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Revising the Resource Curse using a Physical Resource Abundance Indicator

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Julia Gruber, Bakk.

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Abstract

Resource abundant countries bear the environmental impacts of resource extraction and seem to face poorer growth performance according to the resource curse paradox. Using material flow data covering the period 1980-2008, this study evaluates whether the resource curse also exists for resource extraction measured in physical units, which in addition serves as approximation of environmental impacts. Hence, this study offers insights into whether bearing the environmental impacts of resource extraction is associated with higher or lower growth rates. I estimate the impact of physical resource extraction on growth, as well as on institutional quality, using two-way fixed effects OLS and threshold panel regressions. The findings indicate that (i) point source as well as diffuse source resource extraction is a growth blessing rather than a curse, (ii) the level of institutional quality matters in this context, and (iii) point source resource extraction is associated with weaker institutional quality.

Keywords: resource curse, material flow analysis, physical resource extraction, economic growth, institutional quality, ecologically unequal exchange

Ressourcenreiche Länder tragen die Umweltbelastungen des Ressourcenabbaus und scheinen laut dem Ressourcenfluch-Paradoxon geringere Wirtschaftswachstumsraten als rohstoffarme Länder zu haben. Diese Arbeit überprüft mittels Materialflussdaten für die Periode 1980-2008, ob der Ressourcenfluch auch für physischen Ressourcenabbau gemessen in Tonnen zutrifft. Da dieser Indikator die Umweltbelastungen des Ressourcenabbaus approximiert, bietet diese Studie Einblicke, ob das Tragen der Umweltbelastungen mit höheren oder niedrigeren Wachstumsraten verbunden ist. Mittels OLS Panelregressionen (zweifach fixierte Effekte) und „threshold"-Regressionen werden die Zusammenhänge zwischen physischem Ressourcenabbau und Wirtschaftswachstum sowie institutioneller Qualität gemessen. Die Ergebnisse zeigen, dass (i) sowohl „point source" als auch „diffuse source" Ressourcenabbau kein Fluch sondern ein Segen für das Wirtschaftswachstum sind, (ii) das Niveau an institutioneller Qualität eine Rolle spielt, und (iii) „point source" Ressourcenabbau mit geringerer institutioneller Qualität korreliert.

Keywords: Ressourcenfluch, Materialflussanalyse, Physischer Ressourcenabbau, Wirtschaftswachstum, Institutionelle Qualität, Ökologisch Ungleicher Tausch

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1 Introduction

Conventional wisdom suggests that resources are "manna from heaven". Countries rich in resources should benefit from more possibilities to generate economic growth[1]. However, economic literature accuses resource abundance of being a curse rather than a blessing. Natural resource abundance seems to hamper rather than foster economic growth (Bulte et al., 2005; Isham et al., 2005; van der Ploeg, 2011; Sachs and Warner, 1995; Sala-i-Martin and Subramanian, 2003). Moreover, the extraction of resources is associated with environmental impacts (e.g. Bringezu et al., 2009; Haberl et al., 2004). In summary, resource extraction seems to be costly from an economic growth perspective as well as from an environmental perspective.

The term "resource curse" defines the paradox that countries abundant in resources – especially point source resources[2] – tend to have a weaker growth performance than countries less abundant in natural resources (results are summarized in van der Ploeg, 2011). Empirical evidence as well as theoretical results suggest that resource abundance is not only correlated with poor economic performance but with increased inequality, corruption and armed conflicts as well as unsustainable government policies. Economics as well as political science offer several explanations for this puzzling phenomenon. One of the channels through which the "curse casts its spell" is institutional quality. Resource abundance is positively associated with growth in countries with strong institutions while countries with weak institutions face a resource curse (Mehlum et al., 2006). Other studies (Brunnschweiler and Bulte, 2008; Isham et al., 2005; Sala-i-Martin and Subramanian, 2003) argue that institutional quality itself is affected by resource abundance and show that resource abundance influences economic growth indirectly through their impact on institutional quality.

Concerning the environmental perspective, resource extraction[3] causes environmental impacts, which are, like natural resources themselves, not equally distributed around the globe. Some countries bear the environmental impacts of resource extraction while other countries enjoy the pleasure of a resource-intensive living standard. Several studies examining material flows have addressed the geographic distribution of resource extraction and resource consumption – also known as environmental "burden shifting"[4] (e.g. Dittrich, Bringezu, et al., 2012). Other material flow studies focus on the trade relationships between countries from the global North and global South by means of comparing monetary and physical trade balances called "ecologically unequal exchange" (e.g. Giljum and Eisenmenger, 2004; Moran et al., 2013; Muradian and Martinez-Alier, 2001; Pérez-Rincón, 2006). The accusation is that resource revenues do not compensate for the ecological value of resources and the environmental impacts caused by the extraction (summarised in Moran et al., 2013).

[1] The terms "growth" and "economic growth" refer to growth of per capita gross domestic product (GDP) throughout this thesis, unless specified differently.

[2] Point source resources refer to the extraction of resources such as oil and ores, which originate from narrow geographical regions. Diffuse source resource extraction defines the extraction of resources such as biomass, which are geographically widespread.

[3] The terms "resources" and "materials" are used interchangeably.

[4] The term "burden shifting" not only refers to the shifting of CO_2-intensive production but to the broader context of shifting all environmental problems associated with the resource extraction and production processes.

This study sets out to combine the economic and the environmental perspective. In the resource curse debate resource abundance is approximated by monetary indicators. However, monetary indicators are influenced by price fluctuations and may not represent the ecological value of natural resources. This study introduces domestic resource extraction in tonnes per capita as a physical indicator for resource abundance, which is less affected by price fluctuations. At the same time, physical material flows approximate environmental impacts. However, studies investigating material flows and the distribution of environmental impacts do not focus on the relationship with economic growth. Even though they investigate the monetary compensation for material exports they do not assess whether bearing the environmental impacts of resource extraction is associated with a growth compensation.

The aim of this study is to evaluate whether the resource curse also exists for physical resource abundance. In detail, it examines the relationship between physical resource extraction, institutional quality and economic growth for total resource extraction, for point source resource extraction and diffuse source resource extraction[2]. It therefore revises the outcomes for monetary resource abundance indicators using the physical resource extraction indicator obtained by the material flow accounts. This enriches the resource curse debate with a sustainability context. Even though there are some limitations to this approach, this study addresses the question of whether bearing the environmental impacts of resource extraction is associated with higher or lower growth rates. I apply the subsequent methods in order to evaluate the research questions. I use two-way fixed effects OLS panel estimations combining growth regressions and institutional quality regressions following the design of the resource curse literature (e.g. Sachs and Warner, 1995). Furthermore, I apply a threshold regression model, which allows me to test whether the relationship between resource extraction and economic growth is contingent upon the value of institutional quality. The unbalanced panel dataset covers the period 1980-2008 and contains 172 countries.

The resource curse is one of the puzzling paradoxes in economic theory and empirics. Revising the resource curse using a physical resource abundance indicator links this debate to the material flow research. It therefore casts new light on the resource curse as it combines the economic debate with a sustainability context. In addition, it introduces the resource curse debate in the material flow research. Previous studies make the accusation that resource exporting countries do not get an equal compensation in resource revenues for the environmental impacts caused by the resource extraction. This investigation expands the question of compensation to the broader context of economic growth. Furthermore, it classifies according to institutional quality levels instead of classifying by countries' development status in countries from the global South and the global North. This study also links two of my personal areas of interest. I learned about the resource curse debate whilst studying economics and acquainted myself with material flows at the "Institut für Soziale Ökologie" as well as at my previous employer "SERI". Hence, I have an interest in analysing economic questions from a sustainability perspective.

This thesis is organised in the following way. Chapter 2 begins by introducing sustainability in the realm of material flows and the resource curse and further reviews theory and empirical evidence with regard to physical resource extraction and the resource curse. The research questions and hypotheses are then introduced in Chapter 3. Chapter 4 describes the methodology used in this study. The next two chapters present the empirical results and the discussion of these results. The last chapter summarises the main findings.

2 Theory and Empirical Evidence

2.1 Weak versus Strong Sustainability

This study sets out to enrich the resource curse debate with a sustainability context. Up to now, the resource curse literature has mainly focused on the relationship between resource revenues and GDP growth. However, several studies have examined the correlation between resource revenues and genuine savings, which is a weak sustainable progress indicator. These studies argue that GDP is an inappropriate measure of progress in the resource curse debate and hence, replace it with a more sustainable progress indicator. This investigation follows a different approach. I keep GDP but replace the monetary indicator resource revenues with a physical indicator for environmental impacts. My indicator of interest stems from material flow analysis, a method measuring strong sustainability. Material flows and hence, physical resource extraction serves as proxy for environmental impacts[5]. Therefore, this study evaluates whether the resource curse also exists for physical resource abundance and offers insights in to whether bearing the environmental impacts of resource extraction is associated with positive or negative growth rates. This chapter summarizes weak and strong sustainability.

The concept of "Sustainable Development" has achieved wide support since it has avoided being bound to one single narrow definition (Dietz and Neumayer, 2007). In fact, there exists a variety of sustainability definitions. The most famous is the one offered in the Brundtland report: "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development (WCED), 1987, p. 41). Atkinson provides the broader scope of "development that lasts" (quoted after Dietz and Neumayer, 2007), whereas UNEP emphasises the aim of a more equitable distribution of resources between well-off and poor people but also between regions and nations (Dietz and Neumayer, 2007)

From an economic approach, sustainability is defined in terms of utility or human wellbeing. Development is sustainable "if it does not decrease the capacity to provide non-declining per capita utility for infinity" (Neumayer, 2013, p. 7). In general this utility derives from the four forms of capital: produced, natural, human and social. However, in the economic appoach one important distinction in this regard is the treatment of natural capital (Dietz and Neumayer, 2007). Does it need special protection or is it substitutable with other capital forms (in particular produced capital)? That is the crucial difference between weak sustainability and strong sustainability.

Weak sustainability assumes that different forms of capital (produced, natural, human and social capital) can be substituted as long as the sum of all forms of capital stays constant or increases over time (Dietz and Neumayer, 2007). In other words, total net capital wealth is not allowed to persistently diminish. This stems from the Hartwick rule, which states that rents from non-renewable resource depletion should be transformed in to produced capital. Consequently, the depletion of natural capital should be reinvested in produced, human or social capital for weakly sustainable growth. Declining total capital stocks reveal countries, which grow and consume to the detriment of their natural resources.

[5] However, this is subject to criticism, since the aggregation of various material flows loses information on the specific environmental impact of each flow (see chapter 6).

Several studies have evaluated the relationship between resource dependence and the weak sustainability indicator “genuine savings” and thus started to integrate a sustainability perspective in the resource curse debate. Most of the studies analysing the resource curse focus on the effect of resource dependence on growth. High resource dependence implies lowering natural capital, which is not captured in the GDP calculation. Accordingly, it is of utmost interest to examine the effect of resource dependence on the sum of all capital forms (produced, natural, human and social) and not solely on produced capital. Chapter 2.3.3 introduces the weak sustainability measure “genuine savings” as well as research on the relationship between resource abundance and genuine savings.

On the other hand, **strong sustainability** (SS) proponents consider natural capital to be more or less non-substitutable. The reason for this lies in the SS view of the functions of natural capital. Ekins (2003) describes four main functions: the basic life-support functions, the provision of raw materials for production and consumption, the assimilation of waste products and the amenity functions (e.g. beauty of landscape). It is obvious that human welfare is directly dependent on the life-support functions. Whereas the last three functions are considered to be to a greater or lesser extent substitutable, the basic life-support functions are thus far definitely not (Barbier et al., 1994). Dietz and Neumayer (2007) state further reasons for strong sustainability. Firstly, science has not yet explained the way natural capital functions (e.g. global carbon and biogeochemcial cycle). Hence, there remains uncertainty and considerable risk in what might happen if we deplete natural capital. Secondly, some natural capital losses are seen as irreversible. Thirdly, economic evidence leads to the conclusion that humans are risk averse. This might suggest that humans are highly averse to lower utility due to losses of natural capital functions (basic life-support functions but also amenity functions).

One prominent measurement tool in the understanding of strong sustainability is the material flow accounts. The material flow community – though proponents of strong sustainability – follow the realistic approach that resources are needed for social life and economic activities. Resources are nevertheless scarce and their extraction, trade and production processes are associated with environmental impacts. The question of interest is, how many resources do we need for an acceptable standard of living, for our well-being and for our economic growth? Which countries bear the environmental impacts of material extraction? Hence, it is a question of size and distribution (see chapter 2.2.2 for more details).

2.2 Physical Resource Extraction

Resources are indispensable for human living and economic processes; however, the scale of material consumption and extraction depends significantly on the lifestyle of societies. Looking back over the changing models of human society since human civilization began, and in comparison with hunter-gatherer and agrarian societies, energy and material consumption has never been greater than at present in our industrialised society. Even in the last decades the hunger for materials has increased significantly. This growing overall scale of material extraction goes hand in hand with heavy environmental impacts. Even if we do not consider the problem of resource scarcity, the ability of nature’s sinks to absorb our waste and pollution is being pushed to its limits (Rockström et al., 2009).

My focus is not on the total scale of resource extraction but its distribution. It is important to distinguish between materials domestically extracted and imported materials as it reveals the location of environmental impacts associated with environmental extraction (Haberl et al., 2004).

Who bears the environmental impacts of resource extraction? Who enjoys the pleasure of resource consumption while shifting the environmental burden abroad? Some scholars speak of "burden shifting"[6] in this context, others have coined the term "ecologically unequal exchange". The accusation is that resource revenues do not compensate for the ecological value of resources and the environmental impacts caused by the extraction.

This study, among other things, evaluates the relationship between environmental impacts of resource extraction and growth. My indicator for environmental impact is "domestic extraction" and stems from the material flow accounts. Hence, the next chapters introduce the material flow accounts, present the relationship between material extraction and environmental impacts and discuss the distribution of these environmental impacts.

2.2.1 Material Flow Accounts

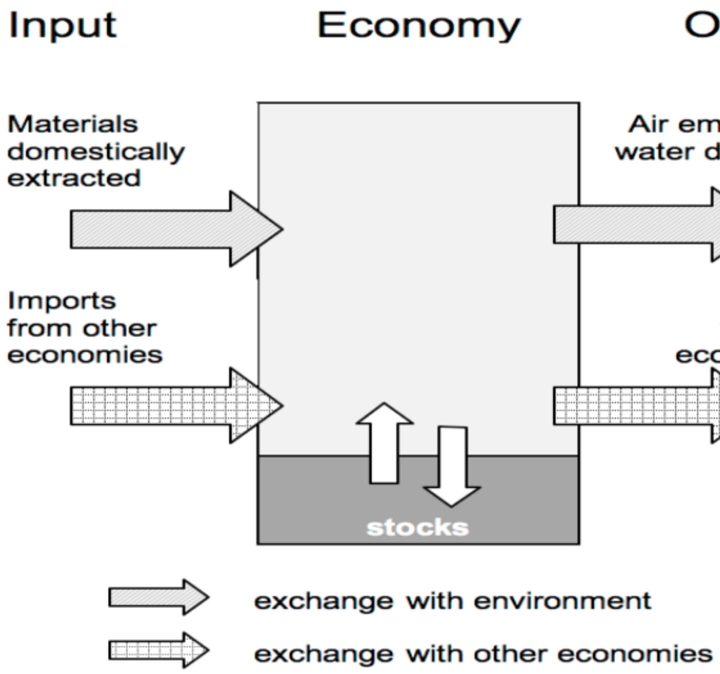
Material flows describe the physical dimension of economic processes. Material Flow Accounts (MFAs) are an important tool to support sustainable policy making because sustainable resource use is one of the key areas of sustainability. MFAs are designed to complement the System of National Accounts (SNA) and thus, economic information is enriched with physical indicators. This allows monitoring decoupling between economic and physical variables. The focus of this study is not on the total volume of material flows but the distribution of resource extraction. The main variable of interest is "domestic extraction", an indicator obtained by MFA. For this reason, this chapter provides an insight in to the accounting of material flows.

Material flow accounts (MFA) measure physical material flows between the economy and the environment in terms of tonnes per year (EUROSTAT, 2012). Material flow analysis accounts for the extraction, the use of materials in production and consumption as well as the trade flows of materials (excluding air and water). The concept behind this is an interrelation model (EUROSTAT, 2009) between the environment and national economies. Food, fossil fuels, ores and construction materials enter the economy as inputs from the natural systems or from other economies. They are transformed to products and enhance the socio-economic stock. In the end, they leave the economic system as export products or waste and emissions output in to the environment (see Figure 1). The distinction between domestically extracted materials and imported materials is important for my investigation, as it reveals where the environmental impacts associated with the extraction occur (Haberl et al., 2004).

In the beginning, the intention of material flow accounts was to monitor the achievement of steady-state-economies, which aim at holding the material throughput of an economy constant (Dietz and Neumayer, 2007). The Wuppertal Institut as well as the Institut für Interdisziplinäre Forschung und Fortbildung (IFF) were pioneering institutes in international research on material flows (Pérez-Rincón, 2006). In the past ten years, several attempts have been made to standardise the material flow accounting methodology. Two international organizations stand out in this regard: the European Statistical Office (EUROSTAT) and the Organization for Economic Cooperation and Development (OECD). Today, a variety of countries have implemented environmental accounting systems in order to gain a better decision-basis for policy-making as well as to monitor the development of material

[6] The term "burden shifting" not only refers to the shifting of CO_2-intensive production but to the broader context of shifting all environmental problems associated with the resource extraction and production processes.

Figure 1: Scope of MFA (EUROSTAT 2009)

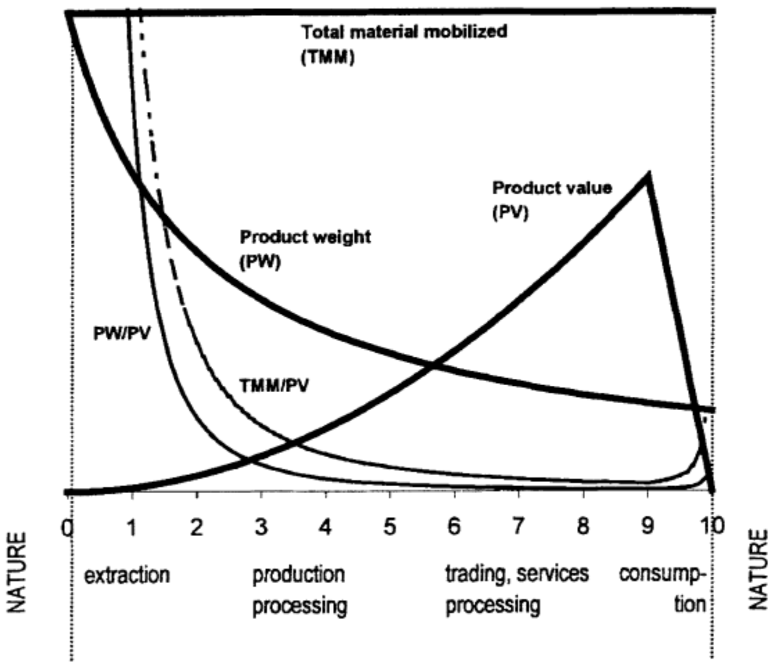


flows, resource productivity and thus, the sustainable use of resources. European Union countries collect their data following the latest EUROSTAT "Economy-wide Material Flow Accounting" methodological guide (EUROSTAT, 2012). Nowadays, MFAs complement the System of National Accounts (SNA) and hence enrich the economic database of a country with information on physical flows.

Material flow accounts can be treated as a satellite system to the System of Integrated Environmental and Economic Accounting (SEEA) (EUROSTAT, 2009). They are, therefore, conceptualized in relation to the System of National Accounts (SNA). This allows enriching the economic accounting systems with information on physical flows between the natural environment and the domestic economy as well as with other economies. Monetary indicators, such as GDP, are supplemented by indicators in mass units. However, it should be noted that monetary and physical flows follow a different logic (Fischer-Kowalski and Amann, 2001). Considering the product life cycle the economic value increases along the way from material extraction, processing, trading and consumption (see Figure 2). On the other hand, the product weight decreases. The first stage of production, the material extraction, is quite material intensive as it includes unusable material wastes, which are removed through the production process. Accordingly, the raw material exports are quite material intensive but have low economic value. Whereas manufactured goods are characterized by high value and lower weight.

Physical flows are gaining importance in the sustainability debate. In the past the focus of environmental policy was mainly on the output side – on the size of output emissions and waste (Neumayer, 2013). From the perspective of material flows, the environmental problems associated with emissions and waste have their origins in the extraction and trade of materials. Proponents concentrate on the input side and on the reduction of material flows in order to reduce the environmental pressure. It is the question of the size of material use and extraction, which causes environmental problems. Hence, lower material inputs (e.g. due to higher resource efficiency) could be an important factor in handling environmental problems like climate change or loss in

Figure 2: Model of extraction, production and consumption stages in physical and economic units (Fischer-Kowalski & Amann 2001, p.31)



biodiversity. Hinterberger and Wegner (1997) proposed the Total Material Requirement (TMR) of an economy as a single long-term environmental objective, others discussed the factor-x-reduction that promotes a reduction of total material consumption by factor x, at least in the global North (Weizsacker et al., 1997).

Furthermore, the research on material flows not only highlights the scale of material throughput but also the distribution of material extraction and material consumption between nations. Who carries the burden of extracting and who profits from the pleasure of consuming? Important indicators in this regard are domestic extraction and the physical trade balance. **Domestic extraction (DE)** refers to national material flows from the environment to the economic sphere – measured in tonnes per year. These flows are used for economic production or direct consumption (EUROSTAT, 2012). The p**hysical trade balance (PTB)**[7] is defined as physical imports minus exports (EUROSTAT, 2009). It thus reveals whether a country is a resource provider (physical trade deficit) or a resource demander (physical trade surplus) and illustrates the international position in physical resource trade. Is a country able to meet its consumption needs with domestic resources or is it dependent on resource imports? Haberl et al. (2004) conclude that the distinction between material inputs from nature and from other economies is decisive since it reveals where the environmental damage caused by the material extraction is situated.

2.2.2 Material Extraction and Environment

Today, we have the highest scale of material extraction in history – 68 billion tonnes in 2008 (Dittrich, Giljum, et al., 2012). No generation before us has extracted and consumed so many resources. In the

[7] The PTB can be interpreted to follow a dynamic component. Resource providers of today can be resource demanders of tomorrow as natural resources – at least point source natural resources – can be depleted. Several studies in the resource curse literature evaluate if countries are preparing for the depletion of natural resources and investing their natural resource wealth in an appropriate way (see chapter 2.3.3 for more detail).

past three decades, global material demand has increased by almost 80 % (see Figure 3). The material categories construction minerals and metal ores have experienced the highest growth rates. Accordingly, the share of global material extraction stemming from non-renewable sources (fossil fuels, metal ores and minerals) has increased from 64 % to 72 %. This highlights that we rely heavily on non-renewable resources.

Figure 3 also reveals two major regional trends (Dittrich, Giljum, et al., 2012). The first, the drop in material extraction in the early 1990s illustrates the economic recessions in the former Soviet Union states. Secondly, the high growth rates in 2003 indicate the material demand of the emerging economies such as China, India and Brazil. Asia plays a special part in providing resources: it is responsible for more than half of worldwide material extraction and has the highest extraction levels in all four material groups. Its material extraction has grown by a factor of 2.5 over the past 30 years. Other regions also show a significant contribution. For example, North America follows Asia as an extractor of fossil fuels, especially of hard coal and natural gas. Concerning metal ores, Latin America (e.g. Brazil, Chile and Peru), Oceania (in particular Australia) and African countries take a significant share in extraction.

Figure 4 allows a different view of resource providers (SERI, 2013a). It shows physical material extraction per capita in 2008. Countries with low population density such as Qatar, United Arab Emirates, Brunei, Kuwait and Australia contribute the highest per capita material extraction. In the past 30 years, they have extracted on average between 60 (Australia) and 90 (Qatar) tonnes per capita. In contrast, China, United States of America, India, Brazil and the Russian Federation lead in absolute material extraction.

Figure 3: Development of global material extraction and growth rates, 1980-2008 (Dittrich, Giljum, et al., 2012, p. 20)

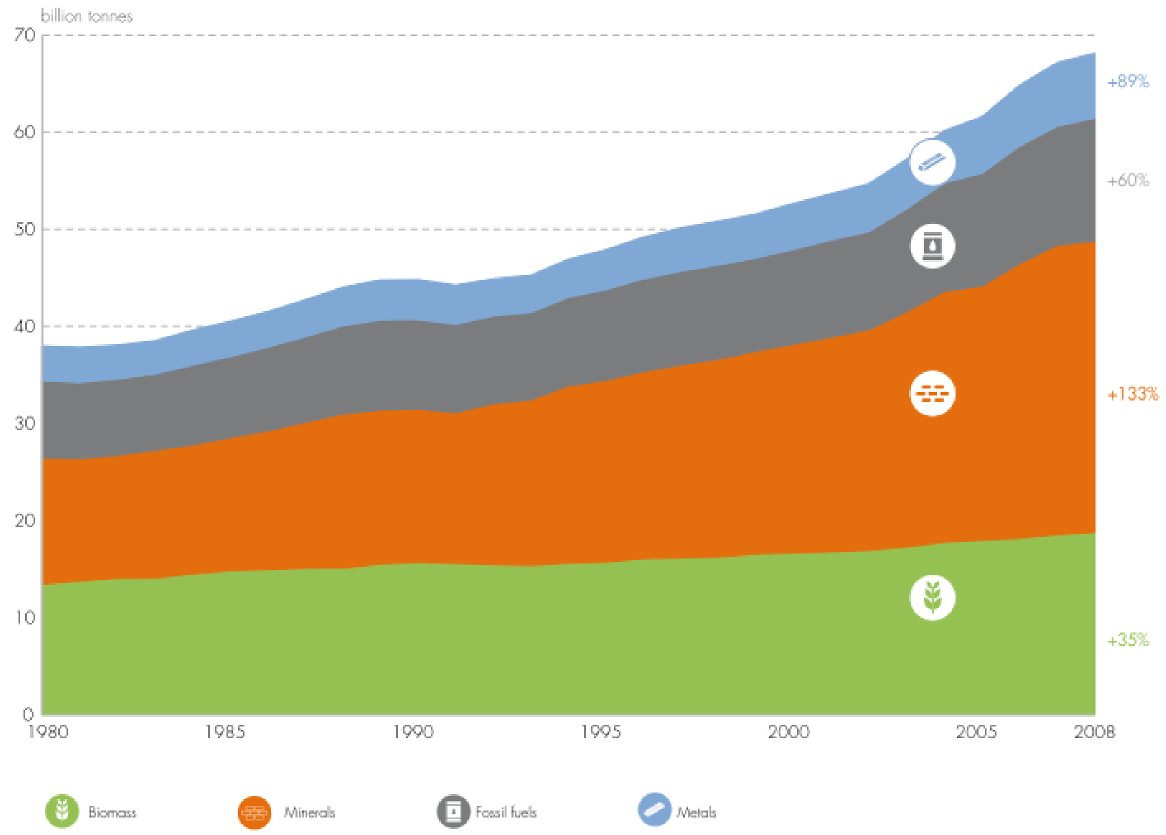
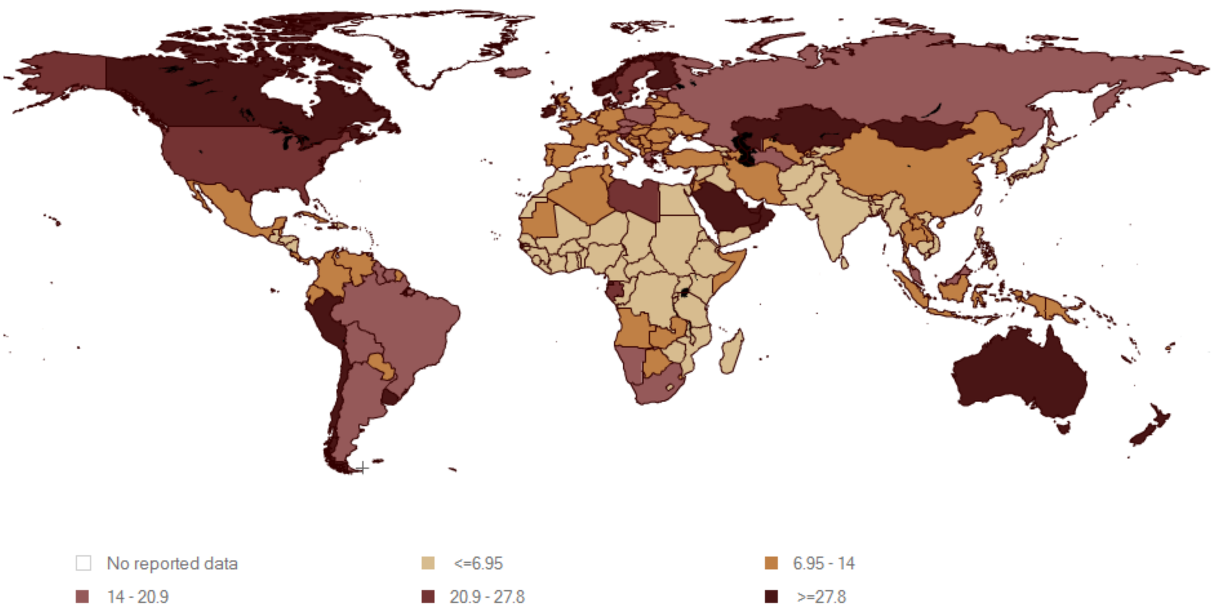


Figure 4: Domestic extraction per capita, 2008, in tonnes (SERI 2013b)



Resource extraction is associated with environmental impacts. It is true to state that almost any environmental problem (e.g. climate change, landscape deterioration, eutrophication and acidification) is linked to material flows. However, the relationship between material flows and environmental impacts is quite complex (Bringezu et al., 2009). It depends on the quantity of extraction, on the quality of the extracted material with regard to potential impact per unit flow as well as the location where it is extracted. For example, mining in the tropical rainforest jeopardizes the environmental system more than mining in a remote and sparsely vegetated area.

Dittrich, Giljum et al. (2012) describe some of the relationships between material extraction and environmental impacts for the four material categories. In the case of biomass cultivation the tendency of highly industrialized monoculture production leads to soil degradation as well as ground and surface water pollution caused by pesticides and fertilizers. Other environmental issues are water scarcity due to irrigation, cleared woodland in order to gain agricultural land and related biodiversity losses. The next category, industrial and construction minerals, has generally a low impact on nature per tonne but the vast sums extracted add up to create substantial effects. One can easily imagine the consequences of fossil fuel extraction in sensitive ecosystems like open sea, river deltas or rain forests. On their way from extraction to consumption, fossil fuels are further responsible for tanker accidents and pipeline leakages on their transportation routes but the main consequence is the emission of greenhouse gases. The last material category is metal ores, which is also characterized by significant environmental impacts. In metal mining, large quantities of metal particles end in the soil and in the ground or surface water. Furthermore, during the extraction process large amounts of materials are moved, which affects ecosystems and causes land use changes. In more detail, one can distinguish 250 different raw materials where each has its unique impact on the environment. Collectively they contribute to the rising pressure on the planets ecosystems.

In a nutshell, different material flows create different environmental pressures. Critics argue that the aggregation of material flows involves a loss of information with regard to environmental pressure. Nevertheless, even if material flows are less suitable to serve as indicators for specific environmental pressures (Bringezu et al., 2009), they enable the monitoring of the overall pressure on the "planet's belaboured ecosystems" (Dittrich, Giljum, et al., 2012, p. 54) and can be interpreted as "early warning indicators" (Dittrich, Bringezu, et al., 2012, p. 33).

2.2.3 Material Trade and Ecologically Unequal Exchange

On a global scale the geographic distribution of resource consumption does not match the geographic distribution of resource extraction and production processes (UNEP, 2011). In other words, the environmental pressure linked to material extraction (see chapter 2.2.2) is, like natural resources themselves, not equally distributed. Global trade enables the transport of materials from resource-rich to resource scarce countries and countries with material intensive lifestyles. Up until now, trade has been mainly assessed in economic terms. However, the physical dimension of global trade has important implications for the distribution of environmental problems. Scholars of material flow analysis (e.g. Dittrich, Bringezu, et al., 2012) investigating the "growing burden shifting"[8] between countries enjoying the benefits of material intensive lifestyle and other countries bearing the environmental impacts of extracting the necessary materials and of producing those products. Another focus is the unequal distribution of environmental costs and economic revenues between global North and South, which is summarized under the term "ecologically unequal exchange" (e.g. Eisenmenger and Giljum, 2007; Moran et al., 2013; Muradian et al., 2002; Pérez-Rincón, 2006). Physical trade balances (PTB) are important indicators in this regard[9]. They express if the physical imports (M) from the rest of the world exceed the physical exports (X). Thus, they illustrate if domestic resource extraction meets the consumption demand or if further impacts are necessary. This chapter investigates who the global burden shifters and takers are and addresses the issue of ecologically unequal exchange.

Let's start with a brief look at the development of global material trade (see Figure 5). Nowadays, more materials in physical terms are traded around the globe than ever before (Dittrich, Giljum, et al., 2012). Trade volume has reached a level of 10 billion tonnes and has grown by a factor of 2.5 over the last 30 years. Materials extracted from a narrow geographic base, such as oil and minerals, are responsible for a large share of global trade volumes. In 2008, fossil fuels dominated physical trade with a share of 50 %, followed by metals with 20 % and biomass with 16 %. The share of industrial and construction minerals in physical trade was relatively low compared with the share in physical extraction (see Figure 3). This is due to their ubiquitous emergence and their low value per tonne.

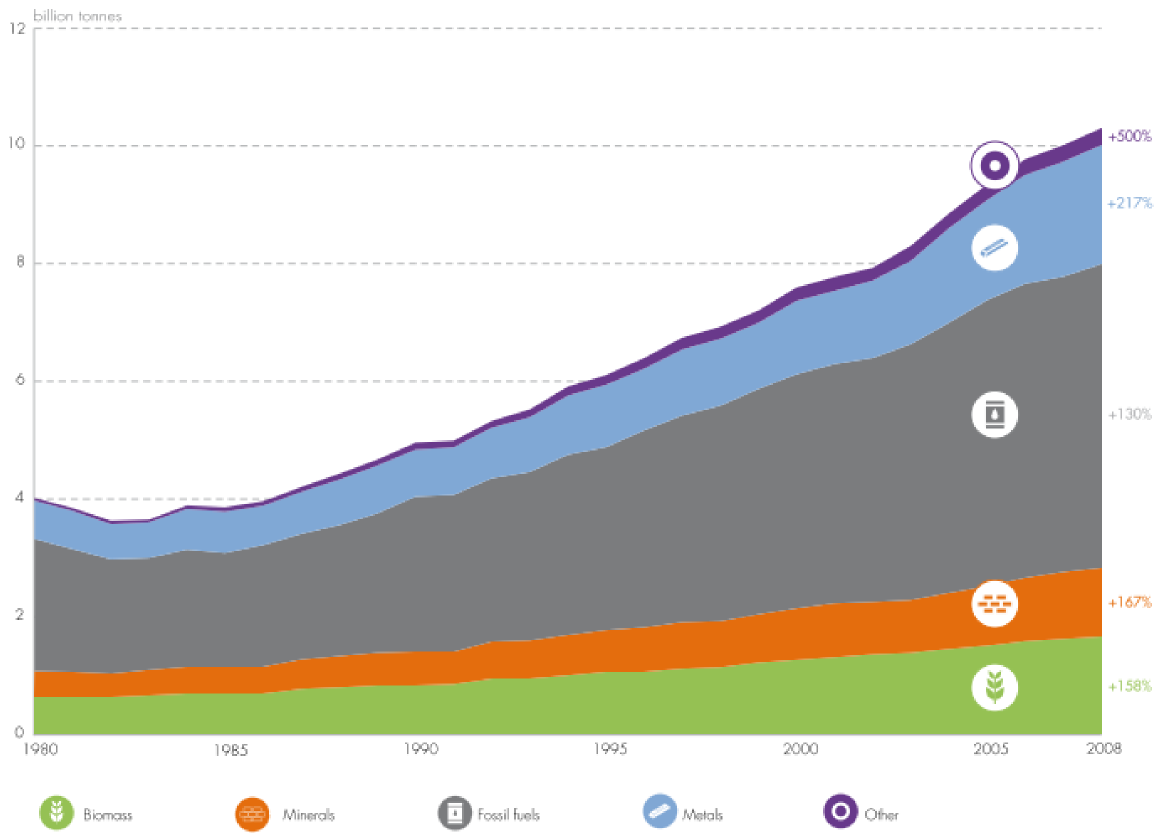
On a country level global resource trade not only offers the potential enjoyment of resource revenues but also the environmental burden of resource extracting. Dittrich, Bringezu et al. (2012) discuss the "growing burden shifting" [10] of environmental impacts. They investigate the environmental distance between producing end products (extracting materials and further processing them) and consuming those products, "which results in some countries being able to

[8] Burden shifting does not necessarily indicate intentional burden shifting (Dittrich, Bringezu, et al., 2012).

[9] At first I had planned to additionally examine the effect of physical trade balance (PTB) on growth as this is a frequently mentioned indicator of environmental burden shifting and ecologically unequal exchange. However, the scatterplot of these two variables indicated only a cluster of points with several outliers (see Figure 11). Hence, I decided to exclude PTB from my research focus.

[10] Please note, that burden shifting in this context not only incorporates the shifting of environmental costs originated from material extraction but also from the production process. Moreover, Dittrich, Bringezu et al. (2012) investigate the effect of direct and indirect flows (see chapter 4.2 for explanation).

Figure 5: Development of global material trade and growth, 1980-2008 (Dittrich, Giljum, et al., 2012, p. 22)

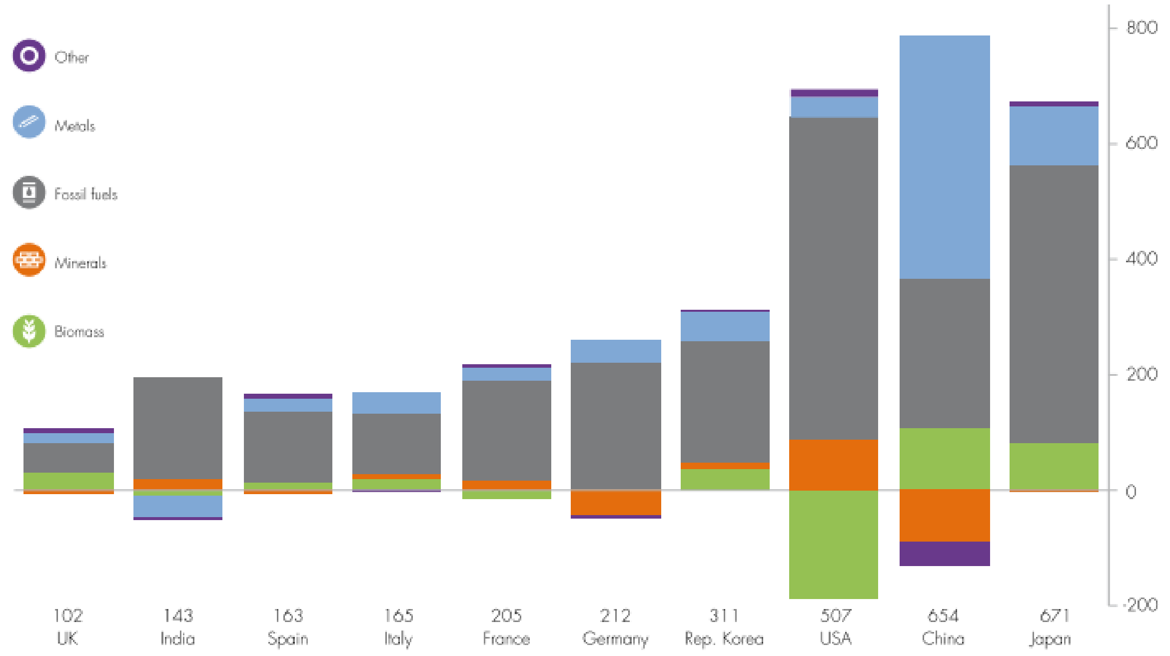


enjoy the consumption of imported goods, while the exporting countries carry the environmental burden caused by the production of those goods" (Dittrich, Bringezu, et al., 2012, p. 1). The key indicator in this regard is the physical trade balance (PTB), which equals physical imports minus physical exports. The PTB reveals whether a country is a resource provider (physical trade deficit) or a resource demander (physical trade surplus) and thus, indicates its international position in the trade of physical resources. Is a country able to meet its consumption needs with domestic resources or is it dependent on resource imports?

Japan, China and the United States of America rank among the countries most highly dependent on resource imports (see Figure 6). Their physical imports greatly exceed their physical exports. Japan has been the leading net-importer of materials since modern trade records began (Dittrich, Giljum, et al., 2012). It is closely followed by China, which has shown a remarkable increase in material demand. In the 1980s China exhibited nearly no resource trade, whereas in 2008 it was the second largest net-importer, of metals in particular. The third rank is taken by the United States, a country with a large share of fossil fuel imports albeit among the resource abundant countries worldwide and the largest exporter of biomass.

On the other side of the coin, we find the key resource providers in absolute terms – the Russian Federation, Australia, Saudi Arabia and Brazil (see Figure 7). These countries export more resources in physical units than they import and thus, their physical trade balance is negative. The Russian Federation – as is to be expected in terms of country size and resource abundance – has been the leading resource provider since 1995 with a share of 16 % of globally traded materials in 2008, in particular fossil fuels (Dittrich, Giljum, et al., 2012). It is closely followed by Australia (share of 14 %),

Figure 6: Main resource demanders and physical trade balances, 2008, in million tonnes (Dittrich, Giljum, et al. 2012, p.25)

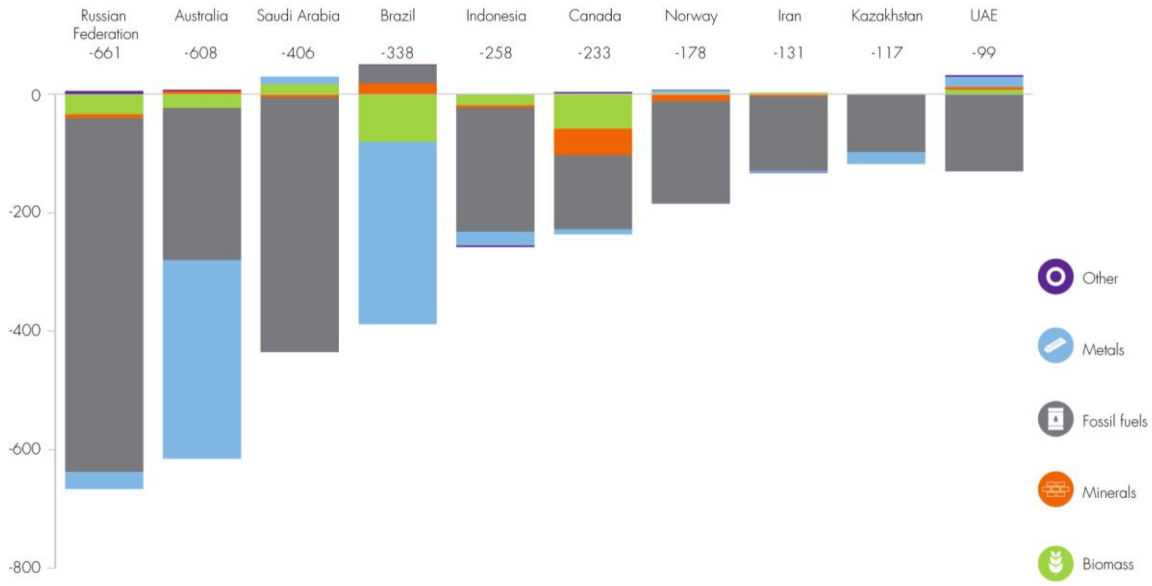


which is the main metal exporter, and then at some distance by Saudi Arabia, the most important petroleum exporter.

This burden shifting seems to follow special patterns in the development context, summarized under the term "ecologically unequal exchange" (Giljum and Eisenmenger, 2004; Moran et al., 2013; Muradian and Martinez-Alier, 2001; Pérez-Rincón, 2006). This term describes the mechanism through which that low-income but resource-rich countries face worsening terms of trade and hence, less possibilities to internalize the environmental problems associated with the extraction and trade of natural resources. As a consequence of the "international conditions determining prices" resource-rich countries in the global South transfer their natural wealth for undervalued prices to the global North. On the other hand high-income countries can shift ecologically intensive production abroad (Muradian and Martinez-Alier, 2001). The accusation is that low- and middle-income countries do not get an equal monetary compensation for their physical exports and the embodied pollution. Critics detect the reasons for this in market failures such as undervalued prices for natural resources and missing monetary valuations for important ecosystem services (e.g. rainforest as lung of the Earth) (Moran et al., 2013). They argue that resource revenues fail to represent the ecological worth of natural resources. This has important implications in the context of developing countries as many developing countries concentrate on exporting primary materials, whereas industrialized countries specialize in manufactured goods (UNEP, 2011).

The economic specialization of developing countries in providing natural resources can have positive or negative impacts on their economic development. The UNEP Decoupling report (2011) offers an insight in to the factors associated with negative implications. Falling resource prices over the past decades has put pressure on indebted developing countries to increase their extraction rates in order to ensure their debt servicing. Exporting raw-materials instead of further processing them hampers additional value creation. Furthermore, if primary sector extraction is in the hands of multi-national companies, their interests lie rather in serving their shareholders than in the long-term development

Figure 7: Main resource providers and physical trade balances, 2008, in million tonnes (Dittrich, Giljum, et al., 2012, p. 24)



of the extracting countries. Moreover, resource extraction is quite capital intensive and thus, offers moderate local job possibilities. The role of rent-seeking and corruption in countries with resource-intensive sectors should be mentioned here, but is discussed in more detail in chapter 2.3.2.

However, recent research questions the ecologically unequal exchange debate. On the one hand Dittrich, Giljum et al. (2012) acknowledge that low-income but resource-rich countries are changing their position in resource trade. A rising number of emerging economies have started to produce semi-finished or finished goods instead of exporting their raw materials. This has led to increasing competition for raw materials, which has affected raw material prices as well as power structures and hence, export dependencies might change to import dependencies. Moreover, high-income countries such as Australia, Canada and Norway are among the top resource providers. On the other hand, Moran et al. (2013) addresses the question of whether "ecologically unequal exchange occurs" in a methodologically broader way. The authors test this hypothesis not only for material flows but for a variety of environmental pressure indicators. They provided a global multi-region input-output table, calculating the trade balances between 190 countries for eight environmental pressure indicators such as GHG emissions, water use, threatened species, material use and ecological footprint. For testing the "ecologically unequal exchange" the authors identify three hypotheses: Firstly, inter-regional trade balances are not uniformly proportional to monetary trade balances. Secondly, exports from low-income countries comprise more environmental burden (i.e. environmental impact per dollar) than exports from high-income countries. Thirdly, high-income countries disproportionately burden lower income countries. They conclude that ecologically unequal exchange seems to occur at least for the first two hypotheses. Monetary and physical balances are disproportional albeit not systematically for all environmental indicators. In relative terms, exports from lower income countries contain higher environmental impacts than those from higher income countries. However, hypothesis three does not hold true. In absolute terms, high income countries are net providers of natural resources. Even though exports from high income countries are relatively cleaner, their large export volumes lead to a higher overall environmental burden in absolute terms. Accordingly, high income countries do not exert their environmental impacts to lower income countries in absolute terms.

In summary, the environmental costs of resource extraction are not equally distributed around the globe. Exports from low-income countries are more ecologically intensive. These exporting countries not only face the environmental impacts but also an unequal monetary compensation for bearing these costs. However, high-income countries take a higher share of environmental burden as exports – though cleaner – are, due to the large volume, ecologically more intense in absolute terms. Where the last chapters have investigated the environmental costs of resource extraction and global resource provision, the next chapters present the economic perspective of resource abundance.

2.3 Resource Curse

> "One of the surprising features of modern economic growth is that economies abundant in natural resources have tended to grow slower than economies without substantial natural resources." (Sachs and Warner, 1995, p. 1)

The term "resource curse" refers to the paradox that countries rich in resources tend to have a poor growth performance. This is puzzling because resources are essentially "manna from heaven", in particular *point source* resources from narrow geographic bases such as petroleum. Several countries have higher endowments of fossil fuels and ores; several have no *point source* resources at all.[11]

From an economic perspective natural resources are associated with resource revenues. Conventional wisdom suggests that a country rich in resources has more possibilities to generate economic growth. A higher stock of assets – financial, social or natural – facilitates economic development. For this reason, an endowment with natural resources is seen as a blessing in conventional economic theory.

In the last 25 years, a substantial body of literature has challenged this view on resources (Bulte et al., 2005; Isham et al., 2005; van der Ploeg, 2011; Sachs and Warner, 1995; Sala-i-Martin and Subramanian, 2003). Their results are puzzling. Empirical evidence suggests that natural resources hinder rather than foster economic growth. Resources are correlated with poor economic performance and growing inequality. They trigger corruption, armed conflicts as well as unsustainable government policies. Therefore, resource abundance is associated with the term "resource curse" rather than "resource blessing".

In the resource curse literature the variable of interest is in monetary terms (e.g. resource revenues as total share of exports, future resource revenues). Thus, the resource curse literature analyses the effect of resource revenues on economic growth or genuine savings respectively. In contrast, this investigation evaluates the relationship between physical resource extraction and growth. The indicator of interest is in physical units (in tonnes) and approximates environmental impacts of resource extraction. Hence, this study examines whether the resource curse also exists for physical resource abundance and in addition considers the question of whether bearing the environmental impacts of resource extraction is associated with increases or decreases in growth rates.

[11] That also holds true for diffuse source resources like biomass. Several countries benefit from more favourable climatic conditions and thus, have better growing conditions.

This chapter presents stylized facts as well as popular explanations for the resource curse. The studies investigate the effect of resource dependence on growth from an economic perspective. I put special focus on the role of institutional quality since I examine this channel of causation in this study. Furthermore, I summarize empirical evidence on the link between resource dependence and the weak sustainability indicator of genuine savings. *Genuine savings* captures the development of environmental, social and economic capital. Subsequently, it is a more sustainable indicator of progress than GDP.

2.3.1 Stylized Facts of the Resource Curse

Resource rich countries show diverse growth experiences. Several countries have escaped the resource curse and benefitted from their natural assets. Others face poor economic development. In this chapter famous examples are discussed and the empirical evidence on the resource curse is introduced.

Nigeria seems to be the most tragic example (van der Ploeg, 2011; e.g. Sala-i-Martin and Subramanian, 2003). Oil revenues per capita rose from US $33 to US $325 in the period 1965 to 2000. However, income per capita (in PPP terms) remained at around US $ 1,100. Nigeria counts amongst the fifteen poorest countries in the world. Furthermore, the distribution of wealth is extreme. In 1970 the bottom 17 % received the same proportion of income as the top 2 %. This relationship has changed dramatically. In 2000 the top 2 % claimed the same share of income as the bottom 55 %. Consequently, the oil revenues have not been filtering down to the average Nigerian.

Other fossil fuel exporters like Iran, Venezuela, Libya, Iraq and Qatar have suffered from negative growth rates during the last decades. All OPEC countries together have experienced a decline in GNP per capita while other resource-poorer countries with similar initial income have enjoyed growth (van der Ploeg, 2011).

On the other hand, a sample of countries are experiencing a resource blessing (van der Ploeg, 2011). In the so called developing world this sample is rather modest. 4 out of 65 countries rich in resources attained average growth rates exceeding 4 % as well as a long term share of investment higher than 25 % of GDP. Those countries were Botswana, Indonesia, Malaysia and Thailand. The recipe for the three Asian countries to escape the resource curse was industrialization and diversification. Botswana is the famous African example. It has earned its wealth with diamonds. The government of Botswana has invested part of the revenue in education. Hence, Botswana is among the countries with the highest public expenditure on education as a percentage of GDP. This seems to be a good growth strategy for Botswana. It is blessed with high growth rates and its GDP per capita is ten times higher than Nigeria.

In the so called western industrialized world Norway is an exemplary country (van der Ploeg, 2011). It is among the main petroleum exporters after Saudi Arabia and Russia. Nevertheless, it has managed to expand its manufacturing sector as well as the rest of the economy in comparison with neighbouring countries. Indeed, it counts as one of the least corrupt countries and enjoys well developed institutions. Chapter 2.3.2 shows the important role of institutions. The United Arab Emirates used their natural resource wealth (crude oil and natural gas) for industrial modernization and the establishment of an education system as well as a generous welfare system. Furthermore, they have invested in a diversified economic structure, which is a good strategy to prepare for the depletion of fossil fuels. Abu Dhabi has expanded into petrochemical and fertilizers, whereas Dubai has strengthened its light manufacturing, finance, telecommunications and tourism.

Empirical evidence tries to find links and explanations for these diverse country experiences. The seminal study by Sachs and Warner (1995) suggests that resource dependent countries - defined as those with a high share of primary export revenues in GDP or total exports – show lower growth rates than their resource poor counterparts. The best available cross-country and panel studies today indicate that countries with high dependence on natural resources have poor growth perfomance and high inequality (van der Ploeg, 2011). Bad quality of institutions, bad rule of law and corruption strengthen this link. Moreover, this relationship is more severe for point source resources (e.g. diamonds, fossil fuels, precious metals). Nevertheless, strong institutions, trade openess and investment in technology can turn the curse into a blessing. The next chapter illustrates empirical evidence in detail and summarizes popular explanations for the resource paradox.

2.3.2 Popular Explanations of the Resource Curse

Empirical evidence suggests that the resource curse exists. Nevertheless, sometimes it is more important to know why the curse exists rather than that its existence. This chapter summarizes eight main mechanism of causation for the curse according to the review paper of van der Ploeg (2011) as well as the main empirical evidence. The theories originate from economics as well as the political science literature. Special focus is given to the role of institutional quality as this investigation concentrates on the relationship between physical resource extraction, institutional quality and growth.

Dutch Disease

The Dutch Disease describes the link between a resource windfall and a shrinking manufacturing sector. It was coined after the decline of Dutch manufacturing as a result of the discovery of a large natural gas field in the 1960s.

The underlying mechanism is a change in the terms of trade according to the model of Corden and Neary (1982). They differentiate between the booming sector, the lagging sector – both producing tradeable goods – and the non-tradeables sector. A resource windfall initially leads to higher aggregate income. This additional income boosts demand. Thus, the prices for the non-tradeable goods will rise, whereas the prices for the tradable goods are set by the international market and stay the same. Therefore, the short-run effects of a resource boom is a stronger national currency compared to other countries – an appreciation of the real exchange rate due to the higher relative price of non-traded goods. This induces an initial expansion of the non-traded sector. Hence, exports to other countries become more expensive. The manufacturing sector becomes less competitive. As an effect, the economy deindustralizes. This is the spending effect. Furthermore, the resource boom sector attracts labour and capital if it needs them as input factors. Accordingly, less labour is available in the lagging or manufacturing sector as well as in the non-tradeable sector, which in turn strengthens the deindustrialization effect. This is the resource movement effect.

Recent empirical evidence by Harding and Venables (2013) examines the Dutch disease effect. They evaluated 41 resource exporters for the period 1970-2006. According to their findings, countries, which experience a resource windfall, reduce nonresource exports by 75 cents and raise imports by 25 cents for each dollar of resource revenue. This suggests that the effect on foreign saving is negligible. However, they conclude that the manufacturing sector is in greater jeopardy of being crowded-out than other sectors.

Nevertheless, economic reasoning suggests that a declining manufacturing sector is a suitable response to a resource boom. Each country should specialize according to its comparative advantages. For some countries this is resource extraction, for others it is manufacturing. Why are resource booms then associated with poor economic performance? The next theory tries to offer an explanation.

Temporary Loss in Learning by Doing Effects

One explanation for the slow economic growth of resource rich countries are temporary losses in learning by doing effects. Evidence from the Dutch Disease suggests that a resource windfall leads to a declining manufacturing sector. But why is this perceived to be a problem for economic growth? One popular reasoning follows a crowding-out logic (Sachs and Warner, 2001). A resource boom crowds-out traded-manufacturing activities as seen above. If the traded sector is the engine of growth and profits most from learning by doing effects, natural resources will hamper growth. Additionally, manufacturing sectors harmed by resource windfalls can not recover fully when resources become scarce (van der Ploeg, 2011). Even though, the question "what drives growth?" has not been finally answered, this partly explains the consequences of a resource boom in the case that the traded-manufacturing sector is the engine of growth.

A large body of empirical literature has analyzed the negative link between natural resources and growth. The seminal study by Sachs and Warner (1995) showed this resource curse most famously. The cross country sample highlightes that resource rich countries grew less in the period from 1971 to 1989 after controlling for standard economic variables (initial income, openess, rule of law, investment). Their measure of resource abundance is the share of primary exports as a fraction of total exports or GDP. Sachs and Warner (2001) further prooved that their resource curse withstands the inclusion of geographical and climate control variables.

This seminal study on resource curse inspired a large body of subsequent cross-country studies (e.g. Auty, 1997; Bulte et al., 2005; Sala-i-Martin and Subramanian, 2003). Following Sachs and Warner, they generally used the share of primary exports as a fraction of total exports or GDP as a measure for resource richness. However, this illustrates the dependence of a country's progress indicator on natural resources rather than the true natural capital resource wealth (Brunnschweiler and Bulte, 2008). Furthermore, this measure seems to suffer from an endogeneity problem. The direction of causality is unclear. For example it remains uncertain if resource dependence causes low income in an income regression or if low income is the reason for an underdeveloped manufacturing sector and therefore, the reason for high resource dependence. Endogeneity is nevertheless a well-known problem in growth regressions (see chapter 4.4).

The former measure for resource dependence was commonly used until the World Bank published data on natural capital endowments in 2006. The World Bank estimated natural, produced and intangible capital as well as various components for nearly 120 countries. It is calculated as the present value (social discount rate 4 %) of resource rents for the years 2000-2025. The natural capital values are approximated by world prices and local costs (van der Ploeg, 2011). The data on capital endowment allows for a better measurement of resource abundance.

Brunnschweiler and Bulte (2008) were among the first to distinguish between the correlation of resource dependence and resource abundance on growth. They properly instrumented for resource dependence and showed that it has no significant correlation with growth. Furthermore, they investigated the relationship between growth and resource abundance, which they defined as used mineral (subsoil) resources. Their cross-country evidence suggests that resource abundance (subsoil resource wealth) has a significant positive effect on growth. Nevertheless, their measure of resource abundance is also criticized as being endogenous because it is calculated as present value of natural resource rents.

Cross-country studies are subject to omitted variable bias. If resource dependence is measured as a fraction of total income (GDP), it is important to include proper control variables for school attainment, quality of institutions and initial productivity. For example a decline in the manufacturing sector can affect the wage premium for education and hence, lead to a decline in education investment. This in turn may affect growth. If an appropriate control variable for education is omitted, the negative effect of resource dependence may be overestimated. Therefore, appropriate control variables for influencing variables are needed. This problem can be avoided with panel data regressions (van der Ploeg, 2011). However, little panel evidence is avalaible for the resource curse question.

Taken together, empirical evidence is sensitive to variable changes as well as different time periods or different samples of countries (van der Ploeg, 2011). It is not easy to distinguish between the effect of trade openess, financial development or institutional quality as these factors influence each other. Nevertheless, the role of institutions is decisive in this context and hence, is highlighted in the next chapter.

Institutional Quality

> "[Natural resource exports] can damage institutions (including governance and the legal system) indirectly – by removing incentives to reform, improve infrastructure, or even establish a well-functioning tax bureaucracy – as well as directly – by provoking a fight to control resource rents. […] There is growing evidence that [this] efffect is the most problematic." (Harford and Klein, 2005, p. 1)

Another important channel between resource dependence and poor macroeconomic performance has to do with rent seeking and hence with institutional quality. A resource bonanza combined with high resource prices leads to large resource rents. This can fuel the appetite for resource rents among particular groups. Entrepreneurs are encouraged to switch to rent seeking activities (e.g. manipulation of social or political power) instead of running productive companies. Hence, there are less productive forces at play in an economy creating new wealth. This may lower total income by more than the extra wealth gained by the resource windfall and subsequently hamper growth and result in lower welfare (Torvik, 2002).

Mehlum et al. (2006) conclude that the quality of institutions is decisive for rent-seeking incentives. It determines whether a country is production-friendly (strong institutions) or rent-grabbing-friendly (weak institutions). For instance, there is a fixed number of people who can either be rent-seekers or productive entrepreneurs. These are competing activities. Consequently, if a resource boom happens in a rent-grabbing-friendly country entrepreneurs move from production to rent-seeking (displacement effect). The authors conclude that this displacement effect is higher than the immediate income effect of higher resource rents. As a consequence, national income falls and the resource curse has cast its spell. On the other hand, in a country with more productive entrepreneuers a resource boom can lead to an industrialisation process. Demand in one sector spills over to other sectors under the condition that there are complementarities between industrialising sectors (Murphy et al., 1989). Profits of each entrepreneur rise. Mehlum et al. (2006) show in their model that in equilibrium profits of entrepreneurs rise. Thus, more people are entrepreneurs in a production-friendly-country. Australia, Botswana, Canada, Iceland, Norway and the United States are examples for resource rich countries with strong institutions (Acemoglu et al., 2003). On the other hand, in countries with weak institutions transparency is low, which enables high returns for rent seeking and thus fosters corruption, shady dealings and crime. As a result, a resource windfall creates more rent seekers. This can serve as an explanation for the growth weaknesses of oil-rich states like Angola, Nigeria, Sudan or Venezuela and diamond-rich states such as Sierra leone, Liberia and Congo. Therefore, the quality of institution is essential for the question of whether natural resources are a blessing or a curse.

Empirical Evidence emphasises the role of institutions. First, institutional quality is positively correlated with growth. Second, strong institutions can transform the curse in to a blessing. Mehlum et al. (2006) find that countries with a high score of institutional quality escape growth weakness. In contrast, resource rich countries with weak institutions face poor economic performance and remain in this state. Hence, the level of institutional quality is decisive for the relationship between natural resources and growth.

The relationship between growth, institutional quality and resource richness has been tested for different forms of natural resources. For example, Isham et al. (2005) classified countries according to their main exporting commodities in *point source* resource exporters, *diffuse source* resource exporters, coffee and cocoa exporters and manufacuring exporters. *Point source* resources such as oil and ores originate from narrow geographic locations, *diffuse source* resources are mainly agricultural products and livestock. Other studies (Mavrotas et al., 2011; Sala-i-Martin and Subramanian, 2003) disaggregate the total resource rents following Isham (2005) into *point source* resource rents and *diffuse source* resource rents. Those studies confirm the negative relationship between *point source* resources and institutional quality indicators, which in turn slows down economic growth. Whereas this correlation seems to be quite robust, the relationship between *diffuse source* resources and institutional quality differs among the studies between insignificant and negative. Taken together, the negative link is stronger for concentrated resources than for ubiquitous agricultural products.

Sala-i-Martin and Subramanian (2003) further test the direct relationship for disaggregated resource measures and growth and control for institutional quality. Their findings suggest that the direct relationship between the disaggregated natural resource measures and growth is not significant once they control for the level of institutional quality. Moreover, they explore the existence of non-linearities – and in particular whether the relationship between institutional quality and natural resource dependence is contingent upon the level of natural resources. Put simply, they examine whether the effect of natural resources on institutions is different for countries with lower resource endowments than those with higher. The authors identified a non-linear relationship. The marginal negative impact of resources on institutional quality seems to be higher for resource rich countries. "Evidently, oil corrupts and excess oil corrupts more than excessively" (Sala-i-Martin and Subramanian, 2003, p. 10).

Bulte and Damania (Bulte et al., 2005) take a broader view of progress. They examine the effect of resource dependence on indicators of human welfare such as the Human Development Index. Their cross-country-evidence suggests that resource dependent countries suffer from lower levels of human development. This falls in line with earlier research on the relationship with growth. Furthermore, they conclude that the indirect effect that operates trough institutional quality is more significant than the direct link.

In summary, institutional quality seems to be decisive for the development of resource rich countries. Unproductive rent-seeking activities occur more often in countries with weak institutions. On the other hand, other scholars investigate the reverse relationship – the harmful influence of natural resources on institutions, which is stronger for point source resources.

Volatility of World Resource Prices

Resource abundant countries face volatility of world resource prices. In the 1970s commodity prices were high. During this period several resource rich countries used their resource wealth as collateral for debt. However, resource prices dropped sharply during the 1980s. Therefore, those countries were faced with debt overhang and had to undertake devaluation and other contractionary measures in order to repay part of their debts. Panel evidence by Manzano and Rigobon (2001) suggests that it is the boom-bust-cycle in commodity prices that causes the poor economic performance rather than the degree of development and the quality of institutions. The effect of resource dependence on economic growth disappears when controlling for debt in the panel.

Further Explanations from Political Science Literature

Sala-i-Martin and Subramanian (2003) summarized three main mechanisms of causation through which resource dependence leads to growth weakness. These are dutch disease, institutional quality and the volatility of world resource prices. van der Ploeg (2011) identifies eight popular explanations in his review paper on “Natural Resources: Curse or Blessing?”. The “Temporary Loss in Learning by Doing Effects” have been explained above. Here, I summarize the four additional mechanisms from the political science literature.

First, cross-country evidence finds that the resource curse is stronger in presidental democracies than in parliamentary democracies (Andersen and Aslaksen, 2008). This seems puzzling initially, but Persson et al. (2000) argue that presidential systems are less transparent, less accountable and less representative. For these reasons, the possibilities for rent-grabing are higher than in parliamentary democracies. Andersen and Aslaksen (2008) suggest that in resource rich countries the nature of the constitutional system has a greater effect on growth than being non-democratic itself. Taken together,empirical findings support that the resource curse occurs mostly in democratic presidential countries and non-democratic regimes.

Second, resource booms drive corruption, in particular in nondemocratic regimes. This works via protection, exclusive exploitation licences and extraction of resources by political elite or oligarchs in order to grasp rents and political power. Panel evidence shows that resource dependence results in corruption only in countries where the quality of democratic institutions is below a particular threshold (Bhattacharyya and Hodler, 2010). Countries rich in resources have a tendency to be corrupt because resource bonanzas strengthens resources seeking activities. This occurs more frequently in countries with weak insitutions.

Third, a resource boom increases the probability of armed conflicts. Higher resource incomes are more susceptible to conflict than higher production income. Cross-country evidence by Collier and Hoeffler (2004) shows a positive relationship between shocks in resource income and risk of civil war. Whereas shocks in production income are negatively correlated with conflicts. Furthermore, the findings suggest that the risk of conflict is influenced the most by the export share of primary commodities since primary export commodities provide possibilities for extortion and thus for rebellion. For example, the probability of conflict is 0.5 % in a country with no natural resources. In contrast countries with an export share of primary resources of 25 % have a 23 % probability of ending up in a state of civil war. This highlightes the high potential for conflict with higher resource incomes.

Fourth, natural resource wealth encourages unsustainable political decision making. As seen above it may lead to excessive borrowing. Current generations profit from the resource extraction as well as from the credit granted against the resource backed collateral. The burden of paying back this debt rests on the shoulders of future generations in times when the resource revenues may have dried up. A resource windfall seems to influence the critical ability of politicians and creates a false sense of security. Politicians appear to neglect growth-boosting policies and instead invest in prestige projects and build-up a welfare state, which can not be maintained once the resources run out. The Netherlands is an example of an irresponsible boost in the welfare state after the discovery of a natural gas field. The global oil price shocks in the 1970s and 1980s caused a significant increase in unemployment. The Dutch government reacted with the expansion of public employment, an increase in unemployment benefits, introduction of the minimum wage and protective labour market laws. It took them two decades to achieve a sustainable size for the welfare state again (van der Ploeg, 2011). It seems that resource wealth induces politicians to lose their long term perspective.

In conclusion, natural resources influence the economy, institutions and rent-seeking activities as well as conflicts and policy. Those eight hypotheses summarise the popular explanations for the existence of the resource curse and show which factors are decisive (e.g. quality of institutions) for the growth performance of countries. The next chapter analyzes the effect of natural resources on a broader progress indicator. It introduces the effect of natural resources on “Genuine Saving”.

2.3.3 Resource Curse and Genuine Savings

The subsequent chapters put forward the effect of natural resources on the growth of gross domestic product (GDP), whereas this chapter investigates the effect of natural resources on genuine savings (GS). Genuine savings is a more sustainable measure of progress than GDP (see chapter 4.4 for limitations of GDP) and hence might be a better tool in the investigation of whether resources are a blessing or a curse. These studies link the resource curse debate to sustainability as genuine savings is an indicator of weak sustainability. Even though I follow a different approach in my investigation[12], these studies offer insight in to the relationship between natural resource dependence and sustainable development.

Most of the resource curse studies investigate the adverse link between high resource dependence and slower growth performance (usually growth of per capita GDP). Resource dependence is

[12] Contrary to this approach, I keep GDP as the economic progress indicator but exchange the montery resource abundance indicator (e.g. economic resource dependendce) through a physical resource abundance indicator, which approximates environmental impacts.

measured as the share of primary exports in GDP or total exports. Therefore, in resource dependent countries high shares of income originate from natural capital depletion. The relationship between natural capital depletion and slow growth performance suggests that rents from resource extraction are insufficiently reinvested. This links the resource curse to the paradigm of weak sustainability (Boos and Holm-Müller, 2013). The weak sustainability paradigm claims that different forms of capital (natural, physcial and human capital) can be substituted as long as the sum of all capital forms does not decrease (see chapter 2.1 for more detail). Consequently, the extraction of natural capital should be transformed to physical or human capital. This matters especially for resource intensive economies as they extract more natural capital. Therefore, it is not enough to test the effect of resource dependence on growth in GDP because it might over- or underestimate the development of a country's total capital stock. A glance at genuine savings allows a broader view on the development of resource rich countries.

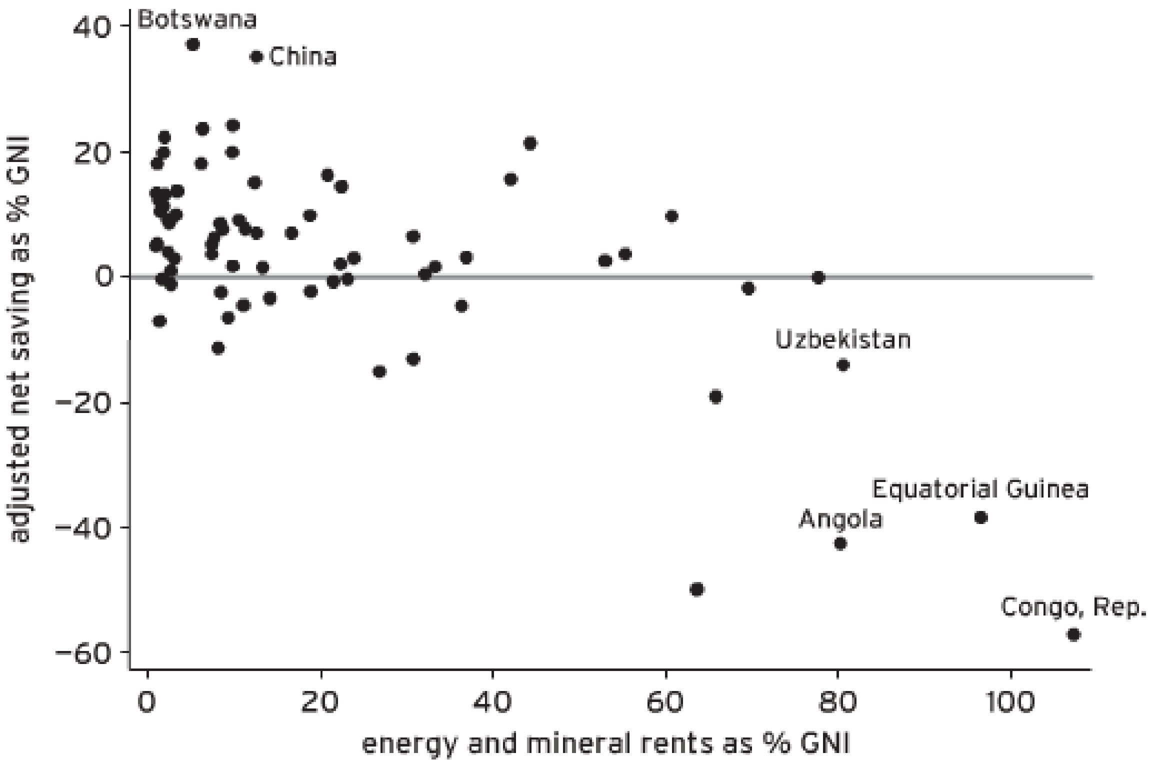
Genuine savings (GS) is an indicator of weak sustainability (World Bank, 2006) It is based on GDP measures and adjusts for some of the shortcomings of GDP. In short, genuine savings accounts for the depletion of natural capital as well as for investments in physical and human capital. In detail, its calculation starts from gross national saving, which is private saving plus gross public saving. Then it substracts for the depreciation of public and private saving (consumption of fixed capital). From this, expenditures on education are added (increase in human capital) and the monetised value of natural capital depletion as well as damages from pollutants (carbon dioxide and pollutants) are subtracted. Genuine savings is the result of this calculation. Genuine Savings shows if a country is increasing or diminishing its total capital stock and thus adding or reducing wealth.

Negative genuine saving rates suggest that total wealth is decreasing and that a country is on a (weakly) unsustainable pathway. Figure 8 presents the performance of resource-rich countries in genuine savings (also known as adjusted net savings (ANS)) measured by their resource dependence (share of resource rents in gross national income (GNI)). It reveals an alarming picture. Highly resource-dependent countries tend to have negative genuine saving rates (calculated by the World Bank (2011)). For example, Angola and Uzbekistan are below the zero line and hence, have negative genuine savings. They do not fully reinvest their resource rents in productive human or physical capital. The total capital stock diminishes in spite of natural endowments. Hence, those countries consume at the expense of future generations and become poorer over time. On the other hand, Botswana and China display a positive genuine savings rate. Their natural capital depletion is overcompensated for by investments in human and/or physical capital.

Boss and Holm-Müller (2012) provide a theoretical overview of the linkages between resource curse and genuine savings. They stress that resource-dependency and other factors responsible for a slowdown in growth of GDP also affect genuine savings negatively. Countries with high resource extraction have to invest more in other capital forms in order to keep their capital stock constant. Boss and Holm-Müller argue that investment behaviour is affected by other factors. The identified exogenous and endogenous factors are variances in world market prices and exchange rates, the politcal system as well as the quality of institutions. These factors influence investment policies and hence, genuine savings and weak sustainable development. Therefore, the channels through which natural resources influence genuine savings are generally consistent with those influencing GDP.

Empirical findings corroborate the theoretical predicitions. Dietz et al. (2007) are the first to regress genuine savings on resource abundance in interaction with institutional quality. They use corruption,

Figure 8: Genuine savings in resource-rich countries, 2008 (World Bank, 2011, p. 39)



bureaucratic quality and rule of law indices as indicators for institutional quality. Their panel analysis supports the view that corruption is among the important factors influencing genuine savings. A reduction in corruption lowers the negative impact of resource abundance on genuine savings. Moreover, they found some limited evidence that a stronger rule of law also positively affects genuine savings. Recent cross-country evidence from Boos and Holm-Müller (Boos and Holm-Müller, 2013) suggest that factors leading to the resource curse are also valid in explaining the development of genuine savings. A 10 % increase in resource dependence (share of primary exports in GNI) reduces the average genuine savings rate by between 1.4 % and 3.5 %. In conclusion, natural resource dependence not only slows down economic growth but moreover, tends to diminish the capital stock of a country, thereby leading to unsustainable development.

3 Research Questions and Hypotheses

The purpose of this thesis is to investigate the relationship between resource abundance, institutional quality and growth. The previous chapters have reviewed the environmental implications of resource extraction as well as the empirical findings concerning the resource curse. The intention is to combine these two fields of research – the material flow and the resource curse themes. So far, the resource curse debate has been limited to monetary indicators for resource abundance. Here, I investigate for the first time the relationship between GDP growth and a physical resource abundance indicator. This adds a sustainability context to the resource curse debate as the physical resource indicator "domestic extraction" approximates environmental impacts. Therefore, this study analyses the important question of whether bearing the environmental impacts of resource extraction are associated with higher or lower growth rates.

The relationship between physical resource extraction[13] and growth is of particular interest as there is an extensive economic literature concerning the negative correlation of resource abundance in monetary terms and growth – referred to as the "resource curse". The most common indicator for resource abundance is the ratio of primary exports to total exports or GDP (following the seminal studies by Sachs and Warner, 1995). Some studies (Brunnschweiler and Bulte, 2008; van der Ploeg and Poelhekke, 2010) criticise that it is rather a measure of resource dependence as it reflects to which degree resource rich countries are able to maintain other economic activities. Hence, I refer to this indicator of resource abundance as "resource dependence". Brunnschweiler and Bulte (2008) promote an alternative measure for resource abundance: resource stocks, which are calculated as the present value of future resource rents by the World Bank (2006). The intent of this study is to explore the resource curse paradox, but this time with a physical indicator for resource abundance: "physical resource extraction". In summary, I distinguish three different measures for resource abundance: "resource dependence", "resource stocks" and "physical resource extraction".

Several studies analysing material flows argue that the environmental impacts of resource extraction and further processing them are on the one hand not equally distributed around the globe and on the other hand are not compensated by the achieved resource revenues. Dittrich, Bringezu et al. (2012) focus on the geographic distribution of physical material extraction and material consumption and thus, on environmental "burden shifting". Furthermore, a large body of literature has investigated the trade relationships between countries from the global North and global South by means of comparing monetary and physical trade balances – known under the term "ecologically unequal exchange". Their accusation is that resource revenues do not compensate for the ecological value of resources and the environmental impacts caused by the extraction. To date, no study of material flows of which I am aware, has evaluated whether countries with higher resource extraction – associated with environmental impacts – differ in their growth behaviour from countries with lower resource extraction. Hence, this study links the resource curse debate with the material flow research.

Yet another question of interest is the role of institutional quality in this regard. In the resource curse debate institutional quality was identified as one of the main channels through which the curse casts its spell. However, the question of causality has not yet been resolved. Mehlum et al. (2006) argue

[13] Throughout this thesis the term resource extraction refers to per capita physical domestic extraction (either aggregated or disaggregated) obtained by the Material Flow Accounts.

that institutional quality is decisive if resource abundance has a positive or negative relationship with growth. Other studies (Brunnschweiler and Bulte, 2008; Isham et al., 2005; Sala-i-Martin and Subramanian, 2003) suggest that institutions itself are affected by resource abundance and are thus endogenous. They showed that natural resources affect growth directly but also indirectly through their impact on institutional quality. For this reason, I test the same relationships for the physical resource indicator.

The following research questions are investigated:

Relationship between physical resource extraction and growth

1 What is the correlation between physical resource abundance and growth?

Relationship between physical resource extraction, institutional quality and growth

2 Is the relationship between physical resource abundance and growth contingent upon the value of institutional quality?

Relationship between physical resource extraction and institutional quality

3.1 What is the correlation between physical resource abundance and institutional quality?

3.2 Is the relationship between physical resource abundance and institutional quality contingent upon the level of resource extraction?

The corresponding hypotheses emerged from previous studies on the resource curse[14]. The seminal study by Sachs and Warner (1995) as well as subsequent research showed that natural resource abundant countries grow slower than their resource poorer counterparts.

Mehlum et al (2006) investigate the effect of institutional quality in this context. Their findings suggest that the marginal impact of natural resources on growth is positive for countries with stronger institutions (i.e. "producer-friendly" institutions) and negative for countries with weaker institutions (i.e. "grabber-friendly" institutions). Moreover, their findings show that the direct negative correlation is stronger for mineral abundance[15].

Concerning the third question, Bulte et al. (2005), Isham et al. (2005) as well as Sala-i-Martin and Subramanian (2003) serve as references. The latter study[16] indicates a negative relationship between institutional quality and resource dependence (ratio of primary exports in aggregate to total GDP/exports) and thus, high levels of resource dependence are associated with low institutional quality. In all three studies, point source resource dependence has a robust negative relationship with institutional quality, whereas the correlation with diffuse source resource dependence switched between being insignificant and negative[17]. Sala-i-Martin and Subramanian (2003) further show that this relationship is dependent on the value of resource dependence. In countries with high resource

[14] For practical reasons, my hypotheses are based on the findings of the most common indicator for resource abundance (resource dependence) as most of the resource curse studies are based on this indicator.

[15] Note that minerals in this context differ from the physical extraction category "industrial and construction minerals". Mineral abundance rather refers to point source resource abundance (see footnote 22).

[16] Bulte et al. (2005) as well as Isham et al. (2005) neglect the aggregated resource dependence (sum of all primary exports as share of total exports or GDP) in favor of point source resource dependence and diffuse source resource dependence.

[17] A study by Mavrotas et al. (2011) concludes that also diffuse source resources weakens institutional quality, which in turn slows down economic growth. However, their sample is limited to developing countries.

dependence the marginal negative impact of resource dependence on institutional quality is higher than in countries with low resource dependence.

This study evaluates the following hypotheses:

Relationship between physical resource extraction and growth

1 Total physical resource extraction is associated with lower growth rates. Point source resource extraction has a stronger negative correlation with growth, whereas diffuse source resource extraction has no significant correlation[18].

Relationship between physical resource extraction, institutional quality and growth

2 Countries with weaker institutions experience a stronger negative relationship between resource extraction and growth, whereas good institutions can turn the curse into a blessing. This effect is stronger for point source resource extraction – the quality of institutions is more decisive for point source resources. Diffuse source resource extraction has no significant correlation[19].

Relationship between physical resource extraction and institutional quality

3.1 Natural resource extraction is associated with lower institutional quality. This negative relationship is stronger for point source natural resource extraction. Diffuse source resource extraction has no significant correlation with institutional quality.

3.2 The relationship between physical resource extraction and institutional quality is nonlinear. Countries rich in resources have a stronger negative correlation with institutional quality. The marginal (negative) correlation between resource extraction and institutional quality depends positively on the level of resource extraction. This impact is stronger for point source resource extraction[20].

Additionally to the comparison between monetary and physical indicators for resource abundance, the use of the physical resource extraction indicator shifts the focus of the research question to an environmental context. Physical resource extraction serves as an approximation of environmental impacts. Furthermore, several studies question the appropriateness of the monetary compensation for resource extraction, arguing that resource prices underestimate the value of natural capital and the environmental impacts of extracting. Hence, it is of utmost interest not only to investigate the relationship between resource revenues and growth but to extend this debate to the environmental context.

This investigation offers insight into whether bearing the environmental impacts of resource extraction has a positive or negative effect on the standard economic progress indicator GDP growth per capita. Or following the resource curse debate: is there a curse in bearing the environmental impacts of material extraction? Hence, I examine the effect of physical resource extraction (measured in tonnes) on growth. Does it pay off in economic growth terms to bear the environmental impacts of resource extraction?

[18] The hypotheses for point source resource extraction and diffuse source resource extraction are based on studies of Bulte et al. (2005), Isham et al. (2005) as well as Sala-i-Martin and Subramanian (2003). These authors used a different methodology. They estimated the impacts of resource dependence on growth through an instrumental variable estimates or three-stage least squares estimates where they instrumented for institutional quality. Despite using a linear growth regression, I expect my findings to be similar.

[19] The hypotheses for diffuse source resource extraction is based on the findings of Bulte et al. (2005), Isham et al. (2005) as well as Sala-i-Martin and Subramanian (2003). See footnote 18 for argumentation.

[20] Sala-i-Martin and Subramanian (2003) mention this nonlinear effect of natural resources on institutional quality for fuel and mineral share. I expect that this also holds true for total physical resource extraction.

4 Methodology

This chapter describes the data and the indicators of interest and provides an overview of the empirical methods used. I use panel growth regression models following the design of the resource curse literature. This literature examines the effect of resource revenues or resource abundance (both monetary indicators) on growth or institutional quality respectively. However, throughout this thesis the term resource extraction refers to physical resource extraction in mass units (in tonnes).

4.1 Data Source and Description

The unbalanced panel dataset covers the period 1980-2008. It contains 172 countries (see Table 11 in the appendix) and about 4,000 observations. Table 1 provides a description of the variables and data sources. Data on the indicators growth (Growth), inflation (Inflation), gross capital formation (InvGDP), population growth (PopGrow) and trade (TradeGDP) come from the World Bank's World Development Indicators (2013). Moreover, I use data on institutional quality from the Freedom House database (2013) as well as data on average schooling years from the Barro and Lee dataset (2013). I interpolated the data on average schooling years because Barro and Lee report in five-years-intervals.

The data for my explanatory variable of interest is obtained from the Global Material Flow Database (SERI and Dittrich, 2012). I use data on domestic extraction (DE) in its four categories[21] as well as physical exports and imports in order to calculate the physical trade balance (PTB). Summary statistics for the variables of interest (see Table 9) as well as a correlation matrix for all included variables (see Table 10) appear in the appendix.

4.2 Description of Variables

This chapter gives a short introduction to the resource extraction indicator domestic extraction (aggregated and disaggregated) as well as the institutional quality index used.

Domestic extraction (DE)

Domestic extraction is an indicator of material flow accounting (see chapter 2.2.1) and refers to direct material flows of used materials from the environment to the economic sphere. These flows physically enter the economy and are intended for the economic production process or direct consumption (EUROSTAT, 2012). DE is measured in four categories fossil fuels, metal ores, minerals and biomass in tonnes per year.

[21] Data on domestic extraction needs some transformation in order to adapt to how STATA deals with missing values. Countries with no extraction of a certain type of material category (e.g. fossil fuels) have no values in this category instead of a zero in the original database. However, STATA interprets no values as missing values, whereas zero means no extraction. Therefore, I change missing values to zero if reasonable. Besides, I eliminate values (mostly zeros) for the Soviet Union countries before 1992. Furthermore, I interpret zero biomass extraction as missing values. In the category point resource extraction I change zero values to small per capita values of 0.000000001 in order to allow for taking the logarithm. Figure 10 demonstrates that this change has only little effect. The Additionally, I interpolate domestic extraction of minerals for two years in Cote d'Ivoire since the original data indicated an inexplicable jump.

Table 1: Variable names and sources

Variable	Definition	Source
DE	Log of total domestic extraction (fossil fuels, metal ores, minerals and biomass) in tonnes per capita	SERI and Dittrich (2012)
DEDiff	Log of domestic extraction of diffuse source domestic extraction (biomass) in tonnes per capita	SERI and Dittrich (2012)
DEPoi	Log of domestic extraction of point source domestic extraction (fossil fuels and ores) in tonnes per capita	SERI and Dittrich (2012)
Growth	Growth rate of GDP per capita (constant 2005 US$)	World Development Indicators (2013)
Inflation	Inflation of Consumer Price Index (annual % change)	World Development Indicators (2013)
InstQual	Index of institutional quality: average of two indicators “civil liberty” and “political rights”	Freedom House (2013)
InvGDP	Gross capital formation as % of GDP (private and public investment in fixed assets, changes in inventories and net acquisitions of valuables)	World Development Indicators (2013)
PopGrow	Annual population growth	World Development Indicators (2013)
PTB	Physical trade balance (physical imports minus physical exports) in tonnes per capita	SERI und Dittrich (2012)
SYR15	Average years of secondary schooling in total population over 15	Barro and Lee (2013)
TradeGDP	Trade as % of GDP (sum of exports and imports of goods and services)	World Development Indicators (2013)

MFA identifies four main material extraction categories (SERI and Dittrich, 2013):

- Fossil fuels (coal, oil, gas, peat)
- Metal ores (ferrous and non-ferrous metals)
- Minerals (industrial and construction minerals)
- Biomass (agriculture, forestry, fishery and hunting)

These four categories are filled with data from various statistical sources (national as well as international). However, the original data needs further editing in order to fulfil the requirements of the MFA concept. Furthermore, estimations are necessary to close data gaps in several categories.

Data on **fossil fuel** extraction is obtained from the International Energy Agency (IEA) world energy statistics and includes hard coal, lignite/brown coal, crude oil, natural gas (converted into tonnes), natural gas liquids and peat for energy use.

Metal ore extraction is based on data from the British Geological Survey (BGS), the US Geological Survey (USGS) as well as the World Mining Database. This category includes ferrous metals (iron) and non-ferrous metals (e.g. copper, nickel, lead, gold). Metal ores not only contain the weight of the content but are also estimated as the weight of the total metal-containing ore. Thus, precious metals in low concentrates like diamonds reach high levels in the MFA in relation to their content weight.

Data on non-metallic **minerals** are taken from the same databases as metal ores and are combined with EUROSTAT data in the case of European Countries. They cover industrial (e.g. chemical and fertilizer minerals, dolomite) as well as construction minerals (e.g. marble, sand and gravel, limestone). Nevertheless, the data quality on construction minerals is still unsatisfactory and requires further corrections and estimations.

Finally the category **biomass** is mainly filled with data from the Food and Agriculture Organization of the United Nations (FAO). It comprises agriculture, by-products of harvest, grazing, forestry, fishing, hunting and other biomass. MFA also covers grazing, which includes biotic material grazed by livestock and mowed for livestock nourishment, which is not reported and thus, has to be estimated and needs further clearing.

Water can also be regarded as material category but is not included in the MFA for two reasons. First, the flows of water have a greater magnitude than those of the other four material categories and would thus shift the focus. Second, good data on water flows is still scarce on an international scale.

MFA distinguishes between used and unused extraction as well as direct and indirect flows (SERI, 2013b). Used extraction covers extracted resources, which are actually used in the economic system for processing or consumption. On the other hand, unused extraction includes materials, which are not economically used (e.g. overburden of mining activities, by-catch from fishing, soil excavation). A second MFA classification is direct and indirect flows. The former accounts for the actual weight of products, whereas the latter also considers the whole life-cycle dimension of products. Therefore, indirect flows include all materials used in the manufacturing process. The difference becomes evident in the domestic material consumption of countries. Indirect flows account all materials required in the production process to the consuming countries. In contrast, direct flows only measure the actual weight of the final product if it is produced abroad. However, the calculation of direct flow data is still in its infancy and hence, I was not able to access data on indirect flows.

In my thesis, domestic extraction refers to direct material flows of used extraction. I use per capita values in order to scale for different country sizes. Furthermore, I structure the four material categories in **point source resources** and **diffuse source resources** following the resource export classification of Isham et al. (2005) and Mavrotas et al. (2011). They classify countries according to their main exporting commodity with point source resource exporters being mainly exporters of resources from a narrow geographical region such as oil and metals, and diffuse source resource exporters being exporters, who rely on agricultural products and on livestock. In this study, point source resources indicate the physical extraction of fossil fuels and metal ores, since they are geographically clustered. Diffuse source resources refer to the domestic extraction of biomass. I exclude construction and industrial minerals from this classification for several reasons. First, they are not captured by the classification of Isham et al. and Mavrotas et al. Industrial and construction minerals tend to be diffuse, but diffuse source resources only include biomass in the former classification. Second, construction and industrial minerals have a higher extraction level than biomass. On the other hand, they are less traded than biomass due to their low prices and ubiquitous emergence. Hence, they play only a marginal role in the resource curse debate. For those reasons, diffuse source resources refer to the MFA category biomass and point source resources refer to the MFA categories fossil fuels and metal ores.

Figure 9: GDP growth rate by total resource extraction per capita, 1980-2008

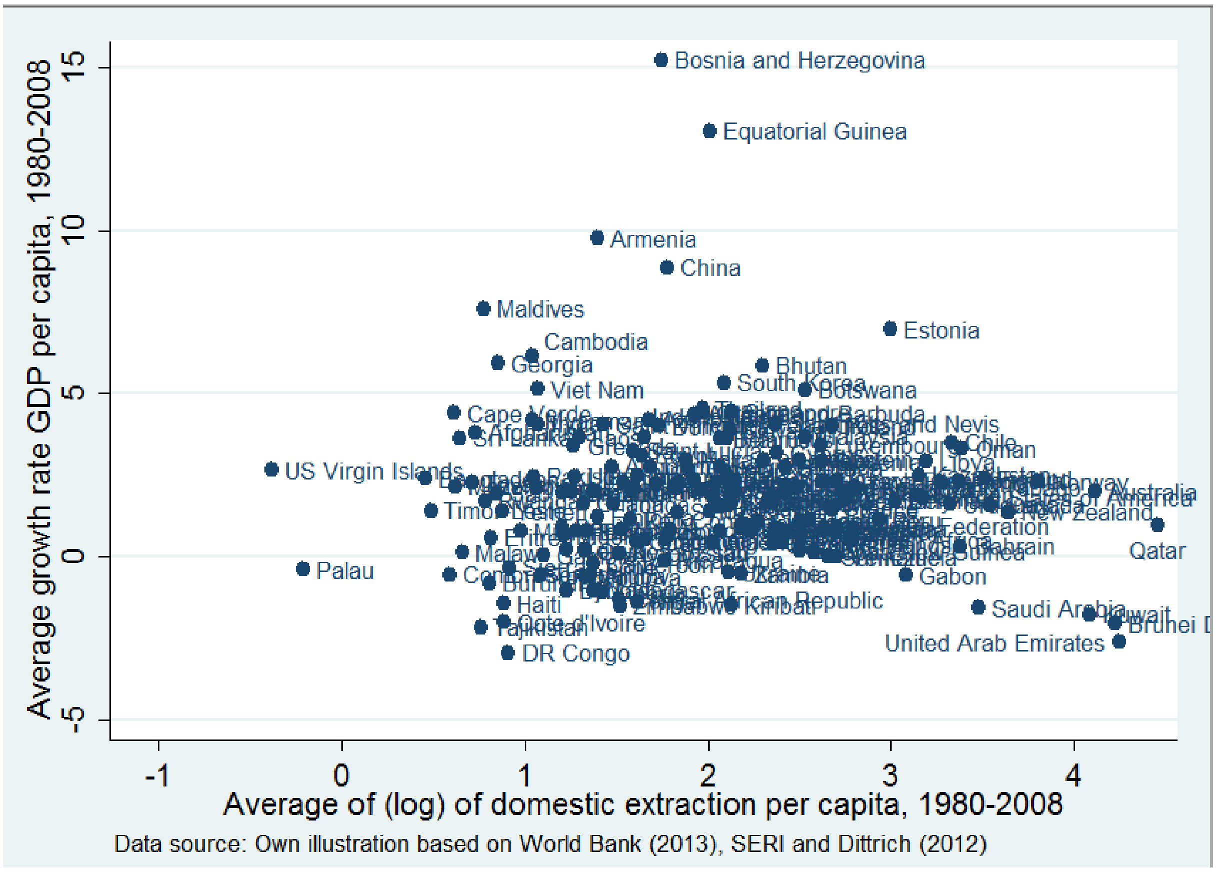


Figure 10: GDP growth rate by resource extraction per capita (point source and diffuse source), 1980-2008

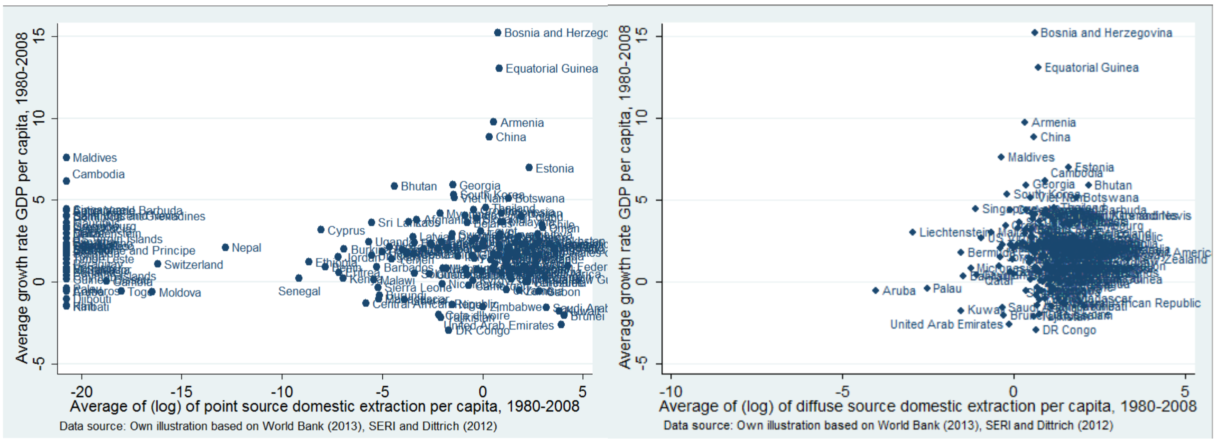


Figure 9 and Figure 10 illustrate graphically the relationship between growth of GDP and the (logs) of aggregated domestic extraction per capita or disaggregated respectively. These scatterplots include all observations (i.e. also outliers). Hence, it is not possible to infer a statistical relationship from the fitted regression lines. However, the graphs demonstrate clearly the existence of horizontal as well as vertical outliers.

Physical Trade Balance (PTB)

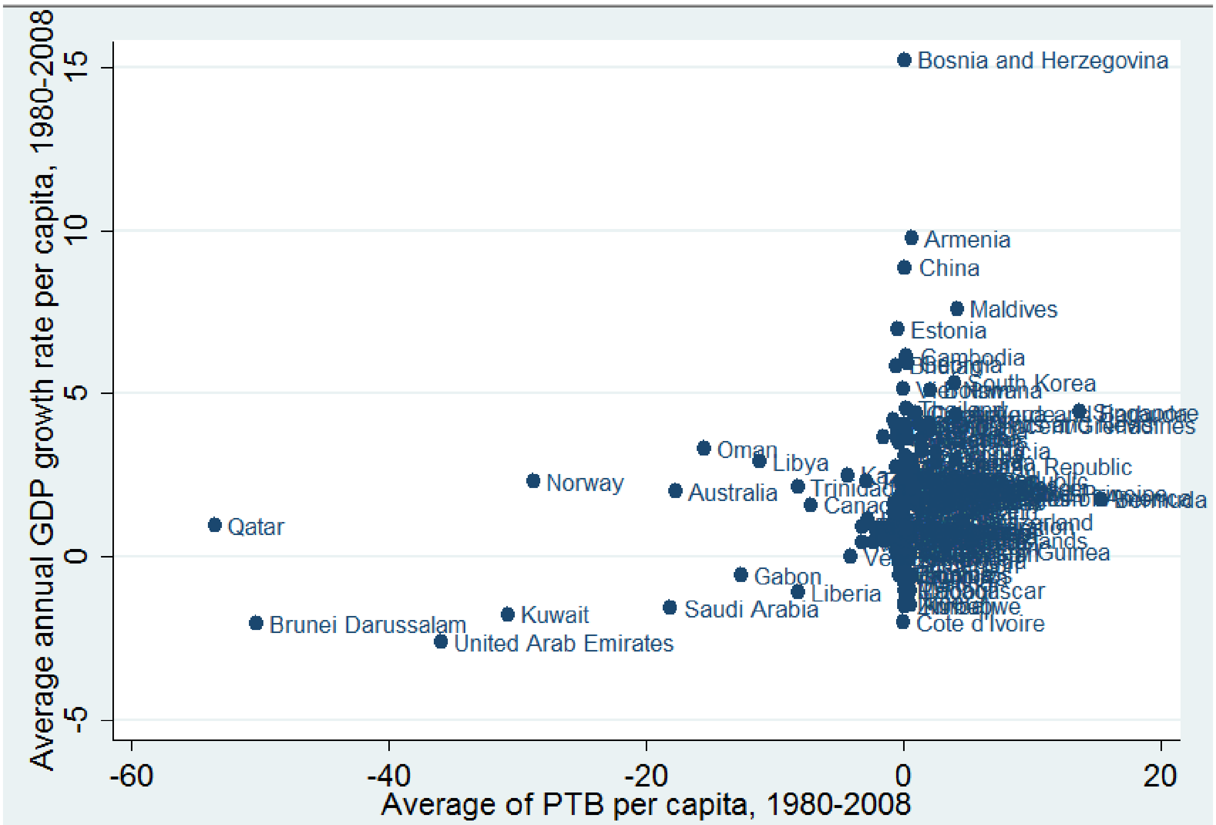
My first intention was to additionally investigate the effect of the physical trade balance (PTB) on growth since this is an often mentioned indicator of environmental burden (e.g. Dittrich, Bringezu, et al., 2012). The PTB reveals whether a country is a resource provider (physical trade deficit) or resource demander (physical trade surplus) and thus illustrates its international position in the physical resource market. Is a country able to fulfil its consumption needs with domestic resources or is it dependent on resource imports? However, the scatterplot of the two variables GDP growth and PTB shows only a cluster of points with several outliers (see Figure 11). This suggests that its relationship with growth is not promising.

Institutional Quality (InstQual)

A large number of indicators have been used to indicate institutional quality. In the resource curse literature, the seminal study by Sachs and Warner (1995) as well as subsequent studies use rule of law (as a dummy variable) as a measure for institutional quality. On the other hand, authors explicitly analysing the effect of resource revenues on institutional quality rely on a bundle of aggregate indicators such as government effectiveness, rule of law or control of corruption (e.g. Sala-i-Martin & Subramanian 2003).

In my analysis, I use the mean of the indicators for civil liberty (CL) and political rights (PR) of the Freedom in the World survey (2013) as an indicator for institutional quality for two reasons. First, the indicator *civil liberty* contains the subcategory rule of law besides freedom of expression and belief, associational and organizational rights, and personal autonomy and individual rights. Therefore, I consider it as a reliable substitution variable for the Sachs and Warner variable rule of law in the cross-country-analysis. Whereas *political rights* (PR) include functioning of government (i.e. corruption), which is another influential factor mentioned in the resource curse literature, as well as

Figure 11: GDP growth rate by physical trade balance (PTB) per capita, 1980-2008



Data source: Own illustration based on World Bank (2013), SERI and Dittrich (2012)

Table 2: Ratings of Freedom in the World survey

Category	Scores
Free	1.0 – 2.5
Partly Free	3.0 – 5.0
Not Free	5.5 – 7.0

electoral processes and political pluralism and participation. Second, they are available on a yearly basis between 1980 and 2008 and hence can be used in the panel analysis. *Civil liberty* is defined as allowing "for the freedoms of expression and belief, associational and organizational rights, rule of law, and personal autonomy without interference from the state" (Freedom House, 2011). *Political Rights* implies the ability to "participate freely in the political process, including the right to vote freely for distinct alternatives in legitimate elections, compete for public office, join political parties and organizations, and elect representatives who have a decisive impact on public policies and are accountable to the electorate" (Freedom House, 2011). Each country is rated on a scale from 1 to 7, where 1 represents the highest level of freedom and 7 the lowest (see Table 2). The Freedom in the World rating is based on an annual survey including analytical reports and numerical ratings. The fundamental assumption is that "freedom for all peoples is best achieved in liberal democratic societies" (Freedom House, 2011).

Physical versus Monetary Indicators for Resource Extraction

One purpose of this study is to examine the resource curse paradox, but in contrast to previous studies with physical indicators instead of monetary indicators. Therefore, it makes sense to compare them. A popular monetary measure of resource dependence is the share of primary exports in GDP or total exports (e.g. Sachs and Warner, 1995; Sala-i-Martin and Subramanian, 2003). Domestic extraction is the physical resource extraction measure in this investigation. Table 3 presents the correlation between resource extraction and the export dependence on natural resources.

Table 3 shows that total resource extraction and the share of all primary resource exports in total exports are not correlated. This is surprising since natural resources are considered as tradable goods. This can result from the fact that construction and industrial minerals make up a high share of resource extraction, whereas they are not represented in the monetary indicator[22]. Construction and industrial minerals are less traded due to their weight and their low price. This highlights that it is not appropriate to treat all natural resources alike. The next two correlations distinguish between point source resource extraction and exports (i.e. fossil fuels, ores and metals) and diffuse source resource extraction (i.e. biomass) and exports (i.e. food and agricultural raw materials). Both show weak correlations, whereas the correlation between point source resource extraction and share in total exports is stronger. This was to be expected as the extraction of fossil fuels, ores and metals is associated with higher rents. Moreover, these materials dominate global trade in physical terms (see chapter 2.2.3) since the emergence of fossil fuels, metals and ores is geographically clustered,

[22] Even though the variable PoiResShareExp includes the exports of minerals, the World Bank definition of minerals differs from the material flow definition of construction and industrial minerals. The World Bank definition refers to "tin, gold, lead, zinc, iron, copper, nickel, silver, bauxite and phosphate". These raw materials are mainly accounted to the category metal ores in the material flow accounts. The category industrial and construction minerals includes materials such as marble, sand and gravel, dolomite or chemical and fertilizer minerals (e.g. see SERI and Dittrich, 2013 for more details).

Table 3: Correlation between the log of domestic extraction per capita and the natural resource shares in total exports, 1980-2008

	DE	DEPoi	DEDiff
NatResShareExp	-0.05		
PoiResShareExp		0.38	
DiffResShareExp			0.26

Notes: The indicators for export dependencies are calculated according Sala-i-Martin and Subramanian (2003) on the basis of World Bank data (World Bank, 2013) for the period 1980-2008. The variable NatResShareExp denotes the share of natural resources in total exports, whereas natural resources sum together the share of fossil fuels, ores, minerals, food and agricultural raw materials. PoiResShareExp presents the share of fossil fuels, ores and minerals in total merchandise exports. DiffResShareExp indicates the share of food and agricultural raw materials in total merchandise exports.

whereas biomass is considered to be ubiquitous. Point source resource extraction is correlated with a higher resource dependency than diffuse source resource extraction.

4.3 Model Specification and Estimation Methods

I start with the growth specification, which follows the resource curse design and the threshold regression analysis. Then I describe the institutional quality specification. Next I go on to the estimation methods including an explanation of outlier detection.

Growth Specification

The econometric models as well as the control variables are motivated by the resource curse literature. Please note that in the standard resource curse literature the variable of interest is always expressed in monetary terms (e.g. share of primary exports as fraction of total exports or GDP). However, I investigate the effect of the physical resource indicator “domestic extraction” measured in mass units (tonnes).

In most resource curse studies, the effect of resource revenues or resource abundance has been tested in cross section studies. However, the main challenge of cross section regressions is to include all relevant control variables to avoid omitted variable bias. There exists a wide variety of variables, which significantly affect growth (e.g. Sala-i-Martin, 1997). Nevertheless, in cross country studies the number of observations is obviously limited by the number of countries for which data is available. Hence, the number of control variables is rather limited. This disadvantage can be avoided by using panel data regressions. Therefore, I decided to run only panel regressions.

Consider the following two-way fixed effects linear panel data model (Baltagi, 2008; Verardi and Croux, 2009):

$$GROWTH_{it} = \propto + \beta Z_{it} + X_{it}'\theta + u_i + v_t + \varepsilon_{it} \quad \text{for } i = 1, \dots, N \quad t = 1, \dots, T \qquad (1)$$

where subscript i denotes the country dimension and subscript t the time series dimension. Hence, $GROWTH_{it}$ is the growth rate of GDP per capita for country i in period t. The term $\propto$ is a scalar. Z_{it} is the indicator of resource extraction and X_{it} denotes the K x 1 column of control variables. Following the standard growth regression literature (e.g. Sala-i-Martin, 1997) as well as the resource curse literature (e.g. Sachs and Warner, 1995), my control variables are average gross fixed capital formation as a percentage of GDP (InvGDP), trade as percentage of GDP (TradeGDP) and an institutional quality index (InstQual). β as well as the K x 1 vector θ denote the coefficients, with the former being of most interest. The term $u_i$denotes country fixed-effects, the term v_t time fixed effects and ε_{it} the residual term. This regression model is used to analyse the effect of aggregated domestic extraction on growth.

Some studies in the existing literature (e.g. Isham et al., 2005; Mavrotas et al., 2011) prove that point source resources and diffuse source resources have a different effect on growth. Hence, in a second step I investigate the effect of disaggregated domestic extraction – the effect of point source resource extraction (DEPoi) and diffuse source resource extraction (DEDiff) – on growth.

Relationship between physical resource extraction, institutional quality and growth

The resource curse literature suggests that the effect of resource revenues on growth differs between countries with high institutional quality and countries with lower institutional quality (e.g. Mehlum et al., 2006). I investigate this relationship on the one hand by including an interaction term (resource extraction x institutional quality) and on the other hand with a threshold regression model (see below). This is based on the question of whether the relationship between resource extraction and growth is contingent upon the value of institutional quality. The regression including the interaction term shows the direct effect of resource extraction and institutional quality on growth. In addition, it presents the interaction effect of these two variables. Is there an additional effect if resource extraction happens in countries with weaker institutions? On the other hand, the threshold regression model distinguishes between two groups of countries – one with stronger and one with weaker institutions – and examines whether the effect of resource extraction on growth is different for those two groups (see below).

Threshold regression analysis

Threshold regression analysis is a useful tool when the relationship between the dependent and independent variable can be affected by the value of another variable. This is of particular relevance for the resource curse question since the effect of resource revenues seems to be different in countries with low and high institutional quality. For this study, I use the threshold regression approach of Hansen (e.g. 2000). This method allows jointly detecting the regression coefficients as well as the threshold values.

Technically speaking, a simple threshold regression model can be written the following way:

$$y_i = \delta_1 x_i + \varepsilon_i \quad \text{for } q_i \leq \lambda \qquad (2)$$

$$y_i = \delta_2 x_i + \varepsilon_i \quad \text{for } q_i > \lambda \qquad (3)$$

where q_i denotes the threshold variable. The threshold variable determines whether the observations belong to the first regime ($q_i \leq \lambda$) or to the second ($q_i > \lambda$.). The variable of interest has a different effect on the dependent variable y_i depending on the level of the threshold analysis. This is shown by the two different regression slopes, δ_1 and δ_2. For example, I investigate whether resource extraction (x_i) has a different effect on growth (y_i) depending on the level of institutional quality (q_i).

The threshold value λ is estimated by minimizing the sum of squares. In detail, this means analysing different values of q_i in order to determine the value of λ where the concentrated sum of squared errors is minimized. This value represents the estimate of the threshold.

In a second step, the method tests if the estimated threshold is statistically significant. This means if the null hypothesis ($H_0: \delta_1 = \delta_2$) holds true or not. However, one drawback is that the threshold cannot be determined under the null model. Hence, the distribution of this test is non-standard and critical values cannot be obtained from standard distribution tables. Therefore, this method simulates a likelihood ratio test via bootstrapping in order to compute a p-value.

In more detail, this implies two steps. First, the model is estimated under the linear null model and then under the alternative threshold model. Hence, one obtains the actual value of the likelihood ratio test. In a second step, the method generates a sample by bootstrapping over the normal distribution of the residuals of the estimated threshold model. This sample is used to estimate the null and the alternative model, which gives the simulated value of the likelihood ratio test. This simulation is performed with 1,000 bootstrap iterations. Finally, we obtain the estimated p-value as the percentage of draws for which the simulated likelihood ratio statistic is higher than the actual one). A p-value < 0.05 indicates that the threshold is statistically significant at the 5 % level.

Institutional Quality Specification

Some studies (e.g. Bulte et al., 2005; Isham et al., 2005; Mavrotas et al., 2011) suggests that resources can have an indirect effect on growth via their effect on institutional quality. They assume that institutional quality itself is endogenous and affected by resource dependence. To investigate this relationship, I regress the indicators for resource extraction – aggregated and disaggregated – as well as the standard control variables on institutional quality. To examine whether the marginal impact of resource extraction on institutional quality differs between resource poorer and resource richer countries, I run a threshold regression model (see above).

Estimation Method

I use OLS estimation with robust standard errors for the panel regression, which is a two-way fixed effects model. Hence, I include country as well as time effects. For excluding outliers I follow the approach of Verardi and Wagner (2012) (see below).

Outlier Detection

To deal with the presence of outliers, I apply the approach of Verardi and Wagner (2012). They propose a method to robustly estimate a fixed effects linear panel data model. For the purpose of considering individual fixed effects, they centre the data around the cross section dimension medians. In a second step, they use a robust S-estimator[23] in order to determine the outliers. Finally, they run a standard fixed effects model excluding the outlying observations.

In more detail, we can write the standard “fixed effects linear panel data model” as following:

$$y_{it} = \alpha_i + X_{it}'\theta + \varepsilon_{it} \quad \text{for } i = 1, \dots, N \quad t = 1, \dots, T \qquad (4)$$

[23] S-estimation is a method for robust regression estimation. This method is highly resistant to outliers however; it also turned out to be inefficient (Verardi and Wagner, 2012).

Like above, the subscript i represents the country dimension and t represents the time dimension.

Firstly, I centre the observations around their country medians in the following way: $\tilde{y}_{it} = y_{it} - med_i y_{it}$ and $\tilde{x}_{it}^{(j)} = x_{it}^{(j)} - med_i x_{it}^{(j)}$ where (j) denotes the jth dependent variable. Hence, I obtain a bundle of new variables.

Then I use an S-estimator (Verardi and Croux, 2009) to regress $\tilde{y}_{it}$ on the $\tilde{x}_{it}$. To identify the outliers, I use the estimated measure of dispersion as well as the residuals. All observations, which have robust standardized residuals larger than 2, are considered as outlying observations and hence are labelled with zero weight. In the last step I run a standard fixed effect linear model with the remaining observations.

4.4 Limitations of Methods

Limitation of Growth Regression (Endogeneity Problem)

Several studies have evaluated "what drives growth" in the past decades. However, the miracle of growth has not been definitely decoded due to some econometric problems such as endogeneity (e.g. Durlauf et al., 2004; Mankiw et al., 1995). In this investigation, the variable for resource extraction can be considered to be subject to an endogeneity problem. The direction of causality remains unclear. For example, fast growing economies might increase their resource extraction in order to satisfy the demand for raw materials. On the other hand, it is also reasonable that higher resource extraction affects growth since they are associated with growth. Cause and effect are hard to distinguish. The same appears in the resource curse literature. It is unclear whether the degree of resource dependency (share of primary exports as fraction of total exports or GDP) affects growth or if it is the other way round. Therefore, the results of this investigation reveal whether domestic extraction and growth are significantly correlated. They cannot clarify the direction of causality.

Limitation of GDP to serve as Indicator of Progress

The concept of GDP was invented by Simon Kuznet during World War II in order to measure wartime production capacity (Talberth, 2012). Nowadays, it is the world's most used indicator for the economic health and the welfare of a nation. However, there is a lot of criticism of GDP as a measure of progress. Even Simon Kuznet never intended it for this purpose. First of all, it shows the economic production of a country during a certain period. It is not able to distinguish between expenditures that gauge well-being and those that reduce it. All expenditures – sustainable or not – are summed together. Therefore, defensive expenditures caused by crime, natural disasters, accidents or toxic contamination are treated the same way as productive expenditures for education, infrastructure, healthcare or housing. However, there are several attempts to develop comprehensive measures of progress including environmental, social and economic indicators (also referred to as "green GDP"). The "green GDP" accounts aim at measuring the welfare and progress of a nation in a more accurate way. These limitations of GDP are also valid for the resource curse literature as most of the time the dependent variable is growth of GDP per capita.

5 Empirical Results

This chapter presents the results for the relationships between physical resource extraction, institutional quality[24] and growth.. My results are based on an unbalanced panel dataset covering the period 1980-2008, which includes 172 countries and about 4,000 observations. The main text focuses on the results of regressions excluding outlying estimations. To test the robustness of these results Table 12 – Table 18 are attached in the appendix[25]. The chapter is structured following the three research questions.

Relationship between physical resource extraction and growth

Table 4 reports the results from the growth regression when physical resource extraction is included linearly[26]. The standard control variables, except for population growth (PopGrow), carry the expected sign whereas gross capital formation (InvGDP) is highly significant. Regression 1 shows the relationship between per capita growth of GDP and total physical resource extraction per capita. The results indicate that there is no statistically significant relationship[27]. A marginal total resource extraction is not linked with economic growth. Regression 2 reports the results for the disaggregated physical resource measures. It distinguishes between point source (fossil fuel and ores) resource extraction and diffuse source (biomass) resource extraction. Both are associated with statistically significant positive growth rates[28]. A marginal increase of fossil fuel and ore extraction of 1 tonne per capita is associated with a marginal increase of the per capita GDP growth rate of 0.1 percentage points. The results indicate a higher growth correlation for biomass extraction. A marginal increase of biomass extraction of 1 tonne per capita is associated with a marginal increase of the per capita GDP growth rate of 1.8 percentage points. In summary, total physical resource extraction is insignificantly correlated with growth, whereas point source and diffuse source resource extraction are associated with positive growth rates.

Relationship between physical resource extraction, institutional quality and growth

Next, we turn to the growth regression with respect to the interactions with institutional quality. I test the findings of Mehlum et al. (2006) by including an interaction term (resource extraction x institutional quality) following their methodology and additionally with a threshold regression model.

Regression 3 in Table 4 includes the interaction term (total physical resource extraction x institutional quality) in the growth regression. The direct effect of physical resource extraction is again negative and insignificantly correlated with growth and weaker institutions are associated with lower growth

[24] The variable institutional quality is obtained from the Freedom in the World survey (2013). High levels denote countries, which are "not free" and low levels denote "free" countries (see chapter 4.2). Hence, I interpret low levels of the institutional quality index as strong institutions and high levels as weak institutions.

[25] Some tests show the regression results for all observations including outliers others present whether the results are sensitive to additional control variables. The latter regressions include inflation (Inflation) and secondary years of schooling (SYR15) as additional conditioning variables, which reduces the sample size.

[26] This implies that the relationship between physical resource extraction and growth is independent of other factors.

[27] This insignificant relationship is robust to the inclusion of outliers and also to the inclusion of additional control variables in a smaller sample (see Table 12 and Table 13).

[28] Table 12 (Regression 2) and Table 13 (Regression 1 and 2) present the results of the robustness checks. The significant positive correlations are robust to the inclusion of additional control variables but the inclusion of outliers in the original sample results in insignificant correlations.

Table 4: Relationship between physical resource extraction, institutional quality and growth

Dependent variable: (log) GDP growth per capita				
	Regression 1	Regression 2	Regression 3	Regression 4
DE	-0.004		-0.011	
	(-0.74)		(-1.62)	
DEPoi		0.001***		0.0003
		(2.64)		(0.63)
DEDiff		0.018**		0.028***
		(1.99)		(3.33)
InstQual	-0.002**	-0.002*	-0.006**	0.001
	(-1.99)	(-1.73)	(-2.51)	(0.60)
DE_InstQual			0.002*	
			(1.71)	
DEPoi_InstQual				0.0002
				(1.56)
DEDiff_InstQual				-0.003*
				(-1.90)
InvGDP	0.151***	0.159***	0.155***	0.169***
	(5.70)	(5.47)	(5.71)	(5.72)
TradeGDP	0.005	0.007	0.001	0.004
	(0.66)	(0.87)	(0.17)	(0.46)
PopGrow	-0.391	-0.379	-0.399*	-0.385*
	(-1.65)	(-1.63)	(-1.69)	(-1.67)
Constant	-0.013	-0.043***	0.003	-0.058***
	(-1.00)	(-3.11)	(0.19)	(-4.19)
Observations	4,020	4,039	4,019	4,041
F-Stat	13.51	12.79	12.079	11.983
Adjusted R^2	0.136	0.151	0.142	0.158

Notes: The numbers in brackets are t-values. All models are estimated using robust standard errors and include unreported time dummies. The significance levels are characterized by stars: * p<0.1, ** p<0.05, *** p<0.01.

Table 5: Net effect of a marginal increase of resource extraction on growth for different levels of institutional quality[29]

	DE	DEPoi	DEDiff
InstQual = 1	-0.015	0.002	0.026
InstQual = 3.5	-0.025	0.005	0.021
InstQual = 7	-0.039	0.009	0.014

rates as expected. The interesting finding is that the effect from the interaction term is positive and significant though only at the 10 % level[30]. Hence, the interaction of weak institutions and resource extraction appears to be associated with higher economic growth rates. However, the net effect of an additional tonne of resource extraction per capita is less negative for strong institutions (see first

[29] Calculated using regression 3 and 4 in Table 4. For example from regression 3 in Table 4, the change is (-0.011 x 1) + (-0.006 x 3.5) + (0.002 x (1 x 3.5) = -0.025 for an institutional quality level of 3.5 and a marginal increase of total resource extraction of 1 tonne per capita.

[30] These correlations are robust to the inclusion of outliers (see Regression 3 in Table 13) but the significance of the interaction term is not robust to the inclusion of additional control variables (see Regression 3 and 4 in Table 13).

column in Table 5) as the negative direct effects of lower institutional quality and higher resource extraction outbalance the positive interaction effect between weak institutions and resource extraction.

The same relationship is tested with a threshold regression model. Regression 1 in Table 6 distinguishes between countries with stronger and countries with weaker institutions. The estimated threshold value is approximately 5.3, which is situated between countries, which are not free (weaker institutions), and countries, which are partly free or free (stronger institutions) according to the Freedom House (2011) classification. For example, Liberia, Yemen and Zimbabwe have an institutional quality index around 5.3. The results show that the relationship between resource extraction and growth is significantly different between the two groups of countries (weaker and stronger institutions) even though the correlation between economic growth and total physical resource extraction remains statistically insignificant for both groups. Nevertheless, the negative correlation of total physical resource extraction tends to be lower in countries with weaker institutions, though both correlations are not significant[31].

Regression 4 in Table 4 distinguishes between biomass extraction (diffuse source) and the extraction of fossil fuels and ores (point source). The direct correlations of point source resource extraction with growth and of institutional quality with growth disappear once I control for the interactions with institutional quality. The interaction of point source resource extraction and institutional quality is positive though not significant. Column 2 in Table 5 summarizes that a marginal increase of point source resource extraction tends to be higher correlated with growth in countries with weak institutions. These effects are not significant however. Concerning biomass extraction, it is interesting that the direct relationship between biomass resource extraction and growth becomes stronger. Moreover, the interaction effect with institutional quality is negative and significant. This shows that the interaction of biomass resource extraction and stronger institutions is associated with higher growth rates (see column 3 in Table 5).

Regression 2 in Table 6 tests the possibility of non-linearities in the relationship between point source resource extraction and economic growth. It shows that the marginal correlation between both is significantly higher in countries with weaker institutional quality[32]. The estimated threshold value is situated in the group of countries, which are "partly free" (e.g. Mali, Bangladesh and Madagascar have an institutional quality index around 3.9). Hence, the model distinguishes between countries, which are "not free" or at the bottom of "partly free", and those above. A marginal increase in point source resource extraction is associated with a marginal increase in the growth rate of 0.06 percentage points in countries with stronger institutions and 0.14 percentage points in countries with weaker institutions, respectively. Regression 3 in Table 6 analyses whether the correlation of physical biomass extraction and economic growth is non-linear. The results indicate a non-linear relationship. Biomass extraction is associated with higher growth rates in countries with stronger institutions[32]. The estimated threshold value for institutional quality roughly distinguishes between countries, which are "free", and countries with an institutional quality below "free" (e.g. El

[31] These correlations are robust for the inclusion of additional control variables (see Table 15). However, in this case the correlation between total domestic extraction and growth is positive for both groups and statistically weakly significant for countries with weaker institutions.
[32] The robustness tests in Table 15 confirm these relationships for biomass extraction (column 3) and extraction of fossil fuels and ores (column 2).

Table 6: Relationship between physical resource extraction and growth contingent upon the level of institutional quality

Dependent variable: (log) GDP growth per capita			
	Regression 1	Regression 2	Regression 3
DE	-0.008		
TH ≤ λ	(0.01)		
DE	-0.001		
TH > λ	(0.01)		
DEPoi		0.0006*	
TH ≤ λ		(0.0003)	
DEPoi		0.0014**	
TH > λ		(0.001)	
DEDiff		0.018**	
		(0.01)	
DEDiff			0.021**
TH ≤ λ			(0.01)
DEDiff			0.015
TH > λ			(0.01)
DEPoi			0.001**
			(0.0004)
InvGDP	0.152***	0.160***	0.161***
	(0.03)	(0.03)	(0.03)
TradeGDP	0.004	0.007	0.006
	(0.01)	(0.01)	(0.01)
PopGrow	-0.385	-0.378	-0.371
	(0.24)	(0.23)	(0.23)
InstQual	-0.005***	-0.001	-0.0005
	(0.001)	(0.001)	(0.002)
Constant	-0.001	-0.046***	-0.050***
	(0.01)	(0.01)	(0.01)
Observations	4,020	4,039	4,039
TH InstQual	5.278	3.920	3.105
p-value	0.000***	0.004***	0.016**
F-stat	12.75	12.48	12.55
R-squared	0.147	0.160	0.160

Notes: The numbers in brackets are robust standard errors. All models are estimated using robust standard errors and include unreported time dummies. The significance levels are characterized by stars: * p<0.1, ** p<0.05, *** p<0.01. The threshold characterizes the level of institutional quality. The non-linear variables are total resource extraction, point source resource extraction and diffuse source resource extraction respectively.

Salvador, Philippines and Peru have an institutional quality index around 3.1). A marginal increase in diffuse source resource extraction is associated with a marginal increase in the growth rate of 2.1 percentage points in countries with stronger institutions or 1.5 percentage points in countries with weaker institutions, respectively. In addition, the direct effect of institutional quality on economic growth disappears.

In summary, I found diverging results for the influence of institutional quality on the relationship between total resource extraction and growth. In addition, they are not significant. Concerning the results of the disaggregated physical resource extraction measures, the direct effect of institutional quality disappears once we control for interaction effects. While the extraction of fossil fuels and ores tend to be associated with higher growth rates in countries with weaker institutions the correlation tends to be reverse for biomass resource extraction.

Relationship between physical resource extraction and institutional quality

My results suggest that neither total resource extraction nor biomass extraction nor the extraction of fossil fuels and ores has a significant linear relationship with the quality of institutions (see Table 7)[33]. Furthermore, I test whether these relationships are contingent upon the level of resource extraction. Table 8 shows that the differences between different levels of resource extraction (weaker institutions and stronger institutions) are significant for all three types of resource extraction (total, point source and diffuse source resource extraction). However, the correlation between resource extraction and institutional quality is insignificant for most of these six groups. The only exception is the group of countries with higher per capita extraction of fossil fuels and ores. In countries with higher levels of fossil fuel and ore extraction, a marginal extraction is positive and significantly associated with weaker institutions[34]. A marginal increase of 1 tonne point source resource extraction per capita is associated with a deterioration of institutional quality of 0.05 units (institutional quality is distributed between 1 and 7)[24].

In summary, there is no clear evidence for a relationship between physical resource extraction and the quality of institutions. The sole exception is that fossil fuel and ore extraction show a significant correlation with weaker institutions in countries with higher point source extraction levels.

Table 7: Relationship between physical resource extraction and institutional quality

Dependent variable: Institutional Quality		
	Regression 1	Regression 2
DE	-0.024	
	(-0.28)	
DEPoi		-0.008
		(-0.93)
DEDiff		0.047
		(0.50)
InvGDP	-0.121	-0.110
	(-0.40)	(-0.37)
TradeGDP	0.042	0.038
	(0.40)	(0.36)
PopGrow	-2.474	-2.545
	(-1.40)	(-1.61)
Constant	3.308***	3.165***
	(16.53)	(18.52)
Observations	3,779	3,779
F-Stat	2.917	2.829
Adjusted R^2	0.042	0.044

Notes: The numbers in brackets are t-values. All models are estimated using robust standard errors and include unreported time dummies. The significance levels are characterized by stars: * p<0.1, ** p<0.05, *** p<0.01.

[33] Both robustness tests confirm these insignificant relationships (see Table 16 and Table 17).
[34] These results are robust for the inclusion of additional control variables (see Table 18 in the appendix).

Table 8: Relationship between physical resource extraction and institutional quality contingent upon the level of resource extraction

Dependent variable: Institutional Quality			
	Regression 1	Regression 2	Regression 3
DE	0.116		
TH ≤ λ	(0.11)		
DE	0.023		
TH > λ	(0.09)		
DEPoi		-0.004	
TH ≤ λ		(0.01)	
DEPoi		0.049**	
TH > λ		(0.02)	
DEDiff		0.031	
		(0.09)	
DEDiff			-0.143
TH ≤ λ			(0.13)
DEDiff			0.108
TH > λ			(0.117)
DEPoi			-0.008
			(0.01)
InvGDP	-0.134	-0.093	-0.117
	(0.30)	(0.29)	(0.30)
TradeGDP	0.037	0.036	0.026
	(0.11)	(0.10)	(0.11)
PopGrow	-2.512	-2.480	-2.824*
	(1.80)	(1.57)	(1.61)
Constant	3.160***	3.195***	3.108***
	(0.21)	(0.17)	(0.19)
Observations	3,779	3,779	3,779
TH log values	1.91	-5.32	0.43
TH absolute values	6.75	0.005	1.54
p-value	0.000	0.000	0.001
F-stat	2.786	2.757	2.928
R-squared	0.055	0.060	0.055

Notes: The numbers in brackets are robust standard errors. All models are estimated using robust standard errors and include unreported time dummies. The significance levels are characterized by stars: * p<0.1, ** p<0.05, *** p<0.01. The threshold characterizes the level of domestic extraction, point source domestic extraction and diffuse-source domestic extraction respectively. The non-linear variables are domestic extraction, point source domestic extraction and diffuse source domestic extraction respectively.

6 Discussion

One main objective of this thesis is to examine whether physical resource extraction has the same correlations with growth as monetary indicators for resource abundance. This chapter starts to discuss different measures for resource abundance. Next, I analyse my results and the similarities and differences between these resource abundance indicators following the three research questions. Finally, I set out to interpret the physical resource extraction from an environmental context.

Resource Abundance Indicators

The most common indicator in the resource curse debate is the ratio of resource exports to total exports or GDP (following Sachs and Warner, 1995). It is questionable whether this indicator is able to reflect true resource abundance. Some studies (Brunnschweiler and Bulte, 2008; van der Ploeg and Poelhekke, 2010) criticise that it is rather a measure of resource dependence as it detects "the degree to which countries do – or do not – have access to alternative sources of income other than resource extraction, […] at some point in time" (Brunnschweiler and Bulte, 2008, p. 261). Consequently, two countries with the same level of resource rents can have different levels of resource dependence contingent on the diversification of their production and exporting structure. Furthermore, most cross-country studies measure resource dependence at some point in time. It is obvious, that the results are sensitive to the choice of the year.

More recently, Brunnschweiler and Bulte (2008) promote resource stocks as a better measure for resource abundance. They use the value of natural capital calculated by the World Bank (2006) as the present value of future resource revenues. However, this indicator can only serve as approximation of true resource abundance, as the calculation of resource stocks is based on flows of natural resource rents in the past.

In this study, I examine a physical resource extraction indicator as an approximation of resource abundance. I therefore investigate the flows of resource extraction on a yearly basis. Once again it is debateable whether this indicator is able to indicate true resource abundance. Countries with the same level of resource stocks can extract different amounts of their resource wealth. The extraction rate may depend on economic, technical, as well as political parameters. Concerning the comparison with monetary resource abundance indicators, it would be best to use studies based on monetary resource rents per capita. I am not aware of such studies in the resource curse debate, which is another limitation[35]. In my view it still enriches the resource curse debate, even though an accurate comparison is not possible. On the one hand it allows an examination independent of price fluctuations and on the other hand it adds a sustainable context.

Relationship between physical resource extraction and growth

Following the outcomes of the resource curse literature I expected that total physical resource extraction is correlated with weaker growth performance. I assumed that this negative linkage is stronger for point source resource extraction, whereas diffuse source resource extraction has no significant correlation. In contrast, my results show a different picture. Total physical resource

[35] I assume that the *physical resource extraction* indicator is more similar with the indicator for resource stocks (used by Brunnschweiler and Bulte, 2008) as it is based on past flows of resource rents.

extraction is not correlated with growth. In disaggregated categories, fossil fuel and ore extraction, as well as biomass extraction is positively correlated with growth, whereas biomass extraction is associated with higher growth rates. Taken together, hypothesis 1 cannot be accepted.

The different outcomes of physical resource extraction and resource dependence may result from the difference between monetary and physical indicators but also from the different definitions (see above). Concerning the former argument, physical indicators are less subject to price fluctuations[36]. Moreover, portions of the physical resource extraction have no counterpart in economic revenues (e.g. grazed biomass for cattle breeding)[37]. Physical flows follow a different logic than monetary flows. The product weight decreases along the product life cycle, whereas the economic value increases. Concerning the second argument, comparing resource dependence with physical resource extraction assumes that countries with high extraction levels are associated with high shares of resource exports to total exports or GDP. This need not hold true. On the one hand, the question is how much of the extracted resources are traded. The traded share is higher for fossil fuel and ore extraction than for biomass and minerals extraction[38]. Hence, the point source resource indicator should be more correlated with resource dependence. On the other hand, other economic exports (such as manufacturing goods) or activities (such as services) play a crucial role for resource dependence as the denominator of this indicator is total exports or GDP. Consequently, it is useful to compare the outcomes for physical resource extraction with these for the second monetary indicator.

The value of resource stocks might be more similar with the physical extraction indicator. It seems reasonable that countries with high resource stocks are associated with high extraction levels, especially as the World Bank calculations are proportional to current rents (van der Ploeg and Poelhekke, 2010). Indeed, Brunnschweiler and Bulte (2008) find that the value of subsoil assets is significantly correlated with growth, which is comparable to my outcome that growth and point source resource extraction are positively correlated[39].

It remains an open question why biomass extraction and the extraction of fossil fuels and ores are growth enhancing, whereas total resource extraction shows no significant correlation. This seems striking but could, however, be a result from the aggregation procedure. As discussed earlier, total physical resource extraction is the aggregate of fossil fuels, ores, minerals and biomass resource extraction. Point source resource extraction comprises the categories fossil fuels and ores while diffuse source reflects the category biomass (see chapter 4.2). I conclude that the difference stems from mineral extraction, which is not included in the disaggregated resource categories. Construction and industrial minerals are characterized by a low economic price and large mass in terms of tonnes. Hence, it is reasonable that total resource extraction is less associated with growth than the disaggregated resource extraction categories.

[36] The level of resource extraction may be influenced by world market prices and market conditions. Nevertheless, the physical indicator neglects the price dimension and thus is less affected.

[37] Another example is that the physical extraction of ores includes not only the weight of the metal content, which is sold on the market but the weight of total metal-containing ore.

[38] Note that (construction and industrial) minerals are hardly reflected in the resource dependence indicator as minerals are less traded and have low value. They are consequently not included in the disaggregated categories.

[39] Brunnschweiler and Bulte (2008) only assess the direct link between subsoil assets and growth. Total natural capital enters in the resource dependence regression and institutional quality regression.

My findings suggest that point source resource extraction and diffuse source resource extraction is a blessing rather than a curse. Still, there remains the question, why biomass resource extraction is associated with higher growth rates than the extraction of fossil fuels and ores. This seems surprising as fossil fuels and ores yield higher rents than biomass extraction.

One could reason that the non-value extraction of ores could be responsible for the lower growth rates[40]. However, further investigation revealed that the extraction of ores has a higher correlation with growth than the extraction of fossil fuels (see Table 19 in the appendix). In addition, parts of biomass extraction also contain mass with no economic value. Especially livestock breeding is responsible for high biomass extraction per capita, because the material flow accounts contain the estimated mass of grazing. Hence, this argument is not reasonable.

Another possible implication is that the extraction of fossil fuels and ores is at least not a curse but less growth enhancing as biomass extraction. Fossil fuels and ores are standard export goods, whereas in comparison only a small portion of extracted biomass is traded (Dittrich, Giljum, et al., 2012). This is confirmed by the correlations between resource extraction and export dependencies (see Table 3 in chapter 4.2). The correlation is higher for point source resources than for diffuse source resources. Countries rich in fossil fuels and ores are more at risk of being resource dependent than countries rich in biomass. Furthermore, the study by Brunnschweiler and Bulte (2008) underlines that subsoil assets are positively correlated with mineral resource dependence. In contrast total natural capital wealth is only weakly correlated with agricultural resource dependence[41]. Moreover, Bulte et al. (2005), Isham et al. (2005) as well as Sala-i-Martin and Subramanian (2003) show that point source resource dependence has a strong robust negative correlation with growth, whereas the results for agricultural resource dependence are inconsistent[42]. As a consequence, I conclude that fossil fuel and ore extracting countries are more at risk of being resource dependent, which in turn hampers growth. On the other hand, biomass extraction might be less associated with agricultural resource dependence, which is in addition less harmful for growth. Taken together, the reason for the lower growth correlation of point source resource extraction might be the association with higher point source resource dependence, which hampers growth.

In summary, total resource extraction seems to be uncorrelated with growth due to the extraction of minerals. This highlights the importance of distinguishing between different resource categories. Point source and diffuse source resource extraction are a blessing rather than a curse. The difference between physical and monetary indicators can either stem from the neglect of prices and revenues, as well as the different aggregation procedures, or from the different definitions of indicators (resource dependence versus extraction levels). My outcomes are in line with the findings for the second monetary indicator of resource abundance – resource stocks. This suggests that resource dependence is responsible for the growth weakness and not resource extraction or resource stocks.

[40] The physical extraction of ores include not only the weight of the metal content but the weight of total metal-containing ore. This implies that a significant portion of mass has no economic counterpart in revenues. In contrary, the main part of fossil fuel extraction is associated with economic revenues. The aggregate of both could be influenced by the non-value extraction of ores, which could in turn lead to a lower correlation with growth.

[41] The authors did not examine the relationship between diffuse source capital and agricultural resource dependence. A precise comparison is therefore not possible.

[42] These authors suggest that point source dependence affects growth indirectly through their impact on institutional quality. I assume that these linkages are also reasonable for the direct effect on growth.

Relationship between physical resource extraction, institutional quality and growth

Mehlum et al. (2006) argue that the level of institutional quality is essential for the relationship between resource abundance and growth. Following their findings, I assumed that the negative relationship between resource extraction and growth is stronger in countries with weak institutions, whereas strong institutions turn the curse into a blessing[43]. Furthermore, I expected that the quality of institutions is more decisive for the extraction of fossil fuels and ores. Different to my expectations, resource extraction tends to be a blessing for countries with strong institutions, as well as for countries with weak institutions. Hypothesis 2 cannot be accepted. Nevertheless, for some resource extraction categories the level of institutional quality does matter.

My findings suggest that the level of institutional quality tends to affect the relationship between total domestic extraction and growth. But the effect of institutional quality differs between the two regression models (growth regression with interaction term, threshold regression model). Additionally, the correlations are only marginally significant or not significant at all. Hence, I conclude that there is no robust relationship.

Once again my results highlight the importance of analysing not only total resource extraction but the two different resource categories. Disaggregating point source resource extraction and diffuse source resource extraction reveals that the level of institutional quality does matter. The marginal biomass resource extraction has a higher correlation with growth in countries with stronger institutions than in countries with weaker institutions. This seems to be in line with the findings of Mehlum et al. (2006) who argue that strong institutions enable a higher positive correlation between natural resource abundance and growth[44]. My outcome of fossil fuel and ore extraction suggests a reverse relationship. The marginal extraction of fossil fuels and ores has a higher correlation with growth in countries with weaker institutions. This appears surprising.

Like above, the reason for the diverging results can be caused by the difference between mass und revenues but also by the different definition of indicators. Mehlum et al. (2006) measure resource abundance by the share of primary exports in GNP in 1970, whereas this study uses yearly physical resource extraction per capita. The findings of Mehlum et al. (2006) therefore suggest that countries with strong institutions can cope better with high resource dependence than countries with weak institutions. On the other hand, physical resource extraction focuses on a different bundle of resources as only a part of the extraction is exported (see also discussion above).

Brunnschweiler and Bulte do not investigate the relationships suggested by Mehlum et al. (2006). They argue for a different causality (see below). I therefore cannot compare my results with their results for the resource abundance indicator resource stocks.

Nevertheless, it is surprising that fossil fuel and ore resource extraction is associated with higher growth rates in countries with weaker institutions. This could imply that weak institutions are necessary to enhance growth in fossil fuel and ore extracting countries. However, this is not covered by theory. Mehlum et al. (2006) argue in their theoretical model that rent-grabbing-friendly countries

[43] Mehlum et al. (2006) differentiate between producer-friendly and grabber-friendly institutions, which I translate into weak institutions and strong institutions (following e.g. Brunnschweiler and Bulte, 2008).

[44] In difference to Mehlum et al. (2006) the correlations are positive for both groups (countries with weak and countries with strong institutions). Moreover, Mehlum et al. (2006) only assess the growth correlations for total resource dependence and point source resource dependence.

(weak institutions) are characterized by low transparency, which is a breeding ground for corruption or shady dealings. So, after a resource boom people move from productive growth enhancing activities such as entrepreneurship to rent-seeking activities. On the other hand, in production-friendly countries (strong institutions) more people are entrepreneurs[45]. My findings suggest that a marginal fossil fuel and ore extraction is correlated with higher growth rates in rent-grabbing friendly countries. This seems to be a counterintuitive as rent-seekers are less growth enhancing as productive entrepreneurs.

My indicator of resource abundance measures tonnes per capita. The revenues of marginal fossil fuel and ore extraction can be quite different between countries. The revenues depend on the price of the extracted individual resources (e.g. crude oil, tin or diamonds), as well as on the average metal-content[46]. Hence, the difference between the two groups of countries can be caused by different income effects of a marginal extraction of fossil fuels and ores. The question is whether countries with weaker institutions tend to extract fossil fuel and ore resources, which are associated with higher resource rents[47]. Still, this is an unanswered question, which needs further investigation.

Furthermore, it is also a question of causality. Does institutional quality affect the relationship between resource extraction and growth? Or is institutional quality itself endogenous and affected by resource extraction. The next section discusses these questions in more detail.

Taken together, my results for biomass resource extraction tend to be in line with Mehlum et al. (2006), even though he does not explicitly investigate diffuse source abundance. Still, there are unanswered questions. It remains unclear, why fossil fuel and ore extraction are associated with higher growth rates in countries with weaker institutions. This is contradictory to theory and previous findings. However, it is also a question of causality (see next section).

Relationship between physical resource extraction and institutional quality

While Mehlum et al. (2006) show that institutional quality is decisive for the effect of resource dependence on institutions, other studies (Bulte et al., 2005; Isham et al., 2005; Sala-i-Martin and Subramanian, 2003) argue for a different causality. They suppose that the quality of institutions is endogenous and affected by resource dependence itself. Following their results, I expected that physical resource extraction is associated with lower institutional quality, whereas this relationship is more severe for point source resource extraction and not significant for biomass resource extraction. In addition, I expected this relationship to be non-linear (following Sala-i-Martin and Subramanian, 2003). I assumed that the marginal negative impact of resource extraction on institutional quality is higher for resource rich countries, in particular for point source resource extraction. Some of my findings are consistent with previous studies[48].

[45] Mehlum et al. (2006) assume complementarities between industry sectors in their model, which leads to spill-over effects. A resource boom not only increases profits in the primary resource sector but also the profits of entrepreneurs in other industry sectors.

[46] The material flow category “ores” include not only the weight of metal content but the weight of metal-containing ore. The average metal-content of individual ores differs between countries.

[47] This question is also valid for biomass extraction. Do countries with stronger institutions extract biomass categories with higher value?

[48] Bulte et al. (2005), Isham et al. (2005) and Sala-i-Martin and Subramanian (2003) analysed the relationship between resource dependence (ratio of primary exports to total exports or GDP) and institutional quality in

Consistent with previous findings, biomass resource extraction is insignificantly correlated with institutional quality (Bulte et al., 2005; Isham et al., 2005; Sala-i-Martin and Subramanian, 2003). This finding is not only robust but also consistent with the properties of diffuse source resources[49]. In general biomass is an ubiquitous resource and thus the associated rents are spread among many agents (e.g. Isham et al., 2005). Different to point source resources, it is more costly to control these areas and the rents for it. Hence, there are fewer incentives for rent seeking. Biomass abundant countries therefore show no tendency for weaker institutions.

Furthermore, fossil fuel and ore extraction is significantly correlated with weaker institutions in countries with abundant point resources. This is in accordance with previous empirical and theoretical research (Bulte et al., 2005; Isham et al., 2005; Sala-i-Martin and Subramanian, 2003)[50]. Point source resources are extracted from a narrow geographical space and contain high rents. These concentrated resource areas can be easily controlled by small groups and thus, the incentives for rent seeking are high (e.g. Bulte et al., 2005). Fossil fuel and ore abundant countries are therefore characterized by an unequal distribution of resource rents and inequality in power – a sign for weaker institutions. Still, there remains the question why the linear relationship between point source resource extraction and institutional quality is not significant. However, in the threshold regression the threshold value is quite low (0.005 per capita tonnes of fossil fuel and ore extraction). I therefore assume that this threshold roughly distinguishes between countries with fossil fuel and ore extraction and those with none. I conclude that countries with fossil fuel and ore extraction tend to be associated with weaker institutions.

Different to my expectations, I found that total resource extraction is not correlated with institutional quality. I assume that this is a combination of the diverging effects of the individual resource categories – biomass extraction and extraction of fossil fuels and ores. Moreover, total resource extraction includes also construction and industrial mineral extraction. I assume that minerals follow the same pattern as biomass as they are ubiquitous and of low value. Taken together hypothesis 3.1 and 3.2 cannot be rejected for biomass resource extraction and the extraction of fossil fuels and ores respectively. They cannot be accepted for the remaining relationships.

Concerning the relationship with institutional quality, my indicator for resource abundance seems to be more in line with the monetary resource dependence indicator. Brunnschweiler and Bulte (2008) show that the alternative monetary measure for resource abundance – resource stocks – is associated with higher institutional quality. Contradictory to previous studies, their findings suggest that resource abundance not only strengthens growth but also institutional quality. They argue that countries with weak institutions are less able to reduce their resource dependence through the strengthening of the non-resource sector. They suggest that high resource dependence might be caused by weak institutions. Following their argumentation we might suppose that countries with

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linear institutional quality regression. Sala-i-Martin and Subramanian (2003) also examined non-linear effects.

[49] Isham et al. (2005) distinguish between diffuse biomass (livestock and agricultural products extracted from smaller farm areas) and plantation crops (extracted from geographically concentrated areas such as coffee and cocoa). My indicator of biomass resource extraction does not allow for this differentiation. Both groups are therefore summarized under diffuse source resource extraction.

[50] In difference to these studies, my findings suggest that point source resource extraction is not significant in the linear institutional quality regression. Still the non-linear relationship correlates well with the literature. The threshold regression results suggest that in the group of countries with higher point source resource extraction the marginal extraction is associated with weaker institutions.

weaker institutions extract higher levels of their resource stocks as they are more dependent on resource income. As a result, I presume that the relationship between resource stocks and resource extraction might be different for countries with strong institutions and these with weaker institutions[51].

One highly discussed question is the causality between institutional quality, resource abundance and growth. Mehlum et al. (2006) argue that the correlation of resource abundance and growth is different between countries with weak and countries with strong institutions. The “new consensus view” (Brunnschweiler and Bulte, 2008) assumes that institutional quality itself is affected by resource abundance. Resource abundance influences the growth performance through the indirect link via institutions (Bulte et al., 2005; Isham et al., 2005; Sala-i-Martin and Subramanian, 2003). Brunnschweiler and Bulte (2008) argue for a different causality. They suggest that institutional quality affects resource dependence. Countries with weak institutions are less able to develop other income generating sectors besides the primary production sectors. Hence, their economic wealth depends on the export of primary resources. Brunnschweiler and Bulte (2008) therefore suggest that the causality runs from weaker institutions to higher resource dependence. However, my results do not indicate causality. This study is not able to confirm one of the three causality arguments. My results just show relationships and correlations.

In summary, the insignificant correlation between total resource extraction and institutional quality might be caused by the diverging effect of individual resource categories. In more detail, I argue that biomass extraction is not associated with weaker institutional quality as there are fewer incentives for rent seeking. The rents of biomass resource extraction are more equally distributed among many agents. On the contrary, rents of fossil fuel and ores are characterized to be easily “lootable” since the acquisition costs are low (extraction areas are geographically concentrated) and acquisition revenues are high (fossil fuels and ores are associated with high revenues). In accordance with previous studies, point source resource extraction is associated with weaker institutions. Still, there are unanswered questions concerning the causality between institutional quality, resource abundance and growth. This study shows relationships and correlations and has no input to the causality discussion.

Environmental Impacts and Growth

This study not only compares the effect of monetary and physical indicators but introduces the resource curse debate in the material flow research. Previous studies focus on the ecologically unequal exchange between countries from the global North and global South, as well as on the growing environmental burden shifting between material extracting and producing countries and countries, which benefit from material-intensive consumption. This investigation revises the resource curse with a physical material flow indicator. Physical resource extraction serves as an approximation of environmental impacts (see chapter 2.2.2). The focus lies on resource extracting countries and their compensation for bearing the environmental impacts in economic growth terms. Furthermore, this study distinguishes different levels of institutional quality, instead of classifying countries as being from the global South and the global North.

[51] I harbor some doubts about this relationship as the calculation of resource stocks is based on past resource revenues.

Haberl et al (2004) argue for the importance of distinguishing between materials domestically extracted and imported materials as it indicates the location of environmental impacts associated with environmental extraction. My findings suggest that bearing the environmental impacts of biomass extraction yields higher growth compensation than bearing the environmental impacts of fossil fuel and ore extraction. On the other hand, there is no significant growth compensation for total resource extraction. As a result, I conclude that the extraction of construction and industrial minerals achieves less economic growth compensation. This makes sense as one tonne of mineral extraction is associated with low monetary value.

However, the material flow indicators are not able to evaluate the different environmental problems and impacts associated with the extraction of biomass or the extraction of fossil fuels and ores respectively. They only indicate tendencies. Therefore, the approach to use material extraction as an approximation of environmental impacts faces some criticism (e.g. Dietz and Neumayer, 2007). By adding up different material flows by weight, the information on the specific environmental impact of each material flow is lost. Hence, highly ecologically intense materials and less ecologically intense materials enter with the same magnitude, if they have the same weight. "Importantly, to aggregate very different material flows by weight without adjustment for their environmental impact leads to nonsensical results" (Dietz and Neumayer, 2007, p. 623). Even though aggregated material flows such as material extraction cannot serve as indicator for specific environmental impacts, they approximate the environmental pressure caused by the scale of material extraction (Bringezu et al., 2009). As a consequence, this study is subject to the inherent limitations of any study using material flow data, which makes it difficult to answer the question, whether the higher growth compensation for biomass resource extraction is justified from an environmental perspective.

My investigation concerning resource curse and institutional quality offers new insights to the research summarized under the term "ecologically unequal exchange"[52] (Giljum and Eisenmenger, 2004; Moran et al., 2013; Muradian and Martinez-Alier, 2001; Pérez-Rincón, 2006)[53]. Whereas these studies argue that the global South is disadvantaged because of its specialization in resource-exporting, most of the resource curse literature classifies countries according to the level of institutional quality, instead of global North and global South. Mehlum et al. (2006) show that resource abundance in general tends to be a blessing in countries with strong institutions and a curse in countries with weak institutions. I assume that countries from the global South tend to belong to the group of countries with weaker institutions[54]. Under this assumption, resource-abundant countries in the global South seem to be disadvantaged by selling their resources for undervalued prices, furthermore, they tend to have a lower growth association due to the weaker institutions. My results for biomass extraction are consistent with this argument. In countries with weaker

[52] This term denotes the mechanism through which low-income, resource-abundant countries face worsening terms of trade, which leads to less possibilities to internalize the environmental impacts corresponding with the extraction and trade of natural resources. The accusation is that resource-abundant countries in the global South transfer their natural capital for undervalued prices to the global North (Muradian and Martinez-Alier, 2001). However, recent studies revising "ecologically unequal exchange" argue that also high-income countries, which in general export less environmental intensive materials, bear environmental burden as they export a larger volume of materials (Moran et al., 2013).

[53] In contrast to my investigation, these studies focus not on resource extraction but on physical and monetary trade balances.

[54] This assumption is based on the positive relationship between income per capita and democracy (e.g. Barro, 1999), even though the UN classification of development status depends not only on income per capita but also on human resource weakness and economic vulnerability (UN, 2008).

institutions the growth compensation for the environmental impacts of a marginal biomass extraction is lower. In contrast, my results suggest that countries with weak institutions benefit more from fossil fuel and ore extraction than countries with strong institutions. This could imply that countries from the global South tend to achieve higher growth compensation for extracting fossil fuels and ores than countries from the global North. This is surprising and counterintuitive to previous resource curse literature (see reasoning above). This relationship should be further investigated.

Considering the relationships between environmental impacts and institutional quality, the geographic pattern of resource extraction does once again matter. Total resource extraction and biomass extraction are not correlated with institutional quality whereas point source resource extraction is associated with lower levels of institutional quality. This highlights that countries rich in fossil fuels and ores not only bear higher environmental impacts through resource extraction but also suffer from less political rights and civil liberties.

Moreover, I tried to investigate an argument motivated by Dittrich, Bringezu et al. (2012). They argue that environmental impacts of resource extraction are not equally distributed around the globe and thus they discuss the "growing burden shifting" of environmental impacts. Some countries enjoy the pleasure of a resource-intensive living standard while other countries bear the environmental impacts of extracting these resources and further processing them. The key indicator in this respect is the physical trade balance (PTB). I intended to analyse the relationships between PTB and growth in order to assess whether bearing the "environmental burden" is associated with an increase or decrease in growth rates. However, a pre-analysis suggested that there is no correlation between physical trade balance (PTB) and growth (see chapter 4.2), which is also suggested by Dittrich, Bringezu et al. (2012). I therefore claim that resource-demanding countries and resource-providing countries show no difference in their growth behaviour.

In summary, revising the resource curse using a material flow indicator introduces a new perspective in the material flow research. In contrast to previous studies, I examine the relationship between resource extracting countries and economic growth. Bearing the environmental impacts of biomass extraction yields the highest growth compensation after the extraction of fossil fuels and ores. Concerning different levels of institutional quality, my results seem to question the ecologically unequal exchange argument. The extraction of fossil fuels and ores is more highly correlated with economic growth in countries with weaker institutions, which tend to be countries from the global South. Further investigations are necessary to detect the reasons for this relationship.

7 Conclusion

In this thesis, I revise the resource curse using a physical resource abundance indicator. I therefore investigate the correlations between growth, institutional quality and physical resource extraction. One main objective is to examine whether the resource curse also exists for physical resource abundance and hence to compare physical and monetary resource abundance indicators. Furthermore, it offers insights into whether bearing the environmental impacts of resource extraction has a positive or negative effect on growth as the physical indicator approximates environmental impacts.

Resource abundance is commonly measured as the ratio of resource exports to total exports or GDP (following Sachs and Warner, 1995) in the resource curse debate. Brunnschweiler and Bulte (2008) introduce resource stocks (value of natural capital calculated by the World Bank (2006)) as an alternative resource abundance measure. In this study I use a physical resource abundance indicator which illustrates flows of resource extraction on a yearly basis. I claim that none of these indicators, reflects "true" resource abundance. The first is rather a measure of resource dependence as it measures to which degree resource rich countries are able to maintain other economic activities. The second is based on flows of natural resource rents and hence is as the third, dependent on yearly extraction rates. Both can only approximate "true" resource abundance as yearly extraction rates depend on economic, technical as well as political parameters. Each of the three shows different aspects of resource abundance, but together they provide an interesting overall picture.

To revise the seminal resource curse studies following Sachs and Warner (1995), I investigated the **relationship between physical resource extraction and growth**. My results indicate that physical resource abundance is associated with a blessing rather than with a curse. Both, biomass extraction as well as the extraction of fossil fuels and ores are associated with positive growth rates. This is in line with the resource abundance indicator resource stocks. The value of subsoil assets is significantly correlated with growth. I therefore conclude that resource dependence is responsible for the growth weakness and not resource extraction or resource stocks. Bearing the environmental impacts of biomass extraction as well as fossil fuel and ore extraction is associated with a growth compensation.

Furthermore, my findings suggest that biomass resource extraction is associated with higher growth rates than the extraction of fossil fuels and ores even though the latter yield higher resource rents. My data confirm that the correlation between resource extraction and resource dependence is higher for point source resources. Moreover, previous studies show that point source resource dependence hampers growth, whereas the results for biomass resource dependence are inconsistent. I thus assume that the correlation with point source resource dependence is responsible for the lower growth association. Concerning environmental impacts, the material flow indicators cannot compare the different environmental problems and impacts associated with the extraction of biomass or the extraction of fossil fuels and ores, respectively. They only indicate tendencies. As a consequence, this study cannot answer the question of whether the higher growth compensation for biomass resource extraction is justified from an environmental perspective.

The resource curse literature identifies **institutional quality** as one of the main mechanisms responsible for the growth weakness of resource abundant countries. However, the question of causality has not yet been resolved. This study investigates two different postulations of causality but cannot confirm one of these arguments as they only show relationships and correlations.

The first causality argument examines the relationship between **physical resource extraction, institutional quality and growth** claiming that resource dependence is a blessing in countries with strong institutions and a curse in countries with weak institutions. In contrast, my results suggest that physical resource abundance (diffuse source and point source) is always a blessing. Nevertheless, the level of institutional quality matters. Indeed, biomass resource extraction is associated with higher growth rates in countries with stronger institutions, whereas the results for fossil fuel and ore extraction show a reverse relationship. This is counterintuitive to theoretical findings.

In addition, these results offer new insights into the research summarised under the term "ecologically unequal exchange"[55]. Assuming that countries from the global South are associated with weaker institutions, this study's results for biomass extraction are consistent with the ecologically unequal exchange argument. As stated above the growth compensation for bearing the environmental impacts of a marginal biomass extraction is lower in countries with weaker institutions. On the contrary, the results for fossil fuel and ore extraction could imply that countries from the global South achieve higher growth compensation for extracting fossil fuels and ores than countries from the global North. Hence, this result is not only counterintuitive to resource curse findings but additionally counterintuitive to the "ecologically unequal exchange" argument and thus requires further investigation.

The second causality argument claims that institutional quality itself is affected by resource abundance. I therefore examine the **relationship between physical resource extraction and institutional quality**. Consistent with the resource dependence indicator, fossil fuel and ore extraction is correlated with weaker institutions in resource abundant countries, whereas biomass resource extraction is not correlated with institutional quality. Moreover, this is in line with the properties of point source and diffuse source resource extraction. Resources from a narrow geographical space such as fossil fuels and ores are associated with easily "lootable" rents which enhances rent seeking incentives. In contrast rents from biomass are spread thinly in space. As a consequence, the appropriation is more costly and less attractive. This highlights that countries rich in fossil fuels and ores not only bear higher environmental impacts through resource extraction but also display fewer political rights and civil liberties.

However, the alternative resource abundance indicator – resource stocks – is associated with higher institutional quality. Brunnschweiler and Bulte (2008) argue for a different causality. Weaker institutions might cause higher resource dependence. This line of argument suggests that countries with weaker institutions extract higher levels of their resource stocks as their dependence on resource incomes is higher. As a consequence, the relationship between resource stocks and resource extraction might be different for countries with strong institutions and these with weaker institutions.

In contrast to previous resource curse literature, **total physical resource extraction** shows no significant correlation – neither with growth nor with institutional quality. The contrasting results are caused by differences between physical and monetary indicators and by the different definitions of indicators (see above). I claim that the extraction of industrial and construction minerals is responsible for the diverging results. They account for large parts of physical resource extraction but

[55] It examines the trade relationships between countries from the global South and North and claims that the global South is disadvantaged as resource revenues do not compensate for the environmental impacts and the ecological value of the exported resources.

at the same time are associated with low economic revenues. Furthermore, they are less traded and hence underrepresented in the resource dependence indicator. As a consequence, industrial and construction minerals are highly represented in physical resource extraction due to their mass and less represented in the monetary indicators due to their low economic value and low trade share.

In a nutshell, the standard resource curse seems to be caused by resource dependence and not by resource extraction or resource stocks. However, my results confirm that institutional quality plays a role in this context even though they cannot indicate causalities. While the correlation between resource extraction and growth is influenced by the level of institutional quality, resource extraction is correlated with institutional quality itself – at least point source resource extraction. My investigation supports that the geographic pattern of resource extraction matters. The results for point source extracted resources differ from these for diffuse source extracted resources.

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9 Appendix

9.1 Descriptive Statistic

Table 9: Summary statistics

	Observations	Mean	Standard Deviation	Minimum	Maximum
Growth	4855	0.02	0.06	-0.50	0.92
DE	5466	1.95	0.95	-2.65	4.94
DEPoi	5466	-6.41	9.59	-21.22	4.73
DEDiff	5456	0.80	1.30	-11.12	3.66
DE (absolute)	5466	11.01	13.33	0.07	139.90
DEPoi (absolute)	5466	4.00	10.22	0.00	113.46
DEDiff (absolute)	5487	3.59	3.73	0.00	38.77
InstQual	5030	3.68	2.04	1	7
InvGDP	4582	0.23	0.09	-0.02	1.14
TradeGDP	4729	0.82	0.47	0.00	4.44
PopGrow	5740	0.02	0.02	-0.08	0.17
Inflation	4163	0.47	6.04	-0.18	244.11
SYR15	4019	2.20	1.36	0.03	7.48

Table 10: Correlation matrix

	Growth	DE	DEPoi	DEDiff	Inst Qual	Inv GDP	Trade GDP	Pop Grow	Infla tion	SYR15
Growth	1									
DE	0.01	1								
DEPoi	-0.01	0.44*	1							
DEDiff	0.001	0.39*	0.29*	1						
InstQual	-0.07*	-0.28*	0.12*	-0.22*	1					
InvGDP	0.25*	0.12*	-0.11*	-0.05*	-0.04*	1				
TradeGDP	0.12*	0.13*	-0.30*	-0.20*	-0.10*	0.34*	1			
PopGrow	-0.11*	-0.08*	-0.01	-0.20*	0.38*	-0.07*	-0.07*	1		
Inflation	-0.09*	-0.03	0.04*	0.01	0.05*	-0.05*	-0.03	0.00	1	
SYR15	0.08*	0.51*	0.19*	0.10*	-0.46*	0.15*	0.19*	-0.41*	-0.004	1

Notes: The significance level is characterized by star: * p<0.05.

Table 11: Country coverage

Qatar	Malaysia	Sudan	El Salvador
United Arab Emirates	Botswana	Uzbekistan	Senegal
Brunei Darussalam	Bahamas	Croatia	Guinea-Bissau
Kuwait	Bolivia	Thailand	Laos
Australia	Brazil	Japan	Philippines
Norway	Belize	Lithuania	Grenada
New Zealand	Cuba	Antigua and Barbuda	Uganda
Canada	United Kingdom	Lebanon	Lesotho
Finland	Fiji Islands	Tunisia	Kenya
Saudi Arabia	Kiribati	Malta	Djibouti
Oman	Spain	China	Tanzania
Chile	Bulgaria	Syria	Benin
Bahrain	Mauritania	Bosnia and Herzegovina	Viet Nam
Mongolia	Netherlands	Honduras	Gambia
Uruguay	Cyprus	Guinea	Togo
Ireland	Romania	Nicaragua	India
Libya	Saint Kitts and Nevis	Azerbaijan	Nepal
United States of America	Belgium	Dominica	Pakistan
Kazakhstan	Vanuatu	Dominican Republic	Cambodia
Sweden	Hungary	Albania	DR Congo
Gabon	Macedonia	Indonesia	Sierra Leone
Denmark	Swaziland	Solomon Islands	Yemen
Estonia	Bhutan	Egypt	Haiti
Peru	Switzerland	Liberia	Cote d'Ivoire
Guyana	Zambia	Niger	Georgia
Trinidad and Tobago	Jamaica	Guatemala	Maldives
South Africa	Barbados	Morocco	Eritrea
Iceland	Iran	Saint Lucia	Burundi
Germany	Mexico	Rep Congo	Rwanda
Austria	Israel	Chad	Tajikistan
Namibia	South Korea	Mali	Afghanistan
Russian Federation	Singapore	Zimbabwe	Malawi
France	Colombia	Kyrgyzstan	Sri Lanka
Venezuela	Ukraine	Central African Republic	Cape Verde
Czech Republic	Slovakia	Angola	Mozambique
Slovenia	Costa Rica	Tonga	Comoros
Poland	Italy	Armenia	Bangladesh
Greece	Turkey	St. Vincent/Grenadines	
Turkmenistan	Mauritius	Panama	
Suriname	Portugal	Ethiopia	
Argentina	Latvia	Madagascar	
Luxembourg	Jordan	Cameroon	
Papua New Guinea	Belarus	Burkina Faso	
Paraguay	Ecuador	Ghana	
Equatorial Guinea	Algeria	Moldova	

Notes: Countries are sorted according their average per capita domestic extraction level (DE) in descending order. Not all years are included for the full period (1980-2008), e.g. former Soviet countries are included for the years 1992-2008.

9.2 Robustness Check

Table 12: Relationship between physical resource extraction, institutional quality and growth, including outliers

Dependent variable: (log) GDP growth per capita				
	Regression 1	Regression 2	Regression 3	Regression 4
DE	0.001		-0.013	
	(0.06)		(-1.31)	
DEPoi		0.0004		-0.001
		(1.06)		(-0.83)
DEDiff		0.018		0.032**
		(1.41)		(2.44)
InstQual	-0.002	-0.002	-0.008**	0.003
	(-1.55)	(-1.51)	(-2.59)	(0.84)
DE_InstQual			0.003**	
			(2.11)	
DEPoi_InstQual				0.0002
				(1.57)
DEDiff_InstQual				-0.004**
				(-1.98)
InvGDP	0.164***	0.161***	0.162***	0.164***
	(5.18)	(5.09)	(5.11)	(5.12)
TradeGDP	0.013	0.012	0.012	0.012
	(1.23)	(1.16)	(1.15)	(1.13)
PopGrow	-0.581***	-0.562***	-0.571***	-0.556***
	(-2.76)	(-2.64)	(-2.73)	(-2.64)
Constant	-0.016	-0.033*	0.012	-0.053***
	(-0.67)	(-1.77)	(0.55)	(-2.66)
Observations	4,254	4,254	4,254	4,254
F-Stat	9.83	9.20	9.31	9.26
Adjusted R^2	0.098	0.101	0.101	0.103

Notes: The numbers in brackets are t-values. All models are estimated using robust standard errors and include unreported time dummies. The significance levels are characterized by stars: * p<0.1, ** p<0.05, *** p<0.01.

Table 13: Relationship between aggregated physical resource extraction, institutional quality and growth, including additional control variables

Dependent variable: (log) GDP growth per capita				
	Regression 1	Regression 2	Regression 3	Regression 4
DE	0.007	0.007	-0.001	-0.001
	(1.22)	(1.24)	(-0.10)	(-0.12)
InstQual	-0.0004	-0.0004	-0.005*	-0.005*
	(-0.34)	(-0.34)	(-1.70)	(-1.69)
DE_InstQual			0.002	0.002
			(1.53)	(1.52)
InvGDP	0.145***	0.146***	0.143***	0.143***
	(5.81)	(5.74)	(5.82)	(5.76)
TradeGDP	-0.005	-0.005	-0.006	-0.006
	(-0.60)	(-0.59)	(-0.73)	(-0.73)
PopGrow	-0.562***	-0.562***	-0.545***	-0.545***
	(-3.69)	(-3.69)	(-3.60)	(-3.60)
Inflation	-0.004***	-0.004***	-0.004***	-0.004***
	(-6.13)	(-6.13)	(-6.14)	(-6.15)
SYR15		0.000		0.001
		(0.03)		(0.14)
Constant	-0.032**	-0.021	-0.014	-0.004
	(-2.31)	(-1.12)	(-0.91)	(-0.19)
Observations	2,953	2,953.000	2,953	2,953
F-Stat	15.74	15.41	14.77	14.51
Adjusted R^2	0.172	0.171	0.173	0.173

Notes: The numbers in brackets are t-values. All models are estimated using robust standard errors and include unreported time dummies. The significance levels are characterized by stars: * p<0.1, ** p<0.05, *** p<0.01.

Table 14: Relationship between disaggregated physical resource extraction, institutional quality and growth, including additional control variables

Dependent variable: (log) GDP growth per capita				
	Regression 1	Regression 2	Regression 3	Regression 4
DEPoi	0.001*	0.001*	-0.00008	-0.00007
	(1.90)	(1.93)	(-0.16)	(-0.14)
DEDiff	0.031***	0.031***	0.040***	0.040***
	(3.70)	(3.69)	(4.53)	(4.54)
InstQual	-0.000	-0.000	0.003	0.003
	(-0.30)	(-0.31)	(1.29)	(1.30)
DEPoi_InstQual			0.000	0.000
			(1.53)	(1.52)
DEDiff_InstQual			-0.003**	-0.003**
			(-2.12)	(-2.13)
InvGDP	0.143***	0.143***	0.163***	0.163***
	(5.88)	(5.82)	(5.95)	(5.90)
TradeGDP	-0.004	-0.004	-0.002	-0.003
	(-0.48)	(-0.48)	(-0.31)	(-0.33)
PopGrow	-0.526***	-0.526***	-0.473***	-0.473***
	(-3.45)	(-3.46)	(-3.19)	(-3.20)
Inflation	-0.004***	-0.004***	-0.005***	-0.005***
	(-6.09)	(-6.09)	(-6.61)	(-6.62)
SYR15		0.000		0.001
		(0.12)		(0.30)
Constant	-0.051***	-0.035**	-0.068***	-0.054***
	(-3.83)	(-2.23)	(-5.12)	(-3.15)
Observations	2,956	2,956	2,979	2,979
F-Stat	14.19	14.15	14.94	14.86
Adjusted R^2	0.183	0.183	0.186	0.186

Notes: The numbers in brackets are t-values. All models are estimated using robust standard errors and include unreported time dummies. The significance levels are characterized by stars: * p<0.1, ** p<0.05, *** p<0.01.

Table 15: Relationship between physical resource extraction and growth contingent upon the level of institutional quality, including additional control variables

Dependent variable: (log) GDP growth per capita			
	Regression 1	Regression 2	Regression 3
DE	0.005		
TH ≤ λ	(0.01)		
DE	0.011*		
TH > λ	(0.01)		
DEPoi		0.0006*	
TH ≤ λ		(0.0003)	
DEPoi		0.002**	
TH > λ		(0.0008)	
DEDiff		0.0304***	
		(0.01)	
DEDiff			0.036***
TH ≤ λ			(0.01)
DEDiff			0.029***
TH > λ			(0.01)
DEPoi			0.0006*
			(0.0003)
InvGDP	0.147***	0.141***	0.140***
	(0.02)	(0.02)	(0.025)
TradeGDP	-0.006	-0.004	-0.003
	(0.01)	(0.01)	(0.01)
PopGrow	-0.553***	-0.515***	-0.515***
	(0.16)	(0.15)	(0.15)
InstQual	-0.003*	0,0001	0.0008
	(0.001)	(0.001)	(0.001)
Inflation	-0.004***	-0.004***	-0.004***
	(0.001)	(0.001)	(0.001)
SYR15	-0.0001	0.0007	-0.0001
	(0.004)	(0.004)	(0.004)
Constant	-0.010	-0.037**	-0.040**
	(0.019)	(0.02)	(0.016)
Observations	2,953	2,956	2,956
TH InstQual	5.346	6.160	2.086
p-value	0.000	0.119	0.003
F-stat	15.23	13.92	13.63
R-squared	0.185	0.195	0.196

Notes: The numbers in brackets are robust standard errors. All models are estimated using robust standard errors and include unreported time dummies. The significance levels are characterized by stars: * p<0.1, ** p<0.05, *** p<0.01. The threshold characterizes the level of institutional quality. The non-linear variables are total resource extraction, point source resource extraction and diffuse source resource extraction respectively.

Table 16: Relationship between physical resource extraction and institutional quality, including outliers

Dependent variable: Institutional Quality		
	Regression 1	Regression 2
DE	-0.112	
	(-0.56)	
DEPoi		0.001
		(0.05)
DEDiff		-0.127
		(-0.51)
InvGDP	0.323	0.295
	(0.57)	(0.51)
TradeGDP	-0.312	-0.311
	(-1.46)	(-1.45)
PopGrow	-6.874*	-7.165*
	(-1.80)	(-1.84)
Constant	4.638***	4.572***
	(9.17)	(10.96)
Observations	4,360	4,360
F-Stat	3.22	3.12
Adjusted R^2	0.120	0.120

Notes: The numbers in brackets are t-values. All models are estimated using robust standard errors and include unreported time dummies. The significance levels are characterized by stars: * p<0.1, ** p<0.05, *** p<0.01.

Table 17: Relationship between physical resource extraction and institutional quality, including additional control variables

Dependent variable: Institutional Quality				
	Regression 1	Regression 2	Regression 3	Regression 4
DE	-0.031	-0.042		
	(-0.21)	(-0.28)		
DEPoi			-0.013	-0.012
			(-1.39)	(-1.33)
DEDiff			0.091	0.092
			(0.77)	(0.79)
InvGDP	0.054	0.082	0.064	0.082
	(0.12)	(0.18)	(0.15)	(0.19)
TradeGDP	0.057	0.045	0.058	0.048
	(0.41)	(0.33)	(0.41)	(0.35)
PopGrow	-4.445	-4.338	-4.441*	-4.371
	(-1.64)	(-1.61)	(-1.67)	(-1.65)
Inflation	-0.001	-0.001	-0.001	-0.001
	(-0.31)	(-0.35)	(-0.34)	(-0.37)
SYR15		0.085		0.071
		(0.89)		(0.77)
Constant	3.064***	2.841***	2.831***	2.650***
	(9.80)	(7.07)	(11.96)	(7.51)
Observations	2,862	2,862	2,862	2,862
F-Stat	3.00	2.92	2.67	2.63
Adjusted R^2	0.045	0.047	0.049	0.051

Notes: The numbers in brackets are t-values. All models are estimated using robust standard errors and include unreported time dummies. The significance levels are characterized by stars: * p<0.1, ** p<0.05, *** p<0.01.

Table 18: Relationship between physical resource extraction and institutional quality contingent upon the level of resource extraction, including additional control variables

Dependent variable: Institutional Quality			
	Regression 1	Regression 2	Regression 3
DE	0.159		
TH ≤ λ	(0.15)		
DE	0.035		
TH > λ	(0.14)		
DEPoi		-0.006	
TH ≤ λ		(0.009)	
DEPoi		0.064**	
TH > λ		(0.03)	
DEDiff		0.061	
		(0.11)	
DEDiff			-0.221
TH ≤ λ			(0.16)
DEDiff			0.292
TH > λ			(0.18)
DEPoi			-0.013
			(0.01)
InvGDP	0.080	0.095	0.085
	(0.45)	(0.43)	(0.43)
TradeGDP	0.035	0.040	0.036
	(0.14)	(0.13)	(0.14)
PopGrow	-4.526	-4.359*	-4.965*
	(2.75)	(2.59)	(2.71)
Inflation	-0.0002	-0.0002	-0.001
	(0.002)	(0.002)	(0.002)
SYR15	0.085	0.087	0.039
	(0.094)	(0.09)	(0.095)
Constant	2.633***	2.650***	2.525***
	(0.42)	(0.34)	(0.36)
Observations	2,862	2,862	2,862
TH log values	1.910	-5.037	0.429
TH absolute values	6.75	0.0065	1.54
p-value	0.000	0.000	0.000
F-stat	3.14	2.51	2.68
R-squared	0.066	0.075	0.071

Notes: The numbers in brackets are robust standard errors. All models are estimated using robust standard errors and include unreported time dummies. The significance levels are characterized by stars: * p<0.1, ** p<0.05, *** p<0.01. The threshold characterizes the level of institutional quality. The non-linear variables are total resource extraction, point source resource extraction and diffuse source resource extraction respectively.

Table 19: Relationship between individual resource extraction categories and growth

Dependent variable: (log) GDP growth per capita	
	Regression 1
DEFF	0.0003
	(0.95)
DEOre	0.001*
	(1.80)
DEMin	-0.00009
	(-0.02)
DEBM	0.019**
	(2.13)
InvGDP	0.169***
	(5.49)
TradeGDP	0.006
	(0.63)
PopGrow	-0.393
	(-1.64)
InstQual	-0.002*
	(-1.73)
Constant	-0.038***
	(-2.61)
Observations	4,053
F-Stat	11.55
Adjusted R^2	0.151

Notes: The numbers in brackets are t-values. All models are estimated using robust standard errors and include unreported time dummies. The significance levels are characterized by stars: * $p<0.1$, ** $p<0.05$, *** $p<0.01$. The variables DEFF, DEOre, DEMin and DEBM denote the log of per capita extraction levels of fossil fuels, ores, minerals and biomass respectively.

9.3 English Summary

Conventional wisdom suggests that countries rich in resources should benefit from more possibilities to generate economic growth. However, economic literature summarized under the term “resource curse” shows that natural resource abundance seems to hamper rather than foster economic growth (Bulte et al., 2005; Isham et al., 2005; van der Ploeg, 2011; Sachs and Warner, 1995; Sala-i-Martin and Subramanian, 2003). Furthermore, resource abundant countries bear the environmental impacts of resource extraction (e.g. Bringezu et al., 2009; Haberl et al., 2004). Taken together, resource extraction seems to be costly from an economic as well as from an environmental perspective.

This study intends to combine the economic and the environmental perspective. Resource abundance is commonly approximated by monetary indicators in the resource curse debate. However, monetary indicators are influenced by price fluctuations and may not fully represent the ecological value of natural resources. In this study, I introduce a physical resource abundance indicator, which serves as approximation of environmental impacts caused by the resource extraction. This indicator is obtained by the material flow accounts and illustrates flows of resource extraction in physical units (tonnes) on a yearly basis.

The aim of this study is to revise the resource curse using a physical resource abundance indicator. One main objective is to examine whether the resource curse holds true for physical resource abundance and hence to compare physical and monetary resource abundance indicators. Furthermore, this study offers insights into whether bearing the environmental impacts of resource extraction is associated with higher or lower growth rates. It therefore combines the economic debate with a sustainability context.

I estimate the correlations between economic growth, institutional quality and physical resource extraction using two-way fixed effects OLS panel estimations. I thereby investigate total resource extraction (fossil fuel, ore, biomass as well as construction and industrial minerals), the extraction of resources from narrow geographical space (fossil fuel and ore, summarized under the term “point source” resources) as well as the extraction of resources spread widely in space (biomass, summarized under the term “diffuse source” resources). Furthermore, I apply a threshold regression model, which tests whether the relationship between resource extraction and economic growth is contingent upon the value of institutional quality. The unbalanced panel dataset contains 172 countries as well as around 4,000 observations and covers the period 1980-2008.

The findings indicate that point source as well as diffuse source resource extraction is a growth blessing rather than a growth curse. In the resource curse debate, the most used indicator[56] measures resource dependence rather than resource abundance (Brunnschweiler and Bulte, 2008). I therefore conclude that high resource dependence is responsible for the growth weakness and not physical resource extraction. However, biomass resource extraction is associated with higher growth rates than the extraction of fossil fuels and ores even though the latter yield higher resource rents. My results confirm that the correlation between resource extraction and resource dependence is higher for point source resources. I therefore assume that this higher correlation is responsible for the lower growth association of point source resource extraction.

[56] Resource abundance is commonly measured as the ratio of resource exports to total exports or GDP.

Furthermore, the results show that the level of institutional quality matters in this context. Biomass resource extraction is associated with higher growth rates in countries with stronger institutions whereas the results for fossil fuel and ore extraction show a reverse relationship. The latter is counterintuitive to theoretical findings from the resource curse literature and the material flow literature and thus requires further investigation.

In addition this study investigates a second causality argument, which states that institutional quality itself is affected by resource abundance. My results show that fossil fuel and ore extraction is correlated with weaker institutions in resource abundant countries, whereas biomass resource extraction shows no correlation. This is in line with the properties of point and diffuse source resource extraction. Resources from a narrow geographical space (such as fossil fuels and ores) are associated with easily "lootable" rents which enhances rent seeking incentives. In contrast rents from biomass are spread widely in space and as a consequence, the appropriation is more costly and less attractive. In the context of resource extraction, rent seeking is associated with corruption and armed conflicts, which weakens institutional quality.

Total physical resource extraction shows no significant correlation as opposed to previous resource curse literature. I claim that the extraction of industrial and construction minerals is responsible for the diverging results as they account for large parts of physical resource extraction but are associated with low economic revenues.

In a nutshell, the standard resource curse seems to be caused by resource dependence and not by physical resource extraction. Bearing the environmental impacts of biomass extraction as well as fossil fuel and ore extraction is associated with a growth compensation. My investigation supports that the geographic pattern of resource extraction matters and that institutional quality plays a role in this context even though they cannot indicate causalities. While the correlation between resource extraction and growth is influenced by the level of institutional quality, resource extraction is correlated with institutional quality itself – at least point source resource extraction.

9.4 German Summary

Ressourcenreiche Länder sollten mehr Möglichkeiten haben, um Wirtschaftswachstum anzutreiben. Die Ressourcenfluch-Debatte zeigt jedoch, dass Reichtum an natürlichen Ressourcen eher ein Wachstumsbremser als ein Wachstumstreiber ist (Bulte et al., 2005; Isham et al., 2005; van der Ploeg, 2011; Sachs and Warner, 1995; Sala-i-Martin and Subramanian, 2003). Weiters tragen ressourcenreiche Länder die Umweltauswirkungen des Ressourcenabbaus (e.g. Bringezu et al., 2009; Haberl et al., 2004). Somit scheint Ressourcenabbau sowohl von einer wirtschaftlichen als auch von einer ökologischen Perspektive mit Kosten verbunden zu sein.

Diese Studie versucht die ökonomische mit der ökologischen Perspektive zu verbinden. In der Ressourcenfluch-Debatte ist Ressourcenreichtum häufig mit monetären Indikatoren approximiert. Monetäre Indikatoren sind jedoch von Preisschwankungen beeinflusst und müssen nicht den tatsächlichen ökologischen Wert von natürlichen Ressourcen abbilden. In dieser Studie verbinde ich die Ressourcenfluch-Debatte mit einem physischen Indikator für Ressourcenreichtum, der als Annäherung für die Umweltbelastungen des Ressourcenabbaus dient. Dieser Indikator wird im Rahmen der Materialflussrechnung erhoben und zeigt die jährlichen Ressourcenabbauflüsse in physischen Einheiten (Tonnen).

Diese Studie überprüft mittels eines physischen Ressourcenreichtums-Indikators, ob der Ressourcenfluch auch für physischen Ressourcenreichtum zutrifft. Daher ist ein Ziel der Studie, monetäre und physische Indikatoren in Bezug auf den Ressourcenfluch zu vergleichen. Weiters bietet diese Studie Einblicke, ob das Tragen der Umweltbelastungen von Ressourcenabbau mit höheren oder niedrigeren Wachstumsraten verbunden ist. Daher kombiniert sie die ökonomische Ressourcenfluch-Debatte mit dem Nachhaltigkeitskontext.

Mittels einer OLS Paneldatenanalyse (zweifach fixierte Effekte) wird die Korrelation zwischen Wirtschaftswachstum, Institutionen und physischem Ressourcenabbau geschätzt. Dabei untersuche ich den gesamten Ressourcenabbau (fossile Brennstoffe, Erze, Biomasse sowie Bau- und Industriemineralien), den Abbau von Ressourcen auf geografisch engem Raum (fossile Brennstoffe und Erze, zusammgenfasst unter „point source“ Ressourcen) sowie den Abbau von räumlich weit verteilten Ressourcen (Biomasse, zusammengefasst unter „diffuse source“ Ressourcen). Weiters verwende ich ein „threshold“ Regressionsmodel, welches testet, ob die Beziehung zwischen physischem Ressourcenabbau und Wirtschaftswachstum von einer dritten Variable, nämlich institutioneller Qualität, beeinflusst wird. Das unbalancierte („unbalanced“) Paneldatenset enthält 172 Länder und über 4.000 Beobachtungen für die Periode 1980-2008.

Die Ergebnisse zeigen, dass sowohl „point source“ als auch „diffuse source“ Ressourcenabbau kein Fluch sondern ein Segen für Wirtschaftswachstum sind. Da der häufigste Indikator in der Ressourcenfluch-Debatte[57] eher Ressourcenabhängigkeit abbildet (Brunnschweiler and Bulte, 2008), schließe ich daraus, dass Ressourcenabhängigkeit und nicht physischer Ressourcenabbau für den Ressourcenfluch verantwortlich ist.

In diesem Kontext spielt das Niveau von institutioneller Qualität eine Rolle. Der Abbau von Biomasse korreliert in Ländern mit stärkeren Institutionen mit höheren Wachstumsraten, während dieser

[57] Als Indikator für Ressourcenreichtum wird in der Ressourcenfluch-Debatte meist das Verhältnis von Ressourcenexporten zu Gesamtexporten oder zu GDP herangezogen.

Zusammenhang für den Abbau von Erzen und fossilen Brennstoffen umgekehrt ist. Das letztere ist widersprüchlich sowohl zur Ressourcenfluch- als auch zur Materialflussliteratur und bedarf weiterer Untersuchungen.

In dieser Arbeit betrachte ich einen weiteren Kausalitätszusammenhang, bei dem die institutionelle Qualität selbst durch Ressourcenreichtum beeinflusst wird. Der Abbau von fossilen Brennstoffen und Erzen korreliert mit schwächeren Institutionen in ressourcenreichen Ländern, während der Abbau von Biomasse keine Korrelation aufweist. Das wird durch die Eigenschaften von „point source" und „diffuse source" Ressourcen unterstrichen. Die Rohstoffeinnahmen von auf engem Raum abgebauten Ressourcen sind leichter „plünderbar", was "rent seeking" Aktivitäten erhöht. Im Gegensatz dazu ist Biomasse räumlich weit verteilt, was die Aneignung von Ressourceneinnahmen teurer und weniger attraktiv macht. „Rent seeking" ist im Rahmen von Ressourcenabbau verbunden mit Korruption und bewaffneten Konflikten, was die institutionelle Qualität schwächt.

Im Unterschied zu den Ergebnissen der Ressourcenfluch-Literatur korreliert der gesamte physische Ressourcenabbau (fossile Brennstoffe, Erze, Biomasse sowie Bau- und Industriemineralien) nicht mit Wirtschaftswachstum. Da Bau- und Industriemineralien einen großen Anteil des gesamten physischen Ressourcenabbaus ausmachen, jedoch auf Grund ihres geringen Preises nur wenig Rohstoffeinnahmen lukrieren und darüber hinaus auch nur wenig gehandelt werden, vermute ich, dass diese Rohstoffgruppe verantwortlich für die Differenz zwischen meinen Ergebnissen und jenen der Ressourcenfluch-Literatur ist.

Zusammenfassend kann gesagt werden, dass Ressourcenabhängigkeit und nicht physischer Ressourcenabbau den Ressourcenfluch zu verursachen scheint. Das Tragen der Umweltbelastungen des Abbaus von fossilen Brennstoffen und Erzen sowie von Biomasse ist mit einer Wachstumskompensation verbunden. Meine Ergebnisse bestätigen, dass die geographischen Merkmale des Ressourcenabbaus von Bedeutung sind und dass institutionelle Qualität in diesem Kontext eine Rolle spielt, auch wenn diese Arbeit keinen Beitrag zur Diskussion über die Kausalität liefern kann. Während die institutionelle Qualität die Beziehung zwischen Ressourcenabbau und Wachstum beeinflusst, ist institutionelle Qualität selbst vom Ressourcenabbau beeinflusst, zumindest im Fall von „point source" Ressourcenabbau.

9.5 Curriculum Vitae

Personal Information

Name	Julia Gruber

Education

since 2010	Master study in Economics, focus on Environmental and Ecological Economics, University of Vienna, Austria
2008 – 2009	Specialization in Environmental Economics (exchange semester), Université Paris Dauphine, France
2007 – 2011	Bachelor study in Environment and Bio-Resources Management, University of Natural Resources and Life Sciences Vienna, Austria
2006 – 2010	Bachelor study in Economics, University of Vienna, Austria

Work Experience

since 2013	University of Graz, ISIS and Wegener Center, Project Assistant
2012 – 2013	Sustainable European Research Institute (SERI), Sustainable Economics, Student Assistant
2010 – 2011	Institute for Advanced Studies (IHS), Input-Output-Analysis, Scholarship
2008 – 2012	University of Vienna, Tutor