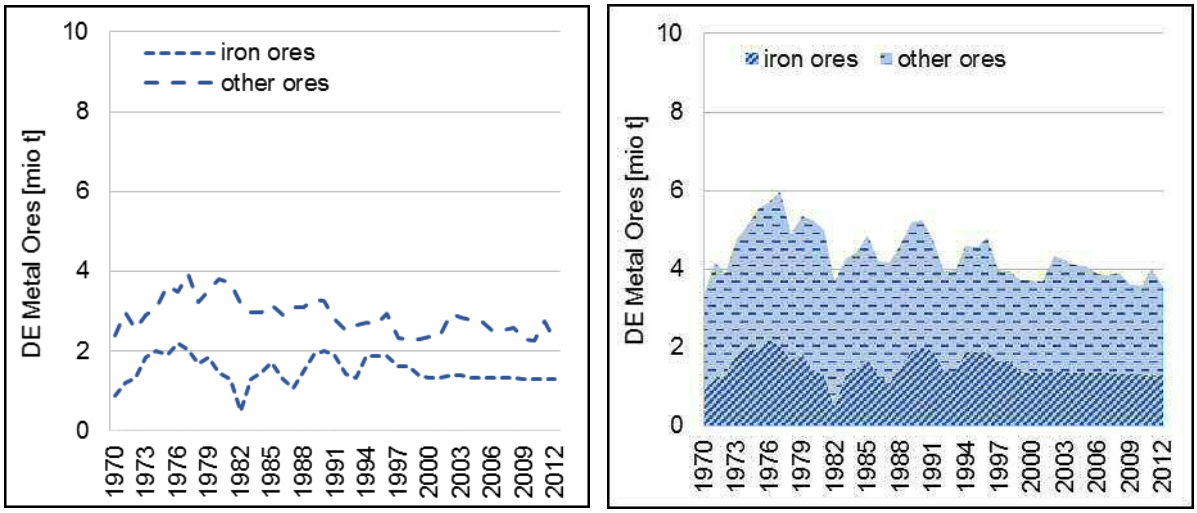

Figure 27 DE of metal ores in million tons, 1970-2012; Source: own calculation

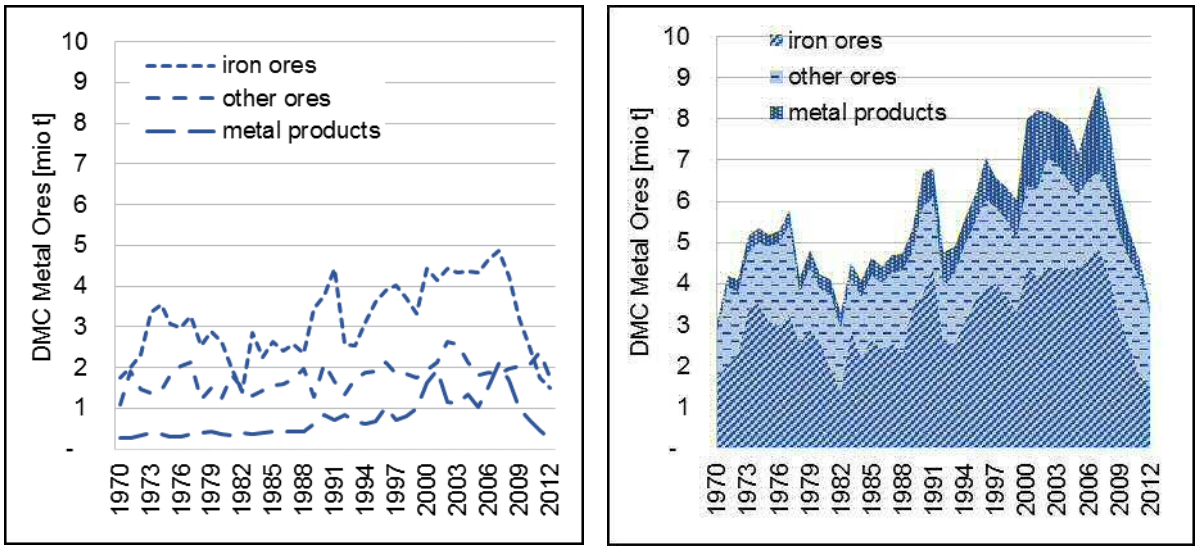

Figure 28 DMC of metal ores in million tons, 1970-2012; Source: own calculation

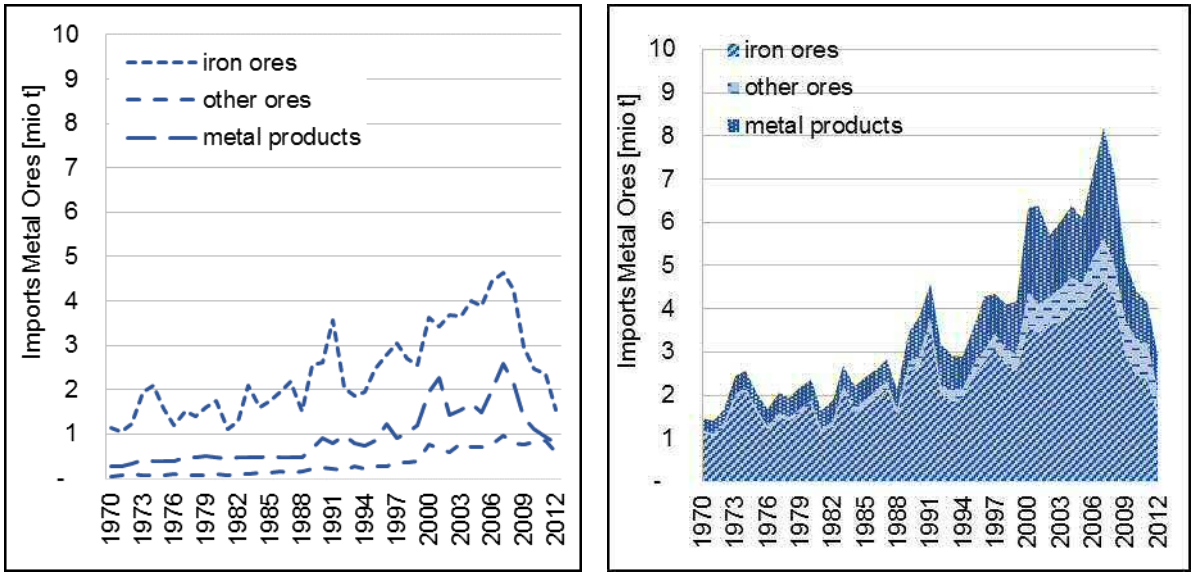

Figure 29 Imports of metal ores in million tons, 1970-2012; Source: own calculation

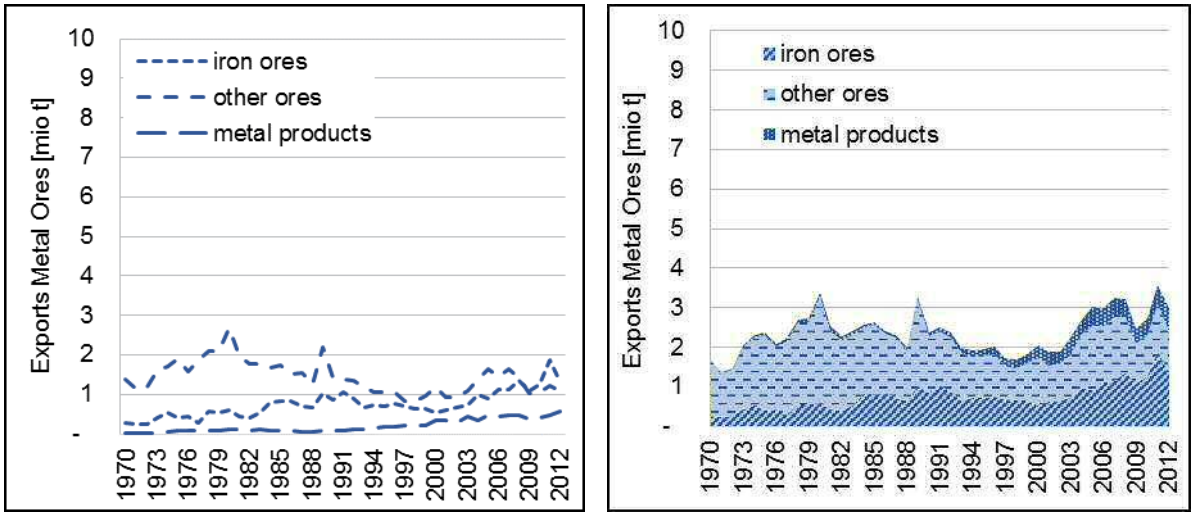

Figure 30 Exports of metal ores in million tons, 1970-2012; Source: own calculation

Greek mining industry is small but significant, because of the country's vast mineral resources. Besides energy minerals, such as lignite, bauxite is found abundantly in Greece. However, extraction of ores already reached a peak in 1977 and has been declining since then (Figure 27). Most important ores extracted are bauxite and iron ore, but a decreasing trend can be observed, too (Table 3).

Table 3 DE of iron ore and bauxite in million tons; Source: own calculation

Ore	1970	Year of Peak		2012
		1976	1977	
Iron ore	1.3	3.2		1.8
Bauxite	2.3		3.2	1.8

Despite its decreasing domestic extraction, Greece is the major bauxite extracting country within the European Union. Major bauxite deposits are located in central Greece within the Parnassos-Ghiona geotectonic zone and on Evvoia Island (Newman 2012:19.1). Bauxite is exclusively used to produce aluminum. Aluminium de Grèce S.A. established its alumina and aluminum plant in 1960, when the large bauxite deposits at the northern coast of the Gulf of Corinth were exploited (US Geological Survey 2004:13.1). In terms of DMC, bauxite is the second most important metal commodity in Greece. Aluminum production is a highly energy intensive process and is carried out where cheap energy is available abundantly. In Greece, electricity for aluminum production is provided by lignite burning, because this is the most easily available energy source. Since the mid-1990s every year between 10 and 12% of the domestically produced aluminum is exported. Most important export partners are other European countries, such as Italy, Macedonia, France, Cyprus, and Germany.

Iron is the most important metal commodity in terms of consumption, which demand is mainly covered by imports – in contrast to Bauxite, which demand is mainly covered by domestic extraction (Figure 28). Iron ore is mainly used to produce ferroalloys such as ferronickel. The leading consumer of ferronickel is the iron and steel industry (US Geological Survey 2008). In comparison with other domestically extracted materials and in terms of weight, metal ores play a minor role in Greece. However, within the EU, Greece is a very important ore extracting country, since European ore deposits are small or already exploited.

Non-Metallic Minerals

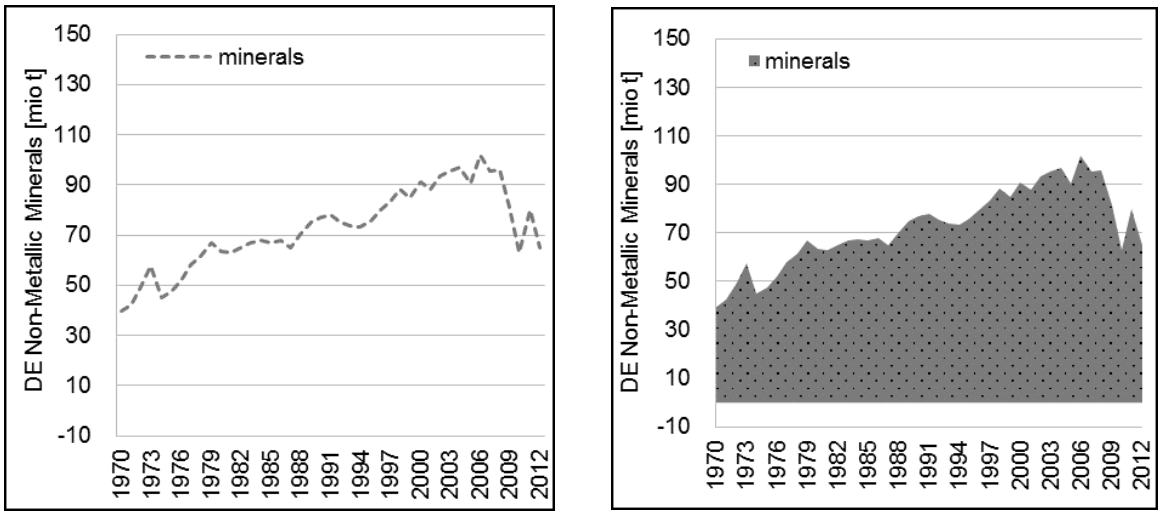

Figure 31 DE of non-metallic minerals in million tons, 1970-2012; Source: own calculation

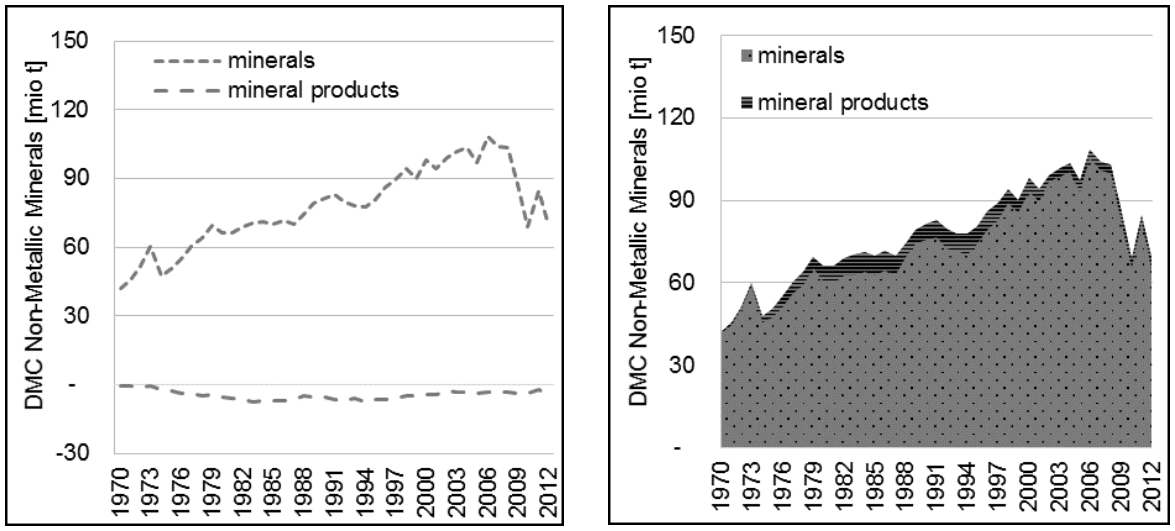

Figure 32 DMC of non-metallic minerals in million tons, 1970-2012; Source: own calculation

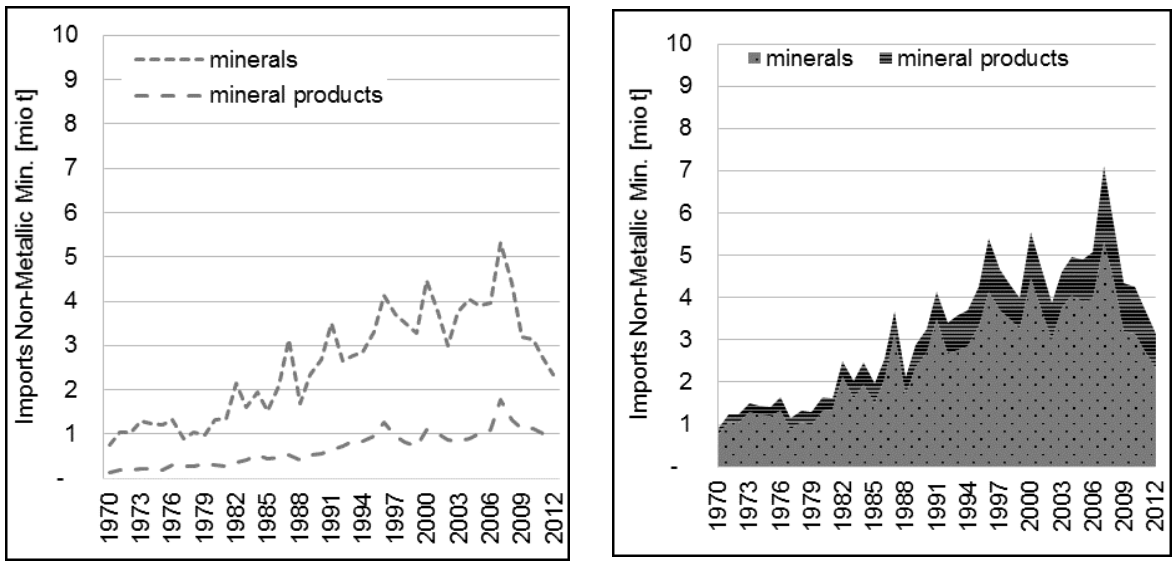

Figure 33 Imports of non-metallic minerals in million tons, 1970-2012; Source: own calculation

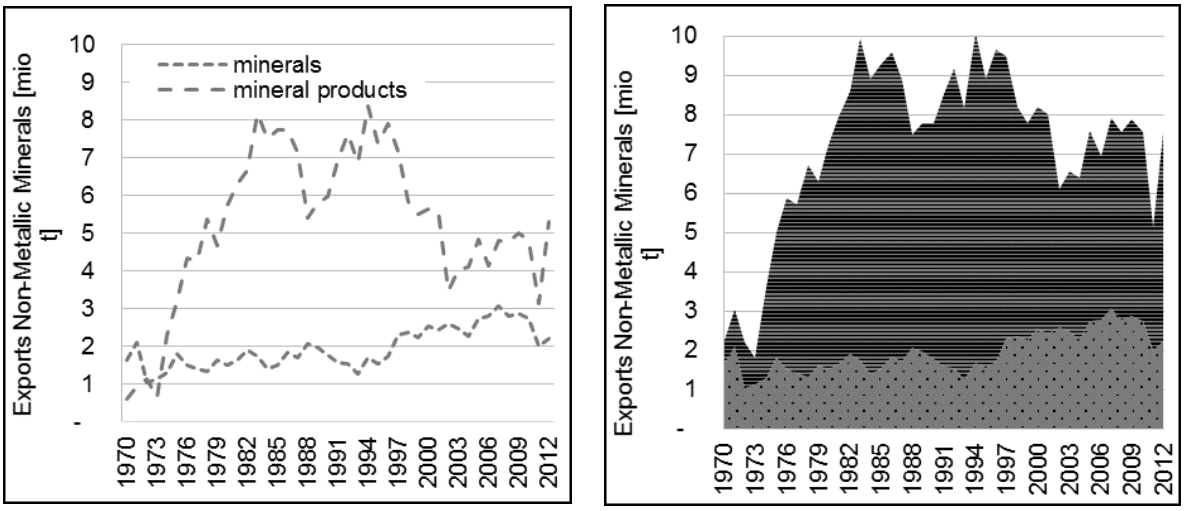

Figure 34 Exports of non-metallic minerals in million tons, 1970-2012; Source: own calculation

In terms of domestic extraction and consumption, non-metallic minerals are the most important material flows by weight in Greek metabolism (Figure 31). Gravel and sand are to rank first, followed by limestone. Construction activities and the production of cement are the main consumers of gravel and sand, as well as limestone. The DE of non-metallic minerals, especially of sand and gravel, increased from 39.7 million tons in 1970 to 65 million tons in 2012 but reached a peak of 101.7 million tons in 2006. After 2008, the DE dropped by almost a third within only four years. There are about 70 authorized quarry sites in Greece with approximately 200 quarries and processing units. They mostly support the regional construction activities and the Greek cement industry (Ministry of Environment Energy and Climate Change n.d.:22). A wide range of infrastructural investments during the 1990s led to a construction boom. This resulted in an increase of DMC from 75.9 million tons in 1990 to 93.4 million tons in 2000 (Figure 32). The EU structural and cohesion fund played an important role when regarding Greek construction activities. The fund's main aim was to enhance social and political cohesion between member states and to reallocate resources providing equal economic development, not only in Greece but in all of the member states. To support economic growth, investments in infrastructure projects were undertaken (Featherstone 1998:31). This influenced Greek economic development as well as material extraction and consumption patterns. The country was entitled to receive up to almost 17 billion in ECU (European Currency Units). During this period of time, major infrastructure projects were realized: the metro in Athens, facilities for the Olympic Summer Games in 2004 or Greece's largest airport in Spata, which was finished in 2001. The EU Commission was an essential patron of these projects and Greece actually needed the injection of EU funds to realize the projects. The construction of the Spata airport was actually the biggest infrastructure project backed by the EU (Featherstone 1998:30). Construction minerals are in general regarded as of less strategic importance, due to their abundant availability (Bleischwitz 2010; Schandl and Eisenmenger 2008). The low value to weight ratio of construction and bulk minerals furthermore results in a comparably low prize per ton. In Greece, construction minerals are, with respect to their use for building up physical structures, of strategic economic importance (Weisz et al. 2006:690). Greek construction industry is furthermore regarded as important for the country's economic development (Karousos and Vlamis 2008).

Aspects regarding tourism also need to be considered when analyzing Greek mineral consumption. As mentioned before, tourism is the most important economic sector in Greece.

It commenced after the Second World War, while major developments began during the 1970s and 1980s. At that time, airports already existed on major islands and living costs were affordable in comparison with other European holiday destinations (Buhalis 2001:440–441). Bed capacity rose from 438.360 beds in 1990 to 584.714 beds in 1999, which indicates a growth rate of 33% (Buhalis 2001:445). Eurostat data also reports a growth in "arrivals of non-residents", an indicator for estimating touristic activities, of 80% from 6.9 million non-residents arriving in Greece in 1994 to 12.5 million people in 2013 (Eurostat 2015g). This led to an increasing demand for infrastructure and construction activities were needed to cope with it (Buhalis 2001:445–446). In his study about the ecological footprint of the tourism industry, Hunter (2002:12) stresses the importance of natural resources. He regards a well-developed infrastructure as a necessity in order to fulfil the demand for energy, food and water supply in a tourism area. The provision of infrastructure of whatever kind requires certain preliminary work as mining or construction activities. He thus concludes that the tourism industry is a crucial determinant for natural resource use.

Non-metallic minerals play a considerable role (Figure 34) in Greek export structure. Until 1994, cement is the most important mineral export commodity. Between 2% (0.6 million tons in 1970) and 11% (8.4 million tons in 1994) of non-metallic minerals extracted in Greece are exported as cement. Trade with non-metallic minerals is rather unusual because of its modest economic value but relative high transportation costs resulting from the heavy weight (Weisz et al. 2006). It, however, has to be kept in mind that Greece has numerous ports and can trade minerals rather easily and cost-efficiently by ship. The export of mineral products nevertheless reached a peak in 1994. In 1994, cement was mainly exported to Saudi Arabia, Italy, USA and Spain (UN COMTRADE 2014). Between 1994 and 2007, Greek mineral exports decreased continuously, but it happened only after 2007 that the export of petroleum products exceeded the export of non-metallic mineral products.

5.1.5. Metabolic Rates and EU-Comparison

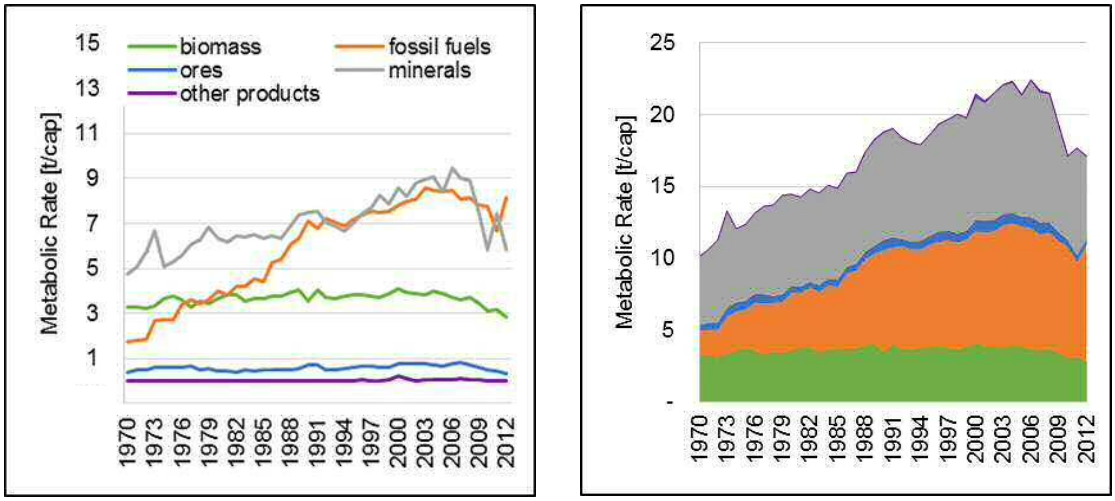

Figure 35 Metabolic rates in t/cap/yr, 1970-2012, Source: own calculation

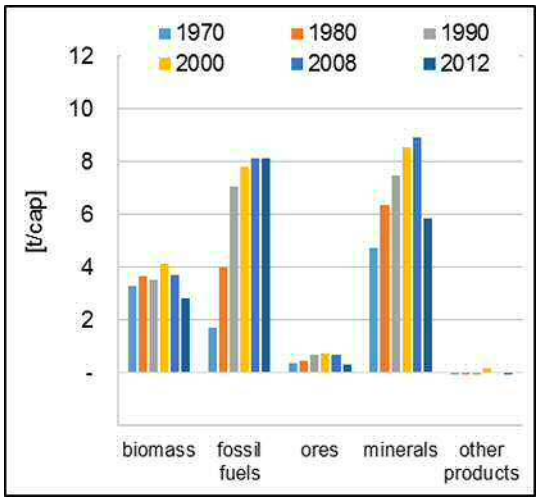

Figure 36 Change in material consumption in t/cap, 1970, 1980, 1990, 2008, 2012; Source: own calculation

The metabolic rates presented in Figure 35 and Figure 36 provide information about Greek per capita material consumption. In the early 1970s, biomass and non-metallic minerals were the most important materials used in Greece. In 2012, fossil energy carriers and non-metallic minerals are the dominant materials. From the early 1970s onwards, fossil energy use per capita increased constantly which resulted in fossil energy carriers becoming the most important material category (besides non-metallic minerals) during the 1990s. Per capita fossil energy carrier consumption increased from 1.7 t/cap in 1970 to 8.1 t/cap in 2012. Consumption of non-metallic minerals increased, too, and reached a peak at 9.5 t/cap in 2007, but declined during the economic recession by -40%. Interestingly, per capita fossil energy consumption was not strongly affected by the economic crisis, while all other material types were showing a drastic decline.

The metabolic rates, which represent material use per person per year, accounted for 10 tons in 1970 and 17.2 tons in 2012 and had reached a peak in 2006 at 21.8 tons. Material consumption per person increased between 1970 and 2006 by 114%. Between 1970 and 2012, Greek population grew by 27% from 8.8 million inhabitants in 1970 to 11.1 million inhabitants in 2012. GDP grew by 125% from 8.1 EUR/cap in 1970 to 18.9 EUR/cap in 2007. Stage of economic development plays an important role for explaining national material consumption. However, national income and income disparities among countries cannot fully account for the differences in material consumption (Steinberger et al. 2013). The per capita material use rather depends on a broad range of bio-geographical and economic factors. The sectoral structure of the economy plays also a role, as well as climate conditions, population density and resource endowment The magnitude of trade, and the natural productivity of land are other important factors (Krausmann et al. 2011; Weisz et al. 2006) Nevertheless, national income shall serve for now as a standard of comparison when comparing Greek per capita material consumption with EU27 average and other European countries. Figure 37 shows a comparison of GDP/cap and DMC/cap values among EU27 countries as well as EU27 average for the years 2000, 2005 and 2010. Data for the EU comparison are included in the appendix (Table A21).

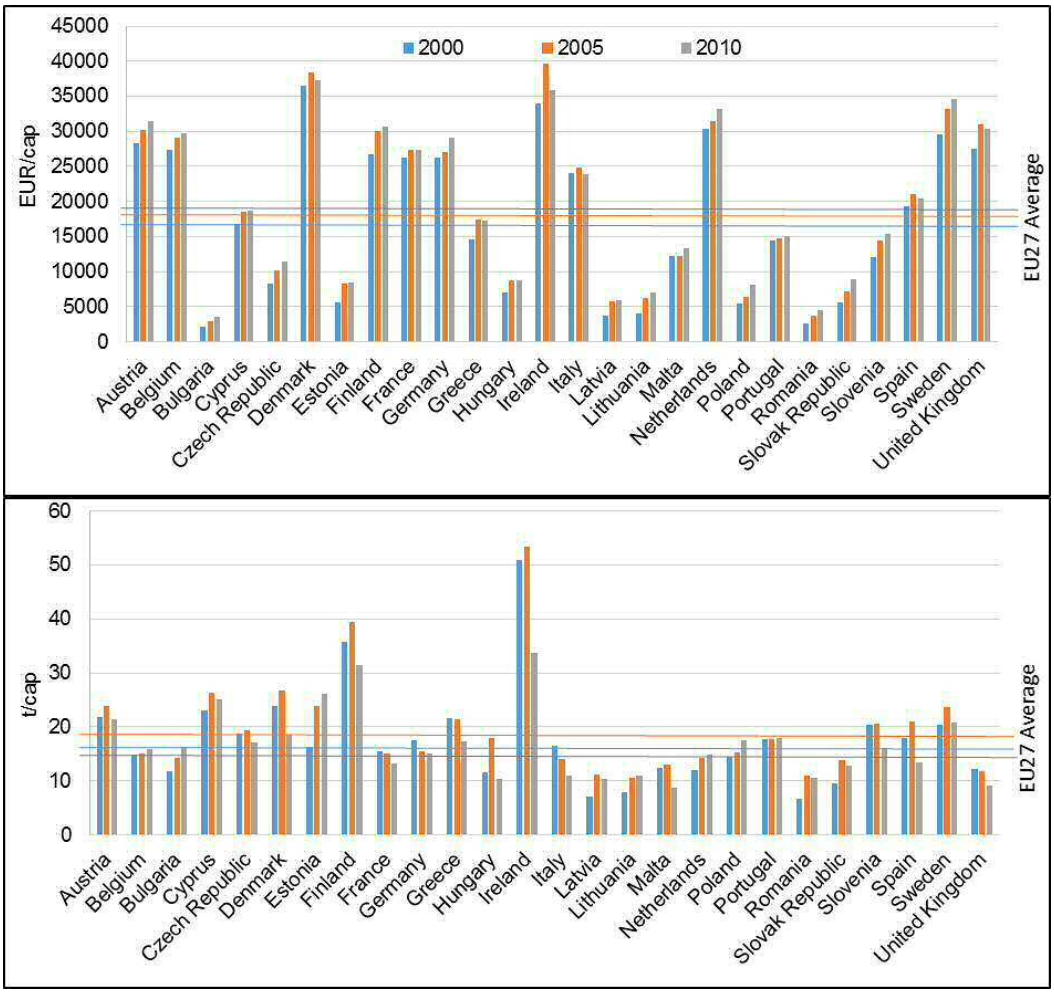

Figure 37 Comparison of metabolic rates and income for EU27 countries (Excl. Luxembourg); Source: DMC: materialflows.net, Greece: own calculation, GDP (chain-linked vol. at 2005 exch. rates): Eurostat 2015b; Population: Eurostat 2015a

Figure 37 shows that Greece exhibits a lower income than the EU27 average. The comparison with countries like Spain and Italy, which are in literature often grouped together under the term "south European countries" or "southern European periphery" (Aiginger 2013), shows that Greece is the lowest income country among those. Even though Greece shows a GDP growth rate of 120% between 2000 and 2005, DMC/cap stayed constant during that period. This indicates that economic growth apparently did not result in growth of material consumption. The same can be observed in France, Germany, Italy, Portugal, Slovenia, and UK, and indicates certain gains in efficiency.

The comparison shows that Greece has a higher per capita material consumption than the EU27 average. It was found by Krausmann et al (2011) that while in most European countries DMC per capita remained constant, countries such as Greece, Spain, Portugal and Ireland show a steep increase in per capita material consumption since the 1970s. Greece also shows higher DMC per capita values than high income countries such as UK and Germany, which registers almost twice as high level of income than Greece (UK: 1.9; Germany: 1.8). The moderate per capita material consumption in the UK and Germany can be attributed mainly to the countries' offshoring of material intensive industries in recent decades. (Krausmann et al. 2011). Wiedmann et al (2015) find that a low per capita DMC in highly industrialized western countries (not only in Europe, such as the UK, but also in other regions, e.g. Japan) is

due to the spatial separation of production and consumption in global supply chains. A consumption based view that takes into account the raw material equivalents of trade flows, representing the material footprint (MF) of nations, reveals that the low per capita DMC in industrialized countries is rather deceptive. Countries tend to reduce their domestic extraction but consume materials and resources extracted in other regions of the world via trade flows (i.e. import commodities). Taking this into account, the *DMC*/cap e.g. in the UK has decreased but the *MF*/cap has increased constantly and accounts according to the calculations by Wiedmann et al (2015:6272) around 25t/cap for the year 2008.

European countries (Figure 37) had a more or less severe economic decline in the years 2008 and 2009, but when regarding the entire period between 2005 and 2010, it appears that some countries recovered better than others. Regarding the average of the EU27 countries, a growth rate almost as high as in the preceding period (2000-2005) can be observed. In Greece, even though the country was highly affected by the economic crisis, national income, expressed in GDP/cap stayed constant between 2005 and 2010. Denmark, Ireland, Italy, Spain and UK show an overall economic decline between 2005 and 2010. In contrast to that, national material consumption declined in most of the countries in the observed period of time, except for Belgium, Bulgaria, Estonia, Lithuania, Netherlands, and Poland. Highest decline rates can be observed in Hungary (-42%), Ireland (-37%) and Spain (-36%). In Greece DMC/cap declined by -20%. On average, EU27 countries recorded a decrease of minus 15% of DMC between 2005 and 2010.

5.1.6. Resource Productivity

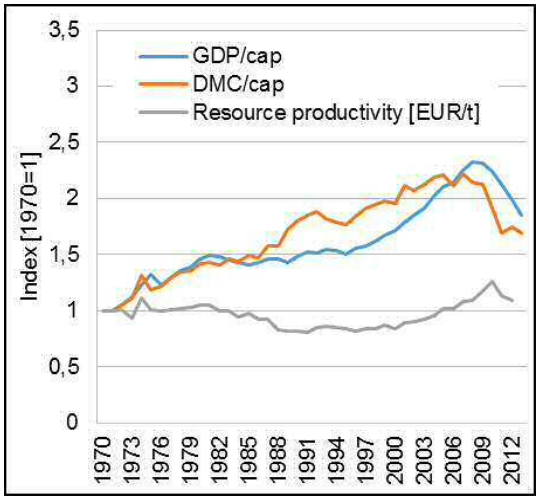

Figure 38 Development of resource productivity in Greece, 1970=1, Source: own calculation

Figure 38 shows Greek development in resource productivity. Growth of DMC and GDP are indexed for the purpose of easier comparison. The development is rather unusual and deserves close examination of what the drivers are. Between 1983 and 2000, Greek resource productivity stayed either constant or declined. During the 1990s, it can be observed that growth in material consumption even exceeds growth in GDP. In terms of productivity, this means that more material is used to produce less per economic output. Within MFA studies, resource productivity is often used synonymously for material efficiency. At a first glance, this suggests the conclusion that Greek metabolism is ineffective with respect to material use. Economic development plays a crucial role regarding resource productivity. The period between 1980 and the early 1990s is characterized by economic stagnation, a significant rise in GDP can only be observed after 1994. The economic growth is closely connected to changes

in the political landscape of the EU, and associated with investments in order to boost economic development. Investments in infrastructure projects are a common political strategy to stimulate economic growth. In Greece, in addition to national growth strategies, EU's structural funds and cohesion policy with the aim of economic convergence became particularly relevant during the 1990s. At the time of the establishment of the EU structural and cohesion fund, Greece, together with Portugal, ranked as "poor cohesion" country. Between 1995 and 2000 both countries received payments higher than 1.6% of their GDP with the purpose of promoting infrastructure investments necessary for convergence (Maynou et al. 2014:4). This explains the take-off of GDP in the mid-1990s. Greek resource productivity can only be enhanced slowly until the 2000s. As described in chapter 5.1.2. Greek material consumption is mainly driven by non-metallic minerals in general and construction minerals such as sand and gravel in particular. Greek economy benefitted significantly from the massive infrastructure projects undertaken. Steinberger and Krausmann (2011:1175) find that economic output is mainly driven by fossil energy carriers. In Greece, however, construction minerals play the important role for economic development, which in turn might also be to the detriment of productivity gains. After 2005, resource productivity increased because many of the material intensive activities declined. Beginning with the year 2006, DMC declines which leads to increasing resource productivity, because GDP growth continues. This can be observed until 2010. After 2010 resource productivity declines, because of both declining DMC and GDP which is a result of the lasting economic recession.

In Greece at three points in time DMC declined prior to GDP resulting in increased resource productivity. This was after the collapse of the dictatorship in 1974, between EU accession and the second oil crisis at the beginning of the 1980s, and prior to the financial crisis of 2008/2009 as described above. Short periods of decoupling of material consumption from economic growth thus can be observed.

5.2. Resource Use and Governance Quality. Correlation Analysis of the EU-countries

A possible relationship between governance quality and resource use is investigated by applying a correlation analysis, including data for EU member states. The analysis aims at uncovering patterns between the included variables in European countries. The findings will provide us with greater understanding of European developments by revealing similarities and dichotomies within EU countries. The results of the analysis will then help us interpreting and contextualizing Greek development.

The correlation is conducted for the years 2000, 2005 and 2010. Europe experienced a fair to middling period between 2000 and 2010 in terms of economic development: it was characterized by economic growth in the first half as well as economic recession during the second half. This observation is encouraging to conduct the correlation for the three years mentioned. Economic development, as described earlier, is a major influencing factor on the dimensions correlated. Data for 26 out of 28 EU member states were included (Luxembourg was excluded since data wasn't available for all variables, Croatia was excluded, too, because it was not member of the EU in the observed years). Besides the results of the correlation analysis I also rely on scatterplots illustrating the individual developments of countries. The descriptive statistics, providing information about mean and standard deviation of the individual indicators, can be found in the appendix (Table A29).

5.2.1. Relations between Resource Use and Governance Quality

Table 4 Correlations for the years 2000, 2005 and 2010. Own calculation.

Correlation for the year 2000	DMC/cap (t/cap)	resource productivity (GDP/DMC)
Income (Euro/cap)	,572**	,774**
cpi score	,480*	,667**
WGI1 (The process by which governments are selected, monitored, and replaced, VA+PV)	,522**	,612**
WGI2 (The capacity of the government to effectively formulate and implement sound policies, GE+RQ)	,512**	,721**
WGI3 (The respect of citizens and the state for the institutions that govern economic and social interactions among them, RL+CC)	,501**	,722**
**. Correlation is significant at the 0.01 level (2-tailed).		
*. Correlation is significant at the 0.05 level (2-tailed).		
Correlation for the year 2005	DMC/cap (t/cap)	resource productivity (GDP/DMC)
Income (Euro/cap)	,526**	,733**
cpi score	,395*	,646**
WGI1 (The process by which governments are selected, monitored, and replaced, VA+PV)	,544**	,319
WGI2 (The capacity of the government to effectively formulate and implement sound policies, GE+RQ)	,484*	,614**
WGI3 (The respect of citizens and the state for the institutions that govern economic and social interactions among them, RL+CC)	,469*	,624**
**. Correlation is significant at the 0.01 level (2-tailed).		
*. Correlation is significant at the 0.05 level (2-tailed).		
Correlation for the year 2010	DMC/cap (t/cap)	resource productivity (GDP/DMC)
Income (Euro/cap)	,386	,754**
cpi score	,480*	,505**
WGI1 (The process by which governments are selected, monitored, and replaced, VA+PV)	,424*	,335
WGI2 (The capacity of the government to effectively formulate and implement sound policies, GE+RQ)	,458*	,556**
WGI3 (The respect of citizens and the state for the institutions that govern economic and social interactions among them, RL+CC)	,444*	,596**
**. Correlation is significant at the 0.01 level (2-tailed).		
*. Correlation is significant at the 0.05 level (2-tailed).		

The table above (Table 4) shows the results of the correlation analyses for the years 2000, 2005 and 2010 including data for 26 of 28 EU countries. The indicator DMC was included in per capita values and resource productivity in EUR/ton. Income was also included in per capita values. Variables correlate in most years significantly and at high levels, which indicates an existing relationship. The significance of the relation increases in most cases between 2000 and 2005, and decreases between 2005 and 2010. The less pronounced relationship in the second half of the decade might be due to a non-linear development within European countries. It could represent different socioeconomic, physical or governance quality developments in individual EU member states. It has to be mentioned that the correlations might be influenced by underlying variables such as status of technology (which might be crucial regarding resource productivity) or national resource endowment. An important aspect is furthermore the status of economic development which seems likely to be a latent factor influencing the correlation. This also emphasizes the close relationship between economic development, resource use and governance quality and is an aspect of discussion in the literature, too (Abed & Gupta, 2002; Lambsdorff, 2006; Pellegrini, 2011). Still, results can be interpreted and in the following interpretation economic status is taken into account as possible influencing factor.

It is recalled that a correlation coefficient of +1 indicates that two variables are perfectly related in a positive linear sense. Correlations between resource productivity and governance indicators are in most cases stronger than for the DMC. Resource productivity correlates highest with income (GDP/cap, 2000: r=0.77, 2005: r=0.73, 2010: r=0.75), which is a logical consequence because resource productivity is defined as "the ratio of economic output (usually Gross Domestic Product, GDP) and resource input" (Krausmann et al., 2011, p. 58). Regarding governance quality variables, highest correlations are found between resource productivity and WGI3 (including the governance dimensions "Rule of Law" and "Control of Corruption"), WGI2 (including "Government Effectiveness" and "Regulatory Quality") and CPI. The latter is of particular interest to me since I focus on corruption as one crucial feature of governance quality. Resource productivity also strongly correlates with the CPI (2000: r=0.67, 2005: r=0.65, 2010: r=0.5), but the significance of the correlation decreases over the observed period of time.

Correlations between domestic material consumption DMC and governance indicators are not as strong as for resource productivity, but still significant. The close relationship between material consumption and income was identified before and a linear association between these two dimensions is assumed as being very likely (Krausmann, 2011; Krausmann et al., 2009; Schaffartzik et al., 2014).

Material consumption and governance quality indicators (WGI1-3, CPI) correlate significantly in all three years. Intuitively, it seems consistent that the implementation of sound environmental policies dealing with the issue of sustainable resource use rather takes place in countries with high governance quality. It was furthermore detected before that governmental services (which also includes sound environmental policies) are deteriorating in countries with prevalent corrupt practices (Lambsdorff, 2006, p. 28). The significance of the correlation however decreases between 2000 and 2010.

5.2.2. Graphical Examination of the Relationship between Resource Use and Governance Quality

In the following, I show the development of individual EU countries between 2000, 2005 and 2010 regarding resource use and governance quality, while the latter is represented by the CPI. The decision to focus on CPI was made considering the underlying assumption that corruption is a crucial feature of governance quality and because corruption is a common dimension to represent governance quality. Questions about the possible influence of corruption on environmental issues (see e.g. Pellegrini, 2011) have received increased attention in recent years, but hardly any research focused on aspects of resource use as a dimension of environmental sustainability.

Material Consumption and the Corruption Perceptions Index

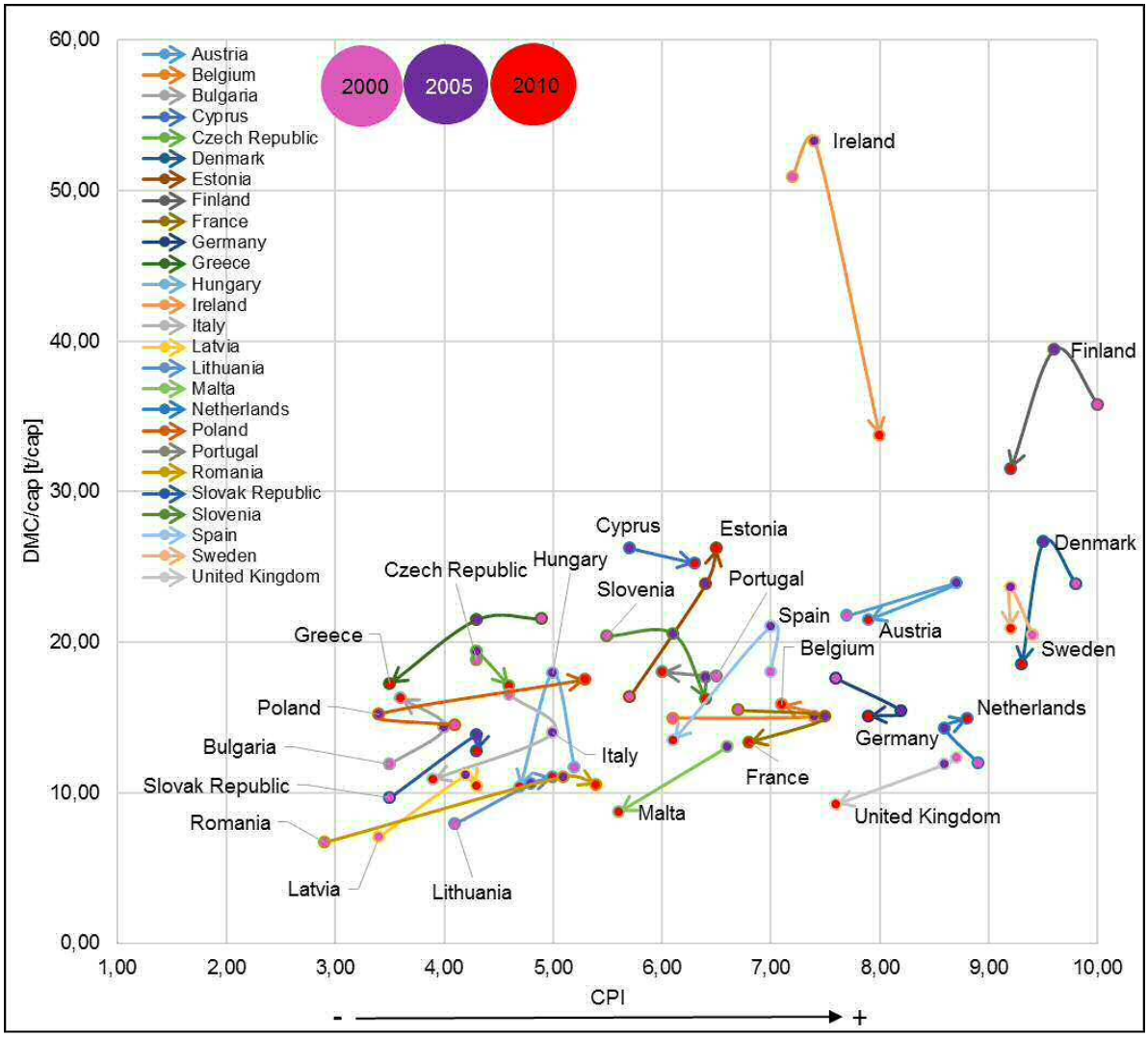

Figure 39 Correlation domestic material consumption (in t/cap) and the Corruption Perceptions Index CPI for the years 2000, 2005 and 2010; CPI ranges from 1 to 10, while higher values indicate lower national corruption levels. Source: DMC: own calculation; CPI: Transparency International, 2015a.

In Figure 39 the CPI is plotted against the per capita domestic material consumption. The graphic shows the development of each country for the years 2000 (pink dot), 2005 (purple

dot) and 2010 (red dot). The arrows additionally emphasize the development of the countries. It can be observed that in most countries, higher CPI, used as a representative for higher governance quality is accompanied by high material consumption, for instance in Austria, Sweden, Finland or Denmark. These countries are rather located on the right side. On the left side of the figure countries are found that exhibit both low governance quality and low DMC/cap values, such as Bulgaria, Romania, the Slovak Republic, etc. However, there are also particular exceptions to this observation, because countries with high governance quality do not necessarily show a high per capita DMC, such as UK, Germany and the Netherlands. These countries are examples of high governance quality but relatively low per capita material consumption. I deal with the question why some high income countries exhibit very low per capita material consumption in chapter 5.1.5. With reference to Wiedmann et al (2015) I relate this question with current research findings that countries tend to reduce their domestic extraction but consume materials and resources extracted in other regions. In Figure 39 most countries show a decreasing governance quality as well as material consumption between 2005 and 2010, which again might be due to the degree countries are affected by the economic crisis. Exceptions to this are Estonia, Lithuania, Poland and the Netherlands, where increasing governance quality is accompanied by higher material consumption. Most interesting are developments in Cyprus, Czech Republic, Latvia, Romania and Slovenia, because they exhibit improved governance quality but managed to reduce material consumption.

The relationship between governance quality variables and individual material categories seems to be worth being investigated, too. For comparison, economic development and individual material categories are indeed more or less tightly linked. Biomass consumption, for instance, is rather related to “bio-geographic factors such as population numbers, the size and composition of livestock, and land productivity” (Krausmann, 2011, p. 57) than to economic growth. Contrarily, fossil energy consumption and economic growth are tightly connected (Steinberger & Krausmann, 2011, p. 1174). However, questions about the relationship between governance quality and individual material categories have to remain unanswered so far.

Resource Productivity and the Corruption Perceptions Index

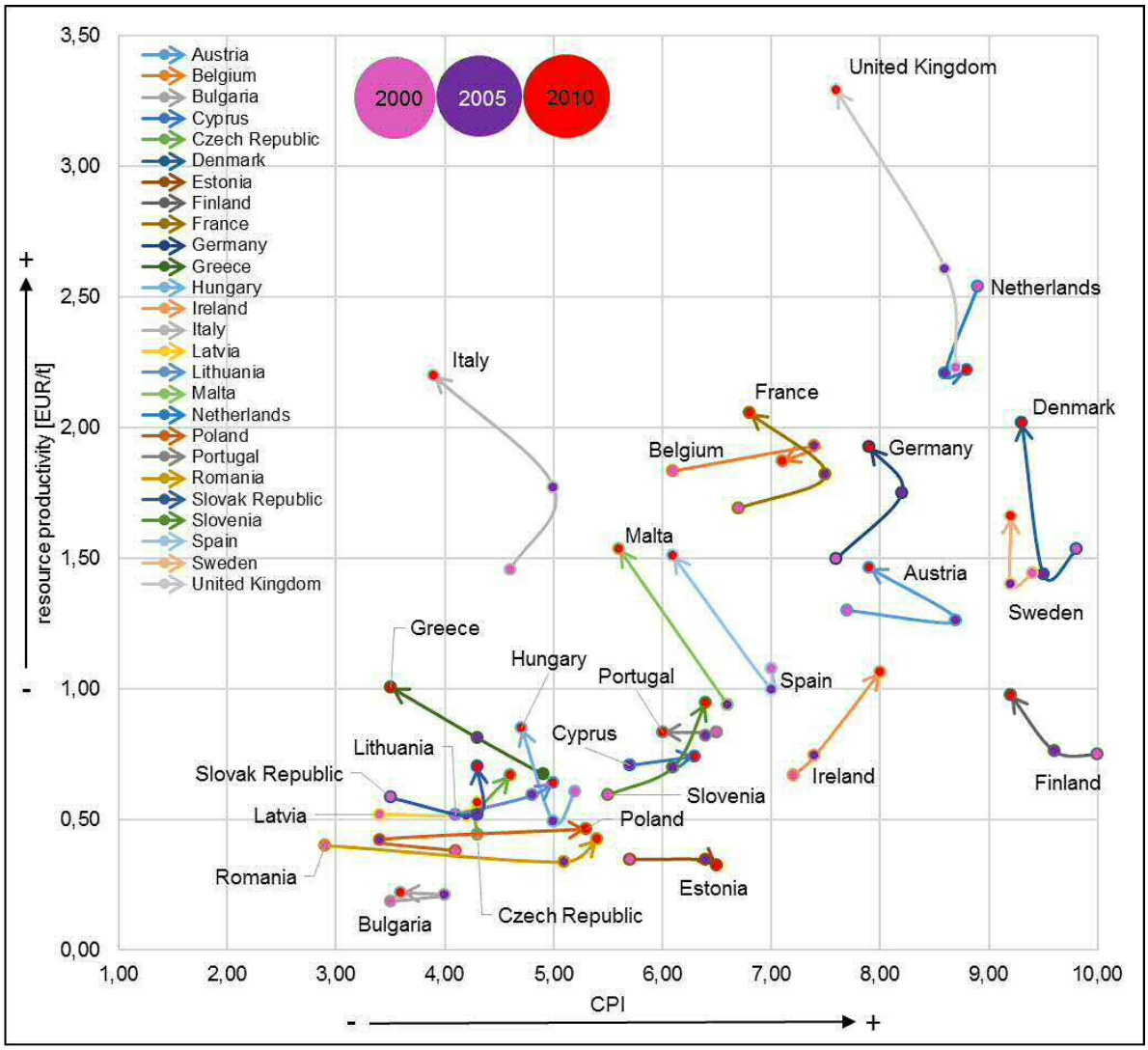

Figure 40 Resource productivity (in EUR/ton) plotted against the Corruption Perceptions Index. Development for the years 2000, 2005 and 2010. CPI ranges from 1 to 10, while higher values indicate lower national corruption levels. Source: RP: own calculation; CPI: Transparency International 2015a

In Figure 40, the CPI is plotted against resource productivity. The CPI ranges from 1 to 10, while higher values indicate lower national corruption levels. Resource productivity is plotted in the scale unit EUR/ton, which means that in Europe up to almost 3.5 EUR can be achieved per ton of material use (see Figure 40). In general it can be said that countries located in the top right corner have a good governance quality (represented by CPI) as well as good resource productivity, which is contrary to countries located in the bottom left corner. The graphic also reveals that countries "in the top right corner" are also high income countries. Between 2000 and 2010, governance quality has increased in most countries or at least stayed constant. Between 2005 and 2010, governance quality has increased in Ireland, Romania, Croatia and Poland. In Austria, Finland, UK, France, Spain, Portugal, Greece, Italy and Hungary governance quality decreased during the same period of time. The decreasing CPI might be due to the socioeconomic situations of countries that are to a greater or lesser extent affected by the consequences of the global financial crisis around 2010. The economic situation plays an important role regarding resource productivity levels, too. Resource productivity increased in

most of the countries between 2005 and 2010. This is a consequence of the economic recession, because less material is consumed when the economy is in recession which results in efficiency gains.

6. Integrated Results Discussion

In the discussion section it is aimed for integrating the results of the preceding chapter. I will discuss different particularities of the Greek metabolism taking into account dimensions of governance quality.

6.1. An Industrial Transformation: Greek Material Consumption and the Role of Europeanization

In recent decades, Greece experienced changes that affected all dimension of society and had mutual influence. The shift towards a high share of mineral and fossil materials is a characteristic feature of the process of industrialization (Krausmann 2011). The transition from an agrarian, biomass-based to an industrial, mineral-based economy was accompanied by an increase in resource extraction and consumption, a feature also found in most other industrialized or still industrializing countries. It led to a metabolic profile typical for industrialized economies: minerals account for more than two thirds of the domestic material consumption while the share of biomass has declined to below 30%. (Schaffartzik et al. 2014:91). The transition not only becomes evident when regarding biophysical but also social and political characteristics of Greece. The political and governance dimension of the transition was influenced by the interaction with the European Union. The EU plays an important role and is also known as 'Europeanization'. The 1960s can be regarded as a starting point of Europeanization in Greece. Since signing the Athens Agreement in 1961, Greece experienced a status as *Associate Member of the European Community* which served as a phase of preparation for full EU membership. This phase of preparation was interrupted by the "colonel's regime" between 1967 and 1974. The literature dealing with Europeanization discusses if, how and to what extent exogenous pressures exerted on domestic political systems produce changes in the institutions and policies of EU Member States (Sotiropoulos 2015:229). In Greece, altering state formations, patterns of policy-making and political culture as well as a new balance of power between state and society occurred. The process was furthermore accompanied not only by the development of a new political and social infrastructure but also by physical infrastructure.

I outlined earlier that infrastructure investments are a common measure for boosting economic development. It would however be an oversimplification to regard investments in infrastructure 'only' as economic measure. Greece actually had a poor physical infrastructure. This had long been considered as a "crucial facet of underdevelopment" (Paraskevopoulos 2005:445) and was regarded as "impediment to the development of other sectors of the economy and the society as a whole" (Paraskevopoulos 2005:445). The development of the new infrastructure was viewed as the first step towards Europeanization (Paraskevopoulos 2005). As a result, the greatest expenditure share originating from the Community Support Frameworks (CSFs) was spent on the development of basic infrastructure (Karousos and Vlamis 2008). This has a lasting effect on Greek material consumption. The demand for infrastructure was on the one hand a driver for material extraction and consumption for the actual construction process, on the other hand it created a demand for minerals and fossil energy carriers for running and maintaining the built structures. Due to the durability of

infrastructure buildings, future material and energy requirements are influenced too (Krausmann 2011).

These developments originate in the 1960s: The consumption of fossil energy carriers has followed a steep growth trajectory since the 1970s, but unlike my expectations, EU membership in 1981 did not show a particular impact on fossil fuel consumption. With reference to a study by Tsani (2010) who deals with the relationship between Greek energy consumption and economic growth, Greek consumption of energy carriers increased already during the 1960s. I regard the 1960s thus not only as the starting point for the intense interaction between Greece and the European Union, but also as an important point in time for the industrial transition.

6.2. Greek Consumption of Construction Minerals and the Role of Corruption

Within the context of infrastructure requirements, I want to discuss the consumption of construction minerals and the role of governance quality. The construction sector, an important branch of Greek economy, plays a crucial role regarding Greek mineral consumption. The construction sector is particularly susceptible to corruption (Sohail and Cavill 2008; Transparency International 2005). Corruption can occur at different stages of construction projects, in particular when publicly funded: during the project selection, different planning or inspection stages, the actual construction process as well as during the maintenance and management stages (Sohail and Cavill 2008:731–732). Consequences of corruption in the construction sector are mainly associated with the undermining of delivering services, ranging from poor infrastructural quality to the insufficient provision of cover in the case of earthquakes. In the Global Corruption Report from 2005, Transparency International focused on the construction sector and concluded that "corruption is likely to lead to more being spent but less being delivered" (2005:13). Corruption thus causes costs: "expensive and low-quality infrastructure may inflict costs on society that are far in excess of the money directly wasted in the process of provision" (Transparency International 2005:18). Tanzi and Davoodi (1998) argue furthermore that corruption is likely to increase the amount of projects as well as their individual size by enlarging them and increasing their complexity. This again results in additional costs (Tanzi and Davoodi 1998:2). These costs are not delimited to monetary but may also apply to resource or material costs. The provision of poor infrastructure quality might enhance the amount of materials used because of increased maintenance costs or rising demand for renovations.

However, the amount of resources actually influenced by corrupt practices is hardly be captured with highly aggregated MFA indicators. More substantial conclusions are to be expected when taking into account disaggregated material use data and considering specific economic sectors within which certain materials are used. Still, when accepting corruption as a phenomenon that is likely to affect social development in a negative way, it may well be that corruption also influences the use of not only construction but other materials. All these aspects considered, the corrupt practices might thus lead to the inefficient use of natural resources in one way or another.

6.3. Greek External Trade Structure

The process of Europeanization is closely associated with the opening up of traditional, national structures. The consequences of changing European political and economic structures can be most clearly traced when considering trade patterns. The creation and

implementation of the European single market on the one hand, and the adoption of the common European currency on the other hand had an intense impact on Greek external trade structure. This becomes obvious when considering physical as well as monetary trade flows. Greece exhibits a negative monetary trade balance, indicating that Greek import expenditure exceeds export revenue. The trade deficit in Greece that developed during the last decades is on the one hand a result of the weak Greek export structures. On the other hand it is also an outcome of the structure of the European market, which consists until its recent enlargement of both persistent surplus-generating countries (e.g. such as Germany, the Netherlands and Austria) and chronic deficit-inducing countries (such as Portugal, Spain, Italy and Greece) (Varoufakis 2011:196). A common mechanism to compensate for a trade deficit is a currency devaluation, which leads to higher competitiveness of export goods and at the same time to a higher acceptance of national goods. Over a longer period of time this would lead to a stabilization of the trade balance. After giving up on the Greek national currency, the Drachma, and adopting the Euro in 2001, this mechanism became obsolete and led to an explosion of the national debt (Schrader and Laaser 2010; Varoufakis 2011). Additionally, the growing imports contributed more and more to the debt accumulation. The positive PTB identifies Greece as net-importer of materials. It can thus be classified along most other industrialized countries, which are also characterized by net-imports, but the dimension of Greek imports is still exceptional (Dittrich and Bringezu 2010; Varoufakis 2011). The explosion of imports in recent years and the unbalanced trade balance can however not only be regarded from the above mentioned economic viewpoint, but governance quality also plays a role within this development. In the literature, first and foremost monetary trade flows are considered. Relevant dimensions of trade such as intensity or openness are measured in monetary units or as the ratio of import per GDP. I could not find any study dealing with dimensions of governance quality and physical trade flows. The studies nevertheless provide explanatory information on developments regarding Greek external trade.

Most theories conclude that some countries benefit more from trade than others. (Dixit and Norman 1998). In recent literature, trade, and who benefits from it most, was regarded from the viewpoint of governance quality, too (Levchenko 2007). Authors regard trade as being influenced particularly by institutional quality. They investigate the relationship between institutional quality and trade and come to the conclusion that countries with high quality institutions have a comparative advantage (Böwer, Michou, and Ungerer 2014; de Groot et al. 2004). The underlying assumption here is that trade intensity, and in particular export performance, is a driver for “economic growth and jobs” (Böwer et al. 2014:6). In open economies, exports are a key issue to foster economic growth, and a main pillar of economic development. De Groot et al (2004) argue that the quality of national institutions matters because international transactions, such as trade, involve components of uncertainty regarding contract enforcement, property rights etc. These components must be assured in order to reduce trade costs, and authors assume that better institutional quality reduces these uncertainties, i.e. trade costs (de Groot et al. 2004). Domestic institutions therefore have to be efficient. De Groot et al (2004) find that institutional quality has a significant, positive effect on bilateral trade flows concluding that countries with good governance quality have more diverse and intense trade patterns than countries with “bad” governance quality. This brings me back to Greece: the process of Europeanization and the associated political and economic developments led to a greater integration into the international market (Böwer et al. 2014; Papazoglou 2007). Greece intensified its trade but hardly benefited from this development. Exports fall short during the whole period observed, while the opposite is true for imports.

The study by Böwer et al (2014) investigates the question why Greek exports are lagging behind. Authors find that Greek poor institutional quality is "a highly significant factor in determining [the] country's export performance" (Böwer et al. 2014:18). Greek institutions thus do not ensure the above mentioned components necessary for reducing trade costs. Böwer et al (2014) emphasize that Greece is less competitive than comparable countries due to a weak export performance. Greek exports are the topic of discussion regarding the question why Greece is struggling to recover from recession. In contrast to Greece are other crisis countries such as Ireland, Portugal and Spain slowly but steadily recovering. In these countries, growing exports provided vital support to economic recovery. In terms of future development and a "Greek way out" (Gros 2015a), exports are also considered as of particular importance. The particularity of Greek exports and the reason why they do not contribute a big share to economic growth is that exports are dominated by products which depend heavily on raw materials imports because no domestic extraction takes place (e.g. for petroleum or metal products) (Schrader and Laaser 2010:543). Greek exports are thus based on the processing of materials providing little prospective revenue (Gros 2015b).

6.4. Greece in the European Context

With respect to the metabolic profile and governance quality, Greece will now be classified among other EU member states. In the literature, Spain, Portugal, Italy and Greece are often grouped together under the term "south European countries" or "southern European periphery" (Aiginger 2013; Sotiropoulos 2007, 2015). Ireland is often counted as periphery country too, but is to some extent a special case because of its geographic location as well as its close connection to the UK and the US economy. Italy is also not necessarily regarded as periphery country. South Italy would definitely qualify as peripheral country, but when regarding the country's overall performance it must not necessarily be included in the periphery country group (Aiginger 2013:11). Italy being exceptional can also be observed when regarding the scatter plots in chapter 5.2.2., which illustrate resource productivity and governance quality. Nevertheless, there exists a general understanding that the above mentioned countries share structural similarities not only regarding their administrative structure, but also with respect to their socioeconomic development in recent decades (Sotiropoulos 2007:405).

Considering the metabolic development, certain similarities were also found within the group of southern periphery countries. For most EU member states it was found that DMC either stayed constant or declined with increasing income. This was not the case for the periphery countries, namely Portugal, Spain, Ireland and Greece (Krausmann et al. 2011:29). Considering this development from the decoupling perspective, it can be concluded that the southern periphery countries are rather materializing than dematerializing (Krausmann et al. 2011:73). I found, too, that Greek DMC increased faster than GDP. Regarding European resource consumption patterns, non-metallic minerals (and among those, first and foremost construction minerals) are the dominant material in the DMC of most European countries when measured in absolute terms (Krausmann et al. 2011:25). This is on the one hand because of the high demand for maintaining infrastructure. On the other hand it is because of the demand for newly built infrastructure in structurally weak EU member states. A "spectacular" (Weisz et al. 2006:690) increase in construction minerals was in particular found for above mentioned southern periphery countries. Fossil energy carriers are the second most important material in the European Union. Both materials are also the relevant ones in the Greek metabolism. In terms of material consumption, Greece even has one of the highest

shares of fossil energy carriers within EU comparison (Krausmann et al. 2011:25). Drawing from Greek MFA results, it can be assumed that other periphery countries also experienced an industrial transition in the second half of the 20th century.

When relating European resource use with governance quality indicators by applying a correlation analysis, I found a significant relationship. Scatterplots revealed that countries with low governance quality range among the lower third of overall European resource productivity levels, between 0.5 and 1.5 EUR/ton. Countries with high governance quality exhibit resource productivity levels up to 3.5 EUR/ton. Countries with low governance quality values within the EU context are foremost low income countries, while countries with better governance quality values are mainly high income countries. Within European comparison, the periphery countries count as low income countries (Aiginger 2013). Greece both in terms of corruption and resource productivity ranks among low income countries, such as "new" EU member states that have joined the EU after 2004, or southern periphery countries. Regarding the relationship between resource use and governance quality, the importance of economic development is twofold: On the one hand, economy plays a particular role with respect to resource productivity since it is defined as the ratio of GDP to DMC. It was also found that material or resource productivity (as a result of efficiency gains) is "a standard feature of economic development" (Krausmann et al. 2009:15). On the other hand, economic development is regarded as being closely linked to governance quality (Pellegrini 2011). The relationship between economic growth and governance quality has received considerable attention in recent decades (Abed and Gupta 2002). The important questions asked are: *Is governance quality a result of economic growth? Or is economic status a result of governance quality?* Pellegrini discusses the direct and indirect "transmission channels for corruption "(2011:60) and finds that corruption has indeed a negative effect on economic growth through its "impact on investment, schooling, trade openness and political violence" (2011:67).

Coming back to the southern periphery countries and when taking into account results of the correlation analysis, it can be concluded that they share the structural similarity of low governance quality and resource productivity. I relate this finding with the impacts of the transition from agrarian to industrial based economies. Transitions are regarded as fundamental transformation processes that are accompanied by certain structural changes (Fischer-Kowalski and Rotmans 2009). The political and institutional structures of agrarian economies differ from industrial economies and a transition requires the development of new (or the adaption of the existing) governance structures. Central aspects of the transition can be observed in Greece and in other southern periphery countries in recent decades. This also exposed them to a global competitiveness that would have required efficiency gains in economic as well as biophysical terms. The existing governance and production structures were not capable of meeting these competitive challenges. Low resource productivity as well as governance quality in the recently industrialized countries can thus be regarded as the result of the missing capability to adapt to necessary conditions required in an industrialized and globally competitive surrounding. High corruption levels or low resource productivity, which are regarded as indicators for governance quality and resource use, are thus symptoms of the adaptive difficulties in recently industrialized countries.

7. Conclusions

In the concluding section I will first deal with the feasibility of my approach. I will then emphasize the key findings of the thesis and will close with a brief outlook regarding the future research potential of the subject.

Regarding the feasibility of my approach, I want to outline the applicability of the methods used. The method of material flow analysis is reliable and well-established, and the inclusion of relevant socioeconomic data allowed a comprehensive description of the Greek social metabolism. The question about the relationships between governance quality and resource use was operationalized by applying a correlation analysis. Significant relationships between biophysical and governance quality indicators could be identified. Certain difficulties occurred when capturing the potential impact of governance quality on resource use. This was mainly due to the high aggregation level of MFA indicators. I outlined central aspects of these difficulties in the discussion section.

The material flow analysis of Greece reveals a transition from a biomass-based, agricultural to a minerals-based, industrial society. This is evidenced by the increase in mineral materials but the rather constant extraction and consumption of biomass materials. The integration into the European Union not only plays an important role regarding resource consumption, but also regarding Greek external trade patterns. Greece intensified trade activities but became mainly a net-importer of goods and commodities. The physical import- and export-flows follow a rather similar trajectory until the early 1990s, although imports exceed exports in all years, which indicates rather weak export structures. It happens only around 1994 that exports stagnate and imports keep growing. The integration into the European Single Market and the following adoption of the European single currency were identified as crucial determinants for changing trade structures in Greece.

For contextualizing Greek material flow results, the metabolic rates were calculated and compared with the EU27 countries. Economic data, namely income, was taken into account as standard of comparison. Results revealed that Greece has a below EU-average income but an above-average resource consumption. When regarding the indicator resource productivity, it could be observed that Greece struggled in order to achieve efficiency gains. Although having a steep economic growth during the 1990s, a rather stagnate resource productivity could be observed. It happened only after the early 2000s that resource productivity increased significantly. It can be concluded that the overall political developments in Europe had a particular influence not only on the Greek political or socioeconomic system but they can also be regarded as determinants for the Greek biophysical development.

I was moreover interested in the relationship between biophysical characteristics, namely national resource use, and governance quality. I found that Greece has a below-average governance quality in comparison with the EU27 countries and argued that governance quality is of particular importance regarding socioeconomic development. In order to gain more insight into the relationship a correlation analysis was conducted. Indicators providing information about biophysical development and governance quality were included. Economic variables were also taken into account. A significant relationship between governance quality and resource use was revealed. I discussed potential aspects where governance quality and resource use may interact, namely in the construction sector or external trade structures. One key dimension when interpreting the correlation results is the transition from an agrarian based to an industrial based economy: In the discussion section I contextualized Greece within

structurally similar European countries, namely the southern periphery countries Spain, Italy and Portugal that also experienced central aspects of the industrial transition in recent decades. I argue that the low governance quality and resource productivity in these countries can be regarded as adaptive difficulties to the newly required governance and production structures in an industrialized economy.

My results set out a number of themes for further analysis. One question that arises deals with the development of individual material categories and their way of interacting with governance quality. Referring to Pellegrini (2011) and his investigation about transmission channels, I consider the question about transmission channels through which governance quality influences biophysical development as another interesting dimension to be explored. With reference to Steinberger et al (2013), who investigated the income-material coupling taking into account individual material categories, the exploration of the relationship between individual materials and governance quality in a similar manner seems promising to me.

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