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# Investments in Resource Efficiency

Costs and Benefits | Investment Barriers | Intervention Measures

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## Foreword

The world is on the verge of a resource efficiency revolution. Renewable energies pave the way: global wind energy installations have soared about 25 % per year since 2006, solar PV even 57 % annually; the more recent market consolidation does not break those trends. But there is more to it. New smart products and materials emerge, be it in liquid wood, software-driven reshuffling of metal blankets, or in e-mobility. Eco-innovation clusters emerge around buildings, IT applications, agriculture and food, recycling and industrial symbiosis, water treatment, grid analytics, bio-based materials, etc. New business models are all over: leasing models bring down upfront costs for new treatment facilities and help maintain high-quality machineries, smart sharing services start to replace ownerships especially in urban markets, benefit sharing agreement between companies open the windows for better value chains.

Perhaps the biggest short-term gains are in process innovation, as many companies have not yet fully grasped the opportunities of managing resources more efficiently. Piping construction, a key element for infrastructure development, increases resource efficiency by some twenty percent by using re-used offcuts. Given that more than half of European companies are paying at least 30 % of their total costs for their material inputs (higher than some believe!) and analyses validate cost savings in the range from 5 % – 20 %, there are bills left on the sidewalk that can also be utilized to unleash investments in long-term resource efficiency strategies.

Why are not all companies and economies around the globe using resources more efficiently? Research findings indicate a ‘web of constraints’ – internal barriers within firms and external barriers resulting from both market failures and policy failures. The recent manifesto of the European Resource Efficiency Platform calls for at least a doubling of resource efficiency compared to pre-crisis trend and develops policy pillars to unleash such dynamics. The Global Reporting Initiative, amongst others, calls for more stringent policies.

This report adds insights from contemporary cost benefit analysis and provides new insights into investment barriers in the context of microeconomic theory of perfectly competitive markets. Written by Florian Flachenecker and Jun Rentschler under my supervision it assesses the costs and benefits from investing in resource efficiency and provides an analytical framework for making investment decisions in practise. Commissioned by the EBRD, this report focuses on the countries in the ECA and MENA regions – yet its insights are applicable to developing and emerging economies around the world. This report is designed to provide practical guidance and an evidence base for resource efficiency investments and market interventions by IFIs, governments and private institutions. The proposed intervention measures range from the firm to the macro level, include structural reforms, as well as financial support for concrete infrastructure investments. As the world is clearly in challenging times it is high time to deliver on the resource efficiency agenda within a diversity of countries.

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## Glossary

*Source: (OECD, 2007) unless otherwise stated*

**Domestic material consumption (DMC)** measures the mass (weight) of the materials that are physically used in the consumption activities of the domestic economic system (i.e. the direct apparent consumption of materials, excluding indirect flows). DMC equals domestic extraction plus imports minus exports. It covers industrial and construction minerals, fossil fuels, biomass, and metal ores.

**Externalities** are a form of market failures, in which economic transactions impose external costs (or benefits) onto third parties, without being reflected in market prices.

**ECA and MENA regions** comprises the following 34 countries for the purposes of this report: Albania, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Egypt, Estonia, FYR Macedonia, Georgia, Hungary, Jordan, Kazakhstan, Kosovo, Kyrgyz Republic, Latvia, Lithuania, Moldova, Mongolia, Montenegro, Morocco, Poland, Romania, Russia, Serbia, Slovak Republic, Slovenia, Tajikistan, Tunisia, Turkey, Turkmenistan, Ukraine, and Uzbekistan. *Source: Authors' own definition.*

**Government failures** describe an inefficient allocation of resources in an economic system, which is the result of inadequate government action.

**Indirect flows** are those material flows, which (i) are needed for the production of a product, (ii) have occurred up-stream in the production process, and (iii) are not necessarily physically embodied in the product itself.

**Market failures** describe an inefficient allocation of resources in an economic system. Efficiency improvements can be achieved by market interventions, which reallocate resources and thus reduce wastage.

**Materials** are usable substances (i.e. resource inputs) obtained or derived from natural resources. These usable substances usually include energy carriers (gas, oil, coal), metal ores and metals, construction and industrial minerals, and biomass. Materials and resource inputs are used synonymously for the purposes of this report.

**Material consumption** refers to the materials consumed in an economy both for intermediate and final consumption. A common weight-based indicator for material consumption is DMC.

**Material efficiency** denotes the efficiency with which materials are used in an economy or in a production process. It is defined as the ratio of useful material output and material input, often two variables sharing the same unit. Material productivity is frequently used as a proxy for material efficiency. *Source: Dahlstrom & Ekins, 2005.*

**Material productivity** makes reference to the effectiveness with which an economy or a production process is using materials. Often, it is a ratio of two variables of different units. Material productivity is frequently defined as the ratio of economic output (e.g. GDP) and material input (e.g. domestic material consumption). *Source: Dahlstrom & Ekins, 2005.*

**Rebound effect** can be categorised into two possible outcomes once it occurs. (i) Partially offsetting efficiency gains by increasing consumption, and (ii) outweighing such gains altogether (*backfire* or *Jevons' Paradox*). *Source: Sorrell, 2007.*

**Resources** refer to renewable and non-renewable resource stocks that are found in nature (e.g. minerals, energy, soil, water, air and biological resources). Resources are commonly divided into non-renewable and renewable resources. Materials are a subcategory of resources. Resource inputs and materials are used synonymously for the purposes of this report.

**Resource efficiency** denotes the efficiency with which resources are used in an economy or in a production process. It is defined as the ratio of useful resource output and resource input, often two variables sharing the same unit. Resource productivity is frequently used as a proxy for resource efficiency. *Source: Dahlstrom & Ekins, 2005.*

**Resource productivity** makes reference to the effectiveness with which an economy or a production process is using resources. Often, it is a ratio of two variables of different units. Resource productivity is frequently defined as the ratio of economic output (e.g. GDP) and resource input. In a policy context, resource productivity and material productivity are usually used interchangeably. *Source: Dahlstrom & Ekins, 2005.*

## Executive Summary

This report analyses the rationale for investments in resource efficiency and provides a framework for assessing such investment decisions in practise. It outlines costs and benefits for those investments from an environmental, economic and political point of view. Furthermore, it evaluates the practical barriers to investments and analyses how they relate to market and government failures as well as additional inefficiencies. It presents various intervention measures for policy makers and international financial institutions to overcome investment barriers and promote resource efficiency investments.

Scope of the report: Geographically, this report focuses on the countries in the ECA and MENA regions, whereas evidence from the European Union and other developed economies are used for comparative purposes. This report considers resources as economic inputs (i.e. resource inputs or materials) comprising industrial and construction minerals, fossil fuels, biomass, and metal ores – however, excluding water, air and soil. Resource inputs and materials are used synonymously for the purposes of this report.

### **Resource inputs – an overview of trends**

Global perspective: Material consumption, price levels and price volatility are on the rise, particularly since the early 2000s. Generally, material prices are determined by a combination of resource-specific characteristics, market fundamentals (i.e. supply and demand), and exogenous factors (i.e. shocks). Since the turn of the century, such price fluctuations are predominantly due to supply falling short of increasing demand, which is primarily stimulated by emerging economies.

ECA and MENA regions: Absolute and per capita material consumption in various countries in these regions (incl. Russia, Poland, Kazakhstan, Mongolia and Turkey) are at fairly comparable levels to the USA and other material intensive EU member states. In line with further indicators such as resource rents (as % of GDP) and net exports, those economies can be considered dependent on resource inputs.

The potential for resource efficiency gains: Economic theory would suggest prevailing price signals (price levels and volatility) to trigger dematerialisation, substitution and resource efficiency improvements. Nevertheless, data on material productivity in countries of the ECA and MENA regions shows substantial gaps relative to developed economies. This is indicative of the potential for resource efficiency gains, which could be realised in the ECA and MENA regions as well as possible barriers hindering such efficiency gains.

However, it must be acknowledged that due to limited data availability and inconsistent methodologies, the resource productivity gaps should not be interpreted as definite and exact measures, but as a general benchmark. Nevertheless, after controlling for heterogeneous industry structures, natural resource intensity and roughly adjusting methodological shortcomings, the substantial resource productivity gaps remain.

## **Resource efficiency – costs and benefits**

This chapter identifies a broad range of costs and benefits, which may result from investing in resource efficiency. This narrative compares costs and benefits of investing in resource efficiency to a business-as-usual scenario (i.e. not investing). For this purpose, the report distinguishes between environmental, economic, and political costs and benefits, and also considers secondary effects (i.e. co-benefits and indirect effects). By taking into account a broader range of issues, this analysis aims to complement purely commercial investment appraisals and facilitate the identification, monitoring and evaluation of specific resource efficiency projects.

Costs in the business-as-usual scenario: If no measures are taken to improve resource efficiency, environmental costs such as negative externalities arise, for instance due to excess waste creation. Those environmental impacts can be substantial and cause further costs (e.g. containment from waste leakages causing health problems). Moreover, not investing in resource efficiency results in not reducing existing resource dependency to the extent possible. Such persisting dependency can impose significant costs for countries as well as firms, once negative impacts generated by volatile prices unfold (e.g. increasing investment uncertainty, fluctuating input costs). Additionally, this reliance on resource inputs could result in geopolitical costs (e.g. supply restrictions) once regional or international disputes arise. Lock-ins of existing technologies and structures can also impose costs (i.e. opportunity costs) causing firms to adopt innovative technology ‘too late’ (i.e. second mover disadvantage) or not at all.

Benefits in the business-as-usual scenario: Evidently, by not investing firms avoid potentially high up-front costs of a resource efficiency investment, thus unlocking funds for alternative investment opportunities. In addition, there are no (political) costs (i.e. decreasing support for future investments) once financially supported resource efficiency projects fail to deliver the envisioned outcomes.

Costs from investments in resource efficiency: Main costs from moving towards resource efficiency include the investments themselves, which can be substantial (e.g. new machinery). Moreover, uncertain investment payoffs due to price fluctuations can impose costs for firms once the actual revenue streams deviate from the expected ones. Furthermore, investing in resource efficiency often binds financial capital, which thus cannot be invested in alternative projects (i.e. opportunity costs). Lastly, a possible rebound effect could reduce or offset benefits from efficiency gains.

Benefits from investments in resource efficiency: Improving resource efficiency can be an important instrument for hedging against volatile resource prices, as it reduces the relative significance of resources for firms’ purchasing costs. Reduced purchasing costs can additionally increase the company’s overall competitiveness. This could be beneficial for consumers as well once lower purchasing costs are passed on to them. Resource efficiency can stimulate innovative capacity, which is critical for realising further technological advances. Moreover,

increasing resource efficiency can improve the corporate image of a firm and thereby trigger higher sales. Going beyond the firm level, such benefits can also improve a country's general macroeconomic environment (i.e. increase economic growth, employment, fiscal stance) and decrease its dependency on resource inputs. Furthermore, relatively lowering resource use may reduce negative environmental impacts, since fewer negative externalities cause fewer environmental damages when for instance waste creation is being reduced (e.g. through industrial symbiosis).

Do investments in resource efficiency deliver net benefits? Given the extensive range of costs and benefits outlined above, it would be misleading to draw definite and universally valid conclusions. This makes a case-to-case evaluation of resource efficiency projects necessary in order to assess their net benefits. A project specific analysis takes into account firm specific circumstances as well as the general investment environment. Every individual cost and benefit discussed throughout this narrative can be used as a 'guideline' for an investment specific cost-benefit analysis.

Whether or not an investment in resource efficiency provides net benefits also depends on expectations about future resource prices (volatility and levels). Future price volatility may be a 'double-edged sword'. On the one hand, it incentivises investments in resource efficiency (i.e. one form of hedging), on the other hand, it increases the uncertainty of future payoffs. The higher resource prices are in levels, the more profitable resource efficiency measures will become. Evidently, future resource prices are uncertain, but several studies suggest them to remain volatile and – on average – high in the future. Thus, the probability of resource efficiency investments yielding net benefits is likely to continue in the future.

Finally, even if a project specific cost-benefit analysis predicts net benefits from an investment in resource efficiency, it may not materialise in practise. Besides an occurrence of unexpected events, investment barriers and further inefficiencies could generally prevent net benefits from resource efficiency measures.

### **Investment barriers and the causes of resource inefficiency**

*Perfectly competitive and efficient markets* can constitute a useful benchmark against which real market outcomes (e.g. regarding resource use) can be evaluated. Such 'perfect' markets are based on various hypothetical assumptions, which need to be met in order to reach perfect efficiency: including perfect information, absence of monopolies, no barriers to market entry or exit, perfect factor mobility, absence of externalities, etc.. Chapter 4 analyses how in reality these assumptions are violated in countless ways and thus cause and perpetuate inefficient resource use. The chapter argues that this leads to investment barriers at the micro and macro level, which impair firms' and policy makers' ability to improve resource efficiency.

*The causes of inefficient resource use.* The report focuses on five specific areas, which can cause inefficient resource use. These are direct violations of the assumptions, on which perfectly competitive and efficient markets are based:

- i. Information constraints can take different forms, including: (i) *Limited information on the scale and type of resource inefficiency*, i.e. due to lacking monitoring and information disclosure, decision makers at firm and state levels may struggle to take targeted actions to improve resource efficiency. (ii) *Limited information on the solutions*, i.e. technologies and processes, which are critical for improving the efficiency of productive operations are not fully known to decision makers.
- ii. Capacity constraints can limit the ability to act upon available information. At the firm level, lacking *technical capacity* can restrict the identification, installation, operation and maintenance of modern efficient technology. Limited *managerial capacity* constrains the ability to implement forward-looking investments, foster innovation, and oversee financing. Limited *institutional and administrative capacity* (at the state level) can create an adverse environment for investments in resource efficiency and beyond.
- iii. Financial constraints can prevent resource efficiency investments, even when information and capacity are adequate. If efficiently functioning credit markets are missing, economic agents may be unable to act upon information on investments with positive net present values. Some issues are of specific relevance to resource efficiency investments: (i) Firms may have *limited access to credit* locally, especially if resource efficiency investments are considered non-essential or risky. (ii) Unknown or uncertain investment payoffs (e.g. due to unknown maintenance costs of technology (cf. information constraints), or volatile commodity prices) can make credit expensive. (iii) Commercial banks may fail to take non-monetary benefits of resource efficiency projects (i.e. reducing externalities, such as environmental impacts of resource use) into account, thus lowering the perceived benefits of projects. (iv) Instable financial markets and banking sectors may make *credit prohibitively expensive* (high interest rates), and generally impair the ability to undertake longer-term investments.
- iv. Market structures may limit competitive pressures, which are usually a key motivation for firms to increase efficiency, reduce costs, and innovate. This includes issues such as: (i) insufficient competition policy and enforcement, (ii) state run monopolies/oligopolies, (iii) ‘entrenched’ incumbents, possibly favoured or protected by policy makers, and (iv) protectionist trade policies, which obstruct the exchange with international markets, and thus might prevent firms from accessing modern and more resource efficient technologies from abroad.
- v. Fiscal mismanagement. While well-designed fiscal measures can redistribute economic resources and increase the allocate efficiency of markets, fiscal mismanagement can distort incentives and thus be a key source for externalities. For instance, *industry subsidies* to inefficient sectors or firms may artificially increase their competitiveness, thus reduce their incentives to pursue efficiency gains – and thus perpetuate inefficient and environmentally harmful resource use practices. *Resource subsidies* may incentivise over-consumption and inefficient usage. This reflects the more general problem of mis- or

unpriced resources. If governments fail to intervene with corrective taxation negative externalities are exacerbated. In this context, this report also emphasises the importance of waste taxes or landfill tariffs, which increase the incentives for firms to recycle, reuse, or invest in more efficient (less waste producing) machinery and processes.

*Inaction can lead to lock-in and path dependency.* If no actions are taken to address the above causes of inefficient resource use and investment barriers, the accumulation of new productive capital is likely to be characterised by inefficiency. This may pre-determine investment and innovation options available in the future. Such ‘path dependency’ can even result in a lock-in situation, in which costs from pre-existing inefficiency prevent future efficiency investments. Thus, investment barriers not only cause underinvestment in the present, but also limit potential efficiency gains in the future. This is particularly true for long-lived physical infrastructure, such as large production facilities or transportation systems, since these are often associated with high up-front costs, which forbid frequent replacement.

*Systemic risks and uncertainty* do not necessarily result in additional market failures. However, in the face of uncertainty existing constraints may be exacerbated as planning horizons are reduced. For instance, if commodity prices are volatile, the expected benefits from a resource efficiency investment are highly uncertain. Payback periods will be difficult to estimate, which may aggravate existing financial and information constraints.

*Wastage of valuable resources – a ‘symptom’ of inefficiency.* The more pronounced the above causes of inefficient resource use and barriers to resource efficiency are, the more (valuable) resources are wasted. Here, the definition of ‘waste’ critically depends on the context: By-products of industrial production processes could in many cases be reused and reprocessed – i.e. they are discarded materials, which theoretically possess an economic value. However, in practice this economic value depends on available infrastructure, regulation, and markets. If the infrastructure for reprocessing and transporting discarded materials is prohibitively expensive or unavailable, the materials are indeed valueless waste; i.e. the economic value cannot be unlocked cost-effectively. Similarly, if markets for such reprocessed waste are missing or unstable, there may be no economic rationale for firms to invest in the waste-to-resource transformation. Thus, discarded materials are seen as valueless. On the contrary, if relevant infrastructure (e.g. technology and finance) is affordable and accessible, ‘waste’ is in fact a valuable resource; i.e. the economic value can be unlocked cost-effectively. This provides a direct rationale for intervention, as the provision of infrastructure can turn waste into a resource.

## **Policy measures and interventions**

In order to design a coherent and comprehensive strategy for improving resource efficiency, interventions of different types should be taken at various levels. In particular, resource efficiency and waste minimisation measures may take the two following forms<sup>1</sup>:

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<sup>1</sup> These could be seen as analogous to ‘adaptation’ and ‘mitigation’ as policy responses to climate change.

- i. Addressing ‘symptoms’: *i.e. reduce the waste and its externalities, which continue to result from pre-existing inefficiencies.* This implies addressing the consequences of inefficient resource use, rather than the underlying structural causes. As inefficient physical infrastructure and regulation may be difficult to change immediately, ‘addressing symptoms’ is of particular relevance as a short-run response. However, this approach may also yield long-term benefits: By linking up the supply of reprocessed waste with demand, new markets may be formed.
- ii. Addressing causes: *i.e. address the pre-existing market failures and inefficiencies, and thus reduce the amount of waste produced in the first place.* This provides a rationale to directly address the investment barriers, mentioned above. As the causes of inefficiency are typically structural and often linked to physical infrastructure, this approach is especially relevant as a medium/long-term response. However certain inefficiencies may also be resolved in the short run (e.g. simple process optimisation measures).

*Intervention level.* The investment barriers mentioned above require a comprehensive approach, which includes technical assistance, lending projects, as well as policy and regulatory reforms. For instance, at the firm level technical assistance may be of particular importance when addressing information and capacity constraints. Lending projects (e.g. to install more efficient machinery) are critical to overcome financial constraints and mitigate uncertainty. Similarly, at the macro level policy and regulatory reforms are critical for addressing issues such as competition or fiscal policy. The report provides a comprehensive overview of necessary interventions at the firm and state levels.

### **Next steps – applying the framework**

The report concludes by suggesting ‘next steps’ for applying the insights of this report operationally – also with reference to the role of international financial institutions. In particular, it is suggested that the general analytical framework (chapters 3 and 4) in this report needs to be applied on a case-by-case basis, in order to complement purely commercial investment appraisals. This can help to evaluate resource efficiency projects within their broader environmental, economic, and administrative systems. Furthermore, this chapter points to the need to further build an evidence base, which is still more than sparse for non-EU countries. Moreover, it is necessary and possible to develop indicators measuring resource efficiency at the firm level in order to adequately assess the success of investments in efficiency.

## 1. Introduction

High and volatile resource prices, uncertain supply prospects, (re-)industrialisation attempts and environmental damages related to resource usage – various factors are putting increasing pressure on policy makers, researchers, firms and international financial institutions (IFIs) to explore pathways towards sustainable and efficient resource management. Resource efficiency is perceived as a key opportunity for addressing such challenges and is thought to yield substantial benefits – both environmentally and economically.

Against this background, this report analyses the rationale for investments in resource efficiency, and considers their implementation in practice. Starting by analysing the potential for resource efficiency investments in emerging economies, it introduces a framework for assessing such investment decisions in practice. Firstly, a comprehensive cost-benefit framework is set up taking environmental, economic and political aspects into account and subsequently filled with evidence from existing literature, case studies and data analyses. Secondly, the report evaluates how market and government failures can create barriers to the implementation of investments in practice. The report proposes a comprehensive intervention typology for policy makers and IFIs to overcome and remove investment barriers and promote resource efficiency investments. Going forward, the analytical framework in this report can be used to assess specific investment projects and complement purely commercial investment appraisals.

Considering economies in the ECA and MENA regions as examples, this report takes into consideration the socio-political and economic conditions, which tend to be common to emerging and developing countries. It considers the role of governments and IFIs in directing and fostering resource efficiency across the relevant sectors. In particular IFIs may thus have a strong intervention rationale, as they are in a position to provide technical assistance, recognise non-monetary (e.g. environmental) benefits, and help to bridge efficiency gaps caused by market failures.

By investing in resource efficiency at the firm level, it is possible to showcase the cost-effectiveness of such investments and create new markets. Such benefits can have an impact on practices of resource use beyond the firm level. A specific example pertains to the recycling of waste: By improving the reprocessing of waste at one firm and making recycled resources available to other firms, it is possible to create supply (of recycled, previously not utilised materials) and link it to demand (e.g. by other firms, which use these resources for their production). If regulated and overseen effectively, this can create new markets and thus realise economy-wide improvements.

The remainder of the report is structured in the following manner: Chapter 2 provides an overview of trends in resource usage globally in within the ECA and MENA regions, and analyses the potential for resource efficiency investments. Chapter 3 introduces a comprehensive framework to assess costs and benefits of investments in resource efficiency

from economic, environmental and political perspectives. Chapter 4 analyses the causes of inefficient resource use and the barriers to resource efficiency investments. Chapter 5 summarises the types of policy interventions, which are needed to improve resource efficiency in the short and long term, and stimulate the investment environment.

## 2. Resource inputs – an overview of trends

### Key messages

- Material consumption, price levels, and price volatility are on the rise.
- Absolute and per capita material consumption in various countries in the ECA and MENA regions are at fairly comparable levels to developed economies. Those economies can also be considered dependent on resource inputs.
- There are substantial gaps in material productivity between the ECA and MENA regions and developed economies, which is indicative of the potential for resource efficiency gains.

This chapter aims to provide evidence on general trends and facts about consumption, trade, extraction, availability, prices, and material productivity. Resource inputs (i.e. materials) are defined as industrial and construction minerals, fossil fuels, biomass, and metal ores. The rationale is to understand patterns of how the world uses its finite resources. A substantial increase in the world population, rapidly growing emerging economies, increasing price levels and volatility, a deeper interconnection among economies, and an amplified awareness of environmental impacts associated with the use of resources, outline the importance of considering such trends. Consumption indicators are particularly crucial for showing increasing demand of resources. Starting from a global perspective, a closer look will be taken on the ECA and MENA regions. Despite shortcomings concerning data availability and methodologies, this chapter indicates the importance of materials as a starting point for the analysis. It also benchmarks the potential for material efficiency improvements in the ECA and MENA regions, by evaluating it against developed countries.

The methodology is a straightforward statistical examination based on the concept of economy-wide material flow analysis (MFA)<sup>2</sup>. The framework is visualised in Figure 1. MFA is a systematic assessment of material throughput and stock additions within and throughout systems (i.e. countries, sectors). MFA has become a frequently used tool by Eurostat, the OECD and academia to analyse material flows and stocks on national level. Several indicators regarding domestic extraction (DE), domestic material consumption (DMC)<sup>3</sup> and trade of materials (imports and exports) can be derived using this methodology. MFA allows for a direct computation with data from the Systems of National Accounts, which is an internationally agreed standard of measuring of economic activity (i.e. GDP) (United Nations, 2009). For example, material productivity combines the MFA indicators mentioned above that are measured in tonnes with GDP in monetary terms. In order to monitor the progress of moving

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<sup>2</sup> For an extensive introduction into MFA, refer to Bringezu & Bleischwitz 2009; OECD 2007; Eurostat 2001; Brunner & Rechberger 2004; Brunner et al. 1998.

<sup>3</sup>  $DMC=DE+imports-exports$

towards a resource efficient economy, the EU publishes its Resource Efficiency Scoreboard<sup>4</sup> using the indicators described above.

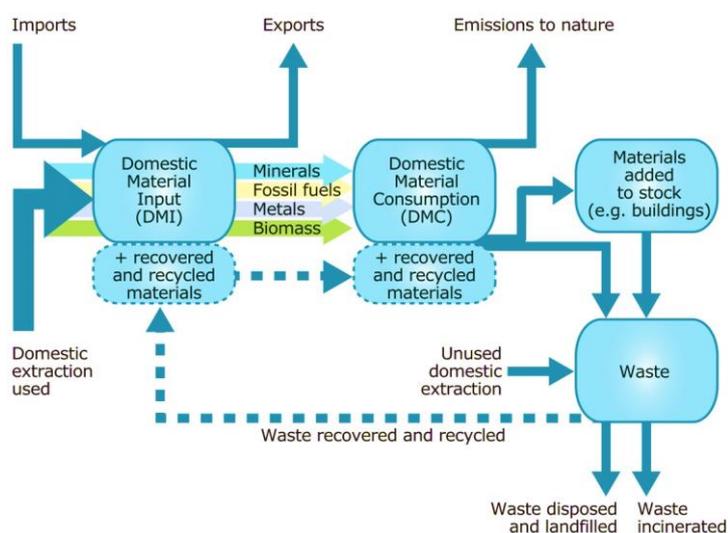


Figure 1 visualises the methodology of the material flow analysis and its derived indicators. Source: European Environmental Agency 2012.

These indicators usually disaggregate material resources into four categories (industrial and construction minerals, fossil fuels, metal ores, and biomass). They are measured in terms of their weight, often in tonnes. Each system (i.e. country) uses different amounts of materials in each category. For example in the EU in 2009, non-metallic minerals account for half of the indicator, fossil fuels and biomass for under one-fourth each, and metals for 3% (European Environmental Agency 2012, p.98). Therefore, relatively heavy and frequently used materials such as industrial and construction minerals (sand, gravel, etc.) make up most of the materials used according to the indicator DMC. Thus, there is no one-on-one relationship between DMC and environmental impacts. In order to address the fact that light materials (e.g. rare earth metals) might have a higher environmental impact compared to heavy materials (e.g. sand), life cycle analysis could be combined with the MFA methodology in order to account for such differences (Voet, Oers, & Nikolic, 2005).

Predominantly, so-called direct material flows are recorded, failing to include indirect flows. The reason why indirect flows are not included goes back to an asymmetry in the way the material flows are measured for the different indicators. DE measures the extraction of material resources as raw materials. Imports and exports, however, are measured in weight of a product, independently of how far the materials of the traded product have been processed. In short, it fails to include all materials measured as raw materials required in the production of (intermediate) goods in the first place. Making these two indicators fully comparable requires measuring them in raw material equivalents (RME).

<sup>4</sup> [http://epp.eurostat.ec.europa.eu/portal/page/portal/europe\\_2020\\_indicators/rec\\_scoreboard](http://epp.eurostat.ec.europa.eu/portal/page/portal/europe_2020_indicators/rec_scoreboard) (5 May 2014).

Currently, there are hardly any comprehensive and international databases for RME publicly available using the same methodology throughout all countries.<sup>5</sup> The EU is currently in the process of potentially adopting an indicator close to Raw Material Consumption (RMC), which would take indirect effects into account and could provide a standard methodology to calculate RMC (European Resource Efficiency Platform, 2014). There are only estimations of the RMC on an aggregated level for mainly industrialised countries. Therefore, for the purpose of this analysis and in the interest of using high-quality and comparable data, DMC will subsequently be used as well as a modified version through roughly approximating the indirect effects. Nevertheless, their shortcomings explained above can only be reduced but not abolished.

The main data source for this chapter is the Global Material Flow Database from the Sustainable Europe Research Institute (SERI). This open-access database comprises data from 1980 to 2009 for 228 countries<sup>6</sup> and combines primary data for materials mainly from the British and US Geological Surveys (BGS/USGS), the World Mining Data and Eurostat. Additional sources include the World Bank, International Monetary Fund (IMF), and selected programs of the United Nations (UN). A detailed explanation of the sources and data shortcomings can be found in SERI (2013). Such shortcomings are poor data quality until the early 1990s when time series data became available, interpolation for missing data in terms of years and also individual countries, and rough estimations mainly of construction materials and unused extraction, which is not economically used (i.e. overburden from mining).

The remaining chapter is structured as follows. Firstly, global trends of material consumption, material prices and material price volatility will be described. Secondly, trends of several material indicators for the ECA and MENA regions will be examined. Lastly, the gap in material productivity between countries in the ECA and MENA regions and developed countries indicate the potential for resource efficiency gains.

## 2.1. Global perspective

### Key messages

- Material consumption, price levels, and price volatility are on the rise.
- Material prices are determined by a combination of resource-specific characteristics, market fundamentals (i.e. supply and demand), and exogenous factors (i.e. shocks).
- Economic theory would suggest price signals (price level and volatility) to affect the behaviour of economic agents by substituting, increasing efficiency, or dematerialising.

Materials are vital for an economy. Typically, the more economic activity takes place, the more materials are being demanded. If no measures for increasing material efficiency are taken, economic growth is accompanied by a growing demand for materials. This is not only visible in developed countries, but especially the emerging economies have spurred the growing demand

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<sup>5</sup> The newly established Eora MRIO database could be a next step in deriving RMC data for the ECA/MENA region.

<sup>6</sup> Dissolved states are the reason why the number of countries in the database exceeds the currently 193 member states of the United Nations.

for materials. This section will focus on three aspects. Firstly, material consumption has increased over time. Secondly, prices of materials have increased and thirdly, price volatility has increased as well.

Figure 2 shows the trend in global material consumption over three decades. Absolute consumption of materials has almost doubled since 1980. Since 2000, the increase in material consumption decoupled from population growth (i.e. material consumption grew faster than population growth). Between 1980 and 2009, global GDP in purchasing-power-parity (PPP) has been growing much faster compared to global material consumption. However, when GDP is measured in constant US-Dollars, decoupling from material consumption is not visible in the data. The result from decoupling consumption and population growth is not only an increase in total consumption but also an increase in consumption per capita. These trends are important to keep in mind throughout the further analysis and are important reasons why resources have become increasingly important on the environmental, economic, and political agenda.

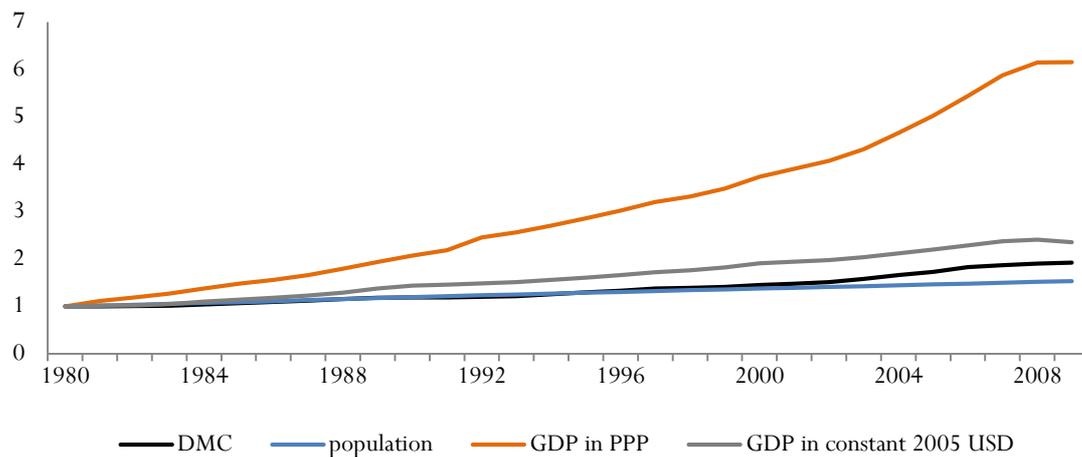


Figure 2 compares index trends in global material consumption (based on DMC), GDP in PPP (in current international dollars based on PPP), GDP in constant 2005 USD (in constant 2005 US-Dollars), and population from 1980 to 2009. The base year is 1980. Sources: SERI, IMF, World Bank, UN, own calculations.

The main driver for the growing consumption of materials is the strong economic growth per capita of emerging economies (Figure 3). The industrialised world, here represented by the United States of America (USA) and the United Kingdom (UK), decreased their overall material consumption compared to the global trend (represented by the x-axis). Industrialised countries typically stay below the world's average of doubling material consumption during the last 30 years (e.g. Canada, Finland, France, Germany, Australia, Japan). Emerging economies are associated with the opposite (e.g. Brazil, Chile, Indonesia, Turkey – except South Africa and Russia since 1992). Emerging economies usually increase their material consumption beyond the global trend. A closer look on the ECA and MENA regions will be taken in the next section.

Within the emerging economies, especially China, India, and Chile show a substantial increase in material consumption. In the case of India and Chile, this can partially be explained by an

increase in population (70% between 1980 and 2009 for India and 52% for Chile). Given China's relative lower increase of around 30% due to policies restricting population growth, the increase in material consumption is astonishing. China has exponentially increased its consumption by a factor of 7.5 since 1980, whereas India *only* tripled and Chile *only* approximately quadrupled its consumption. China's growth started to pick up since the early 2000s coinciding with its membership in the World Trade Organisation. However, one has to keep in mind that the per capita consumption in the industrialised world remains much higher compared to the emerging economies. In 2009 and on the basis of DMC, the USA consumed 21 tonnes of materials per person compared to 4 tonnes in India, 43 tonnes in Chile, almost 16 tonnes in China, and 12 tonnes in Russia. The EU-27 average citizen consumes about 15 tonnes (SERI, 2013). The higher growth rates in material consumption indicate a typical catch-up scenario: Once economic activity of emerging economies catches-up to industrialised countries, they also catch-up in terms of material consumption.

Occasionally, urbanisation is considered a further driver. Cities consume a lot of materials in absolute terms also because most economic activity takes place there (McKinsey Global Institute, 2013a). However, urban areas may profit from economies of scale. Thus, material consumption per capita might often be lower. Hence, there is no clear evidence that urbanisation is a key driver, especially in terms of contributions of metropolitan areas to climate change (Dodman, 2009; Satterthwaite, 2008). Nevertheless, an increased population density increased the importance of recycling. For example, Japan increased its recycling rates substantially in the last decades (Tietenberg, 2009).

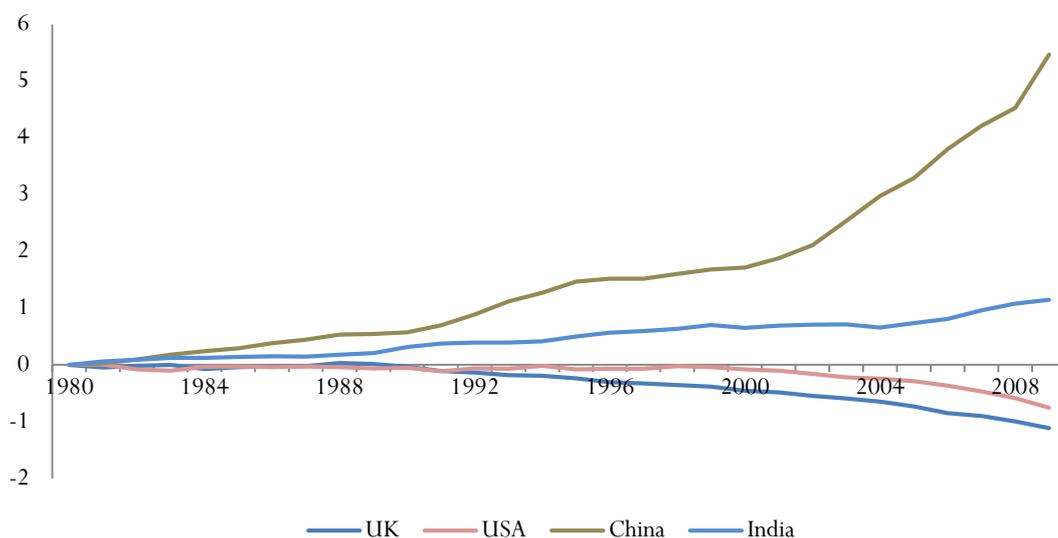


Figure 3 displays trends in material consumption based on DMC for selected countries relative to the world trend from 1980 to 2009. The base year is 1980. All positive values indicate a faster increase in material consumption than the world's average. Sources: SERI, own calculations.

Global material consumption is increasing – especially due to emerging economies and particularly since the early 2000s when consumption decoupled from population growth. This increased pressure from the demand side is one cause of the structural price increase of

materials (Valiante & Egenhofer, 2013). While demand pressures play an important role in forming commodity prices, other factors can also impact on both price levels and volatility (see Table 1). Naturally, there is a certain overlap between price level and price volatility determination. This report introduces the key determinants of prices, without claiming completeness. An extensive evaluation of price drivers thus goes beyond the scope of this report.

Prices and their determination are crucial for resource efficiency investments, because market participants rely on price signals for their investment decisions and resource purchases. Price fluctuations as a barrier to such investments will be discussed in greater detail in section 4.6.

	<b>Drivers</b>
<b>Price level</b>	<ul style="list-style-type: none"> <li>▪ <i>Materials characteristics</i></li> <li>▪ <i>Economic growth perspectives (especially in key producer / consumer economies)</i></li> <li>▪ <i>Investments in supply capacity (i.e. infrastructure, transportation)</i></li> <li>▪ <i>Exploitation of market power (vertically &amp; horizontally)</i></li> <li>▪ <i>Input costs (i.e. labour costs / shortages, infrastructure)</i></li> <li>▪ <i>Environmental regulation</i></li> <li>▪ <i>Long-term energy costs</i></li> <li>▪ <i>Storage capacities</i></li> <li>▪ <i>Ore grades (for metals)</i></li> <li>▪ <i>Product development</i></li> </ul>
<b>Price volatility</b>	<ul style="list-style-type: none"> <li>▪ <i>Financialisation (for most commodities since approx. 2002)</i></li> <li>▪ <i>Short-term costs fluctuations of connected resources (i.e. energy)</i></li> <li>▪ <i>Shocks to the business cycle</i></li> <li>▪ <i>Close connection between futures and spot markets (i.e. high-frequency trading)</i></li> <li>▪ <i>Short-term production interruptions (i.e. strikes, natural disasters, electricity shortages, political changes)</i></li> </ul>

**Table 1 summaries main drivers of the price level and price volatility of materials, based on Valiante and Egenhofer 2013.**

**Drivers for price levels:** As shown above, the global consumption of materials displays an increasing trend. However, such rising demand is only one factor for the determination of price levels. Material prices formed in markets are driven by a combination of resource-specific characteristics (i.e. product characteristics, substitutability, etc.), market fundamentals (i.e. supply and demand), and exogenous factors (i.e. access to finance, interventions, inefficiencies, etc.).

Some resource-specific characteristics might change over time (i.e. material properties) or only seldom (i.e. storability, change in demand patterns). However, their market value will change depending on innovation cycles and changing demand patterns. For instance, the introduction of new technologies such as smartphones increased the demand for rare earth metals.

Market fundamentals consist of supply and demand and are considered a relatively important determinant for future price formation. In the case of metals, supply factors seems to be a more important price driver relative to demand factors (Valiante & Egenhofer, 2013). At the same time, metals are durable goods. Thus, metal prices are positively correlated with the business cycle and therefore demand fluctuations. However, some studies do not always find clear evidence for a relationship between economic growth and metal consumption (Jaunky, 2013). Ultimately, the price level increases seem to be a combination of increased demand and supply lagging behind.

Supply restrictions in combination with increasing demand in the short and medium term might still be the bottleneck as capital-intensive investments are necessary to extract them in the first place (Valiante & Egenhofer, 2013). The breakdown of the former Soviet Union resulted in an oversupply of many commodities on international markets since the early 1990s, and it took some time for markets to identify future investment needs for new supply. Generally, metal extraction faces a time lag. For example, it takes about 9 to 25 years to develop a large copper project (POLFREE, 2013). This is partly due to under-investments in the past decades (Bleischwitz, Welfens, & Zhang, 2009). Such lack of investment might also hold true for future investments as the increase of exploration investments has slowed down since the 2008 financial crisis (Ericsson & Larsson, 2013). Moreover, the market concentration of globally operating material firms has increased substantially in the early 2000s and could be another driver of price increases (Bleischwitz et al., 2009). Physical scarcity of materials in the long run does not seem to be a binding constraint as long beforehand rising opportunity costs will have gone up to the extent that no further materials will be extracted (Söderholm & Tilton, 2012).

Thus, material prices are likely to remain volatile and – on average – high in the future (McKinsey Global Institute, 2011). Estimations about price fluctuations, however, are crucial in *ex ante* determining the cost-effectiveness of resource efficiency investments, which seems to be a ‘double-edged sword’. On the one hand expected increasing price levels and volatility steer investments in resource efficiency (i.e. hedging against negative impacts of fluctuations), and on the other hand volatility increases the uncertainty of future payoffs, thus decreasing incentives to invest

Turning to the data, Figure 4 shows trends of material price indices. Starting during the early 2000s, prices increased significantly. This goes hand in hand with the substantial increase of material consumption by emerging economies, while supply is lagging behind. For example, nominal prices for copper have more than tripled between the beginning of 2004 and mid-2006. The same amount of increase within 2.5 years occurred during 44 years before 2004. Iron ore follows a comparable pattern. The prices quadrupled between 1960 and 2004 – since then they quintupled. For a short time interval (approximately 2004-2006), prices even increased exponentially.

Once the 2008 financial crisis in the industrialised world turned into a macroeconomic crisis, demand for and trade of materials decreased sharply also in the emerging economies. This economic downturn resulted in a short run oversupply and lowered expectations initiating a

downward spiral of material prices. However, prices did not remain on these lower levels, but increased rapidly again. Currently, prices may seem to have stabilised again, but at higher levels compared to the pre-2000s. These developments imposed substantial costs on companies as price levels rose and uncertainty concerning future prices increased as well.

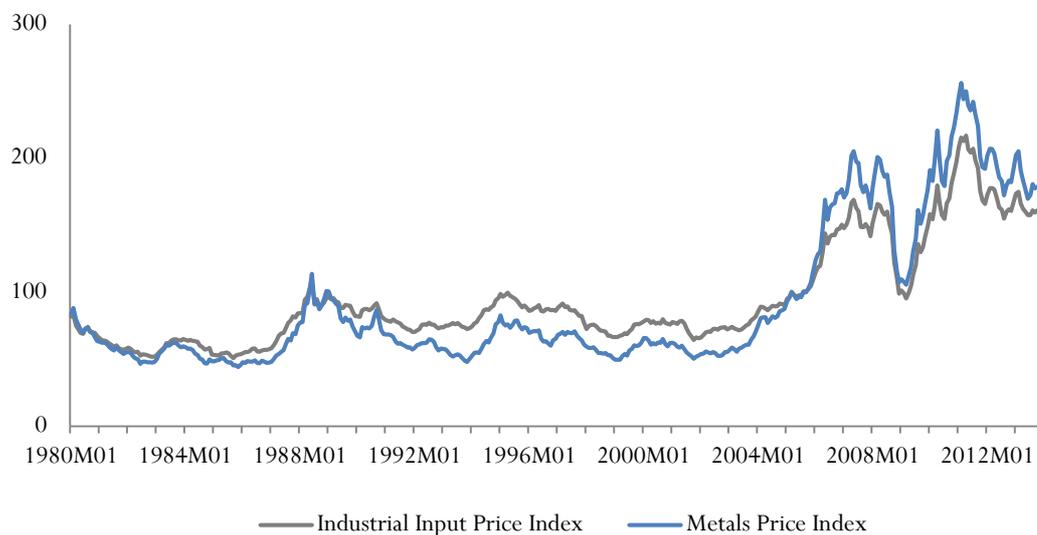


Figure 4 shows the monthly Industrial Input Price (includes Agricultural Raw Materials and Metals Price Indices) and the Metals Price Index (includes Copper, Aluminium, Iron Ore, Tin, Nickel, Zinc, Lead, and Uranium Price Indices). Prices are non-seasonally adjusted nominal USD and range from 1980 to 2014. The base year for both indices is 2005. Source: IMF.

**Drivers for price volatility:** Resource-specific characteristics, market fundamentals, and exogenous factors also determine price volatility. Since resource-specific characteristics either do not change over time (i.e. material properties) or only seldom (i.e. storability, change in demand patterns), they have a relatively little or one-off effects on volatility. Table 1 summarises key drivers for determining price volatility. Market deregulation, technological advances (i.e. digital trading, innovations of financial products, etc.), and improved access to finance are some reasons for increased transactions as well as the responsiveness of materials on global markets to changes of any factors mentioned above.

Spillover effects of price volatility from one resource to another can also influence price fluctuations. Such effects occur since resources become increasingly connected (resource nexus). For example, energy prices drive prices levels for materials, as they are an important factor for the production costs of materials (i.e. steel price). At the same time, once energy prices are volatile, they cause spillover effects to for instance material prices – given certain flexibility in price setting. There seems to be little evidence for volatility spillovers within the metal markets in the short-term. However, there is evidence for such spillovers in the long-term (Todorova, Worthington, & Souček, 2014). Generally, commodity price spillovers are most strongly across resource groups (e.g. metals and energy) in comparison to within groups (e.g. copper and iron ore) (UNEP IRP, 2014).

Price speculation might not be the key driver, but price manipulation (i.e. coordinated action) is a possible driver for price volatility (POLFREE, 2013). Generally, there is a substantial and almost exponential influx of capital into the derivative markets of resources since the early 2000s (Chatham House, 2012). However, there is no clear consensus to which extent financialisation has led to price fluctuations.

Turning to Figure 4, intermonth price volatility has increased substantially. For copper and iron ore, this development started in about 2004. Even if prices recently seem to have found a new equilibrium at much higher level, their volatility remains high. The standard deviation for copper between 1960-2004 compared to 2004-2013 increased by a factor of 3.4. The standard deviation for iron ore increased by a factor of 4.8 for the same time intervals. In the case of iron ore prices used to be negotiated between key producers on a quarterly or yearly basis. The so-called annual benchmark pricing was a bilateral negotiation of a yearly iron ore price to which all market participants were bound. This benchmarking ended by the end of 2009. Since 2010, these time spans have decreased to quarterly price setting taking average spot prices (Ecorys, 2012). Increasing the frequency of price setting does not *per se* increase volatility. In fact, spot price volatility of iron ore has decreased between 2010 and 2012 (Ma, 2013). However, increasing the frequency of information may increase the likelihood of short-term shocks influencing the price increases. Besides the frequency of information, the quality of information matters as well (Transatlantic Academy, 2012).

Why does price volatility matter? Once price volatility increases, firms face increased uncertainty about future prices. In order to manage these price fluctuations, they need secure future prices through *hedging* by reduce their exposure to price changes (e.g. by increasing resource efficiency) or once they reached a critical size, *hedge* future resource prices on financial markets. However, SMEs might not reach the critical size to engage in financial markets, as it is costly to build the capacity to engage and operate in them, the purchasing volumes are too low or there are no adequate hedging products for certain resources (Inverto, 2014). The quoted survey among mid-sized companies also shows that most firms do not engage in financial hedging. This results in fluctuating input costs for them if they simultaneously do not invest in resource efficiency. Hence, as material prices increase in levels and volatility, economic costs at the micro and macro level increase accordingly.

Additionally, price volatility increases uncertainty about future prices. Increased uncertainty tends to increase the discount rate for future income streams and may thus delay or hinder long-term investment decisions. Short-term investments are given priority. Increased price volatility thus decreases the efficiency of market operations of long-term investments. Ultimately, such inefficiency can lower economic growth since physical capital accumulation decreases (Cavalcanti, Mohaddes, & Raissi, 2011) and deter private-sector investments (McKinsey Global Institute, 2013a).

**Price signals and resource investments:** Generally, standard economics would suggest such price signals (price level and volatility) to affect the behaviour of economic agents – by substituting, increasing efficiency, or using less. Dematerialisation is one possibility for firms to

reduce negative impacts from changes in price levels and volatility once there are economic incentives to pursue such an option.

Substituting individual materials is not always possible, often leading to performance losses and could require considering substitution of entire products and technologies. For some technologies such as low-carbon energy production, substituting materials (especially metals) could be an option (Moss, Tzimas, Kara, Willis, & Kooroshy, 2013). Additionally, substitution also depends on the end-user. For example, recycled paper might not be a perfect substitute for virgin pulpwood paper for high-end users (i.e. magazines, brochures), but for the low-end user (i.e. offices) (Nicolli, Johnstone, & Söderholm, 2012).

Whether increasing efficiency can be an economically beneficial response to high and volatile material prices will be evaluated in chapter 3. Generally, given the limited possibility of dematerialisation and partially of substitution, investments in efficiency could be expected to play an important role for firms' investments decisions.

Three developments can be concluded. Firstly, material consumption has increased, especially in emerging economies. Secondly, material prices have increased significantly since the early 2000s. Lastly, material price volatility has substantially increased as well. These three developments are crucial for understanding the importance of materials from an environmental, economic, and political point of view. They impose incentives for firms to deviate from their 'business-as-usual approach' as costs increase in terms of prices as well as uncertainty. One would expect a clear change in business practises and investments taking place. However, such changes entail costs and a 'web of constraints' (POLFREE, 2013), which will be analysed in chapter 4. The next section will explore the role of resources in the ECA and MENA regions as examples for an economically growing region with resource-intensive economies.

## 2.2. The ECA and MENA regions

### Key messages

- Absolute material consumption in the region grows slower compared to the global average
- Absolute and per capita material consumption in various countries in the region (incl. Russia, Poland, Kazakhstan, Mongolia, and Turkey) are at fairly comparable levels to the USA and other material intensive EU-countries.
- In line with further indicators such as resource rents (as % of GDP) and net exports, those economies can be considered dependent on resource inputs.

Economies heavily exporting and importing materials are most affected by price changes. Thus, such 'vulnerability' provides a rationale for these economies to consider options to mitigate possible negative impacts resulting from price fluctuations. Improving efficiency as one option will be discussed in greater detail later. Overall, these findings are crucial for determining the costs and benefits of investing in efficiency improvements, which will be the focus of chapter 3.

From a regional perspective, since 1993 the economies in the ECA and MENA regions increased their absolute material consumption at a lower rate compared to the world's average (Figure 5). Nevertheless, the increase of around 34% is still much higher compared to the USA (2%), the UK (-21%), Germany (-17%), and Finland (15%).

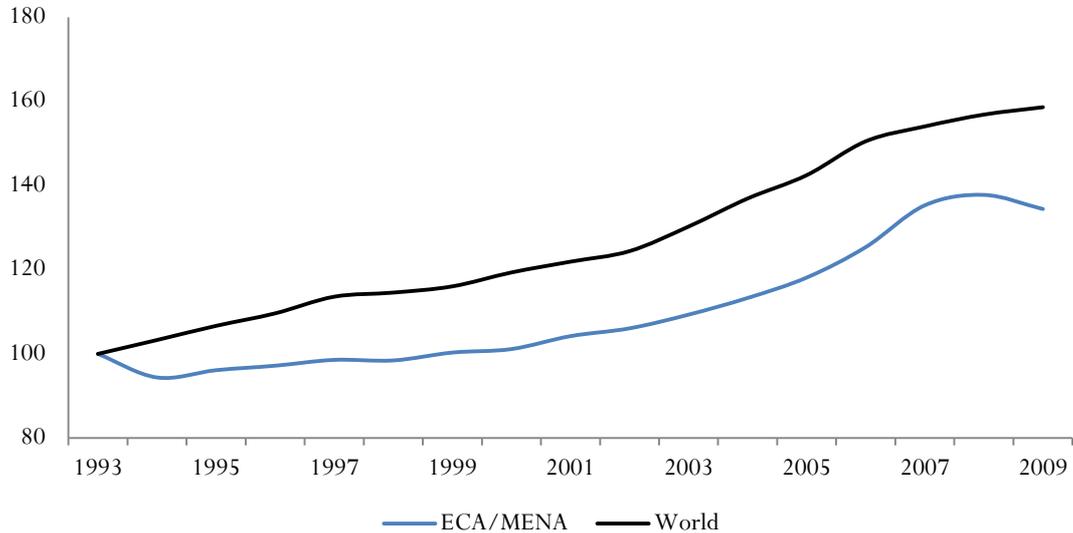


Figure 5 shows the trends of absolute material consumption in the ECA and MENA regions and globally from 1993 to 2009. The base year is 1993. Material consumption is shown in DMC terms. Sources: SERI, own calculations.

As mentioned above, domestic material consumption (DMC) consists of domestic extraction and trade statistics. Data for domestic extraction and its subcategories (minerals, metals, biomass, and fossil fuels) is available. Figure 6 shows the decomposition of such subcategories revealing that in the ECA and MENA regions fossil fuels account for 50%, minerals for 21%, biomass for 18%, and metals for 11% of total domestic extraction. Fossil fuels from Russia account for approximately 50% of total domestic extraction of the region. Russia, Poland, Kazakhstan, Turkey, and Ukraine make up 72% of the region's total domestic extraction. In comparison to other economies, the ECA and MENA regions shows a similar pattern compared to the USA. Chile exceeds the metal ore extraction of the ECA and MENA regions.

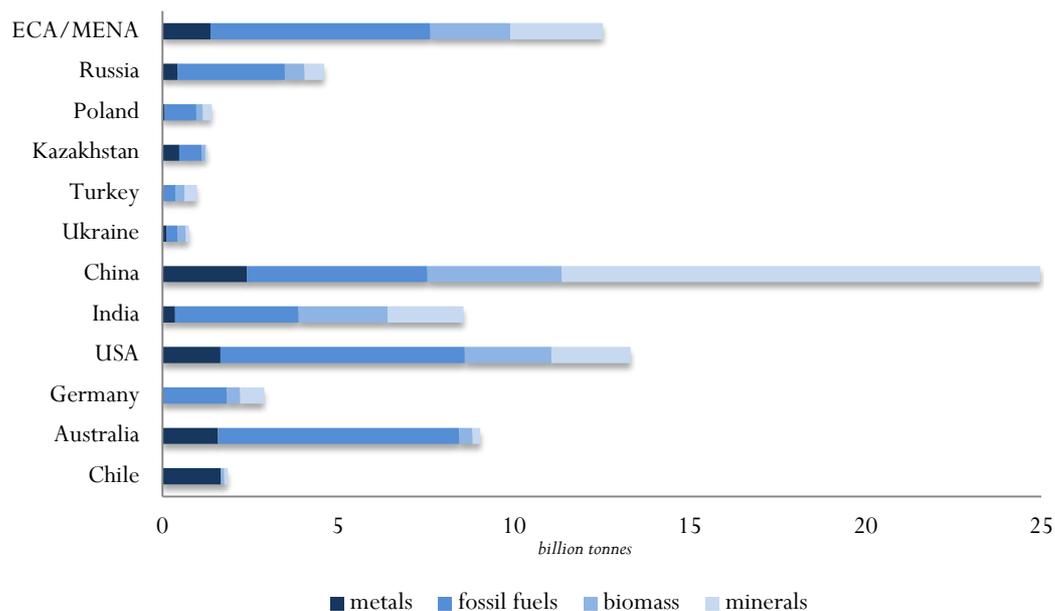


Figure 6 shows the decomposition of total domestic extraction (metals, fossil fuels, biomass, and minerals) in billion tonnes. The ECA and MENA regions consists of 32 countries. Sources: SERI, own calculations.

DMC is used to gain a general understanding of the importance of material use in an economy. Figure 7 shows DMC of each country in total and in per capita terms, relative to the median value of the entire ECA and MENA regions. Notably, Russia appears to be an outlier in terms of total material consumption and is far above the median when it comes to material consumption per capita. The figure therefore identifies Russia, Poland, Kazakhstan, Turkey, Bulgaria, Romania, and Mongolia as being the most prominent examples of countries above the median in terms of total and per capita material consumption. Mongolia consumes the highest amount of materials per capita and Turkey the second highest total amount of materials after Russia. This implies that materials are a particularly important factor within these economies. Thus, fluctuations of prices can have significant (negative) effects on the development path of these countries.

The countries stated above are the major consumers of materials in the ECA and MENA regions. This is not only the case for this specific region but also in comparison with the USA (21 tonnes per capita, 6.5 billion tonnes total) and China (16 tonnes per capita; 21.6 billion tonnes total), and material intensive European countries such as Germany (15 tonnes per capita, 1.2 billion tonnes total) and Finland (35 tonnes per capita; 0.2 billion tonnes total)<sup>7</sup>. In conclusion, there is a clear importance of materials in the economies of the ECA and MENA regions and their consumption is at fairly comparable levels to other material-intensive countries. Whether such prominence of materials is a curse or a blessing for a country is determined by a large range of aligned factors and requires a case-by-case analysis (World Bank, 2014).

<sup>7</sup> As discussed above, the DMC indicator does, however, not include indirect effects, which would increase the material consumption in the USA and Germany.

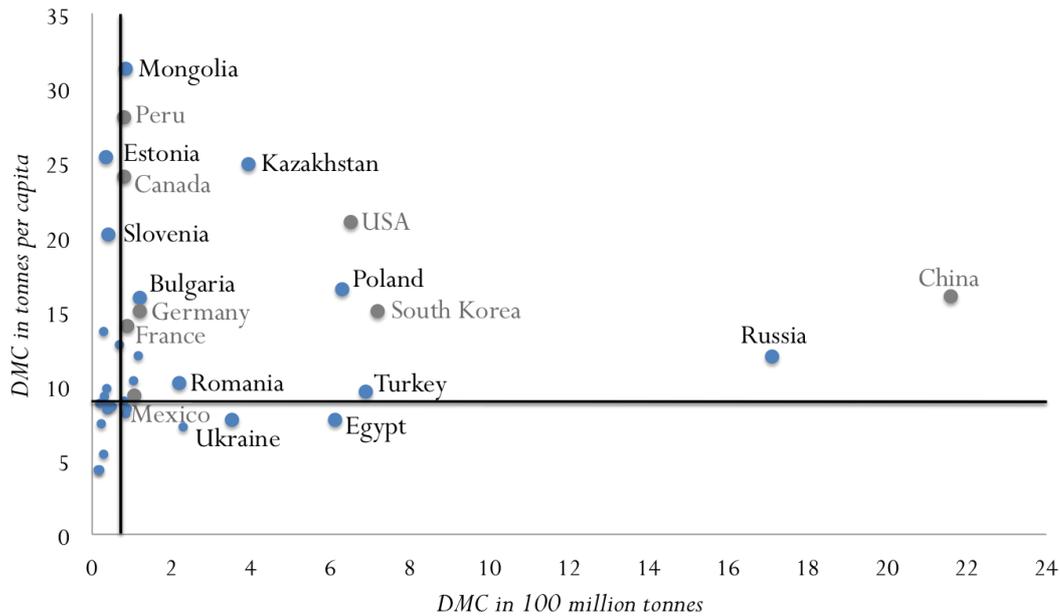


Figure 7 shows material consumption in the ECA and MENA regions. The horizontal axis displays total DMC in 100 million tonnes, the vertical axis DMC in tonnes per capita. The black lines are the median values across all countries in the ECA and MENA regions. Sources: SERI, own calculations.

The following series of figures will show the specific dependency of individual economies on materials in the region. An extensive academic literature has focused on the downsides of relying on natural resources – the *resource curse* (Atkinson & Hamilton, 2003; Bleischwitz, Johnson, & Dozler, 2013; Mehlum, Moene, & Torvik, 2006; Sachs & Warner, 2001). A recent report by the World Bank emphasises once more that dependencies themselves are not the main concern, but rather the lack of well-functioning institutions (World Bank, 2014) or the implementation of transparency, sometimes even through the extractive industry itself (e.g. EITI) (Corrigan, 2014). The World Bank report measures dependencies in terms of resource revenues, commodity exports and value added from natural resources. Similarly, this analysis uses comparable indicators to show the specific dependency of materials for an economy – material consumption, net exports of minerals, extraction, and percentage share of mineral rents of GDP. The aim is to show the impact of materials as an economic factor for certain countries within the ECA and MENA regions. The higher this importance is, the more pronounced are the effects of price changes.

Some of the countries mentioned above are also the ones, which are either the main exporters or importers of materials in absolute terms (Figure 8). Russia, Kazakhstan, Ukraine, Turkmenistan, and Azerbaijan mainly export materials, whereas Turkey, Poland, Morocco, Bulgaria, Slovakia, and Romania foremost import materials. All remaining countries in the ECA and MENA regions have relatively low net exports and are not displayed here.

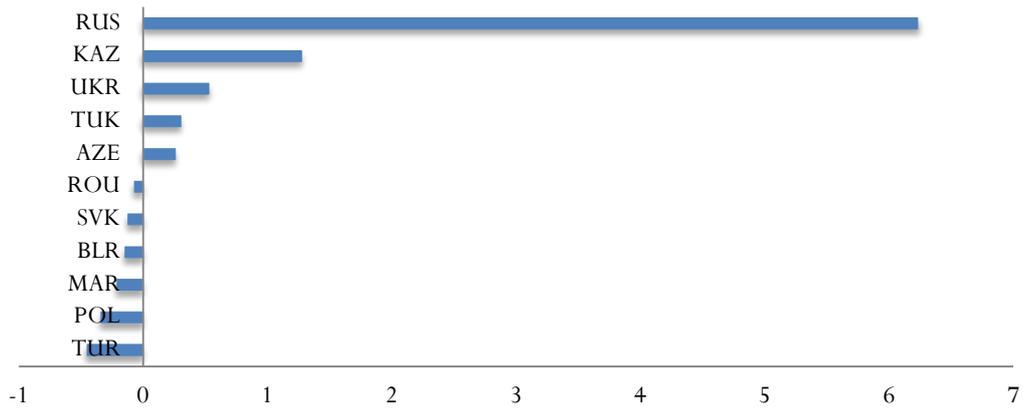


Figure 8 shows net exports of materials in 100 thousand tonnes in 2009 for the countries that are either the main net exporters or the main net importers. All other countries of the region export almost as much as they import. Sources: SERI, own calculations.

A similar pattern can be seen in Figure 9. Used and total extraction indicates two aspects. Firstly, total material extraction is most pronounced in Russia, Poland, Kazakhstan and Turkmenistan. Secondly, the difference between total and used material extraction provides an approximation of unused material, which often can be considered waste. This waste is for example tailing rock from mining. The unused material extraction can be quite considerable. In the case of Russia, it is about 50% of total extraction. For Kazakhstan and Poland, it accounts for more than 50%. Only in Germany (65%) and the USA (54%) have similar levels. India (40%), UK (29%), Finland (26%), and China (19%) have much lower values. Making use of such unused extraction could become part of a strategy to explore markets for such ‘hitchhiker’ or ‘by-product’ materials, some of which are considered ‘critical’ (e.g. gallium is a by-product of the aluminium-bearing mineral bauxite). In addition, analysing such unused materials in absolute terms is of relevance for environmental pressures in those countries. It also serves as a proxy for the efficiency of domestic extraction. Generally, the more an economy uses of total extraction, the more efficient its extractive industry is. However, such an approximation of efficiency does not only depend on the industry itself, but also on natural factors such as ore grades and types of materials and their by-products.

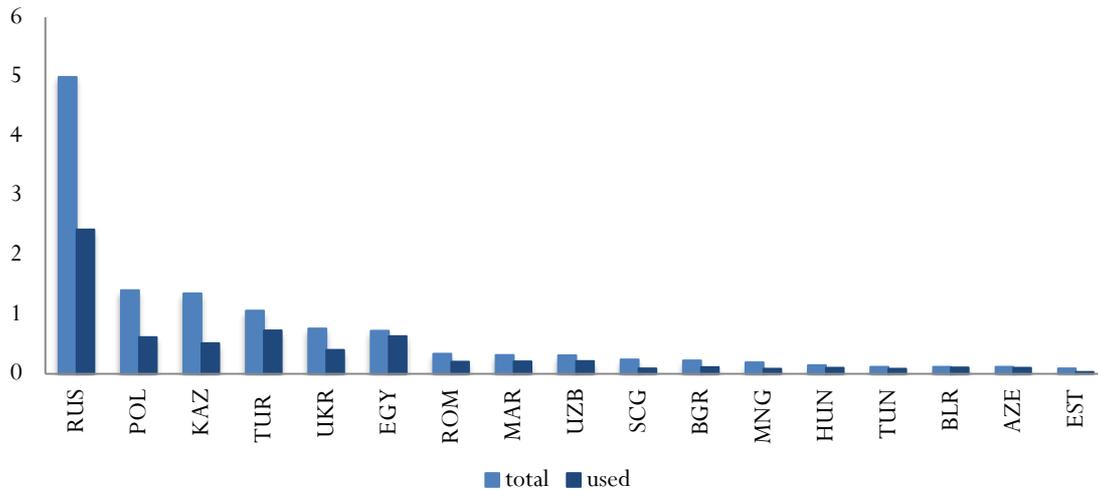


Figure 9 shows selected countries in terms of total and used material extraction for 2010 in billion tonnes. Source: SERI.

A prominent indicator for a country’s economic dependency on materials is their percentage share of GDP (Figure 10). The economies of Mongolia, the Kyrgyz Republic, and Uzbekistan are most dependent on mineral resources in terms of mineral rents. The world average is around 1%, whereas the EU’s average lies even below that. The higher the share of mineral rents in the countries’ GDP is, the more their ability to generate economic growth is affected by material prices and their volatility. These economies are also likely to have most potential in absolute terms with respect to material efficiency gains.

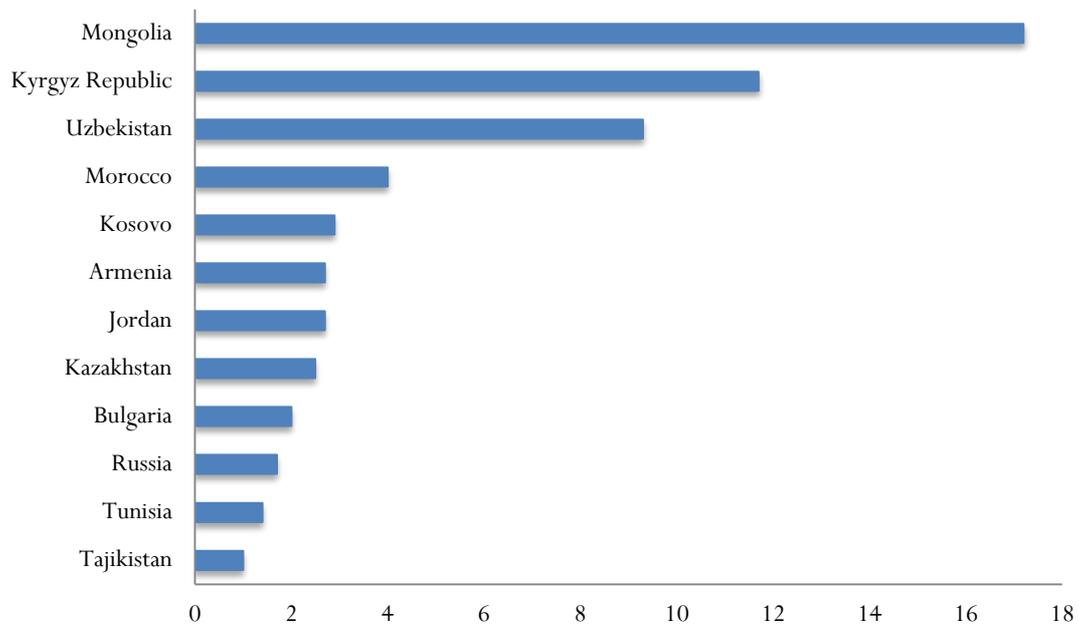


Figure 10 shows the percentage of rents from mineral resources as part of a country’s GDP in 2013. Source: World Bank.

In summary, three observations can be made. Firstly, absolute material consumption in the region grows slower compared to the global average. Secondly, absolute and per capita material consumption in various countries in the region (incl. Russia, Poland, Kazakhstan, Mongolia, and Turkey) are at fairly comparable levels to the USA and material intensive EU-countries. Thirdly, in line with further indicators such as resource rents (as % of GDP) and net exports, those economies can be considered dependent on resource inputs.

### 2.3. Gap in material productivity – an indicator for the potential of efficiency gains

#### Key messages

- There are substantial gaps in material productivity between the ECA and MENA regions and developed economies.
- This is indicative of the potential for resource efficiency gains, which could be realised in the ECA and MENA regions as well as possible barriers hindering such efficiency gains.
- After controlling for heterogeneous industry structures, natural resource intensity, and roughly adjusting methodological shortcomings, the substantial resource productivity gaps remain.

Material efficiency is sometimes defined as the ratio of useful material output (MO) and material input (MI) – the two variables are often in the same unit. Productivity however, is a ratio of two variables of mostly different units. For example, material productivity is defined as the ratio of economic output (Y) and material input (MI) (Dahlström and Ekins 2005). Thus, productivity is a measure for the effectiveness with which material input generates value added output. However, both ratios are frequently used interchangeably. Due to data availability constraints, in practice as well as in this report, material productivity is defined as the ratio of GDP and DMC – DMC is thereby taken as a proxy for material input.

Table 2 provides data on how countries have increased their material productivity (MP; ratio between GDP and DMC), the change in productivity between 1992 and 2009, the share of the industrial sector of total GDP, and the share of rents from natural resources of GDP. The ECA and MENA regions are almost entirely included as well as other economies (marked in grey) for comparison.

Between 1992 and 2009, the UK more than doubled its productivity whereas Egypt, Macedonia, and Morocco remained at their 1992 levels. In terms of productivity increase, Bosnia and Herzegovina, Armenia, and Russia among others outperformed the USA, Germany and Finland. Generally, the ECA and MENA regions performed better in terms of material efficiency improvements relative to Latin America and the Caribbean (West & Schandl, 2013).

However, considering absolute material productivity, the picture turns. The *MP*-column in the table provides an insight into the absolute material productivity (GDP/DMC). Comparing the productivity measures for the UK, Germany, and the USA with countries of the ECA and MENA regions reveals a substantial productivity gap. The first non-EU country, Turkey, is less than one-fifth as productive as the UK. The USA is more productive than Mongolia by a factor

of 51, which given Mongolia's impressive growth rates over the last years since 2009 is likely to have been reduced in the meantime. However, these resource productivity gaps should not be interpreted as definite and exact measures, but as a general benchmarks as the underlying data is subject to shortcomings, which will subsequently be explained.

In order to ensure high-quality and comparable data, domestic material consumption (DMC) is used throughout this report. As mentioned in the previous chapter, DMC and raw material consumption (RMC) differ in the way they take imports and exports of materials into account. RMC considers imports and exports in raw material equivalents (i.e. including indirect effects such as all raw materials necessary to produce traded intermediate goods), whereas DMC does not. Thus, two scenarios are possible:

$$RMC \geq DMC \text{ if } IM \geq EX$$

$$RMC \leq DMC \text{ if } IM \leq EX$$

The assumption is that in those equations imports (IM) and exports (EX) are measured in raw materials equivalents. Net importing economies are likely to have a higher RMC relative to their DMC. The UK, Germany, the USA, Finland, India, and China are all net importers of materials (not including the indirect effects). As their RMC increases, their material productivity will *ceteris paribus* decrease. Therefore, the comparisons between the grey-marked economies and most of the ECA and MENA regions in Table 2 are likely to overestimate the magnitude of the gap – a prominent exception is Turkey as a net importer of materials (Figure 8). Developed countries outsourced their material intensive productions into the ECA and MENA regions among others. This results in a relatively higher material productivity level in industrialised countries at the expense of emerging economies (Bringezu & Schütz, 2001; Schütz, Moll, & Bringezu, 2003; Wiedmann et al., 2013). From an EU-27 perspective, especially Russia and China bear such indirect effects (European Commission JRC, 2012).

In order to account for such shortcomings and to make the productivity gaps somewhat more comparable, a modified indicator of material productivity (MP\*) is constructed. The RMC and DMC share the same methodology with the exception of how imports and exports are calculated (RMC takes the indirect effects into account, DMC does not). Thus a corrected material productivity indicator needs to take such trade data asymmetries into account. As there is little reliable and comprehensive RMC data availability, a very rough approximation is calculated based on the EU-27 level, which provides the best available data on RMC.

The correction will be calculated as follows: In 2009, RMC exceeded DMC in the EU-27 by 4.2% (the average between 2000 and 2009 was 5.8%). The EU-27 is a net importing economy in terms of materials (trade outside the EU-27). The share of net imports with respect to total trade (exports and imports) is 47.6% in 2009. Thus, in the EU-27 in 2009, for every percentage point of net imports, there was a difference in RMC compared to DMC by a factor of 0.088. This result will be extrapolated throughout Table 2. Material productivity (MP\*) of net importers will therefore be reduced and for net exporters increased by the factor of 0.088 for every percentage point of the share of net imports or exports to total trade.

Evidently, such an approximation lacks to consider the specific imports and exports of each economy – especially of intermediate goods. This correction takes the EU-27 as a proxy for all countries in the ECA and MENA regions. Multi-regional input-output analysis among other techniques could provide more accurate results (Schoer, Giegrich, Kovanda, & Lauwigi, 2012; Schoer, Wood, Arto, & Weinzettel, 2013). What matters for the purposes of this report is not the exact numerical value, but the insight that there is indeed a substantial resource efficiency gap between developed and economies and those from the ECA and MENA regions.

	<i>MP</i>	<i>MP*</i> (modified)	<i>1992-2009</i> (% <i>MP</i> -change)	<i>Industry</i> (% of <i>GDP</i> )	<i>Natural</i> <i>resources</i> (% of <i>GDP</i> )
United Kingdom	3.92	3.83	106	21	1.2
Germany	2.30	2.25	50	30	0.2
USA	2.04	2.00	52	20	1.3
Croatia	1.27	1.27	14	26	1.6
Slovakia	1.06	1.04	44	31	0.7
Finland	1.05	1.03	49	25	1.4
Hungary	1.04	1.04	55	28	0.9
Slovenia	0.94	0.93	23	29	0.4
Lithuania	0.87	0.87	75	28	1.0
Latvia	0.78	0.80	31	26	2.6
Turkey	0.75	0.74	30	27	0.7
Poland	0.58	0.57	65	33	1.9
Romania	0.52	0.51	39	37	2.8
Russian Federation	0.51	0.54	77	38	18.7
Tunisia	0.45	0.45	29	30	7.4
Georgia	0.41	0.39	20	22	0.9
Estonia	0.40	0.40	23	30	2.6
Albania	0.36	0.34	11	15	5.5
Bosnia and Herzegovina	0.34	0.34	88	26	2.3
Belarus	0.34	0.33	75	46	2.5
Azerbaijan	0.33	0.35	39	63	39.8
Armenia	0.32	0.30	80	37	5.2
Serbia (and Montenegro)	0.32	0.31	75	32	4.3
Jordan	0.32	0.31	40	30	2.8
Morocco	0.32	0.31	6	32	5.0
Turkmenistan	0.29	0.32	36	24	34.4
Bulgaria	0.27	0.27	26	30	2.8
Ukraine	0.25	0.26	44	30	4.6
Macedonia	0.25	0.25	7	28	3.9

India	0.22	0.22	57	17	5.6
Moldova	0.21	0.20	31	20	0.5
Egypt	0.19	0.19	7	38	11.9
Kazakhstan	0.18	0.19	72	38	32.1
China	0.16	0.15	50	45	5.8
Kyrgyz Republic	0.11	0.11	36	34	15.0
Mongolia	0.04	0.04	52	33	28.7

Table 2 shows the absolute material productivity (MP) and a corrected MP\* in 2009, the increase in material productivity in the ECA and MENA regions and other countries in 2009 compared to 1992 in percentage, contains the contribution of the industrial sector to total GDP in percentage for 2013, and the percentage of rents from natural resources (oil, gas, coal, minerals, and forest rents) as part of a country's GDP in 2012. The industrial sector includes mining, manufacturing, energy production, and construction. Material productivity is measure as the ratio between GDP (in thousand constant 2005 USD) and DMC (in tonnes). The corrected MP\* takes the EU-27 as the baseline of correcting material productivity by a factor of 0.088 (taking from the EU-27 level) for every percentage point of the share of net imports or exports relative to total trade of each economy. Sources: World Bank, SERI, CIA World Factbook, own calculations.

Four aspects can explain most of the reasons for these substantial differences. Firstly as the last two columns of Table 2 reveal, several economies in the ECA and MENA regions have a different and mostly material-intensive economic structure (see also Figure 10). This structural difference creates a natural gap between service sector dominated economies (e.g. the UK and USA) and resource intensive ones (e.g. Azerbaijan, Turkmenistan, and Kazakhstan). However, the table can only serve as a preliminary analysis. In order to fully comprehend all differences, a more in-depth industry-level examination is necessary, which goes beyond the scope of this report.

Secondly, it is questionable if historically resource intensive economies should aim for the same productivity levels as service-based economies. However, differences in the industrial and resource intensive share of GDP alone do not explain the substantial gap of material productivity across countries even if the best performing countries generally have lower shares of resources relative to GDP.

Notably, Germany has a similar level of industrial share of GDP compared to the ECA and MENA regions, but its material productivity is much higher. Egypt and Kazakhstan are at similar levels of material productivity and industry share of GDP but have a very different reliance of natural resources of GDP. Bulgaria and Latvia have similar levels of resource rents and industrial share, but Latvia is much more material productive. This holds true even after roughly correcting for the indirect effects.

Thirdly, industrialised countries tend to import (intermediate) goods from emerging economies. Such imported goods are material-intensive in their production, but are not counted within the DMC indicator since they are considered indirect effects as explained above. Therefore, material efficiency is typically overestimated for industrialised countries and underestimated for emerging economies. The modified version of material productivity (MP\*) attempts to correct for this.

Fourthly, industrialised economies usually have a stronger societal and political agenda in terms of resource efficiency (e.g. Europe 2020). This results in higher and more sophisticated efforts to also increase material productivity. Thus, their institutional capacity necessary for implementing this agenda is higher as well. Accountability, formal and informal institutions, and a robust legal framework are only briefly mentioned here, but are preconditions for moving towards more material efficiency. Moreover, the investment environment in industrialised economies tends to be more favourable for material efficiency related investments. This is due to lower market barriers, fewer government and market failures, and incentivising regulation. These barriers will be discussed in greater detail in chapter 4.

Nevertheless, the substantial gap between industrialised and emerging economies, especially in the ECA and MENA regions, also reveals the technological, political, and societal difference regarding material efficiency. It also indicates the existence of possible barriers hindering investments in resource efficiency. Thus, there could be a major potential for the ECA and MENA regions to benefit from improving efficiency once such barriers are being mitigated.

In summary, materials increasingly matter. From a global perspective, material consumption, prices, and prices volatility have increased simultaneously. All countries, importer and exporter of materials face challenges (i.e. uncertainty concerning prices and supply, higher costs, lower investments, etc.) associated with these developments. The ECA and MENA regions are partly highly material-intensive and therefore material-dependent regions, showing substantial material productivity gaps. These gaps to industrialised economies provide a preliminary indication for the potential of material efficiency gains as well as an indication for possible barriers hindering investments. The costs and benefits with regards to increasing efficiency will be discussed in the subsequent chapter.

### 3. Investments in resource efficiency – costs and benefits

#### Key messages

- *Costs in the business-as-usual scenario* include negative externalities, not reducing existing resource dependency, geopolitical costs (e.g. supply restrictions, decreased bargaining power), and lock-ins of current technologies and structures.
- *Benefits in the business-as-usual scenario* include avoiding up-front costs, thus unlocking funds for alternative investment opportunities, and no (political) costs (i.e. decreasing support for future investments) upon investment failures.
- *Costs from investments in resource efficiency* include the investments themselves (and opportunity costs), uncertain future investment payoffs, and a potential rebound effect.
- *Benefits from investments in resource efficiency* include hedging against price volatility, reducing resource purchasing costs, increasing competitiveness, stimulating innovative capacity, and generally improving the macroeconomic environment while decreasing a country's resource dependency, and reducing negative environmental impacts.

This chapter identifies and evaluates an extensive range of implications when investing in resource efficiency and thus provides a framework for identifying, monitoring, and evaluating specific investment projects in practise. Therefore, its objective is to draft a list of costs and benefits potentially arising from investments in resource efficiency and compares such costs and benefits to a scenario of not investing (i.e. business-as-usual scenario).

The business-as-usual scenario comprises implications of a situation in which firms do not invest in resource efficiency. The arising positive impacts (benefits) and negative impacts (costs) for individual firms, surrounding firms as well as entire economies are outlined. It is to some extent a minimum scenario as it assumes no or very little investments taking place.

The scenario of investing in resource efficiency describes a situation in which firms heavily invest in efficiency improvements. The associate costs and benefits of such investments are also evaluated for individual firms, surrounding firms as well as entire economies. Similarly, this scenario can be considered a maximum scenario as a substantial amount of investments take place.

The structure of the cost-benefit narrative is as follows.

**a. Environmental implications**

- i. Costs in the business-as-usual scenario*
- ii. Benefits in the business-as-usual scenario*
- iii. Costs from investments in resource efficiency*
- iv. Benefits from investments in resource efficiency*

**b. Economic implications**

- i. Costs in the business-as-usual scenario*
- ii. Benefits in the business-as-usual scenario*
- iii. Costs from investments in resource efficiency*
- iv. Benefits from investments in resource efficiency*

**c. Political implications**

- i. Costs in the business-as-usual scenario*
- ii. Benefits in the business-as-usual scenario*
- iii. Costs from investments in resource efficiency*
- iv. Benefits from investments in resource efficiency*

In order to assess the costs and benefits comprehensively, both primary and secondary effects of an investment decision need to be evaluated (Cellini & Kee, 2010). Primary effects are those impacts closely related to the investments main objectives (i.e. direct investments). Secondary benefits include indirect (i.e. second round) effects, multiplier, spillovers, and co-benefits (i.e. by-products). The same applies for costs.

Naturally, there is a certain overlap among the environmental, economic, and political classifications. Table 3 summarises key benefits and costs. In the following sections, exporting and importing countries are sometimes considered separately. In order to assess all costs and in

particular environmental ones (Barbier, Markandya, & Pearce, 1990), inter-temporal considerations (i.e. net present value) are also required (Layard & Glaister, 1994; Pasqual & Souto, 2003).

This broad cost-benefit narrative takes up a macroeconomic and microeconomic perspective. The analysis is mostly based on quantitative and qualitative evidence from the academic literature concerning materials. General lessons can be drawn, but individual investment decisions for projects require a case-by-case analysis. In fact, each individual project has to be evaluated within the context of the specific country, region, industry, and firm – even then monetisation remains difficult (Pearce, 1998), especially for non-market goods (i.e. environment) (Perman, Ma, Common, Maddison, & Mcgilvray, 2011). Additionally, a sensitivity analysis with regards to expectations (e.g. for future resource prices) and assumptions would also be required to proof the robustness of the general recommendations of this narrative.

Analysing costs and benefits can provide an understanding of the trade-offs involved for resource efficiency investments. Besides the up-front investment expense, costs are often associated with making such investments possible (i.e. building capacity) and the result of a ‘web of constraints’ consisting of market and government failures – leading to an inefficient use of resources (POLFREE, 2013). These inefficiencies entail further costs and might create overall barriers to investments, which will be discussed in chapter 4.

Depending on the severity of such barriers as well as the potential to mitigate them, costs and benefits vary across countries, sectors, and firms. For the purpose of this chapter, costs from existing inefficiencies are considered to be part of the business-as-usual scenario. Benefits from investing in resource efficiency include reducing such costs and hence only tackle the symptoms of market and government failures. However, resource efficiency investments themselves do not address the causes of these inefficiencies. These ‘remaining’ costs from inefficiencies are not explicitly mentioned in the resource efficiency scenario, but are likely to prevail in reality. By taking into account the costs from existing inefficiencies, chapter 5 argues that a comprehensive approach is necessary, which promotes investments as well as implements complementary policies to tackle structural investment barriers.

Generally, one can envision four scenarios for costs and benefits of resource efficiency investments: (i) There are positive net benefits and no inefficiencies. (ii) There are positive net benefits despite inefficiencies. (iii) There are negative net benefits due to inefficiencies. (iv) There are negative net benefits regardless of inefficiencies. In scenarios (i) and (ii), one would expect private investments in resource efficiency taking place without any public intervention or financial support. Scenario (iii) provides a rationale for interventions, which aim to enable investments. In scenario (iv) no investments should take place. Thus, scenarios (ii) and (iii) provide a mandate for governments as well as international financial institutions to play an active role.

## Costs and benefits of investments in resource efficiency

Benefits			Costs		
Environmental	Economic	Political	Environmental	Economic	Political
<b>Business-as-usual</b>					
	<p>No initial expenditures needed for RE investments</p> <p>Lower compliance costs of environmental regulation*</p>	<p>No implementation costs</p> <p>No political costs upon failures of investments</p>	<p>Environmental impacts / negative externalities (i.e. waste)</p> <p>Reduced human &amp; natural capital (*)</p>	<p>Resource dependency for economies and firms</p> <p>Exposure to price volatility (uncertainty)</p> <p>Lock-ins / switching costs</p> <p>Second-mover disadvantage</p> <p>Inefficiencies resulting from resource prices not reflecting true costs*</p>	<p>Geopolitical dependency (decreased bargaining power)</p> <p>Instability*</p>
<b>Resource efficiency</b>					
<p>Reduced environmental impacts / negative externalities (through e.g. industrial symbiosis)</p> <p>Reduced negative impacts on human &amp; natural capital*</p>	<p>Hedging against price volatility / uncertainty</p> <p>Improved competitiveness &amp; innovation activity</p> <p>Positive spillovers from innovations*</p> <p>Improved corporate image (env. &amp; social liability)</p>	<p>Increased bargaining power due to lower geopolitical dependency</p> <p>Improved fiscal stance due to efficiency gains</p> <p>Political credibility towards tackling environmental issues</p>	<p>Increased negative externalities due to intensified exploitation of resources</p> <p>Rebound effect*</p>	<p>Initial &amp; uncertain investment</p> <p>Transaction costs*</p> <p>Opportunity costs</p> <p>Macroeconomic costs (i.e. Dutch Disease)*</p>	<p>Political risks of investments (regulatory capture)</p> <p>Provision of capital for RE-programmes</p> <p>Opportunity costs</p>

Table 3 summarises the environmental, economic, and political benefits and costs. This is done through distinguishing two scenarios: (a) investing in resource efficiency and (b) business-as-usual. Primary and secondary effects are considered. Secondary effects are marked with an asterisk (\*)

The aim of this chapter is to identify costs and benefits of investing in resource efficiency relative to a business-as-usual scenario. Chapter 4 will look at the market inefficiencies involved. Combined, the report will provide a general understanding of which scenarios are more realistic than others. The remaining chapter will discuss environmental issues, followed by economic and political ones.

### 3.1. Environmental implications

#### Key messages

- *Costs in the business-as-usual scenario:* Negative externalities (e.g. excess waste creation), which can be substantial and can cause secondary costs (i.e. health implications).
- *Benefits in the business-as-usual scenario:* There are no substantial benefits.
- *Costs from investing in resource efficiency:* Decreasing environmental capital due to intensified exploitation of resources if there is a positive relationship between the intensity of exploitation and environmental impacts, and a theoretically possible rebound effect.
- *Benefits from investing in resource efficiency:* Lower resource use can reduce negative environmental impacts, because fewer negative externalities cause fewer environmental damages.

This section will first assess environmental costs and benefits from the business-as-usual scenario and subsequently turns to costs and benefits from investing in resource efficiency. It follows the main conclusions from the International Resource Panel of the United Nations Environmental Programme (UNEP IRP, 2010, 2013).

**Environmental costs in the business-as-usual scenario:** There are two main issues here: Environmental impacts (negative externalities) mainly from excess waste, and more general secondary costs on human and environmental capital. Externalities “occur when the production or consumption decisions of one agent have an impact on the utility or profit of another agent in an unintended way, and when no compensation/payment is made by the generator of the impact to the affected party” (Perman et al. 2011, p.121). Externalities are not only a cost, but also an investment barrier, which will be discussed in chapter 4. Throughout each stage of the life cycle, resources directly or indirectly affect the environment and thus generate costs. **Error! Reference source not found.**<sup>11</sup> shows a representative life cycle for minerals and metals. Typically, four stages can be identified – (i) extraction, (ii) production, (iii) consumption, and (iv) disposal.<sup>8</sup> The following grouping will use minerals and metals as examples on which costs (i.e. negative externalities) are associated with a business-as-usual scenario.

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<sup>8</sup> For a detailed description of the environmental impacts during all stages, please refer to UNEP IRP 2013 p.108; Da Rosa et al. 1997; International Institute for Environment & Development and World Business Development Council for Sustainable Development 2002; Spitz and Trudinger 2008; Kempton et al. 2010.

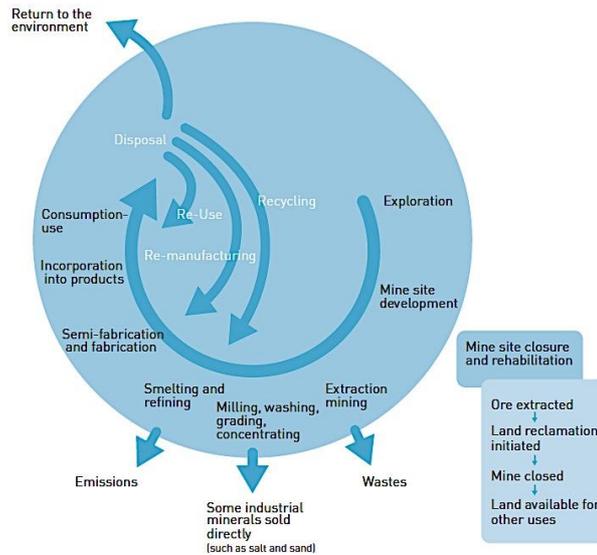


Figure 11 illustrates the life cycle of minerals and metals. Along the cycle, environmental impacts occur going beyond the ones pointed out here. Source: UNEP IRP 2013, p.96.

(i) The extraction stage: This stage has the highest impact on the environment (UNEP IRP, 2010), especially relative to its value added along the supply-chain for specific products (Clift & Wright, 2000). The grinding stage, which can be considered a sub-category of the extraction stage, is also where most energy is being consumed, making it necessary to consider indirect environmental impacts from electricity generation (this can be applied to all stages). This nexus between various resources (here materials and energy) is crucial to consider when addressing negative environmental impacts from individual resources. Examples for negative externalities in the extraction stage are emitting particulates (i.e. dust), erosions from mining, and leakages of chemicals used in the separation process into the environment.

(ii) The production stage: This stage uses resource inputs and incorporates these in products – especially in the industrial sector. For example, in the EU-25, the manufacturing industry accounts for 27% of all direct emissions of greenhouse gases, 27% of all direct emissions of ground-level ozone precursor gases, and 15% of direct emissions of acidifying gases (European Environmental Agency, 2013). These are some examples of negative externalities arising in the production stage.

(iii) The consumption stage: This stage is the most difficult to assess as materials are part of different products. Environmental impacts in individual stages could be higher for one resource input in comparison to another stage, yet have an overall lower impact on the environment. This is possible once the higher impact in one stage is compensated by in other stages. For example, aluminium induces negative impacts on the environment in the extraction and production stage, which are high substantial. However, if aluminium is used in technology generating renewable energy, environmental impacts in the consumption stage might be relatively lower compared to aluminium with lower impacts in the production stage but used in a car. Another example of the difficulty in assessing the environmental impact of resource

inputs due to the consumption stage is the Millau Viaduct in France. It is a major cable-stayed road bridge and consists of 65,000 tonnes of steel. The production of the steel harmed the environment, but at the same time the bridge reduced transport routes considerably and therefore its total CO<sub>2</sub> footprint (UNEP IRP, 2013). Thus, even if materials have higher impacts in one stage, it is always important to take their impact along the entire life cycle into account.

(iv) The disposal stage: This stage is mainly about negative externalities arising from disposed waste. However, waste is also generated in all other stages (e.g. tailings waste during extraction or leftover material during production). Externalities are not only a cost, but also an investment barrier, which will be discussed in chapter 4. Generally, waste can be categorised in solid/effluent, hazardous, and in form of emissions. Table 4 lists two aspects. Firstly, it identifies impacts of negative externalities resulting from such waste categories. Generally, such impacts are associated with waste collection, treatment, and disposal depends on the quantity and ‘quality’ of the waste itself as well as the management of it (European Environmental Agency, 2012b). Secondly, it provides examples of wastes in the manufacturing and mining industry without claiming completeness.

Externalities of waste/pollution			
	Solid & effluent waste	Emissions	Hazardous waste
Impacts	<ul style="list-style-type: none"> <li>▪ Land quality</li> <li>▪ Water quality</li> <li>▪ Further indirect impacts on health, food chains, tourism, etc.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Local air pollution</li> <li>▪ Climatic change due to greenhouse gas emissions</li> </ul>	<ul style="list-style-type: none"> <li>▪ Land quality</li> <li>▪ Water quality</li> <li>▪ Further indirect impacts on health, food chains, tourism, etc.</li> </ul>
Manufacturing	<ul style="list-style-type: none"> <li>▪ Production waste</li> <li>▪ By-products from drilling, turning, milling, welding, punching, etc.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Emissions during production (e.g. dust)</li> <li>▪ Indirect emissions from energy production</li> </ul>	<ul style="list-style-type: none"> <li>▪ Chemical leakages</li> </ul>
Mining	<ul style="list-style-type: none"> <li>▪ Tailings</li> <li>▪ Waste rock</li> <li>▪ Water pollution (e.g. separation stage)</li> <li>▪ Landscape destruction</li> </ul>	<ul style="list-style-type: none"> <li>▪ Particulates (i.e. dust) during crushing</li> <li>▪ Pollution during smelting</li> <li>▪ Indirect emissions from energy production</li> </ul>	<ul style="list-style-type: none"> <li>▪ Chemical reactions during extraction</li> <li>▪ Leakage of chemicals used during separation process</li> </ul>

Table 4 summarises the impacts of externalities from solid & effluent, emissions, and hazardous wastes. It differentiates between the manufacturing and mining industry.

Waste is created during all stages of resources’ life cycles. Thus, it is important to evaluate what role waste can play for firms and economies in becoming resource efficient. Typically,

minimising wastes is referred to as one strategy or instrument to achieve resource efficiency. In order to minimise waste, it is important to consider why waste is created in the first place.

While waste may still have an economic value, it may be impossible to unlock it cost-effectively once handling, reprocessing and transport costs are taken into account. Also, transaction costs such as searching for potential buyers, bureaucratic costs (i.e. permits) may lower the net value of waste after subtracting such costs. Waste legislation plays an important role as well – especially regarding labelling. Declaring resources as waste could automatically decrease its net value since for instance transportation and processing requires costly permission and supervision. If however such ‘waste’ would be declared a resource input, its handling costs might be lower, which would increase its net value. It is crucial to consider that waste is being recycled, reused or remanufactured when the benefits from doing so exceed the costs from landfilling it. Thus, barriers (i.e. market and government failures) also hinder the minimisation of waste, which will be discussed in greater detail in chapter 4.

Decisions about landfilling versus returning ‘waste’ into the production cycle are taken on the individual level. Economic agents play a role on both, the supply and demand side of wastes. Hence, there are two possibilities available if waste and its resulting externalities should be minimised. Firstly, increasing demand for wastes by increasing benefits from diverting waste away from landfills (i.e. reduce transaction costs, enable industrial symbiosis, internalise social costs into for instance energy prices to increase benefits from secondary production, etc.). Secondly, reducing supply of waste by increasing the costs for landfilling (i.e. landfill tax, extended producer responsibility, etc.) (European Environmental Agency, 2011a). Clearly, the quality of a recycled material is also crucial (e.g. metals are one prominent example of hardly losing any quality through secondary production).

Table 5 lists impacts of negative externalities resulting from an inefficient use of resources (i.e. waste). The causes of such inefficiencies will be in-depth discussed in chapter 4. Direct and indirect effects can be distinguished. Environmental costs of using resources inefficiently can also negatively impact economic activity (i.e. land fertility, mudflows, reduced labour productivity due to health impacts, etc.) (UNEP, 2014). Additionally, direct and indirect costs such as adverse impacts on human and natural capital arise within the business-as-usual scenario. Examples for such direct impacts are particle emissions polluting the air. An example for indirect impact is negatively affected human health, which may trigger reduced labour productivity, tourism, or the quality of agricultural activity.

Furthermore, it is crucial to take the concept of irreversibility of environmental functions into account. Once the environment is harmed beyond a certain threshold, it cannot fully recover its functions anymore, which calls for the cautionary principle (i.e. safe minimum standard) (Perman et al., 2011).

Impacts of resource inefficiencies		
	Direct effects	Indirect effects
Economic capital	<ul style="list-style-type: none"> <li>▪ <i>Over-consumption / extraction of resources</i></li> <li>▪ <i>Excess waste (potential long-term treatment costs for hazardous waste)</i></li> <li>▪ <i>Higher depreciation of machinery</i></li> <li>▪ <i>Higher production costs</i></li> </ul>	<ul style="list-style-type: none"> <li>▪ <i>Higher maintenance costs for entire production equipment</i></li> <li>▪ <i>Lower positive spillovers (e.g. new production technique) to other parts of the firms</i></li> <li>▪ <i>Lower linkages to other firms (lacking industrial symbiosis)</i></li> </ul>
Natural capital	<ul style="list-style-type: none"> <li>▪ <i>Emissions (e.g. CO<sub>2</sub>)</i></li> <li>▪ <i>Environmental degradation</i></li> <li>▪ <i>Pollution (air, water, land)</i></li> <li>▪ <i>Noise</i></li> </ul>	<ul style="list-style-type: none"> <li>▪ <i>Further negative impacts on natural and human capital reduces recreational and reproductive potential</i></li> </ul>
Human capital	<ul style="list-style-type: none"> <li>▪ <i>Negative health impacts due to obsolete machinery (e.g. in terms of operational safety, or longer term impacts due to for instance dust, etc.)</i></li> </ul>	<ul style="list-style-type: none"> <li>▪ <i>Lower productivity</i></li> <li>▪ <i>Increased health expenditures</i></li> </ul>

Table 5 summarises direct and indirect impacts of resource inefficiencies on economic, natural, and human capital.

Additionally, there are non-environmental externalities from resource inefficiency. Such externalities are effects of one firm on another. The design of a product of one firm clearly has an influence on the recyclability of material possibly done by another firm down stream. For example, packaging using multi-layer plastics (for hygienic reasons) cannot be recycled mechanically, and producing multi-coloured glass bottles results in increasing recovery costs (Nicolli et al., 2012). The problem is that there is little incentive to design the product to be easily recycled if there is no gain for the firms designing the product upstream. Also, there might be no setting in which the recycling firm can provide an incentive for the designing firm to change the characteristics of its product (Calcott & Walls, 2005). The result could be excess waste, which could entail negative externalities on the environment. This shows the interlinkages between non-environmental and environmental externalities.

Generally, these examples show how important firm-level interactions across supply-chains are to improve resource efficiency (Schliephake, Stevens, & Clay, 2009). However, the crucial question remains whether or not the product would be designed differently once the designing firm would take the recyclability into account. One possibility to strengthen such supply-chain interaction is by making the producer responsible for dealing with the end of life cycle product or increase the cost-competitiveness of the recycling market (Tietenberg, 2009).

The main issue is not that environmental impacts happen at all, but rather the extent (quantity and quality) to which they happen – how much waste, and emissions are generated, and to what extent other resources are being affected. Such externalities are a source of market failures. Resource prices that do not reflect all costs from negative externalities incentivise over-consumption and over-production of resources (Bleischwitz, 2010). Resource prices, which fully reflect negative externalities would only cause adverse environmental impacts to the extent to which end-users are willing to pay for them.

As shown above, externalities can take several forms. For example, countries not imposing a cost of CO<sub>2</sub> emissions during metal production will result in not internalising such externalities in the private decision making process (Söderholm & Tilton, 2012). Thus, externalities are costs not reflected in the price of resources. Not investing in resource efficiency means bearing such costs.

**Environmental benefits in the business-as-usual scenario:** There are no apparent environmental benefits in the business-as-usual scenario. This leaves the environmental element of a cost-benefit narrative in all circumstances with a net negative result. Thus, from an environmental perspective, there is little in favour of remaining on the path of a business-as-usual scenario. Resource efficiency can therefore be considered as an environmentally beneficial investment opportunity.

**Environmental costs from investments in resource efficiency:** Resource efficiency means using a given resource in such a way to extract more output from it. Thus, a direct cost is for instance the increased intensity of exploiting resources. The economic rationale is that there could be a positive relationship between the intensity of exploitation and environmental impacts. One example is the mining industry. Let us assume the degree of exploitation is increased through efficiency gains in the grinding stage. Just because the output of ores increases relative to the amount of inputs, relatively more externalities such as particulates (i.e. dust) could be produced or indirectly relatively more energy might be required (e.g. since the grinder uses relatively more energy at its capacity limit) outweighing the efficiency gains. Such an increase of externalities (here particulates) might outweigh an efficiency-induced reduction of negative impacts of other externalities (e.g. waste rocks). Thus, efficiency gains could theoretically result in higher net environmental impacts.

Moreover, a potential rebound effect may be considered as a reduction of environmental benefits arising from increased resource efficiency. This is not *per se* a cost, but rather minders positive benefits. Generally, the literature distinguishes between two possible outcomes. (i) Partially offsetting efficiency gains by increasing consumption (reducing benefits), and (ii) outweighing such gains altogether (*backfire* or *Jevons' Paradox*). (Sorrell, 2007). Only (ii) entails environmental costs.

Additionally, there are three categories of rebound effects – a direct, an indirect, and a combined economy-wide effect (Barker, Ekins, & Foxon, 2007). For example, increasing the fuel efficiency of a car might result in driving more kilometres, which is considered a direct

rebound effect. An indirect rebound effect would be using more air transportation with the savings from increased fuel efficiency in a car, which is complex to calculate. Economy-wide rebound effects combine such direct and indirect rebound effects (Sorrell, 2007). Estimates of the direct rebound effect in respect of energy efficiency improvements vary widely between sectors, and even within a sector. In the residential sectors, a number of studies estimate the effect to offset approximately 30% of the initial efficiency gains (Dimitropoulos, 2007; Sorrell, Dimitropoulos, & Sommerville, 2009; Sorrell & Dimitropoulos, 2008). The economy-wide effects may be considered to be much higher, but no accurate methodologies exist to measure them (Sorrell, 2007, 2009). However, conclusions from energy efficiency are not necessarily transferable to resource efficiency.

Generally, there has been little debate on materials and the rebound effect, partially because it is expected to be of little significance for example on construction materials (Bahn-Walkowiak, Bleischwitz, Distelkamp, & Meyer, 2012). However, studies using quantitative models show that economy-wide rebound effects from resource efficiency in terms of CO<sub>2</sub> reduction are potentially high. For instance, CO<sub>2</sub> emissions in a resource efficient scenario may not further be reduced compared to a baseline scenario. Nevertheless, such economy-wide rebound effects for material consumption are lower relative to efficiency gains and thus, absolute decoupling of GDP from material consumption could still be possible (Meyer, Meyer, & Distelkamp, 2011).

Thus, the rebound effect only entails environmental costs once it outweighs the initial efficiency gains. For the direct rebound effect, there seems to be little evidence to suggest a *Jevons' Paradox*. More research is needed to understand economy-wide effects for resource efficiency in order to evaluate whether the rebound effect needs to be considered a net cost. In conclusion, there is a theoretical cost arising from a potential rebound effect; its likelihood seems to be rather limited.

**Environmental benefits from investments in resource efficiency:** A more efficient use of resources implies a higher output per unit of resource input. In the absence of a 'backfiring' rebound effect (and *ceteris paribus*), this results *ex post* in a relatively lower use of resources. Hence, fewer resources are extracted, produced and consumed, which lowers negative environmental impacts and thus contributes towards mitigating for instance climate change (Barrett & Scott, 2012). For example, material savings (in terms of environmentally-weighted material consumption) of three sectors in the EU-27 (food and drink manufacturing, fabricated metal products, and hospitality and food services) could reduce 2 – 4% of total annual EU-wide GHG emissions (AMEC & Bio IS, 2013). For the UK, resource efficiency improvements could reduce GHG emissions by as much as 13% of its total annual GHG emissions (Oakdene Hollins, 2011).

Direct benefits for the environment arise from reducing externalities (see Table 5). Furthermore, key strategies to achieve resource efficiency include the industrial symbiosis and increasing recycling, reusing, and remanufacturing (3Rs) efforts (ECSIP Consortium, 2013). Such strategies result in a reduction of waste generation and subsequently lowering negative impacts described in Table 4. Especially through recycling, the environmentally harmful first

stages of the resources' life cycles (i.e. extraction) could be substituted by the production of secondary material (Allwood, Cullen, & Milford, 2010; Ignatenko, van Schaik, & Reuter, 2008).

This entails lower direct (i.e. less primary production) and indirect (i.e. lower energy use) externalities. For example, secondary production of certain materials reduces energy use by 55% (lead) to 98% (palladium) (UNEP IRP 2013, p.93). Metals are particularly promising when it comes to recycling, as their potential to be fully recycled over and over again is very high. Diverting waste from landfills back into the production cycle does also secure access to material supply as it substitutes imports. Furthermore, the 3Rs enable the creation of surrounding businesses and services in the recycling-industry. In the EU, this has resulted in a major market creation and fostering of innovations as well as employment (European Environmental Agency, 2011a). This result from the EU is particularly relevant for the ECA and MENA regions as market creation helps them to experience a strong transition impact.

Therefore, a reduction of waste creation would lower the environmental impacts substantially. The 3Rs play a crucial role here. Industrial symbiosis is another related subject (Tukker 2013), as waste by one firm becomes a resource of another one. Such 'cooperation' between firms can draw from the benefits of reduced costs of resources (especially raw materials) by replacing more expensive primary with cheaper secondary produced materials. Additionally, costly waste treatment becomes obsolete for the firm producing the waste. The firm buying the waste might have to invest in order to recycle the waste into useable resources at lower costs relative to purchasing virgin resources. Moreover, supply security and 'environmentally-friendly' production are benefits (Duflou et al., 2012). Often imperfect information and labelling prevents such a symbiosis to materialise. Sufficient information is key and the role of policy in that matter will be discussed in greater detail in a chapter 4.

Indirect benefits result from reduced impacts on human and natural capital, as outlined in Table 5. For example, reduced environmental degradation may help to recover the recreational value of affected areas. Depending on the specific location, such positive indirect benefits may have substantial positive impacts on human health and tourism.

### 3.2. Economic implications

#### **Key messages**

- *Costs in the business-as-usual scenario:* Costs from not reducing existing resource dependency, and lock-ins of existing technologies and structures manifesting inefficiencies.
- *Benefits in the business-as-usual scenario:* Avoiding potentially high up-front costs, thus unlocking funds for alternative investment opportunities.
- *Costs from investing in resource efficiency:* The investment itself (and opportunity costs), uncertain future investment payoffs, and possible macroeconomic costs.
- *Benefits from investing in resource efficiency:* Hedging against price volatility, reducing resource purchasing costs, increasing competitiveness, stimulating innovative capacity, increasing the corporate image, and generally improving the macroeconomic environment while decreasing resource dependency.

This section evaluates the costs and benefits of resource efficiency with regards to economic implications. This section is of particular importance as resource efficiency investments typically are expected to fulfil commercial profitability criteria (e.g. for firms, banks, investors, etc.).

**Economic costs in the business-as-usual scenario:** The business-as-usual scenario entails several costs (i) from a business specific perspective, (ii) from an economy-wide perspective, and (iii) general costs from the business-as-usual scenario.

(i) From a business specific perspective: Not investing in resource efficiency means being fully exposed to price fluctuations (unless other measures are taken such as substitution). Price fluctuations are an important cause of investment uncertainty (Chatham House, 2012). Such uncertainty results in a premium, which firms have to account for in form of higher discount rates and lower expected net present values of investment decisions (i.e. since their costs/revenues are uncertain), and hedging costs (i.e. long-term contracts or direct ownership of suppliers). Additionally, if price volatility increases and prices for firms are not hedged, production costs become volatile as well. Depending on the stickiness of the firms' prices, this may cause high fluctuations of the cash flow, which in a worst-case scenario can lead to insolvency.

Depending on the market power of firms, companies may have difficulties to pass on all parts of those additional costs to their customers (AMEC & Bio IS, 2013). Thus, increasing material costs are a major concern to firms. EU companies in the industrial sector, for instance, have expressed concerns over future prices (Eurobarometer, 2011). Especially when it comes to recycling, firms not investing in resource efficiency cannot take advantage of reducing their exposure to volatile resource markets through recycling or selling their waste. Alternatively, firms could try to substitute or dematerialise resources in the face of such price fluctuations. However as described in the previous chapter, substitution and dematerialisation are not always possible (i.e. critical metals) or desirable.

(ii) From an economy-wide perspective: Resource-exporting economies face similar problems once resource prices fluctuate and there are no resource efficiency investments. As Figure 10 showed, highly resource-dependent economies are vulnerable to price volatility. The reason is that their GDP fluctuates once resource prices fluctuate, especially if resource rents are a significant source of revenue and much of the resources are being exported (Crivelli & Gupta, 2014). In that regard, a report identifies Azerbaijan, Kazakhstan, Mongolia, Russia, and Turkmenistan as highly and Egypt, Kyrgyzstan, and Uzbekistan as medium vulnerable economies once prices fluctuate (Chatham House, 2012). However, the costs for resource-exporting countries are different compared to importing economies with regards to resource efficiency investments. If the use of resources is not efficient for resource-importing countries, opportunity costs arise. At the same time, once import prices fluctuate heavily, a country's balance of trade will change frequently as well. Thus, the business-as-usual scenario entails such opportunity costs from not efficiently taking advantage of the resource efficiency potential.

(iii) General costs from the business-as-usual scenario: Not investing in resource efficiency results in more general costs or exacerbates already existing costs by not changing the business-as-usual scenario. Such costs are for example lock-ins. Lock-ins can cause inefficiencies, and vice versa. Lock-ins describes a situation in which a technology prevails due to economies of scale, network and learning effects even if it initially is sub-optimal or inefficient (Arthur, 1989). For instance, if steel producers have substantially invested into inefficient technology previously, they may be unable to invest into more modern efficient technology due to financial constraints – i.e. they are locked in (Allwood, Ashby, Gutowski, & Worrell, 2011). Firm investing in resource efficiency will have to bear such costs.

There are also behavioural (Barnes, Gartland, & Stack, 2004) and organisational lock-ins (Schreyogg & Sydow, 2011). Such lock-ins can cause economic costs and also barriers for investments in more efficient technologies (European Commission, 2011a, 2011b). If an inefficient technology or process is widely used, it is relatively costly to change the *status quo*. The reason is that breaking up lock-ins (a) requires initial capital for investments in new technology and (b) are costs arising from changing the current technology (switching costs).

(a) Path-dependencies caused by high initial investments manifest the *status quo* and leave little room for product and/or process improvements. This is often due to irrational behaviour known as the sunk cost fallacy as retrospective costs should not but often are taken into account for prospective investment decisions (Varian, 2010). Such substantial initial investments are only important if there are high one-off investments, which are in the case of eco-innovations only seldom the case (Eco-innovation Observatory, 2012).

(b) Switching costs can take several forms. For economies of scale, changing e.g. producing products becomes relatively more expensive, the higher the quantity has already been produced; for network effects, consumers will bear costs through a decreased utility once a new product is being introduced; and for learning effects, the benefits from having learnt in previous production will be lost once a new product is being produced.

Moreover, there are switching costs to newer and more efficient technology, which might postpone technology adoption. A firm adopting a new technology relatively late might not be able to benefit from the new technology as much as a first-mover. The reason might be that consumers purchasing products from the first-mover would bear switching costs while changing to a later adopter (Lieberman & Montgomery, 1988). The resulting second-mover disadvantage for firms arise due to opportunity costs from a late adoption of resource efficient technologies and innovations. Since there is uncertainty concerning which new technology entails a first-mover advantage, risk assessment often is key in deciding whether or not to adopt a new technology in an early stage.

Lastly, an economic cost pertains to structural market inefficiencies. Relatively lower resource prices due to not internalised negative externalities cause such costs to be born by a third party. This can be considered a ‘benefit’ for firms as they can purchase their resources at lower prices.

However, from an economic welfare perspective it is a cost. Once prices fail to represent social costs, overconsumption is incentivised – which is considered a market failure.

**Economic benefits in the business-as-usual scenario:** In the business-as-usual scenario, firms can avoid potentially high up-front costs of investing in resource efficiency. However, not all resource efficiency improvements require investing capital. Sometimes, changing practises, behaviour, and organisational structures is sufficient for resource efficiency gains. Thus, in the short-term not investing in resource efficiency does not require costs, but in the long-term such initial costs result in even higher benefits. Hence, not investing might have a short-term benefit, but a long-run cost. Not investing capital into resource efficiency means that such capital can be invested in potentially more profitable and less uncertain alternatives. Therefore, all possible alternatives to resource efficiency investments should be considered before advising such investments.

Additionally, benefits take the form of lower administrative and compliance burdens to firms and the economy as a whole. This can only be considered a secondary effect from not investing, because it is a benefit from an existing lack of environmental regulation. Changing the *status quo* through expanding monitoring, reporting, and compliance with environmental policies will most likely increase costs for firms. Thus, in the absence of such policies, firms operate on lower legislative grounds – and thus cheaper compliance costs.

**Economic costs from investments in resource efficiency:** Generally, there are three main costs associated with investing in resource efficiency. (i) The initial investment including transaction costs, (ii) opportunity costs, and (ii) macroeconomic costs.

**(i) Initial investment costs:** Such costs consist of investing in innovations or in adopting a new technology. Resource efficiency investments typically generate annual income streams (i.e. savings for process improvements and higher income streams for product improvements), but the initial investment might be substantial and thus hindering the investment taking place (AMEC & Bio IS, 2013). While the up-front costs of efficiency-enhancing investments are mostly known, the returns may often be uncertain. An envisioned break-even point might also be relatively distant in time, depending on the type of investment. If firms are risk averse, they are less likely to invest as they attach a certain probability to the (expected) net present value (NPV) or increase the discount rate of an investment decision (Perman et al., 2011).

Thus, the benefits have a lower NPV relative to risk-neutral firms and the investment might not take place. The same holds true for banks providing loans for such investments – they typically demand higher interest rates for timely distant payoffs. The likelihood of not investing increases if firms or banks additionally have a time-inconsistent (i.e. hyperbolic) discounting rate. This means that they discount the long-term future higher than the short-term future. This could lead to myopic expectations increasing economic costs (i.e. inefficiently high interest rates) (Varian, 2010). However, an empirical study on (real-estate) investments suggests relatively low discount rates and risk premia in the very long-term (Giglio, Maggiori, & Stroebel, 2014).

International financial institutions, governmental-secured loans or occasionally local banks might help to mitigate the problem through long-term commitments. It is also the rationale for a number of existing programmes such as the German DEMEA programme,<sup>9</sup> the Eco-Innovation Agency of North/Rhine-Westphalia,<sup>10</sup> the environmental innovation programme implemented through the *Kreditanstalt für Wiederaufbau* (KfW),<sup>11</sup> or the Knowledge Transfer Network programme in the UK.<sup>12</sup>

Investing in new technologies, management approaches, and innovation mostly implies uncertainty about the associated benefits. In order to overcome this ‘barrier’, the expected future benefits do not only have to at least cover the initial, operation, and maintenance costs, but also the transaction costs for the investment (i.e. switching costs in the presence of lock-ins). Transaction costs can include capacity building (e.g. training personnel to use the new technology effectively), the organisational resentment of changing current practises, and finding an adequate way of financing the investment (i.e. searching costs). Even if changes in behavioural and organisational practises often do not require capital investments to achieve resource efficiency gains, transactions costs in most cases remain.

(ii) Opportunity costs: Money can only be spent once. Thus, firms only have an incentive to invest in resource efficiency if no other feasible alternative offers a higher benefit (i.e. opportunity costs). One alternative is substitution of price-fluctuation resources, which is not always possible or desirable as mentioned in the previous section. A second alternative to investments in resource efficiency comes from the fact that labour costs often comprise an important budgetary position. Thus, increasing labour productivity is potentially important in order to reduce overall costs. This is why firms might have a higher incentive to invest in increasing labour productivity, if materials are considered by their cost as raw materials (not including upstream labour, transportation, and storage costs) (Bruyn, Markowska, de Jong, & Blom, 2009), which traditionally has been a preferred strategy of businesses and consultants. The same holds true for investments in energy efficiency. Therefore, data reveals that in the EU-15 productivity has increased by 144% for labour, by 73% for energy, and by 94% for materials between 1970-2007 (Bleischwitz, 2012).

The described increase in resource prices and a more recent debate however takes a more comprehensive look at the relevance of resource costs and shifts attention to the combination of technical as well as environmental potentials of resource efficiency along with capacity building and training (cfr. UNIDO & AFD, 2013). Considering material costs as a percentage of gross production value, material costs in the German manufacturing industry for instance account for 45.3%, while labour only for 20.5% (Statistisches Bundesamt 2011, p.372). On an EU-level, material costs account for similar levels and are specifically outlined in Table 7 as well as discussed in further detail later. For some sectors within the manufacturing industry, namely the automobile and machinery sector, materials account for more than 50%. Given higher

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<sup>9</sup> <http://www.demea.de> (30 May 2014).

<sup>10</sup> [http://www.umwelt.nrw.de/umwelt/wirtschaft\\_umwelt/nachhaltiges/effizienz\\_agentur](http://www.umwelt.nrw.de/umwelt/wirtschaft_umwelt/nachhaltiges/effizienz_agentur) (30 May 2014).

<sup>11</sup> <http://www.umweltinnovationsprogramm.de/Materialeffizienz> (30 May 2014).

<sup>12</sup> <https://www.innovateuk.org> (30 May 2014).

wages in the EU relative to the ECA and MENA regions, it can be assumed that the German example is a rather high threshold for labour costs elsewhere. Thus, labour costs in the ECA and MENA regions might be even lower compared to Germany. For example, the Russian ferrous foundry industry has 92% lower labour costs compared to the comparable German industry and also reveals lower labour productivity (IFC, 2010). However, the relevance of material input costs relative to other costs depends on the specifics of each sector (UNEP, 2014).

(iii) Macroeconomic costs: Moreover, there is one important secondary effect, which applies to resource-exporting countries: the *resource curse*. This concept states that countries with high resource endowments not only fail to benefit from these resources, but also may even incur substantial economic and social costs. This is often due to lacking institutions (formal and informal), concentrated ownership structures of the resources, prioritising consumption over long-term growth-enhancing investments, not-functioning redistribution schemes among other decisive factors (McKinsey Global Institute, 2013b) or a lack of transparency within the industry (Corrigan, 2014).

One aspect of the *resource curse* can fairly be connected to resource efficiency – even if the extent might be debatable. Once a resource-exporting economy becomes more efficient in e.g. extraction of materials, *ceteris paribus* it could export relatively more resources. If the export of materials is a very important part of that country's economic structure (compare Figure 10), resource efficiency could increase the country's exchange rate (Dutch Disease) and potentially alter a country's growth path (Davis, 1995). Once the material sector exports more due to higher efficiency rates, it could supply more products to the world market. Since the prices for materials are set internationally, the real exchange rate would increase. This could result in making it more expensive for other sectors to export.

Moreover, if one also takes into account that labour will shift to the material sector, the material sector would boom whereas other sectors such as the industrial sector would contract (Gylfason, Herbertsson, & Zoega, 1999). The dependency of the economy with regards to materials could further increase, as the material sector would become even stronger. As discussed above, this dependency does not necessarily have negative consequences provided that strong institutions are in place (World Bank, 2014). Also, the effect becomes only significant once the material sector would be very strong and the efficiency gains high. The already mentioned rebound effect could further exacerbate such macroeconomic costs.

**Economic benefits from investments in resource efficiency:** The section discusses following benefits from resource efficiency investments: (i) Reduced uncertainty of resource price fluctuations (i.e. hedging), (ii) improvements for competitiveness, (iii) increased innovation (including spillovers), and (iv) reduced environmental and social liability (i.e. corporate image).

(i) Reducing the uncertainty of resource price fluctuations: For a resource-importing country and resource-purchasing firm, increasing resource efficiency *ceteris paribus* means that less

resource have to be purchased, which also decreases its dependency on such imports (ECSIP Consortium, 2013). This could decrease the absolute and relative exposure of an economy to resource imports and could thereby improve the balance of trade (Schmidt & Schneider, 2010). Thus, price fluctuations will have a relatively lower (negative) effect on the economy – one form of hedging against such uncertainty. Therefore, investment decisions become more likely to take place as the expected net present value increases or the discount rate decreases.

For a resource-exporting country or resource-selling firm, the reverse effect might be true. Since efficiency gains allow exporting countries to export/sell more resources, they can benefit from higher revenues. These increased benefits could be collected in sovereign wealth funds (Hamilton & Hartwick, 2005; Hartwick, 1977). The Hartwick Rule provides a framework for spending profits from non-renewable resources, which the *Statens pensjonsfond* in Norway is a prominent example of. The idea is to initiate capital investments to trigger co-benefits such as long-term growth enhancing investments in human capital, institutions, and infrastructure. Thus, increasing resource efficiency can entail not only primary but also secondary benefits and therefore contribute to mitigate the *resource curse*.

(ii) Improvements for competitiveness: Resource efficiency could increase the competitiveness of (a) economies and (b) firms. The rationale is that by becoming more productive, implementing new technology, and triggering innovations, economies and firms become more competitive on the world stage (Bleischwitz et al., 2009, Chapter 10; European Commission, 2011c).

(a) Considering economies, increased resource efficiency may strengthen their competitiveness, by generally stabilising their macroeconomic environment. A study focusing on Germany models a policy induced increase in resource efficiency until 2030 and divides such policy measures into three categories (Distelkamp, Meyer, & Meyer, 2010). Firstly, economic instruments (i.e. substituting income with resource taxes) heavily reduce material consumption with only little negative impact on GDP and employment. Secondly, information instruments (i.e. *best practise* campaigns for firms) allow GDP and employment to substantially increase and material consumption to decrease. Thirdly, regulation instruments (i.e. recycling rules) cause minor positive effects on GDP and employment, but a major decrease in material consumption. Combining all three instruments, material productivity would double between 2010 and 2030. There are positive effects on GDP (+14%), employment (+1.9%), public debt (–11%) and a reduction of material consumption (TMR –20%). Such effects are the upper threshold and can therefore be referred to as the potential for efficiency gains. Noteworthy is that economy-wide rebound effects are included and substantial, but nevertheless lower than the efficiency gains (Meyer et al., 2011).

A similar EU-wide study using a variety of different methodologies finds similar positive macroeconomic impacts of resource efficiency improvements until 2030 such as a reduction of resource use by 17-25% (compared to the baseline scenario), increase in real GDP between 2 and 3.3%, and real labour income increases combined with a creation of up to 2.6 million jobs (Meyer, 2011).

(b) Considering firms, looking at investment decisions of SMEs in the EU reveals a generally positive attitude towards resource efficiency, as it seems to increase their competitiveness. Competitiveness gains for firms could result from lowering negative impacts of resource price fluctuations, lowering production costs, increasing innovative activity, and an increased corporate image.

A recent study considered the tangible benefits from EU-27 firms in the food and drink manufacturing, fabricated metal products, and hospitality and food services sector from introducing resource efficiency measures (AMEC & Bio IS, 2013). Resource efficiency in the scope of the study entailed a reduction of waste generation, water use, and material use. The average net benefit (after subtracting the investments costs) for firms is between 10% and 17% of annual turnover. This accounts for €27,500 – €424,000 reflecting heterogeneous firm sectors and sizes, whereas SMEs gain relatively more from such investments. Thus, resource efficiency provides a steady annual income stream with often only a single up-front cost.

Even if SMEs in the EU-28 are not fully comparable with SMEs in the ECA and MENA regions, it provides general evidence for competitiveness gains by reducing their production costs (Figure 12) – once a resource efficiency investment has been taken. These results are in line with the analysis of the report. Such investments are for about two-thirds of SMEs in the EU-28 are equal or lower than 5% of their annual turnover (Eurobarometer 2013).

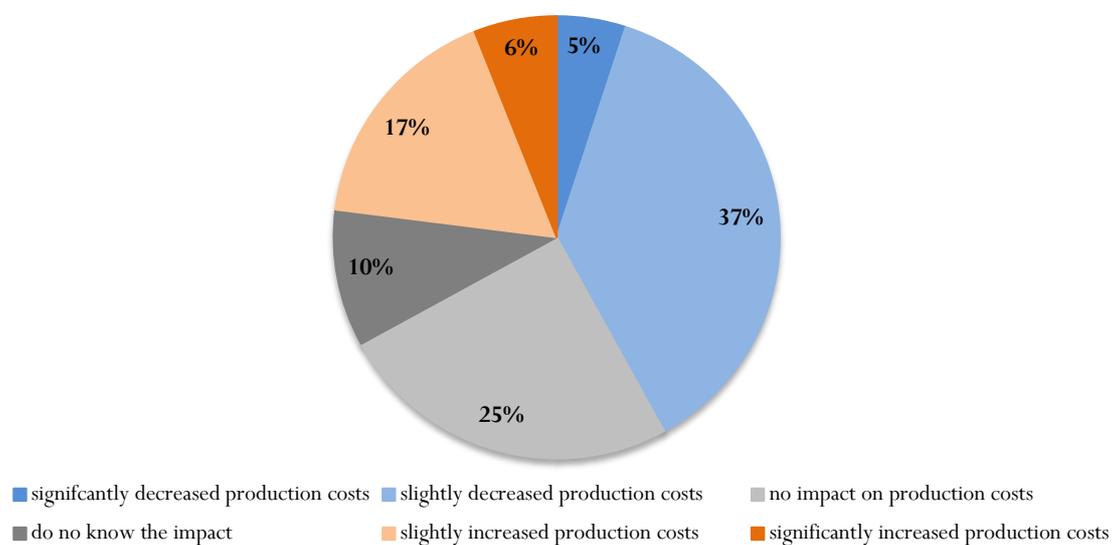


Figure 112 shows the impact of investments in resource efficiency on production costs of 10,511 SMEs in the EU-28, which took at least one resource efficiency action. The question asked: “What impact have the undertaken resource efficiency actions had on the production costs over the past two years?”. Source: Eurobarometer 2013.

Decomposing the results above reveals that in most cases there is a reduction in production costs, especially for large SMEs (50-249 employees) and SMEs in the manufacturing sector, 54% and 50% respectively (Table 6). The survey also compares the experiences of EU-SMEs with those of the ECA and MENA regions. Especially Russia (58%), Turkey (52%), and

Macedonia (61%) show a higher percentage of firms for which their production costs has decreased after investing in resource efficiency relative to the EU-28. Potentially, this may hint at the existence of a threshold up to which investments in resource efficiency are economically sound. As shown in Table 2, there is a gap between the ECA and MENA regions and highly efficient countries, which might indicate such a threshold. This could mean that developed countries might be close to the efficiency frontier and therefore increase their efficiency gains by a slower rate compared to economies that are further away from such a frontier (catch-up). Such a scenario cannot be supported for all countries (Table 2). A recent EU-study suggests that the increase of material productivity beyond 2.5% *per annum* in the EU would lead to net GDP losses as the abatement costs exceed the efficiency gains (European Commission, 2014). Thus, there might also be a threshold in pace of moving towards material efficiency.

<b>Impact of resource efficiency</b>	<b>Decreased production costs</b>	<b>Increased production costs</b>	<b>No impact on production costs</b>	<b>Do not know the impact</b>
<i>EU-28</i>	42%	23%	25%	10%
<i>USA</i>	39%	29%	23%	9%
<i>Germany</i>	37%	24%	23%	16%
<i>Russia</i>	58%	22%	14%	6%
<i>Turkey</i>	52%	34%	7%	7%
<i>Poland</i>	39%	21%	29%	11%
<i>Macedonia</i>	61%	19%	18%	2%
<i>Albania</i>	34%	20%	18%	28%
<b>Company size</b>				
<i>1-9</i>	41%	22%	27%	10%
<i>10-49</i>	44%	25%	20%	11%
<i>50-249</i>	54%	22%	13%	11%
<b>Sector groups</b>				
<i>Manufacturing</i>	50%	25%	17%	8%
<i>Retail</i>	38%	23%	26%	13%
<i>Services</i>	45%	19%	27%	9%
<i>Industry</i>	40%	27%	23%	10%

Table 6 decomposes the results from 10,511 SMEs from Figure 12 into company size (number of employees) and sector groups (NACE). The sector groups are manufacturing (C), retail (G), services (I,J,K,H,L,M), and industry (B,D,E,F). It also compares the EU-28 with other countries for which a total sample of 12,343 SMEs was taken. Source: Eurobarometer 2013.

Reducing production costs is particularly important when it comes to materials. Prices of raw materials are thus a crucial factor for the business performance (Inverto, 2014). The reason is that materials make up a high share of total costs firms have to bear. As mentioned above, in the German manufacturing industry, material costs in terms of their purchasing costs as percentage of gross production value account for 45.3% (KfW Bankengruppe, 2009; Statistisches Bundesamt, 2011, p. 372). For some sectors within the manufacturing industry, namely the

automobile and machinery sector, materials account for more than 50%. On a EU-level, material costs account for similar levels and are specifically outlined in Table 7. For 27% of all companies in the manufacturing sector, materials account for more than 50% of total costs. Generally, for more than half of the EU-27 companies, material costs make up more than 30% of their overall expenses. Such material costs do not only include the cost of the raw materials, but all upstream labour, transportation, and storage costs. However, they vary between EU-countries. For instance, in France *only* 38% of the firms state that their material costs account for more than 30% of total costs, whereas in Poland it is 73% of the firms (Eurobarometer, 2011).

<i>Material costs as share of total costs</i>	<10%	10-29%	30-49%	>50%	NA
<b>EU-27</b>	9%	25%	31%	24%	11%
<b>Company size</b>					
<i>10-49</i>	10%	25%	31%	23%	11%
<i>&gt;50</i>	7%	25%	30%	26%	12%
<b>Activity</b>					
<i>Agriculture/fishing</i>	9%	28%	31%	23%	9%
<i>Construction</i>	10%	24%	33%	24%	9%
<i>Water supply &amp; waste management</i>	29%	19%	13%	14%	25%
<i>Manufacturing</i>	8%	24%	32%	27%	9%
<i>Food services</i>	10%	39%	22%	10%	19%

Table 7 decomposes the cost of materials as a percentage of a companies' total costs. The total sample consists of 5,222 SMEs in the EU-27. The question asked: "What percentage of your company's total cost - i.e. gross production value - is material cost? Material cost is the cost of all materials used to manufacture a product or perform a service." Source: (Eurobarometer, 2011).

Thus, resource efficiency (in the production process) reduces production cost and generates a substantial saving potential. One study assumes that the internal rate of return exceeds 10% for approximately 70% of all resource productivity opportunities (McKinsey Global Institute, 2011). There is evidence that the energy and resource efficiency enhancing investments contribute substantially to a firm's economic success (Rennings & Rammer, 2009). R&D budgets, research and innovation infrastructure, and economic proximity to other firms are necessary for a firm to benefit from efficiency-enhancing innovations.

Additional evidence suggests payback periods for material efficiency measures of less than six months. Average savings have been estimated in the order 7-8% of material costs for German SMEs in the manufacturing sector (Fh-ISI, Wuppertal Institute, & Arthur D. Little GmbH, 2005; Schröter, Lerch, & Jäger, 2011). Most of such costs saving potentials are not the direct material purchasing costs, but rather *hidden costs* (i.e. disposal, transportation, production, energy, etc.) (Schmidt & Schneider, 2010). For the UK, the estimated saving potential of become resource efficient for firms is GPD 23 billion in 2009 (GDP 18 billion for waste

prevention) with pay-back periods of less than 12 months (Oakdene Hollins, 2011; OECD, 2011).

Moreover, such gains from resource efficiency investments are also important for future investments. Two-thirds of all companies have experienced an increase in material costs over the last 5 years. This trend is likely to increase even further, as 87% expect an additional increase of material costs in the coming 5-10 year (Eurobarometer, 2011). Hence, empirical evidence seems to suggest that typically there are indeed net benefits from investing in resource efficiency.

(iii) Increased innovation: Innovations can give early adopters a first-mover-advantage and also reduce costs for late-adopters. Positive macroeconomic effects of material efficiency innovations on growth, employment, and competitiveness are particularly pronounced if first-mover advantages can be established (Walz, 2011). Early adopters enjoy an additional cost advantage over their competitors until the innovation is being diffused throughout the market and every firm shares the same cost reduction. The profits being made during this time can trigger further investments in innovations and thereby rewarding the initial investments and financial institutions providing loans (spillovers).

These innovations can also break up lock-ins if their benefits surpass the switching costs mentioned above (POLFREE, 2013). Thus, the benefits from resource efficiency investments allow firms to invest in additional areas. It also sets a positive example within the firm and therefore could support the firm-internal incentive, capacity, and organisational structure for future innovative activity. Such co-benefits are also possible and could take the form of revising the management structure, enhancing transparency, additionally investing in education of the staff, paying higher wages to attract skilled workers, and thereby initiating further investments – a virtuous circle, which has been demonstrated in economic models e.g. for the EU and for Germany (Meyer, 2011).

(iv) Reducing environmental and social liability: Firms operate in a social sphere. As environmental concerns gain increasing importance on the political and social agendas, it is likely that environmental regulation will become more pronounced in the future. Introducing measures against negative environmental impacts before they become mandatory, could be another first-mover advantage and could reduce current as well as environmental liability. Therefore, investing in resource efficiency has a clear benefit. Firm-level evidence suggests that resource efficiency investments are partly due to anticipating future changes in environmental regulation (12% in the EU-27, 27% in the UK, 16% in Turkey, and 20% in Russia) (Eurobarometer, 2012)

Also, for some industries (i.e. extractive industry), *social licensing* is crucial and puts societal as well as economic pressure on firms (Gunningham, Kagan, & Thornton, 2004). Coping with such pressure by reconsidering the relationship between firms and local governments, and investing in local communities (i.e. infrastructure, employment, compensation for reallocation, etc.) can be profitable for firms in the long-term (McKinsey Global Institute, 2013b) by increasing the corporate image and providing innovative products (Ecorys, 2011). These are

some reasons why firms sometimes voluntarily go beyond current environmental regulation. The number of firms is substantial, as 11% in the EU-28, 13% in Germany, 9% in Russia, and 16% in Turkey go beyond current regulation (Eurobarometer, 2013). Resource efficiency can be one of such measures to decreasing a firm's environmental and social liability since environmental impacts can be reduced through efficiency gains. Additionally, new innovative products and processes triggered by investments in resource efficiency can thus increase the economic performance of a firm also by increasing its corporate image.

### 3.3. Political implications

#### Key messages

- *Costs in the business-as-usual scenario:* Resource dependency could result in geopolitical costs (e.g. supply restrictions, decreasing bargaining power) once disputes arise.
- *Benefits in the business-as-usual scenario:* Avoiding costs (i.e. decreasing support for future investments) upon investment failures.
- *Costs from investing in resource efficiency:* Costs of implementation (i.e. regulatory capture), the provision of financial capital, and opportunity costs (i.e. investing in education, health).
- *Benefits from investing in resource efficiency:* Reduced geopolitical dependency, improved fiscal stance due to efficiency gains and lower exposure to price volatility, and political credibility towards tackling environmental issues (i.e. long-term commitment).

Even if political aspects are difficult to quantify in monetary terms, they play an important role in strategic decisions of countries and their incentives for a resource efficiency agenda. This goes beyond governments *just* providing financial support to firms, but also focuses on policies to either increase the benefits or reduce barriers and costs from investments in resource efficiency.

The term 'political' focuses on the implication of resource efficiency investments on governments. However, part of those implications go beyond governments and includes non-governmental actors and private individuals. It is important to acknowledge that the 'government' as one entity does not exist. In reality, the governmental sphere is a combination of heterogeneous actors (i.e. politicians, administration, political parties, etc.). For the scope of this cost-benefit narrative, such a simplifying assumption does not affect the main conclusions outlined below.

**Political costs in the business-as-usual scenario:** There are generally two main costs in a business-as-usual scenario; (i) geopolitical dependency and (ii) instability as a possible secondary effect.

**(i) Geopolitical dependency:** Once a country is a net resource importer, not investing in resource efficiency results in not reducing existing resource dependency to the extent possible. Thus, such persisting dependency can impose significant costs once negative impacts generated by volatile prices unfold (e.g. increasing investment uncertainty, fluctuating subsidy costs). Additionally, this reliance on resource inputs could result in geopolitical costs (e.g. supply

restrictions) once regional or international disputes arise and no alternative sources are feasible in the short-term. An insecure access to affordable resources might become an obstacle to economic growth.

This could decrease the political bargaining power of a country internationally. For an assessment of such vulnerabilities, it is necessary to look beyond individual resources and consider the interconnections of resources as well (Bleischwitz et al., 2013).

(ii) Instability: Domestically, such geopolitical dependency could result in lacking support for the political system. Especially if resource prices become volatile, they put pressure on the fiscal stance of a country once prices are guaranteed through for instance domestic subsidies (IMF 2013). The money spent on such subsidies thus cannot be invested in alternatives (e.g. education, health care, infrastructure, etc.). This could undermine public support for the political system causing instability. Generally, economic growth requires political stability (Feng, 1997).

**Political benefits in the business-as-usual scenario:** There are two main issues, namely (i) no implementation costs of resource efficiency initiatives (i.e. policies and financial support), and (ii) no political costs due to investment failures.

(i) No implementation costs: Identifying, negotiating, and implementing policies are always costly in terms of financial support as well as administrative costs (i.e. capacity building). This is also the case for resource efficiency policies. Such policies often include instruments to financially support resource efficiency investments (European Environmental Agency, 2011b). Financial support can be direct (i.e. providing loans) and indirect (i.e. tax reduction, support of capacity building). Direct provision of financial capital might be criticised by the public, as popular alternative investments receive relatively fewer funds. Not investing in resource efficiency might thus help to channel investments into areas of higher political priority (i.e. social benefit system) or higher certainty of beneficial returns (i.e. certain infrastructure investments). All such costs from investing in resource efficiency are being avoided in the business-as-usual scenario.

(ii) No political costs upon failure: Changing the *status quo* produces winners and losers, which often are often unknown *ex ante* (UNIDO, 2011). This could lead to a 'system lock-in' in which changing existing processes becomes difficult making progress towards resource efficiency difficult (UNEP IRP, 2014). Given those heterogeneous interests between winners and losers, compromises could potentially result in insufficient implementation of resource efficiency measures and hinder the success of such investments. Such indecisive policy-making might make investments more costly and increases the probability of their failure (UNEP IRP, 2014). Once failure occurs, political costs (i.e. loss of trust, reputational disadvantage) arise. Therefore, not investing in resource efficiency results in the benefit of not facing such costs upon investment failures.

**Political costs from investments in resource efficiency:** There are three aspects: (i) Political risks of providing financial support (i.e. regulatory capture), (ii) provision of capital, and (iii) opportunity costs.

(i) Political risks of providing financial support: Once governments provide direct financial support or implement policies facilitating investments in resource efficiency, potential winners and losers of such measures will bid for their share of the available financial resources. If the allocation of the financial support is not transparently tendered giving all firms equal opportunity to participate and receive funding, inefficient allocation and thus costs potentially arise.

Since firms will try to influence the allocation of such funds, regulatory capture (i.e. the regulator not acting in the public interest) is a possible government failure. The resulting negative impacts include that investments may not be implemented where the highest potential for resource efficiency gains exists. Thus, there is a political risk in providing such funds, a risk which is not specifically to resource efficiency investments, but governmental support in general.

(ii) Provision of capital: Financial costs for governments arise when they provide funding for investments in resource efficiency. Such costs can take different forms such as direct through for instance financially supporting the development of efficiency-enhancing technologies or indirect through for instance funding R&D for resource efficiency improvements. These support mechanisms are costs associated with investments in resource efficiency and depend on the amount of all direct and indirect supporting measures.

(iii) Opportunity costs: Opportunity costs arise for governments when deciding to invest in resource efficiency. Depending on the political priorities as well as financial stance, it might be more appropriate for an economy to support other policy areas (i.e. social policies) instead of attempting to improve resource efficiency. Incentives for alternative priorities are crucial. Especially given short political cycles, it might be more opportune for politicians to invest in projects with short-term and visible payoffs rather than in invisible long-term savings of materials. Therefore, providing financial assistance for resource efficiency might entail high opportunity costs.

**Political benefits from investments in resource efficiency:** There are three main benefits, (i) decreased geopolitical dependency, and (ii) improved fiscal stance for both, resource importing and exporting economies, and (iii) political credibility through tackling environmental issues.

(i) Decreased geopolitical dependency: In analogy to the political costs of the business-as-usual scenario, investing in resource efficiency for net importing economies can help to reduce geopolitical dependencies (ECSIP Consortium, 2013). Thus, a country less dependent on foreign resource supply may increase its political bargaining power internationally and its political support domestically. Given that a potential rebound effect does not overcompensate

such efficiency improvements, economies are also less exposed to price fluctuations and thus volatile input prices.

This is especially important once the interlinkages between resources are also considered. A recent paper identifies Libya and Algeria at high risk for causing global resource supply disruptions (mainly for gas), and Egypt, Morocco, Kazakhstan (fossil fuels and metals), and Russia as relevant risk countries (Bleischwitz et al., 2013). Therefore, resource efficiency might be one solution for resource importing economies to protect themselves from such vulnerabilities.

(ii) Improved fiscal stance: Once resource revenues account for a significant amount of a country's GDP, improved resource efficiency is likely to strengthen fiscal stance for (a) importing and (b) exporting countries.

(a) For resource-importing countries, lower import quantities due to efficiency gains helps to improve their trade balance (McKinsey Global Institute, 2011). Therefore, the economy does not have to import as many resource inputs, which in turn means higher savings/investments. If a country guarantees a certain price level of resources through subsidies, improved efficiency also reduces the cost of maintaining a subsidy system, independent from price fluctuations on the world markets. Generally, this improves the fiscal stance of a country.

(b) For resource-exporting countries, resource efficiency improvements in the exporting sectors could result in (slightly) higher exports, thus resulting in higher income. However, it could also increase its dependency on resource exports. In order to avoid the negative impacts associated with dependency, strong institutions are required (World Bank, 2014). For instance, improving institutional capacity can help to overcome the *resource curse* (McKinsey Global Institute, 2013b; Mehlum et al., 2006). Therefore, benefiting from resource efficiency in fiscal terms for exporting countries also depends on several other issues besides resource efficiency.

(iii) Political credibility through tackling environmental issues: Environmental policies are usually long-term oriented, as they might have few visible benefits in the short-term. However, they are crucial in the long run. Thus, such policies require long-term political commitment, even across legislative periods. Policies and investments in resource efficiency considered to combine economic with environmental policy (Bleischwitz, 2012). As environmental concerns are rising, resource efficiency could strengthen on the one hand the credibility of the political system to tackle long-term issues, and on the other hand combine environmental and economic issues.

### 3.4. Do investments in resource efficiency deliver net benefits?

#### **Key messages**

- Some empirical evidence seems to suggest net benefits from investing in resource efficiency.

- However, it would be misleading to draw universal conclusions, as a case-by-case analysis is necessary taking project specific circumstances into account.
- Whether or not there are net benefits also depends on expectations about future resource prices.

In summary, this chapter has identified key costs and benefits for firms and entire economies of investing in resource efficiency and compared them with a business-as-usual scenario. There are no definite and universally valid conclusions possible, as to whether the environmental, economic and political costs always outweigh the benefits. However, some empirical evidence outlined throughout all three dimensions of the cost-benefit narrative seems to suggest that typically there are indeed net benefits from investing in resource efficiency.

One important bottleneck of drawing more general conclusions is a lack of reliable and comprehensive firm-level data concerning resource efficiency developments (also in the ECA and MENA regions). This makes a case-to-case evaluation of resource efficiency projects necessary in order to assess their cost-effectiveness (Oakdene Hollins, 2011). A project specific analysis takes into account firm specific circumstances as well as the general investment environment. Every individual cost and benefit discussed throughout this chapter can be used as a ‘guideline’ for an investment specific cost-benefit analysis. After conducting such an analysis in accordance to those ‘guidelines’ and comparing all individual costs and benefits, project specific conclusions can be drawn.

Whether or not an investment in resource efficiency provides net benefits also depends on expectations about future resource prices. A sensitivity analysis according to such expectations is particularly important in terms of price levels and price volatility. Future price volatility may be a ‘double-edged sword’. On the one hand, it incentivises investments in resource efficiency since it is one measure to reduce the dependency on resources with volatile prices (i.e. hedging). On the other hand, price volatility increases the uncertainty of future payoffs, thus decreasing incentives to invest. The higher resource prices are in levels, the more profitable resource efficiency measures will become, as a given reduction in resource use delivers relatively higher cost savings.

Evidently, future resource prices are uncertain, but several studies suggest them to remain volatile and – on average – high in the future (Chatham House, 2012; Inverto, 2014; McKinsey Global Institute, 2013b). Thus, the probability of resource efficiency investments yielding net benefits is likely to remain in the future. Future price determination requires firms to form expectations about future resource supply and demand, which among others depend on future growth paths, technical innovations, political stability, and policy coherence (AMEC & Bio IS, 2013). Furthermore, firms already invested in the most profitable resource efficiency measures might not invest in more risky areas (decreasing marginal returns).

Finally, even if a project specific cost-benefit analysis predicts net benefits from an investment in resource efficiency, they may not materialise in practise. Besides general risks, investment barriers and market inefficiencies could prevent net benefits from resource efficiency measures. Thus, assessing whether an investment has net benefits not only depends on the project specific costs and benefits, but also on the constraints and barriers in the wider investment environment, which will be evaluated in the next chapter.

## 4. Barriers to resource efficiency investments

Cost benefits analyses and appraisals of specific investments in resource efficiency may (or may not) conclude that a project is likely to deliver positive net benefits. However, the path to successful implementation is in practice beset with numerous investment barriers, which may mean that investments do not deliver the anticipated resource efficiency gains, or that they are not undertaken at all.

### Key messages

- The factors which cause inefficient resource use are diverse and interlinked. They are typically related to information, capacity, and financial constraints, uncompetitive market structures, or financial mis-management.
- The associated market and government failures can constitute substantial barriers to investment in resource efficiency, and provide the rationale for efficiency enhancing market interventions.

In practice, resource markets are characterised by inefficiency: in many countries resource productivity remains low, and valuable resources are wasted despite the existence of cost-effective recycling technologies. The factors, which cause and perpetuate such inefficiencies, are commonly found in the areas of (i) information availability and access, (ii) technical, managerial, and institutional capacity, (iii) financial markets, (iv) market structure and competition, and (v) public policy and regulation, especially in the fiscal area. These drivers of inefficiencies are often interlinked and reinforce each other. For instance, the lack of information can lead to an overly negative risk assessment of efficiency enhancing investments, thus making access to credit even more difficult than it might already be.<sup>13</sup>

In many cases the drivers of inefficiency can be traced back to market failures or inadequate public policy (leading to government failures). Leading to distorted incentives, and perpetuating pre-existing inefficiencies, they can constitute substantial barriers to investments into resource efficiency – even if these investments are found to be cost-effective.

In addition, systemic risks and uncertainty can prevent forward looking investment decisions and lead to policy myopia. While such uncertainty can materialise in different forms (e.g. commodity prices, macroeconomic fundamentals, or socio-political conditions), it commonly results in risk averseness and reduced planning horizons. For instance, increased volatility of resource prices increases the perceived uncertainty surrounding future price developments – this in turn can have a substantial impact on the payback periods of resource related investments and thus lead to postponing investment decisions.

*Inaction can lead to lock-in and path dependency.* If no actions are taken to address the above causes of inefficient resource use and investment barriers, the accumulation of new productive capital is likely to be characterised by inefficiency. Such infrastructure then pre-determines and possibly restricts investment and innovation options available in the future. Such so called ‘path dependence’ can even result in a lock-in situation, in which costs associated with pre-existing

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<sup>13</sup> The analysis presented in Chapter 4 builds on the framework presented in Chapter 2 of the World Development Report 2014 (World Bank, 2013) and Hallegatte & Rentschler (forthcoming).

inefficiency prevent any future investments into efficiency and innovation. Thus it must be taken into account that investment barriers not only cause underinvestment in the present, but also limit the investment opportunities and possible efficiency gains in the future. This is particularly true for long-lived physical infrastructure, such as production facilities, transportation systems, etc.

Barriers to Investments in Resource Efficiency					
Investment barriers at the firm or government level	Information constraints	Capacity constraints	Financial constraints	Market structures	Fiscal mismanagement
	<ul style="list-style-type: none"> <li>Limited information on scale and type of inefficiencies (monitoring &amp; disclosure)</li> <li>Limited information on solutions (access &amp; dissemination)</li> </ul>	<ul style="list-style-type: none"> <li>Technical capacity</li> <li>Managerial capacity</li> <li>Institutional capacity</li> <li>Lacking awareness &amp; Individual biases</li> </ul>	<ul style="list-style-type: none"> <li>Uncertain payoffs hamper financing (e.g. due to lacking information)</li> <li>Non-monetary benefits not accounted for (externalities)</li> <li>Inadequate credit markets</li> </ul>	<ul style="list-style-type: none"> <li>Lack of competition</li> <li>Protected industries</li> <li>Trade protectionism</li> </ul>	<ul style="list-style-type: none"> <li>Subsidies incentivising inefficiency</li> <li>Lacking environmental regulation and enforcement (e.g. taxes &amp; tariffs)</li> </ul>
Systemic risks & uncertainty	<ul style="list-style-type: none"> <li>Commodity price volatility</li> <li>Economic, political and social stability</li> <li>Policy reliability</li> </ul> <p style="text-align: right;">} Can exacerbate existing barriers.</p>				

**Table 8.** Barriers to efficiency investments: Underinvestment in resource efficiency can be due to various market or government failures. Barriers extend from the individual level, to firms and governments. Systemic risks and uncertainty do not necessarily cause inefficiency – but they may exacerbate the adverse effects of existing barriers.

#### 4.1. Competitive Markets, Market Failures, and the Rationale for Intervention

Key messages
<ul style="list-style-type: none"> <li>The First Fundamental Welfare Theorem suggests <i>perfectly competitive markets</i> as a hypothetical benchmark for investigating the efficiency of actual market outcomes.</li> <li>The hypothetical case of perfectly efficient markets is based on various assumptions, including perfect information and no barriers to market entry. Market failures and inefficiencies result from the violation of any of these assumptions.</li> <li>Most causes of inefficient resource use can be related to these violated assumptions.</li> <li>The Second Fundamental Welfare Theorem states that <i>market interventions</i> can have an efficiency enhancing effect.</li> </ul>

At the heart of the microeconomic theory of competitive markets are the *First and Second Fundamental Welfare Theorems*<sup>14</sup>. Roughly speaking, the First Theorem suggests perfectly competitive markets as a hypothetical benchmark for investigating actual market outcomes. Such perfectly competitive markets are based on several assumptions, including:

- 1) *Perfect information*, i.e. unrestricted, public knowledge of price and quality of products
- 2) *Large number of producers and consumers*, i.e. no oligo-, or monopolistic markets
- 3) *No barriers to market entry (or exit)*
- 4) *Perfect factor mobility*, and zero transaction costs
- 5) *Absence of externalities*, i.e. no third-party impacts of economic actions

If all these assumptions of perfect competition are fulfilled, the resulting economic allocation is *Pareto efficient*. While Pareto efficiency does not inform about the distributional equity of a given resource allocation, it does imply that there is no waste in the allocation – as such it is a minimal notion of economic efficiency. This also means that *waste* is a symptom of inefficiency: less efficient production processes are associated with more waste, i.e. a higher share of resources is not used productively.

*Market failures* result from the violation of any of the above assumptions, and are ubiquitous in practice. To name a few of such violations: Information constraints can lead to inefficient decision making (see Section 4.2). Insufficient investment in human capital (e.g. staff training and education) can constrain technical capacity and the ability to act on available information (see Section 4.3). Missing or inefficient markets (e.g. for credit) can constrain the implementation of positive net present value projects (see Section 4.4). Other missing markets (e.g. for carbon) can lead to severe externalities and excess waste (see Section 3.1). Large firms and protected industries face little competitive pressures to invest in efficiency gains (see Section 4.5). Physical production infrastructure tends to be difficult and expensive to adjust to frequently changing market conditions, leading to long-term technology lock-in. In practice, the violation of above assumptions is often to a fair extent due to inadequate policy making and regulation. However on the flipside, the Second Welfare Theorem states that market interventions (e.g. by governments) can theoretically play an important positive role by redistributing resources and improving the Pareto efficiency of a given economic allocation. In practice however, the government's role can also be negative, if public policy provides perverse incentives (e.g. by subsidising inefficient behaviour) which perpetuates inefficiencies (see Section 4.6).

The remainder of Chapter 4 will focus particularly on those barriers at the firm level, which are of direct relevance to resource efficiency investments. Table 9 outlines these barriers, and describes how they each potentially obstruct improvements of resource efficiency. However, it must also be acknowledged that the causes of inefficiency (outlined in Table 8) span a wider field. In fact, many of these causes can be seen as factors, which affect the investment environment for firms more generally. This implies that these barriers may not be directly linked to resource efficiency investments, but can play a significant role in obstructing them nevertheless. Thus, this chapter will also acknowledge these broader factors.

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<sup>14</sup> For details see Mas-Colell, Whinston & Green (1995).

Direct Barriers to Resource Efficiency at the Firm Level		
Type of constraint	Barrier	Consequence for resource efficiency
Imperfect information	Limited access to information, e.g. on technology from abroad	→ Hampers ability to identify cost-effective investments. → Effectiveness of projects cannot be maximised.
	Inadequate information disclosure by firms (e.g. on resource efficiency, or criticality of material supplies)	→ No benchmarking possible. → Targeted policies and regulations cannot be designed. → Hampers ability of banks to assess profitability of resource efficiency project
	Lacking/insufficient monitoring of resource efficiency performance	→ Prevents identification of cost-effective investments. → Prevents performance tracking over time.
Capacity constraints	Lack of technical capacity within firms	→ Technology cannot be adequately installed, operated, and maintained. → Firms cannot identify efficiency gaps and solutions, and external consultants may be costly/unavailable
Financing constraints	Non-monetary benefits of resource efficiency investments	→ Resource efficiency investments may yield non-monetary benefits (e.g. addressing externalities), which do not increase their commercial attractiveness.
	Uncertain payoff structure of investments	→ Volatile resource prices make it difficult to evaluate the payoffs from longer term investments in resource efficiency. → Lacking information on profitability, reliability, maintenance costs etc. of resource efficiency projects increases the perceived financial risk. → Resource efficiency investments may be considered non-essential and risky (potentially leading to high lending rates).
Constrained competition	Lacking competitive pressures	→ Lacking incentives to innovate and cut costs by improving (resource) efficiency → Resource efficiency measures taken by one firm are less likely to be adopted by competitors.
Fiscal disincentives	Energy, resource and industry subsidies	→ Distorting prices, thus incentivising inefficient use of energy-intensive resources, and reducing incentives for increasing efficiency → Artificially increase competitiveness of energy-intensive firms and perpetuates inefficiencies
	Lacking landfill taxes and waste tariffs	→ Discourage investments in waste minimisation and recycling

Table 9 Summary of direct barriers to resource efficiency.

## 4.2. Information constraints

### Key messages

- Limited *access* to information (e.g. on technologies) prevents firms from identifying and maximising the potential of efficiency projects.
- Lacking *monitoring* of resource efficiency indicators can impair the identification and benchmarking of resource efficiency projects within firms.
- Lacking information *disclosure* by firms (e.g. on efficiency performance) prevents the assessment of project profitability across firms, and impairs targeted policy making. Weak *legal disclosure requirements* may make firms complacent about monitoring efficiency.

The presence of ‘imperfect’ information is a key violation of one of the central theoretical assumptions, which underlie efficient, perfectly competitive markets (see Section 4.1). In fact, information constraints and asymmetries are one of the most common obstacles to the efficiency of economic markets, including those for resources.

Also in the context of resource efficiency, certain information constraints can play a central role in causing inefficiencies and preventing investments: (i) Inadequate monitoring of resource efficiency related performance indicators at the firm level may make it difficult for firms to identify and address efficiency gaps. (ii) Lacking information disclosure on behalf of firms, makes it difficult for policy makers to design targeted policies and support mechanisms for improving resource efficiency at a wider scale. (iii) If firms cannot access relevant information on resource efficient technologies and processes, it is likely to impair their ability to implement effective resource efficiency projects.

### *Monitoring & Disclosure: Limited information on the scale and nature of resource inefficiencies*

Information constraints may refer to the lack of information on the nature and scale of the problem: Which are the most inefficient processes in a specific firm (or industry)? How inefficient are they? What is the scale of the problem, and the related consequences? Without this knowledge firms may be less able to undertake targeted investment decisions, and governments may be able to design appropriately targeted regulation. Overall this means that there are two major issues: (i) Insufficient internal (firm level) monitoring of resource efficiency performance, possibly due to insufficient information disclosure requirements prescribed by law, and (ii) insufficient information disclosure and external (industry level) monitoring, which impairs policy design.

In the EU, firm level surveys have managed to identify the key barriers, which prevent firms from improving their resource efficiency (European Commission, 2013). Such information can be important in informing and driving resource related investments and policy making by firms and governments. Also in the ECA and MENA regions such information would be critical for understanding what the main impediments to resource efficiency are. However, no such information is available, which would help to understand the exact scale and nature of inefficient resource use.

Chapter 2 has shown that former Soviet economies are particularly resource intensive, compared to other industrialised economies. As this observation holds even when considering their higher industrial share in GDP, there is evidence that resource efficiency in the industrial sector remains anything but optimal. Evidence exists for selected industries and countries, but not at a comprehensive scale: For instance, there is evidence that the Russian foundry industry is highly resource inefficient, using 3 times more energy, 3.6 times more sand, and 161 times more water than comparable EU firms (IFC, 2010) However, no such cross-sectional data exists across industries and firms in the ECA and MENA regions.

Limited data availability makes it difficult to evaluate and compare performances across firms, sectors, and regions. The lack of comprehensive, regular monitoring at the firm and household level makes it difficult to track potential improvements, and thus single out particularly successful investments. Even publically listed firms do not always monitor corporate performance data, or do not make them publically available (World Bank, 2006).

*Corporate Governance.* One reason that the monitoring of resource efficiency (and other performance indicators) is suboptimal, may be the simple lack of legal requirements to disclose such corporate information. The OECD Principles of Corporate Governance (2004) argue that an effective legal framework is critical for ensuring an industry wide practice of information disclosure. When enforced effectively, this will entail better performance monitoring at the firm level, also resulting in higher (resource) productivity (see OECD, 2004; World Bank, 2006).

The scarcity of production relevant resources can pose substantial risks to firms. In the context of climate change this risk may materialise in the form of water scarcity due to reduced precipitation in certain regions (World Bank, 2013). In order to mitigate the risks from water scarcity, firms will need to improve water efficiency. However, the monitoring and disclosure of such resource related risks remain limited. In Ukraine for instance, the law requires companies to disclose details on risks, which could affect company operations such as: political, financial, economic, production, technological, social and environmental risks (World Bank, 2006). In a series of Corporate Governance Country Assessments the World Bank has shown that throughout the ECA and MENA regions, disclosure of corporate information remains insufficient in terms of coverage and quality (World Bank, 2006; 2004; 2004). This is the case for legally required information relevant to shareholders, and even more so for information which is not mandated by law.

While the issues related to corporate governance are broad (ranging from shareholder & stakeholder rights, disclosure & transparency, to board responsibilities), the link to corporate resource efficiency is evident: Effectively enforced legal requirements are necessary in order to create a culture of monitoring and information disclosure. This will enable benchmarking, standard setting, auditing and performance monitoring with respect to resource productivity. Furthermore, Onischka et al. (2012) argue that reporting requirements on corporate resource efficiency performance and investments are critical for increasing the acceptance by firms (and banks) of resource efficiency projects. The authors also argue that in the longer term such disclosure practices can play an important role in making commercial financing of resource efficiency more accessible and affordable.

If implemented comprehensively, the benefits of performance monitoring and disclosure can extend to the macro level: As policy makers gain better understanding of deficiencies in the resource use of the private sector, they are able to design targeted policy measures and regulation. In the EU, firm level surveys have managed to identify the key barriers, which prevent firms from improving their resource efficiency (European Commission, 2013). The comprehensive “Roadmap to a Resource Efficient Europe” (European Commission, 2011), which outlines goals and policy measures for increasing resource efficiency at a large scale, critically relies on such information.

***Dissemination, access and management: Limited information on the solutions***

Information constraints are not one-directional: while information about firm level resource efficiency may be limited, firms may also struggle to access external information relevant for effective investments in resource efficiency.

Particularly in the manufacturing sector, efficiency gains in terms of resources (or energy) are commonly achieved through innovation, and the modernisation of technology and processes. However, firms are necessarily unable to improve the efficiency of resource use in their production processes, when markets (or governments) fail to provide adequate information on the costs, benefits, and methods of increasing resource efficiency.

*Corporate management of information.* A substantial body of literature shows that the management of information is a key determinant of innovation and technological change in firms. For instance, in a study of 206 manufacturing firms in Sweden, Frishammar and Hörte (2005) find that the way in which firms manage external information determines innovation and efficiency gains to a significant extent. Several activities on behalf of the firm are particularly important: (i) closely following the technological sector, (ii) fostering cross-functional integration, (iii) making decisions based on information from the industry environment.

Also, in the context of energy efficiency – a generally wider researched and better understood topic than resource efficiency – studies describe the critical role of information (e.g. see (Anderson & Newell, 2004), (Sutherland, 1991)). This is not least because energy (and resource) efficiency gains are often closely linked to technological innovation and modernisation. The knowledge about the existence, usefulness and functionality of such new technology requires effective information infrastructure, for enabling dissemination to end-users (Howarth & Andersson, 1993).

*Access to information.* Expertise and technology, which is required to address typical inefficiencies, may already exist in certain segments of the market, but be unavailable or inaccessible at a wider scale. In particular small and mediums sized enterprises (SMEs) may not have the same level of access as their larger competitors<sup>15</sup>. A recent survey by the European Commission (2013) found that close to 50% of SMEs in the EU perceive information constraints as a key obstacle to improving resource efficiency. In this context, they stated that the most useful support mechanism for improving resource efficiency would be either (i) firm

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<sup>15</sup> Section 4.4 discusses issues which are of particular relevance for large firms: Even if access to information is possible, large firms may not choose to improve resource efficiency, if they face little competition, or are state owned.

specific technical assistance (i.e. consultancy), or (ii) detailed information on technologies and processes for resource efficiency. It is reasonable to assume that firms in lower income economies face information constraints to a larger extent.



**Figure 13** Whether latest technologies (and related information) are available and accessible to firms, determines to a significant extent whether firms adopt such technologies into their operations. This figure shows availability and absorption scores (standardised, where 7 represents the maximum). In global comparison, the USA rank 6<sup>th</sup> and Kyrgyzstan 138<sup>th</sup>. (World Economic Forum , 2013)

Similar issues were confirmed by Rohdin et al. (2007): In an empirical study of the Swedish foundry industry, they show that information constraints are a key obstacle to improving energy efficiency. They identify two information constraints in particular, which can reasonably be assumed to exist in lower income economies too:

- (i) Difficulties in obtaining information about efficient technology
- (ii) Lacking information on opportunities for efficiency gains

*The need for efficiency audits.* Furthermore, Rohdin et al. (2007) find that consultants and auditors, who are knowledgeable about common efficiency issues, play a critical role in overcoming these information constraints. In fact, limited access to relevant information may be directly linked to missing markets, for instance of efficiency auditors and consultants that are able to advise firms on opportunities for efficiency gains and the necessary technologies.

The significance of such information services can be understood when considering the significant success of past information programmes. In the USA for instance, the government has financed information programmes, which aimed to increase awareness for resource efficiency and offer technical assistance. These information programs took a variety of forms including educational workshops, training programmes, advertising, or on site efficiency audits. Andersen and Newell (2004) show that in the USA such information programmes have been very successful in alerting firms of cost-effective efficiency investments, and providing technical information, which helped in reducing the risks and uncertainty, related to the adoption of new technology. They show that as a consequence of such information programmes, manufacturing firms adopted at least half of the recommended energy efficiency projects.

*Information constraints hinder effective implementation of regulation.* Along the same lines, DeCanio (1993) also emphasises the importance to provide informational services as a complement to standard regulatory instruments and technology investments. Also in the context of public regulation, the availability of and easy access to information plays a critical role. Resource efficiency targets, standards, and environmental regulation more generally cannot trigger the desired effects, if information on alternative, more efficient technology is not available. Firms, without the knowledge of effective ways to increase efficiency, will continue to operate within the existing information constraints – thus unable to realise the efficiency gains envisaged by regulators.

*Information infrastructure is a public good, which the competitive market may fail to provide.* The specific reasons for limited availability and access to information vary from case to case. Often however, they can be linked to the market failure known as the public good problem: Infrastructure for sharing and disseminating information freely and widely is considered a public good – and the private sector faces few incentives to provide them; the fear of competitive disadvantages may even cause firms to conceal information on potential efficiency gains. It is thus the government's (e.g. Ministry of Economy and Industry) responsibility to maintain infrastructure for providing information on e.g. best practices in resource efficiency (the Japanese Top Runner programme provides an interesting case study on mainstreaming industry best practice (Kimura, 2010)).

### ***Policy measures and interventions – Mitigating information constraints***

In summary, in order to address information asymmetries and constraints it is critical to understand their cause. A lack of legal disclosure requirements may cause firms to be complacent about monitoring their efficiency of performance. As a consequence there exists little information on the nature and scale of resource inefficiency. Moreover, the government may be failing to assume its responsibility of providing public goods, such as effective systems for pooling and disseminating information on resource efficiency. Thus, information constraints in the context of resource efficiency will require a case by case analysis, based on which specific actions can be taken. Generally speaking however, the above discussion highlights following information measures to be of particular importance for improving resource efficiency:

- 1) Improve the monitoring of resource efficiency at the firm level.
- 2) Improve the monitoring of resource efficiency at the industry and macro level.
- 3) Improve the access to, management and dissemination of resource efficiency related information and technology.
- 4) Improve the disclosure of resource efficiency related performance data, and introduce stricter legal disclosure requirements.

With these objectives in mind, following measures have proven successful in the past, and could constitute a starting point:

*Legal requirements for corporate governance – especially disclosure & transparency.* Corporate Governance Country Assessments conducted by the World Bank (e.g. for Ukraine, World Bank, 2006) suggest that firms throughout the Eastern Europe and Central Asia region are

making progress with respect to general information disclosure and transparency. However, significant shortcomings continue to exist, particularly in terms of quality and breadth of disclosed information.

Particularly those countries heavily relying on resource imports may have a strong incentive to introduce legally binding disclosure requirements for firms' resource efficiency indicators. In doing so, the OECD Principles of Corporate Governance (2004) can provide guidance. The potential benefits are numerous: At the government level, better understanding of efficiency gaps allows targeted policy making. Performance figures may open opportunities for benchmarking, and identifying best practice. At the firm level, stricter disclosure requirements can trigger more comprehensive monitoring, which in turn can subsequently create the basis for informed investments in resource efficiency.

*Efficiency audits.* In the EU almost 20% of (11,000 surveyed) firms state that the difficulty of identifying cost-effective resource efficiency projects is a key obstacle to improving resource efficiency (European Commission, 2013). This figure is likely to be higher in environments, where technical information and advisory services are less widely available. In this context studies show that information programmes can play a key role in helping firms to identify, plan and implement resource efficiency projects (Anderson & Newell, 2004). This constitutes an opportunity for governments and external advisors to conduct targeted efficiency audits, possibly paired with subsequent project lending.

### 4.3. Capacity constraints

#### Key messages

- Lacking *technical capacity* at the firm level impairs the ability to identify projects and install, operate and maintain modern (more resource efficient) technology.
- *Awareness* and *managerial capacity* are necessary to drive and implement resource efficiency investments.
- More generally, *institutional capacity* (e.g. administrative effectiveness) determines the broader investment environment within which resource efficiency projects are implemented.

Having access to or possessing relevant information does by no means guarantee implementation of resource efficiency measures. In fact, the capacity to process information and make (rational) decisions accordingly is another central theoretical assumption on which perfectly competitive and efficient markets are based (see Section 4.1). In practice however, capacity constraints at the individual, firm, or government level may mean that even if information exists (e.g. about the scale of existing resource inefficiencies in the production processes, or the cost-efficiency of solutions), decision makers may not be able or willing to act upon it.

This section discusses capacity constraints at the firm and institutional (i.e. government) level. It furthermore briefly outlines biases and capacity constraints at the individual level, which can influence decision making at all levels.

**Box 4.1.** Neoclassical economic theory and beyond

**Efficiency investments: Do the characteristics of firms matter?** (*Yes, they do.*)

All investments with a positive net present value (NPV) will be implemented by profit maximising firms – at least so claims standard neoclassical theory. In practice however, not all such profitable projects are implemented by firms. The literature on energy efficiency for instance provides many examples, including simple investments such as energy efficient light bulbs. Also cost-effective investments in resource efficiency are often not implemented as firms face various constraints – including capacity constraints within firms (European Commission, 2013).

In a discrete choice model, DeCanio and Watkins (1998) show that the characteristics of firms play a key role in determining whether firms implement profitable efficiency projects or not. They identify characteristics such as the number of employees, company earnings, or the industrial sector to influence decision-making. This shows that the simple availability of a positive NPV project will not ensure its implementation, if the firm is unable or unwilling to do so. In another study DeCanio et al. (2000) show that organisational structure is a key determinant for the effective adoption of innovations, and thus of efficiency and productivity gains. They emphasise that certain organisations are better adapted than others, thus enabling them to implement efficiency gains more effectively.

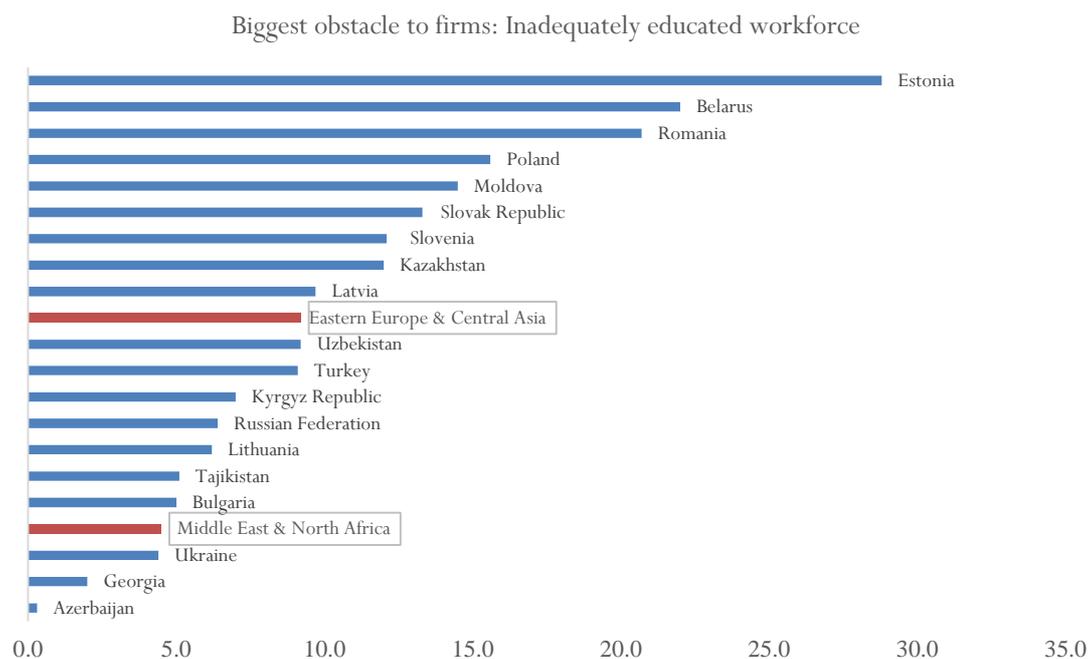
***At the firm level: Technical expertise and management capacity***

In the context of resource efficiency, technical and managerial capacity are arguably among the most important factors at the firm level to influence investment decisions and strategy. Various elements of resource efficiency investments require strong management, including: (i) Understanding the costs and benefits of resource efficiency investments, (ii) Identifying specific cost-effective opportunities for such investments, (iii) Managing the implementation and operation of new technology, without disrupting ongoing production, (iv) Identifying financing, and managing operational risks which may be associated with efficiency investments (e.g. technical faults, price risks). Overall, this makes it evident that corporate management not only needs to effectively handle innovation, operations, monitoring, financing and more, but also needs to have a technical understanding of production processes.

*Technical capacity plays a central role at the firm level in enabling resource efficiency gains: Technical capacity is essential, particularly at operational levels, in order to effectively assess, install, operate and maintain modern, efficient technology. In order to identify and prioritise opportunities for resource efficiency gains, a certain degree of technical capacity is also essential at the management level. This implies that investments in physical infrastructure (e.g. production machinery), which aim at improving resource efficiency, should be accompanied by measures to build technical expertise within firms.*

Improving resource efficiency in manufacturing firms is in many cases related to technological change. For instance, more modern and efficient machinery, advanced monitoring techniques, and adequate installation and maintenance of machinery are critical to achieving a higher degree of resource productivity. However, in order to realise such opportunities firms must possess relevant technical expertise and experience. Basic technical knowledge will help managers appreciate the importance of efficiency related investments, and the opportunities associated with them. Throughout the workforce, especially at the operational level, technical expertise is critical in order to effectively implement, operate and maintain efficient technology.

*Evidence from the EU.* According to a study for the EU, 20% of (11,000 surveyed) firms state the ‘lack of specific expertise’ to be the biggest obstacle to resource efficiency investments (European Commission, 2013). Another 17% state that ‘difficulties in identifying suitable actions’ (i.e. investment opportunities) as the reason for not being able to invest in resource efficiency (European Commission, 2013). While a direct survey of barriers to resource efficiency is not available for the ECA and MENA regions, there is evidence that firms in this region also struggle with technical capacity, even more than their EU counterparts. Thus it can be assumed that firms in the ECA and MENA regions will face similar obstacles to resource efficiency investments as their EU counterparts – possibly to a larger extent.



**Figure 14** Percentage of manufacturing firms, which state an inadequately educated workforce to be the single biggest obstacle to their operations. Note: a small percentage is not necessarily positive, as it could simply indicate that even larger obstacles exist. (Source: EBRD, 2009)

For instance, evidence from the EBRD’s (2010) Management, Organisation and Innovation (MOI) survey suggests that technical capacity, which is vital for resource efficiency improvements is a problem for firms throughout the ECA and MENA regions. Figure 14 shows that a large percentage of manufacturing firms consider an inadequately educated workforce to be the single most significant impediment to their firms’ operations. It must be acknowledged that this data represents “inadequate education” of different types, including technical and technological capacity, but also more general operational skills. However, it is safe to assume

that technical capacity, which is inadequate for existing requirements, will also be inadequate for more advanced, more efficient technology. Furthermore, it is important to note that a low percentage does not necessarily indicate that most firms perceive their workforce to be adequately educated: it may simply be the case that firms perceive other obstacles (e.g. lacking access to finance) as more significant.

*Management capacity.* Furthermore, also at the firm level, managerial capacity is critical for effectively implementing efficiency investments. Resource efficiency investments are typically subject to the process of developing technological innovations, and then implementing them within operating production and consumption systems. Such a process requires forward-looking management, which is able to identify opportunities for efficiency gains.

Bloom and van Reenen (2007) have developed a methodology, which aims to capture key features of effective management, particularly those related to innovation, operations, monitoring, and financing. They have investigated and empirically documented that management practices correlate not only with the profitability and survival rates of firms, but also with their efficiency and productivity.

The Management, Organisation and Innovation (MOI) Survey conducted by the EBRD (2010) uses Bloom and van Reenen’s (2007) methodology and investigates management practices in manufacturing firms throughout the ECA and MENA regions. The survey allows the computation of management scores, using different criteria according to which management practices can be assessed across countries. Figure 15 presents management scores for manufacturing firms in selected transition and industrialised countries. The scores are based on survey results, which assess managerial capacity with respect to four management criteria: The management of (i) operations, (ii) monitoring, (iii) targets, and (iv) incentives.



**Figure 15** Management scores in selected countries, with the average management score normalised to zero. (EBRD, 2010)

Overall, managerial and technical capacity at the firm level are critical for implementing resource efficiency innovations at the firm level (see (DeCanio & Watkins, 1998)). Capacity constraints determine to what extent firms can act upon available information, and define the *internal* environment for making resource-related investment decisions.

### *Institutional capacity*

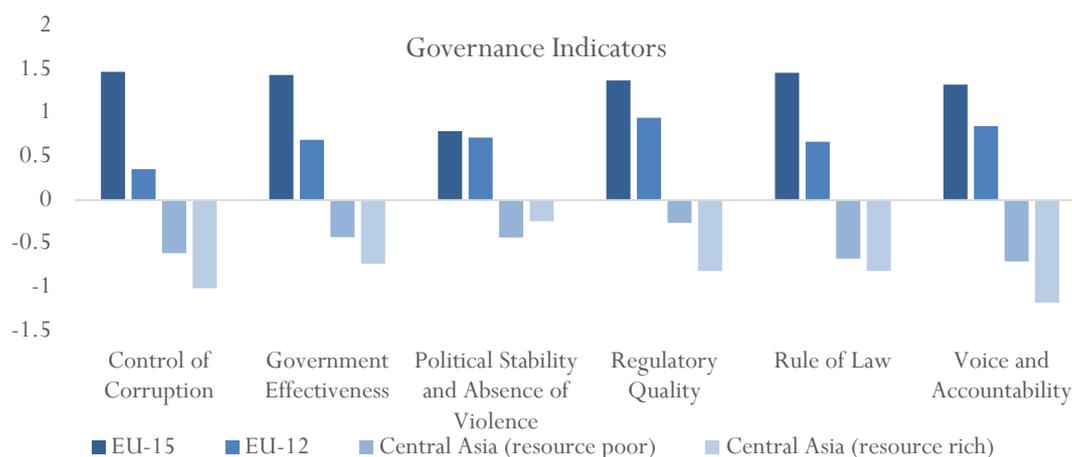
While managerial and technical capacity at the firm level are of particular importance for resource efficiency, the *institutional capacity* of administration and government determines the wider operating space for firms. It is thus critical for resource efficiency and beyond: Effective policy making, regulation, enforcement, and administration set the stage on which efficiency gains and innovation can materialise. Forward-looking policy making can create the right incentives and provide adequate support for increasing the efficiency of the entire industrial base.

The *external* environment for resource efficiency investments is determined by the quality of government and administrative capacity. Firms, aiming to implement resource efficiency measures, must operate within the institutional setting, which is provided by the national or local government. Inadequate government capacity can create major obstacles to firms: corruption, politicised planning, ineffective enforcement, cumbersome bureaucratic processes, and the lack of competitive market regulation can make it difficult for firms to undertake resource efficiency investments in practice. Certainly these issues are relevant beyond resource efficiency and affect corporate investments and operations more generally.

*Evidence from the EU.* The fact that the administrative environment can obstruct resource efficiency investments, can even be observed in the EU, which can be considered to be an environment of relatively high administrative capacity: A survey by the European Commission (2013) investigated the key obstacles to implementing resource efficiency at small and medium sized enterprises in the EU. The survey data shows that 26% of SMEs indicated complex legal or administrative procedures to be a significant obstacle to implementing resource efficiency. In environments, where government effectiveness, regulatory quality, transparency, and the rule of law are considerably weaker, this percentage can be thought to be considerably higher.

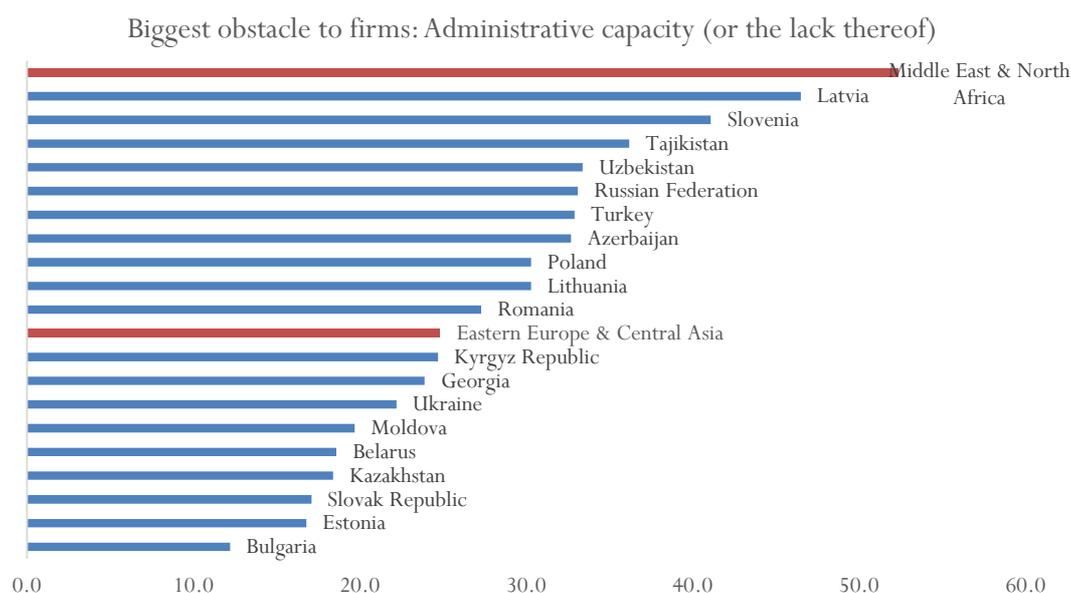
Data by the World Bank shows that countries in Central Asia perform poorly with respect to various governance indicators.

Figure 16 shows that across all applied measures of governance, countries in the ECA and MENA regions perform worse than the EU average. Resource rich countries perform particularly poorly with respect to corruption, or regulatory quality.



**Figure 16** Governance indicators (normalised scale from -2.5 to 2.5): Central Asia performs poorly on average with respect to institutional capacity. (Source: Worldwide Governance Indicators, World Bank)

Indeed, data from the EBRD’s MOI survey (EBRD, 2010) shows that a significant share of firms in the ECA and MENA regions perceive lacking administrative capacity to be the single most severe obstacle to their operations. Figure 17 summarises these findings. Lacking administrative capacity accounts for issues including corruption, the rule of law, tax administration, and bureaucratic procedures.



**Figure 17** Percentage of firms who perceive administrative capacity of local and national authorities as the single biggest obstacle to their operations. (EBRD, 2010)

### ***Biases at the Individual Level***

Of course, it must also be acknowledged that behavioural biases at the individual level strongly influence decision making, and can prevent the implementation of efficiency measures, which make economic sense. Such factors can partly root in the cultural and socio-economic context. Partly they can be due to information constraints. Most fundamentally, the failure to act upon information may also reflect behavioural biases, which are simply linked to human nature.

*Awareness.* Lacking awareness and understanding of the benefits of resource efficiency lead decision makers to underestimate opportunities. Lacking awareness can typically be attributed

to information deficits. These cases provide a direct rationale for implementing targeted information programs to build awareness. Studying a sample of SMEs in Germany, Jordan et al. (2014) identify lacking “awareness” to be one of five key barriers to investments in resource efficiency.

*Behavioural biases.* DeCanio (1993) notes that ‘bounded rationality’ can create substantial hurdles within firms to the implementation of energy efficiency measures. In fact, even if information exists that would enable individuals to make cost-effective investments in resource efficiency, they may not do so. Issues related to irrational decision making and behavioural biases have been explored most prominently by Kahneman and Tversky (1986), who showed that economic agents may make decisions, which contradict basic principles of rationality. A large body of experimental research investigates such fundamental behavioural biases, analysing how individuals perceive risks and payoffs. For instance, the benefits associated with resource efficiency may be perceived to be intangible, and materialise only in the medium to long term. While such behavioural biases may offer little scope for direct intervention in the context of resource efficiency investments, they are important to acknowledge nevertheless: they can play an important role in how corporate decision makers opt for or against investments in resource efficiency.

### ***Policy Measures and Interventions: Building Capacity***

Certainly, there is a close link between information and capacity constraints, as for instance, the lack of access to information can impair capacity. Thus capacity building and information programs must be designed and implemented jointly. Based on the above discussion following issues are of particular relevance in the context of capacity constraints:

*Building technical capacity.* Building technical capacity at the firm level is arguably the most relevant intervention necessary to enable resource efficiency investments. The identification, installation, operation and maintenance of modern, more efficient technology critically depend on adequate training and expertise to be available within firms. To build such expertise firms need to be able to obtain effective technical assistance, e.g. from the government or other institutions. Such technical assistance could include trainings on specific technology or processes, benchmarking and monitoring, or also firm specific consulting in order to identify opportunities for resource efficiency investments. Technical assistance could also be vital in establishing internal audit committees.

*Building awareness* is certainly closely linked to and information constraints (see Section 4.2) and building technical capacity. However, while technical capacity is particularly important at the operational level, general awareness can be critical particularly at the management level. As the ultimate decision makers within firms, managers need to be aware of the potential benefits from resource efficiency investments.

*Building institutional capacity* is a long-term endeavour, the benefits of which extend well beyond resource efficiency. Generally, institutional capacity building and reform will not constitute a suitable entry point for targeted resource efficiency measures. However, reducing institutional

inefficiencies in the resource sector one by one, can contribute to the overall transition of a country. Measures such as the reduction of red tape, strengthening of administrative effectiveness and transparency, and more effective enforcement of existing regulation, can improve the investment environment substantially.

In the specific context of resource efficiency it is necessary to investigate closely the role of institutions and authorities involved in the management and regulation of natural resource use. Targeted reform of institutions, performance standards, best practice benchmarking, and resource audits can yield direct benefits to resource efficiency, while contributing to a more general improvement of institutional capacity.

#### 4.4. Financial market constraints

##### **Key messages**

- *Uncertain investment payoffs* (e.g. due to resource price volatility, or unknown maintenance costs) may make financing difficult or expensive.
- *Non-monetary and third party benefits* (especially from addressing externalities) are typically not acknowledged in commercial profitability assessments. Thus, resource efficiency projects may be more difficult or expensive to finance.
- *Structural problems* (e.g. access to credit, financial instability) in the banking sector can hamper investments more generally.

Especially for SMEs in low and medium income economies, cash flows may not permit major investments in infrastructure, without relying on external credit sources. Investments in hard infrastructure (such as modern production machinery), which are a common measure for resource efficiency improvements, may be associated with considerable upfront costs. Thus, even if resource efficiency investments are found to be cost effective, such investments may be infeasible in the absence of functioning credit markets.

Allwood et al. (2011) for instance note that businesses, which previously invested heavily in production systems, may face a lock-in situation preventing them from investing in modernisation and efficiency gains: For instance, in metals production replacing old uncoupled thermal cycles with new integrated production lines is often prohibitively expensive, as it implies the replacement of entire production facilities (Allwood, Ashby, Gutowski, & Worrell, 2011). Thus, modernisation and improvement of resource efficiency may critically depend on the availability of credit.

In the EU for instance, a survey has shown that 34% of firms perceive high up-front investments costs to be the most significant obstacle to improving resource efficiency (European Commission, 2013). Notably, this is despite the various financial support mechanisms available from the EU and its member governments (incl. loans, grants, and subsidies, such as the material efficiency support programme by the German Ministry of the Environment and KfW (KfW, 2013)). In other regions, such as the ECA and MENA regions, where such support options for resource efficiency are less widely available, financial constraints are likely to be of even higher significance.

Following issues related to the financing of projects can pose substantial obstacles to their implementation: (i) Uncertain investment payoffs (e.g. due to resource price volatility) may make it difficult or expensive to finance projects. (ii) Resource efficiency investments have various benefits, which are not necessarily measurable in monetary terms (i.e. they address negative externalities on e.g. human or natural capital). Thus, assessing the profitability of such projects on purely monetary terms may lead conventional banks to deny credit. (iii) More generally, an instable banking sector, high interest rates, and limited access to credit can make it difficult for firms to plan ahead and finance longer term investment projects.

### *Uncertain investment payoffs hamper financing*

In an environment in which resource efficiency investments are not widely recognised as an important way of cutting operating costs and increasing competitiveness, the commercial viability of such investments may not be perceived positively. In fact, various studies show that lacking information and proliferation may lead firms (and banks) to perceive the benefits of resource efficiency investments as uncertain (European Commission, 2013; Anderson & Newell, 2004; Rohdin, Tholander, & Solding, 2007). Moreover, banks are also likely to perceive resource efficiency investments as risky, especially if there is no larger scale reporting on the performance of other resource efficiency projects (Onischka, Liedtke, & Jordan, 2012). One reason for the perceived uncertainty pertains to technology: Unknown technology is associated with risks, as information on reliability and durability may not exist (Anderson & Newell, 2004).

Another important uncertainty in the context of resource efficiency pertains to resource prices: The viability and profitability of resource related investments critically depend on the prices of resources. If resource prices are low, investments in the conservation and efficient usage of resources may be perceived to be less attractive. If resource prices are high, such investments prove more attractive, as payback periods on investments are shorter. Furthermore, decreasing commodity prices can pose severe risks for firms, if resource efficiency investments have already been made: annual payoffs from the investment will be reduced, while high interest rates remain. Overall, uncertain commodity prices, also make benefit of resource efficiency investments uncertain – this in turn will make obtaining credit for such investments even more difficult and expensive than is already the case. Accordingly, highly volatile resource prices make it difficult for firms to plan resource related investments. In an environment of slow moving and stable prices with a clear trend, resource efficiency investments are a safer investment for liquidity constrained firms.

### *Non-monetary and third party benefits from resource efficiency investments*

The true costs of inefficient resource use go beyond the economic value of the resources wasted. In fact, resource inefficiency is likely to cause significant costs to natural and human capital (Allwood, Ashby, Gutowski, & Worrell, 2011; Onischka, Liedtke, & Jordan, 2012; European Commission, 2011), for instance as excessive production waste harms environmental quality or human health (for a more comprehensive coverage of externalities see Chapter 3). Such externalities are typically difficult to monetise per se, but can lead to further indirect monetary costs, for instance in terms of reduced tourism or employee productivity.

Surely, this also defines the nature of benefits, which can result from resource efficiency investments. Besides direct financial payoffs, improvements in resource efficiency may have significant environmental or human capital benefits (Onischka, Liedtke, & Jordan, 2012). However, if investment benefits are not monetary, and not borne by the investor but by third parties, the monetary profitability of an investment may appear lower. This is likely to adversely affect the ability to obtain financing for such projects. The resulting funding gap is a prime example of a market failure, as external benefits of projects fail to be accounted for by existing credit markets.

To external lenders, for whom success criteria of projects may extend to non-monetary benefits (e.g. developing competitive markets structures and addressing negative externalities), this provides a strong rationale for bridging the funding gap.

***Structural issues in the banking sector.***

Uncertain payoffs and non-monetary benefits from resource efficiency investments can make the financing of resource efficiency projects difficult. However, beyond these two issues, more general financial constraints to investments exist, particularly in the ECA and MENA regions.

*Structural problems in the banking sector.* Credit markets, particularly in Eurasia, have undergone significant turbulences in the past decade. Turbulences have resulted in a general loss of credibility of local banks, making credit less available and more expensive (World Bank, 2014). As resource efficiency investments in hard infrastructure are typically associated with payback periods of several years, turbulences in financial markets, make such forward looking investments difficult.

*Credit for resource efficiency projects may be expensive and difficult to access.* As a consequence of structural problems in the banking sector, firms experience difficulties in gaining access to credit sources. That this constitutes a significant obstacle to resource efficiency investments can be recognised when considering a survey in the EU (European Commission, 2013): 20% of all 11,000 surveyed firms undertake resource efficiency investments, because financial public support is available. 24% of all firms perceive the up-front costs of investments to be the main obstacle to resource efficiency investments – thus underscoring the importance that financial support mechanisms and availability of credit play.



**Figure 18** Throughout the Eastern European and Central Asian regions, financial services are not only less commonly available, but also more expensive than in high-income countries. Countries scores are standardised to a scale from 0 to 7, where 7 is the best. In global comparison, the USA rank 10<sup>th</sup>/7<sup>th</sup> (affordability/availability), while Kyrgyzstan ranks 130<sup>th</sup>/131<sup>st</sup>.

Even in high-income economies like Sweden, with relatively well developed banking sectors, research has shown that access to capital is the biggest obstacle to improvements in efficiency in industrial sectors such as the foundry industry (Rohdin, Tholander, & Solding, 2007). Similarly, Jordan et al. (2014) show that in Germany restricted access to financing is one of five key barriers to investments in resource efficiency. Onischka et al. (2012) emphasise that the extent to which banks are “sensitised” to resource efficiency investments, i.e. the extent to which they recognise the profitability of projects, will also depend on monitoring and reporting practices by firms: the more is known about profitable resource efficiency projects, the more they are likely to be financed and disseminated throughout the economy. However, if such reporting is not widely practiced, local banks may perceive resource efficiency investments as risk and non-essential. If credit becomes expensive as a consequence, SMEs may decide not to undergo the expensive and risky process of external financing.

While little research or empirical evidence exists on the role of financial constraints in the context of resource efficiency, some insight can be gained from the literature on innovation more generally: Hyttinen & Toivanen (2005) for instance provide empirical evidence that financial constraints can play a significant role in holding back innovation in industries and firms, which are dependent on external financing. They thus argue that in order to promote innovation (and efficiency gains likewise), public interventions ought to complement incomplete or inefficient credit markets.

### ***Policy measures and interventions - Reforming and complementing credit markets***

In the EU firms state that high up-front costs are one of the most significant obstacles to resource efficiency (European Commission, 2013). Thus, they have stated that dedicated loans, grants, subsidies, and other financial support would be the single most helpful measure for supporting resource efficiency investments at the firm level. Also in the ECA and MENA regions, addressing the specific obstacles to resource efficiency investments (i.e. uncertain

payoffs, and non-monetary benefits) requires the provision of financial services, which complement existing credit markets:

*Project based lending.* Financial constraints provide an immediate rationale for lending interventions, and funding of specific resource efficiency projects. The provision of credit at the micro level (i.e. to firms) can bridge the gap left by the deficiency of local financial institutions. This can initiate resource efficiency investments even in the short term, but does not address underlying issues of inadequate credit markets. This role could for instance be assumed by international financial institutions and development banks, which may be in a position to recognise non-monetary benefits.

*Financial market reform and regulation.* The problems associated with inefficient, or even missing credit markets, can typically be traced back to suboptimal policy making and regulation. Thus, also for the purpose of increasing resource efficiency investments in the long term at an economy wide scale, more comprehensive and structural measures need to be taken – particularly, reform and stabilisation of the local financial system. The main actor in this task is the national government, possibly supported by external technical assistance. The government is required to implement regulations aiming at building financial stability and resilience. Assuming sufficient institutional capacity and political will, government interventions can tackle such issues both at the micro and macro level.

#### 4.5. Uncompetitive market structures

##### **Key messages**

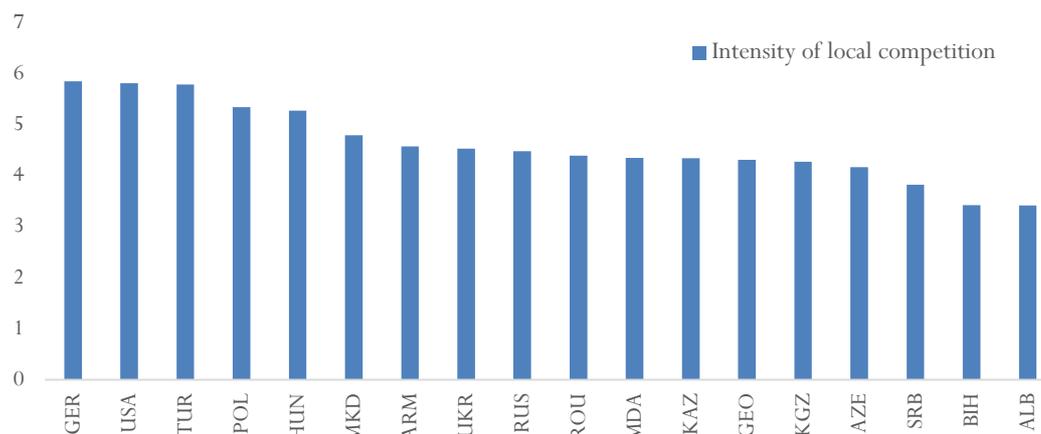
- In markets with restricted *competition*, firms face fewer incentives to cut costs and increase (resource) efficiency.
- In the EU competition is one of the key drivers of investments in resource efficiency.
- Competition is essential for proliferating efficiency gains made by one firm to the whole industry, as efficiency measures by a first-mover require similar action by competitors.

In well-functioning markets competitive pressures are the key driver of innovation and efficiency gains. By cutting production costs, firms can offer the same product at a lower price than competitors – thus, gain a competitive advantage over them, if market structures permit open competition.

However, if market structures do not allow free competition, and grant advantages to certain firms and industries, some of the key assumptions of perfectly efficient markets (Section 4.1) are violated. Monopolies and oligopolies may face lesser incentives to cut costs and increase resource efficiency. Barriers to market entry (and exit), for instance in the form of protectionist regulation, can prevent more efficient/productive firms from entering a market, and outperforming possibly less productive incumbents. Similarly, protectionist trade policies can make it difficult for firms to compete internationally and benefit from modern technologies, which may not be available domestically. Overall, if firms operate in inefficient markets, where competition is suppressed or certain incumbent firm protected, competitive pressures may not

suffice to incentivise continued resource efficiency investments. The consequences are market failures leading to inefficient resource use and wastage.

Thus, market structures determine the wider context, within which firms make investment decisions, for instance related to resource efficiency. Certain market characteristics can play a direct role in obstructing resource efficiency improvements, but are likely to have additional adverse effects on the economy at a larger scale. Reforming market structures, i.e. transitioning away from protected and controlled markets, towards competitive, free markets, brings about a wide range of benefits, which go beyond resource efficiency. Thus, it must be acknowledged that a general reform of market structures does not constitute a suitable entry point for *targeted* resource efficiency interventions.



**Figure 19** Intensity of competition in selected countries. The scores are standardised to a scale from 0 to 7, where 7 corresponds to a maximum intensity of competition. The scores are aggregated across different sectors. According to this index, Germany ranks 10<sup>th</sup> and Albania 144<sup>th</sup> in global comparison (World Economic Forum , 2013).

*Lack of competition.* The importance of competitive pressures in motivating and driving resource efficiency is emphasised by the insights of an EU study (European Commission, 2013). Out of 11,000 surveyed firms 63% state that their main motivation to improve resource efficiency are “cost savings”, i.e. cutting costs in order improve competitiveness. Further 18% of firms directly state “creating a competitive advantage” as their main reason to invest in resource efficiency. Another 9% state that improving resource efficiency is necessary for “catching up with main competitors” who have already invested in resource efficiency (European Commission, 2013) – this also implies that competition plays an important role in disseminating resource efficiency starting from a first mover to the entire sector.

In the EU competition can be seen to drive and proliferate resource efficiency measures. However, markets dominated by large state run (or formerly state run) monopolists or few oligopolists may provide fewer incentives for investments towards efficiency gains, as there are fewer or no competitive pressures. This issue is of particular relevance in formerly Soviet economies, where certain market structures are still shaped by a communist legacy. While the transition towards fully market based economies is progressing across the ECA and MENA regions, many key elements of a market economy are still missing. This is particularly true in industries which were formerly state-run monopolies, and which still operate under significant

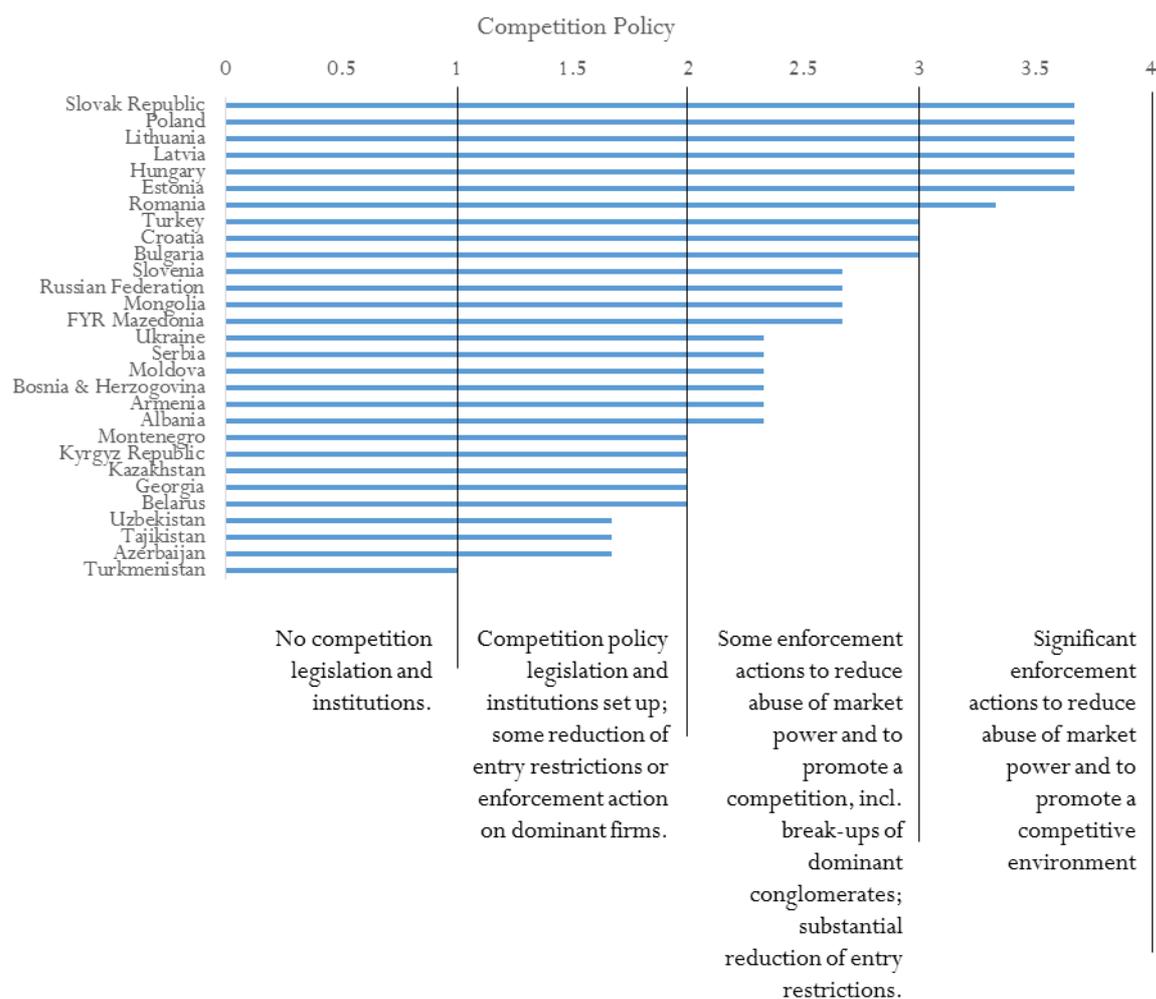
state influence. In this context Schleifer (1998) argues that private ownership of firms is more conducive to innovation and efficiency gains than public ownership.

Sector	State market share			
	No public ownership	Less than 50%	50-99%	100%
Gas industry			X	
Production/import sector			X	
Gas transmission			X	
Gas distribution			X	
Electricity industry			X	
Generation of electricity			X	
Transmission of electricity			X	
Distribution			X	
Rail transport				X
Operation of infrastructure				X
Operation of passenger transport				X
Air transport			X	
Domestic and international traffic			X	
Telecommunications			X	
Postal services				X

**Table 10** Russian state participation in selected sectors, 2008. It is evident that state involvement remains substantial. This is indicative for the wider post-Soviet region. (Source: World Bank 2014, based on Conway, Lysenko, and Barnard (2009))

The empirical insights from surveys such as the above mentioned by the European Commission (2013) are also supported by theory: Aghion et al. (2002) develop a model on competition and innovation, and find a strong relationship between the two (which they subsequently back by further empirical evidence). By showing that competition may increase the incremental profits from innovating, they implicitly emphasise the importance of competitive markets to foster resource related innovations and efficiency gains.

However, these competitive market forces, which are an essential driver of gains in resource efficiency, are obstructed in numerous economies. The World Bank has developed an indicator to assess competition regulation and enforcement, and to compare performances across countries. Figure 20 shows that countries in the ECA and MENA regions have a mixed record of protecting and enabling market competition, indicating shortcomings in regulation and enforcement.



**Figure 20** Competition policy scores across countries in the ECA and MENA regions. It is evident that especially countries in the Central Asian region have little legislation and few institutional arrangements in place to promote competition. (Source: World Bank, Worldwide Governance Data)

*Trade protectionism.* Furthermore, it must also be recognised that such pre-existing market structures and certain industries may be protected from foreign competition through protective trade policies. In the context of resource efficiency trade barriers can have various consequences, including: (i) lacking competition from more efficient foreign firms, which reduces competitive pressures and thus incentives to innovate, and (ii) more difficult access to foreign technologies and services, which may be crucial for improving resource efficiency – especially when technologies and expertise are not available domestically.

While direct empirical evidence on the role of trade restriction in the context of resource efficiency is scarce, the literature on innovation and productivity does offer some insights. The relationship between trade liberalisation measures and industrial productivity gains, has been explored in an early theoretical study by Rodrik (1988), and subsequently confirmed by various empirical studies. These studies argues that by being able to import modern technology from abroad, firms are able to realise efficiency gains: For instance, firm-level evidence from Turkey suggests that following a number of trade liberalisation measures in the 1980's, innovation among Turkish manufacturing firms increased significantly (Pamukcu, 2003). Most notably,

improvements in innovation took the form of imported machinery, enabling increases of firm productivity. Similar results are presented by Krishna and Mitra (1998), who show that trade liberalisation measures in India increased competition and the growth rate of productivity across various industrial sectors.

#### ***Market transition - Scope for policy measures and interventions:***

Market structures determine the broader business environment, and their reform needs to be an integral part of a comprehensive transition strategy. *Targeted policy reforms* can address certain specific barriers resource efficiency (e.g. by removing a specific protectionist legislation, which prevents technology transfers), especially when targeting specific resource intensive industries. However, in order to improve the overall environment for investments (e.g. in resource efficiency) a step-by-step longer term market transition needs to be achieved.

*Market transition.* Transforming market structures is a long-term challenge, and its benefits extend well beyond resource efficiency (EBRD, 2013). Governments and international institutions, which are committed to fostering efficiently functioning markets, carry a particular responsibility in addressing market structures, which cause resource inefficiencies. Efforts towards such a market transition are likely to yield co-benefits in the context of resource efficiency.

#### 4.6. Fiscal mismanagement

##### **Key messages**

- *Energy and fossil fuel subsidies* incentivise inefficient usage of energy intensive resources.
- *Industry subsidies* artificially increase the competitiveness of certain industries, and thus perpetuate existing inefficiencies.
- *The lack of waste tariffs* discourages investments in recycling and waste reduction.

Most adverse social and environmental impacts from material use and (resource intensive) energy production fail to be reflected in market prices of materials (Allwood, Ashby, Gutowski, & Worrell, 2011). In the context of market failures and externalities, fiscal policy plays a critical role. Broadly speaking, a comprehensive taxation and subsidy policy can direct firms and households towards desired economic outcomes by providing financial incentives, which the market per se may fail to provide sufficiently. This corresponds directly to the Second Fundamental Welfare Theorem (Section 4.1), which states that market interventions (e.g. by governments) can mitigate market inefficiencies by redistributing resources and improving the Pareto efficiency of a given economic allocation. Such interventions are however difficult, and setting taxes too high or too low can increase market inefficiencies.

In the context of resource efficiency this equally implies that fiscal mismanagement can lead to distorted incentives and undesired economic outcomes – i.e. encouraging and perpetuating resource inefficiencies and the associated environmental externalities. Especially by subsidising specific resources or resource intensive industries (such as manufacturing, energy, or resource

extraction) governments may be artificially increasing the competitiveness of inefficient industries and discouraging investments (Allwood, Ashby, Gutowski, & Worrell, 2011).

On the contrary, introducing a landfill or waste tax, or subsidising modern efficient technology can incentivise more resource efficient practices. While the concrete fiscal circumstances must be subject to investigation on a case by case basis, this section will discuss some common examples of fiscal mismanagement in the context of resource efficiency and suggest entry points for fiscal reforms.

### ***Subsidies***

One common example of a distortive fiscal policy is the provision of resource subsidies – often found in resource rich economies, governments use subsidies to ease the usage or increase the commercial attractiveness of a specific resource, for instance by artificially suppressing the local market price of a resource (Yeo, Partner, Steptoe, & Johnson, 2010). In practice resource subsidies can take many forms, including a preferential treatment of resource intensive industries (incl. mining), or lacking taxation to mitigate externalities. As a consequence, end users (such as firms) who face lower usage costs tend towards overconsumption and inefficient usage of the resource. In addition to such environmental and efficiency issues, resource subsidies cause an increasing burden to national accounts and budgets: as international resource prices increase (in levels and volatility), providing price subsidies becomes increasingly expensive and unpredictable for governments. A prominent example are fossil fuel subsidies (in particular for petroleum and its derivatives), which are particularly common in oil exporting countries. As a consequence of low fuel prices, firms and households do not face the price pressures, which would otherwise incentivise e.g. fuel efficient driving.

*Fossil fuel subsidies and resource efficiency.* As Allwood et al. (2011) note lower energy prices (for instance due to subsidies) may increase the overall demand for energy intensive materials<sup>16</sup>. In fact, fossil fuel subsidies can directly impact on the resource efficiency of firms, since energy and resource efficiency are closely linked. Increasing the efficiency of energy usage requires modernised machinery and technology, which in turn can have a direct impact on the efficiency of resources used. Similarly, more resource efficient production will increase energy efficiency, as fewer resources need to be processed for a given amount of output. Overall, this means that if energy is cheap due to fossil fuel subsidies, the processing of production materials is cheap, and thus energy prices play a lesser role in motivating resource efficiency. Particularly in energy intensive industries, fossil fuel subsidies can thus reduce the incentives to improve resource efficiency.

A concrete example can illustrate this issue: For each ton of output, the Russian foundry industry is estimated to use 3 times more energy, 3.6 times more sand, and 161 times more water than comparable EU plants (IFC, 2010). Thus, if Russian plants were to match the level of resource efficiency in European plants, they would be able to save close to 20,000GWh of energy, 5.7m tons of sand, and 879m cubic meter of water – corresponding to \$3.3bn of savings per annum (IFC, 2010). However, Russia subsidises energy more than any other high-

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<sup>16</sup> For other less energy intensive materials other factors, such as labour costs, can play an important role too.

income high-emitting country (E11<sup>17</sup>), spending \$31.3bn on various types of energy subsidies in 2010 (Whitley, 2013). These subsidies play a significant role in lowering energy costs, which are 54% lower than for instance in Germany (IFC, 2010). Thus, Russian foundry plants would face considerably higher incentives to invest in resource efficiency, if energy prices were not subsidised.

*Industry subsidies.* Governments may not only choose to subsidise energy or certain resource, but also specific resource and energy intensive industries. Such industry subsidies (i.e. paid to producers) are far less documented, partly because of the many non-transparent forms they can take. Nevertheless, Legeida (2002) argues that industrial subsidies cause substantial efficiency losses. By granting subsidies to inefficient industries, and thus artificially increasing their competitiveness, governments may be prolonging existing resource inefficiencies. The steel industry, for instance in Russia, Ukraine and Poland, has been documented to receive substantial preferential treatment by the state, for instance through low interest loans, tax privileges, or write-offs of tax arrears (Legeida, 2002). Such advantages, which can all be considered a type of subsidy (see Whitley (2013)), may not come as a surprise as the steel sectors in these countries faced substantial structural problems such as over-capacity, over-employment, and inefficient, obsolete machinery (Legeida, 2002). Overall, subsidies paid to inefficient industries directly support and perpetuate (resource) inefficiency.

Of course it must also be noted that prudent subsidy schemes, targeted at improving competitiveness (rather than preserving inefficiencies), can play a substantial positive role. Targeted investments by the government and/or international financial institutions, can help to modernise inefficient industries, and thereby improve competitiveness at a large scale. Following the same rationale the Chinese government for instance announced \$6 bn in investments in the steel sector in 2000, in order to introduce modern technologies, and improve efficiency (US Dept. of Commerce, 2001).

### ***Waste tariffs***

The European Union Landfill Directive (1999) aims to reduce the negative environmental externalities resulting from waste disposal, and has had a profound impact on the way waste in the EU is being recycled, or disposed. As in many other EU countries, in the UK one of the key instruments for the implementation of the Landfill Directive has been the introduction of a landfill tax, which increases the cost of discarding waste (Morrison, Phillips, & Read, 1998). The landfill tax has proven to be very successful in increasing recycling rates, and constitutes a significant revenue source for the government (£1.2bn in 2010) (Leicester, 2012).

The underlying idea of waste tariffs is that by increasing the cost of landfills, (i) waste treatment and recycling technologies become commercially more attractive, and (ii) less waste is produced in the first place. In the absence of waste tariffs, low disposal costs lead firms to produce ‘excess’ waste – which is often associated with significant environmental externalities (Morrison, Phillips, & Read, 1998). After all, inadequate pricing of environmental services and

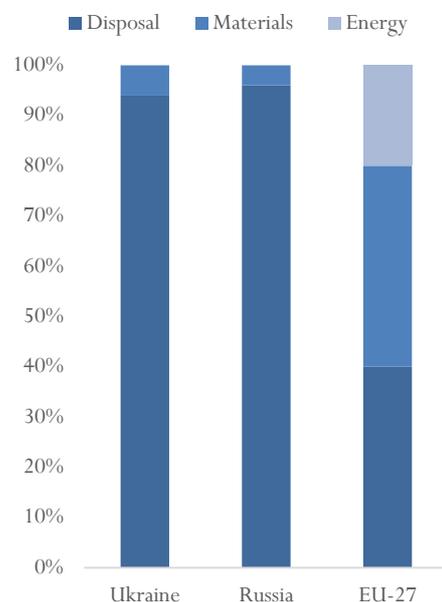
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<sup>17</sup> The E11 country grouping is defined as Australia, Canada, France, Germany, Japan, Italy, Poland, Russia, Spain, United Kingdom, and United States.

common goods is a central reason for such suboptimal market outcomes. However, as with all fiscal interventions, it is critical that the level of such tariffs is set carefully.

While waste tariffs and similar taxes have succeeded in the EU to increase recycling and material recovery rates, countries throughout the ECA and MENA regions perform relatively poorly. According to an assessment by the IFC (2013a) for instance, 50-70% of Russia’s waste collection and haulage infrastructure is obsolete. In the municipal solid waste segment, recovery of materials is almost non-existent: with a mere 4% of materials being recovered, Russia performs poorly compared to the EU – in some countries, including Switzerland and Austria, recovery rates are above 95%. The IFC (2013a) estimates that Russia could achieve a 40% recovery rate by 2025 at a per capita breakeven cost of EUR 30-35 per annum (EUR 40.5bn in total). In this time frame the recovery of materials is estimated to generate a revenue of EUR 2bn, and reduce the demand for new landfill capacity by 20-30%.

Similar observations can be made in Ukraine, where only around 5% of municipal solid waste is recovered, and more than 70% of waste management infrastructure is estimated to be obsolete (IFC, 2013b). Extrapolating the current trend, Ukraine will need to double its landfill capacity within the next 10-15 years. As in Russia, the IFC (2013b) sees the opportunity for increasing recovery rates to 40% by 2025, if capital investments of EUR 11.5bn are made in order to upgrade and complement existing waste management infrastructure. These investments imply a break even cost per capita of EUR 30 per annum (IFC, 2013b). While it must be acknowledged that municipal solid waste does not include all industrial waste streams, these figures are indicative for the ineffectiveness of waste management and recycling infrastructure.



**Figure 21** Waste recovery rates in Ukraine and Russia are very low relative to the EU, where only 40% are disposed of on average. (IFC, 2013a; IFC, 2013b)

### *Scope for policy measures and interventions: Fiscal reforms*

Fiscal reforms and the introduction of waste taxes are likely to be politically sensitive endeavours, which however can significantly improve the incentives for investing in resource efficiency. Governments can refer to previous successfully implemented fiscal reforms of this

kind (e.g. (IMF, 2013), and seek the technical and policy expertise of e.g. development organisations:

*Subsidy reform.* To remove distorting incentives, which discourage resource efficiency investments, it is critical to reduce resource subsidies. The freed up resources can be used more productively, for instance by subsidising modern technologies, which increase resource efficiency. Andersen and Newell (2004) show that when making investment decisions related to resource and energy efficiency, manufacturing firms are 40% more sensitive to the up-front costs, than to expected annual savings. This may partly reflect the uncertainty associated with the future benefits of efficiency investments (e.g. since future benefits depend on resource prices). Overall, this suggests that governments could play a central role in inducing resource efficiency investments by subsidising modern and efficient technology – i.e. reducing the hurdle of high up-front costs. Such a subsidy scheme would also be suited for low capacity policy environments, as the subsidy would be a one-off reduction of up-front investment costs – firms do not need to rely on the subsidy scheme to be in place for many years in order for their investment to pay off.

*Waste tariffs and landfill taxes.* Increasing the price of waste will increase the incentives to reprocess waste whenever it is economically and technologically viable. However, this must be complemented with measures to support the implementation of reprocessing infrastructure (e.g. technology subsidies and grants for firms to acquire necessary recycling infrastructure, and technical assistance to disseminate effective recycling techniques). For introducing “pay-as-you-throw” waste tariffs, monitoring is critical.

#### 4.7. Uncertainty, volatility and instability

##### **Key messages**

- Firms can hedge against *volatile resource prices* by investing in resource efficiency; at the same time it is price volatility which makes investment payoffs uncertain, thus reducing the attractiveness of resource efficiency projects.
- More general *economic, social and political instability* may decrease the planning horizons of decision makers, thus possibly restricting forward-looking investments – such as those in resource efficiency.

The previous sections (4.2. – 4.6.) have presented issues, which can prevent investments and result in inefficient market outcomes in the context of resource use. In addition, it is important to acknowledge that from a firm’s perspective, uncertainty and systemic risks can play a significant role in corporate decision making. While uncertainties can take many forms, some uncertainties (e.g. concerning commodity prices) are in fact immediately relevant to resource investments.

In principle, a firm aiming to improve its resource efficiency faces various constraints, for instance with respect to information, capacity, or credit. In the presence of uncertainty the adverse effects of these constraints can be exacerbated: Without the knowledge of suitable hedging and preparation measures, without the capacity or capital needed for implementation,

investments in the face of uncertainty may be postponed or not taken at all. For instance, if economic or political uncertainty (in the form of crises) is imminent, investment decisions with medium to long run payback periods may not be chosen. Thus, the longer the payback horizon for a specific resource efficiency investment is, the more stability matters. Overall this means that uncertainty per se does not necessarily cause, but may exacerbate existing market failures and inefficiencies.

*Commodity price volatility.* The most immediate uncertainty in the context resource efficiency has been briefly discussed in Section 4.4: Volatile resource prices can make the expected payoffs uncertain, thus affecting the expected profitability of investments and the ability to finance them. This issue has prominently been explored by Pindyck (1990), who showed that irreversible investments (e.g. in physical infrastructure with large sunk costs) are particularly sensitive to cash flow risks. In a later paper Pindyck (2006) relates this issue explicitly to environmental policies and emphasises the ubiquity of uncertainty surrounding environment related investments (including those in resource efficiency).

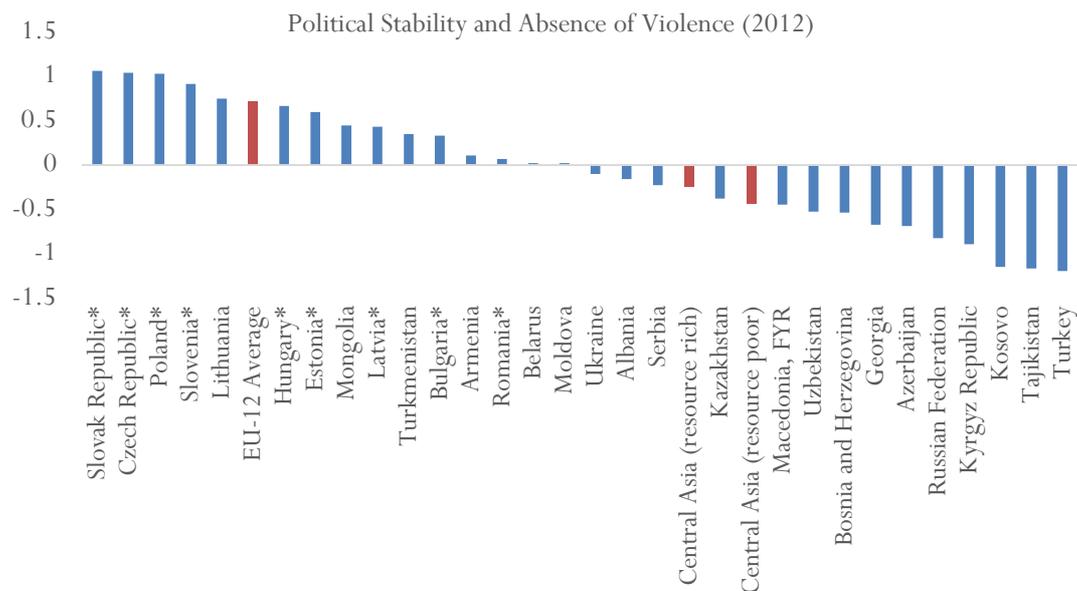
At the same time it must be noted that resource efficiency is an important way to reduce the dependency on resources and the exposure to volatile prices, i.e. to hedge against price uncertainty (e.g. see Ebrahim et al. (2014) in the context of oil). This implies that implementing resource efficiency can act as a hedging measure against price volatility, and at the same time be obstructed by price volatility (as outlined in Section 4.3).

Furthermore, more general uncertainties and systemic risks are of relevance in the context of resource efficiency:

*Policy reliability.* The implementation of subsidies, for instance for the installation of efficient technology, may be a right step per se in favour of resource efficiency. However, it must be paired with credibility – both in the reliability, and longer term direction of policy making. Subsidies fail to trigger the desired economic actions, if decision makers perceive such policy schemes as unreliable or unpredictable. A typical example in the energy sector are feed in tariffs, which aim to incentivise investment into renewable energy. If such tariffs lack long term credibility, investors may not take up the offer. Such a lack of credibility is typically a consequence of frequent changes or time-inconsistency in policy making (World Bank, 2013). This leads to less stable investment environment, discouraging investments in resource efficiency and beyond. Certainly, this not only refers to fiscal, but also to monetary policy. Frequent interest rate changes, and unpredictable central bank actions create an instable investment climate. As a consequence firms may not build longer term strategies.

*Economic, political, and corporate context.* Besides the above types of uncertainty, which are directly associated with resource efficiency investments (e.g. resource prices, or reliability of relevant regulation), more general uncertainties will also affect investment decisions. This is not least due to their impact on discount rates (see for instance Gollier (2002)). If uncertainties are perceived to be more significant, future benefits from efficiency investments may need to be discounted more. This negatively affects the cost benefit ratio of resource efficiency investments, since benefits are typically spread throughout the future, while costs are up-front.

While uncertainties can have many roots, this section shall (briefly) discuss two causes explicitly: (i) *Economic instability* can impact on resource efficiency in various ways. First and foremost, the stability of the banking sector is typically highly correlated with economic performance. This influences the availability of and access to credit. General macroeconomic indicators influence the investment climate more generally, and thus affect planning horizons. (ii) *Political instability*. The general socio-political stability of a country will critically determine planning horizons. In fact, the EBRD MOI survey (EBRD, 2010) shows that firms throughout the region perceive political instability to be a major obstacle to their operations.



**Figure 22** Countries in the Central Asian Region perform poorly with respect to political stability and absence of violence. The country scores are standardised to a scale from -2.5 to 2.5. (Source: Worldwide Governance Indicators, World Bank)

**Scope for policy measures and interventions:** Uncertainty in the political, and economic context are not necessarily to be addressed directly, as systemic risks are ubiquitous, and typically even beyond control. More importantly it is necessary to design resource efficiency projects in a robust way, such that they take uncertainty into account: For instance rather than designing a resource efficiency investment based on a “likely” future resource price, the investment project should be able to deliver acceptable outcomes in a range of scenarios (Hallegatte, Shah, Lempert, Brown, & Gill, 2012).

## 5. Policy instruments for improving resource efficiency

### Key messages

- Measures at the *micro (i.e. firm) level and macro level* are needed in order to achieve sustainable and larger scale improvements of resource efficiency.
- Measures need to target not only the ‘*symptoms*’ of resource efficiency (e.g. excess waste, environmental externalities), but also the *structural factors* which cause inefficiencies in the first place.

- A *comprehensive strategy for improving resource efficiency* needs to comprise complementary measures in the form of targeted investments, technical assistance, as well as policy and regulatory reforms.

The investment barriers outlined in the previous chapter constitute distinct obstacles to improving resource efficiency, and suggest the need for different types of policy measures. In fact the practical implementation of the theoretical Second Welfare Theorem (see Section 4.1) is difficult, and requires a carefully designed package of complementary policy measures. For building such a comprehensive strategy for improving resource efficiency, various types of information programmes and technical assistance should complement hard infrastructure investments, as well as more structural regulatory reforms. This section structures and summarises the policy measures necessary to address the key causes and symptoms of resource inefficiency, and to foster investments in resource efficiency.

Resource efficiency interventions can broadly be distinguished into micro and macro interventions: i.e. firm level measures, which support firms in overcoming the above mentioned investment barriers, and more comprehensive macro measures, which reform structural deficiencies and inefficiencies of the overall system. Particularly in the short and medium term a firm level approach is important, as it can bring about quick efficiency gains in targeted industries, and eventually cause a (bottom up) improvement of overall efficiency.

However, at the same time the market and government failures which led to such inefficiencies in the first place must also be addressed, as they will create new inefficiencies and perpetuate existing ones. This is important in order to achieve a larger scale enhancement of resource efficiency as well as to sustain efficiency gains over time. Of course, addressing such structural and systemic issues requires time (and patience). After all, inefficiencies are in many cases the product of structural market problems and the wider business and regulatory environment – thus, measures must also address the underlying problems, and not just symptoms.

### ***The definition of waste, and the rationale for intervention***

While inefficiencies in the use of resources can have various causes (see Chapter 4), they have a common consequence – wastage of valuable resources. This is based on the very definition of market inefficiencies: The theoretical case of a perfectly efficient market (see Section 4.1) is characterised by the absence of wastage of valuable resources. In other words, production processes, which waste a certain share of inputs and discard valuable resources as by-products, can be seen as inefficient.

In this context, it is important to outline what is meant by ‘waste’. *In fact, the definition of waste crucially depends on the context.* By-products of industrial production processes could in many cases be reused and reprocessed – i.e. they are discarded materials, which theoretically possess an economic value. However, in practice this economic value depends critically on available infrastructure, legislation, and markets. If the necessary infrastructure for reprocessing and transporting these discarded materials is prohibitively expensive or unavailable, the materials are indeed valueless waste; i.e. the economic value cannot be unlocked cost-effectively. Similarly, if markets for such reprocessed waste are missing (e.g. lack of demand) or too uncertain (e.g. volatile demand), there is no economic rationale and incentive for firms to

invest in the waste-to-resource transformation. As a consequence, discarded materials are seen as valueless. On the contrary, if relevant infrastructure (e.g. technology and finance) is affordable and accessible, 'waste' is in fact a valuable resource; i.e. the economic value can be unlocked cost-effectively. Overall, establishing markets for reprocessed waste and providing the infrastructure and incentives for recycling constitute key efficiency enhancing interventions – and thus provide an important argument for market interventions.

### ***Two Approaches to Waste Minimisation***

*As waste is essentially defined by its infrastructure, regulatory, and market context, there is a strong rationale for market interventions, which establish or improve necessary infrastructure and markets. The provision of loans for instance can make reprocessing infrastructure more affordable for firms, thus helping to unlock the economic value of waste. Formalising and regulating markets for recycled materials can create stability and increase incentives for firms to supply reprocessed waste. Essentially, this prescribes two possible approaches for waste minimisation:*

- (i) Addressing 'Symptoms':** Reduce the waste, which continues to result from pre-existing inefficiencies;
- (ii) Addressing 'Causes':** Address the pre-existing market failures and structural inefficiencies, and thus reduce the amount of waste produced in the first place.

These approaches are not mutually exclusive, and both need to be part of a comprehensive strategy for resource efficiency.

### ***Intervention level and types of measures.***

The practical implementation of above intervention approaches needs to effectively target 'symptoms' and 'causes' at two levels.

***Micro level*** interventions support specific firms with the implementation of resource efficiency projects. *Technical assistance*, is important for instance for (i) strengthening the understanding of the importance of resource efficiency, (ii) addressing various information constraints (promote monitoring, and disclosure practices, and efficient technologies), (iii) building technical and management capacity needed for the operation of modern technology, (iv) identification of investment opportunities, and (v) resource efficiency audits. Specific *project based lending* is the key instrument for implementing concrete efficiency projects at the firm level, for instance by (i) installing more efficient machinery, (ii) modernising processes, (iii) retrofitting obsolete machinery, or (iv) establishing effective systems for monitoring efficiency. Overall, micro level measures first and foremost address inefficiencies at the firm level and may (eventually) lead to a bottom-up improvement of sector-wide resource efficiency. Firm level measures are however less suitable for addressing the structural causes of resource inefficiency.

***Macro level*** measures especially pertain to policy and regulatory reforms, which address incentives structures, and improve the investment environment within which firms operate. As

at the firm level, macro measures comprise non-monetary and monetary ones likewise. Targeted *reform actions* are critical in various areas: (i) Fiscal policy reforms (including subsidy reforms, waste tariffs, externality taxes, etc.), (ii) regulatory reforms (e.g. on monitoring and disclosure requirements, efficiency targets, environmental and waste management), (iii) strengthening the banking sector, (iv) improving institutional capacity, and (v) institutionalising dedicated lending facilities for resource efficiency investments. These measures span a wide field and are likely to yield benefits beyond the improvement of resource efficiency. In developing and emerging economies such reform commitments can typically be supported by *development lending and budget strengthening* measures (for instance by development banks). Overall, macro level measures are particularly important in addressing the structural factors which cause and perpetuate inefficient resource use practices (*'causes'*). Only by addressing *'causes'*, it can be assured that efficiency improvements are sustainable and that future infrastructure investments are also guided by resource efficiency considerations.

Policy Measures and Interventions				
	Micro (i.e. firm) level		Macro level	
	Technical Assistance	Project Lending	Technical Assistance & Policy Dialogue	Development Lending
Addressing Inefficiency and its Symptoms	Efficiency audits Identification of specific projects	New infrastructure for recycling and reusing Modernisation of production processes Retro-fitting	Building strategies to improve material recovery from waste	
Addressing the Structural Causes of Inefficiency	Building technical and managerial capacity Establish monitoring & disclosure Awareness building Disseminate information & technology Foster in-house R&D and innovations	Building infrastructure for information sharing and training Building infrastructure to link markets (e.g. transport infrastructure linking supply & demand for recycled materials)	Institution building Fiscal policy reforms (removing energy subsidies, introducing waste tariffs) Legal requirements for monitoring and disclosure of efficiency performance data Strengthening the financial sector Dedicated lending facilities for resource efficiency projects Foster competition	Developing markets and infrastructure for reprocessing waste Strengthen macro-economy Institution building More general 'green economy' strategies

**Table 11** This rough typology presents a policy toolbox for micro and macro interventions towards building resource efficiency. The categorisation is indicative and not definite: For instance, micro level measures may eventually lead to more structural macro improvements.

In line with these recommendations and the suggested policy interventions in Chapter 4, Table 11 presents an overview of policy measures and interventions. Certainly, the adequacy and necessity of each of these measures need to be assessed on a case by case basis (see Chapter 6).

***Specific measures depend on specific circumstances***

The specific way in which micro and macro interventions are designed in practice depends crucially on case-specific circumstances. These circumstances are likely to vary across time, countries and sectors, making it difficult or even inappropriate to formulate universal recommendations for interventions.

Resource efficiency measures implemented by EU SMEs (%)					
	Agriculture and fishing	Construction	Food services	Manufacture	Water supply; sewage & waste management
Purchasing more efficient technologies	69	56	49	57	48
Developing efficient technologies in-house	57	46	45	58	45
Recycling	41	52	59	52	34
Improving material flows in supply chain	50	46	44	47	43
Substituting expensive materials	45	38	37	38	28
Outsourcing production or services	31	32	18	31	28
Changing the business model	34	22	29	28	31

**Table 12** The implemented resource efficiency measures vary across different sectors. Values are percentages of overall surveyed firms. The question was “Which changes to reduce material costs have you implemented in the past 5 years?” (Source: (European Commission, 2011))

For instance, evidence from the EU shows that in the agricultural sector the “acquisition of more efficient technology” is a more widely implemented resource efficiency measure than in the water management industry (European Commission, 2011). Table 12 summarises how the resource efficiency measures taken by a sample of European firms vary significantly across different sectors. The European Commission (2011) provides further evidence, which shows that the same sectors in different countries also display very different preferences for certain resource efficiency measures. For instance, in the same sample 77% of firms in Ireland acquired more efficient technology as a means to improve resource efficiency, while only 43% did the same in Austria (European Commission, 2011). In interpreting this data however, it is important to recognise that low percentages may not only reflect preferences, but also investment barriers.

Overall, this highlights the need for case-by-case assessments – not only of the expected costs and benefits of specific resource efficiency investments, but also of the barriers and incentive structures, which may influence the success of such projects. Section 6 thus argues for case specific analyses, which go beyond standard commercial investment appraisals, and take into

account the costs of inaction, environmental and social externalities, as well as investment barriers.

### *Comprehensive strategies for improving resource efficiency*

Chapter 4 provides an idea of the complexity and inter-connectedness of barriers to investments in resource efficiency. To successfully overcome this “web” of barriers, it is important not to address barriers in separate ‘silos’, but to recognise their complexity and inter-connectedness. For instance, providing financial support may not be effective if large technical capacity constraints persist at the firm level. Similarly, environmental regulation may not be effective if firms do not have access to information on how to meet stricter requirements.

This means that it is important to not only assess the potential costs, benefits and efficiency gaps, but also the wider investment environment and the barriers to resource efficiency it may create. Policy makers, regulators, investors, banks, and firms are all critical actors and carry an important role within a comprehensive strategy towards a more resource efficient economy. External entities, such as international financial institutions can play a key role in supporting the above actors, especially by providing technical assistance, financing and impulses for policy reform.

## 6. Next steps – applying the framework

### Key messages

- Applying this report’s framework to specific projects, can complement purely commercial investment appraisals, and identify obstacles to implementation.
- Existing firm surveys (such as the EBRD’s MOI survey) can be complemented with efficiency related questions, in order to *build a stronger evidence base*.
- ‘*Success indicators*’ need to be defined, which can evaluate resource efficiency projects not only commercially, but also in the context of environmental externalities and market transition.

This chapter outlines how the insights of this report may be applied operationally. In particular, it is suggested that the general analytical framework (chapters 3 and 4) in this report needs to be applied on a case-by-case basis. This can help to evaluate resource efficiency projects within their broader environmental, economic, and administrative systems. Furthermore, this chapter points out the need to further build the evidence base, which is still more than sparse for non-EU countries.

### 6.1. Case-by-case analyses of costs, benefits and investment barriers

The narrative of costs and benefits (chapter 3), and investment barriers (chapter 4) provide a comprehensive framework for assessing investments in resource efficiency. In order to assess specific investment projects however, this framework needs to take the project specific characteristics of the firm, and the broader investment and policy environment into account. In order to fully understand the investment environment and drivers of and barriers to resource efficiency several factors need to be analysed on a case-by-case basis:

- The resource efficiency gap at the national, sector, and firm levels (i.e. performance relative to a benchmark)
- The potential costs and benefits of investing in resource efficiency (or not investing) for specific projects
- The multitude of barriers which prevent individual firms from realising efficiency gains
- The structural causes of inefficiencies in the use of resources and their impact on specific sectors and firms

Such an analysis is also critical for identifying the role of different actors, such as policy makers and administrative authorities, auditors, firms, banks, and international financial institutions. A sector level analysis in a specific country for instance, could subsequently inform resource efficiency investments for various firms within a given sector. This kind of analysis is likely to complement a purely commercial investment appraisal, which may omit crucial factors such as investment barriers, or non-monetary benefits (i.e. reducing negative externalities).

## 6.2. Formulating a generic checklist for assessing resource efficiency projects

Based on the comprehensive framework presented in this report a generic project ‘checklist’ could be distilled, which summarises the key elements of a comprehensive project appraisal. Such key elements include costs and benefits (including non-monetary benefits), market and government failures, as well as the main barriers to resource efficiency investments. While not all issues may be relevant in every single investment project, such a checklist would help capturing crucial aspects, which can determine the success of a specific resource efficiency investment within its wider investment environment.

## 6.3. Building the evidence base

In the EU, firm level surveys have managed to identify key barriers, which prevent firms from improving their resource efficiency (European Commission, 2013). Such information, paired with comprehensive macro data on material consumption has enabled the European Union to formulate policies and targets for resource efficiency alongside tools for implementation (see the “Roadmap for a resource efficient Europe”, European Commission, 2011). Overall, the existence of an (still imperfect) evidence base has been an important factor in the EU in informing and driving resource related investments and policy making by firms and governments.

Also in the ECA and MENA regions such information would be critical for understanding what the main impediments to resource efficiency are. However, such information is limited, and the evidence base is sparse. Several measures are important for building such an evidence base, which would help to understand the exact scale and nature of inefficient resource use:

Building comprehensive macro indicators: Currently, high-quality macro data on raw material consumption (RMC, which takes indirect effects of production into account) is sparse. RMC is available for some EU countries, and even for these not always with sectoral granularity. Moreover, RMC data for different countries is often based on inconsistent methodologies. However, in order to assess the ‘resource efficiency gap’ and the potential for future efficiency gains, it is crucial to track and benchmark trends in material productivity and efficiency comprehensively.

Firm-level data on investment barriers: Firm-level surveys can identify key issues in the context of resource efficiency. For the ECA and MENA regions it would be conceivable to include resource efficiency related questions to the regularly conducted EBRD MOI survey, which analyses manufacturing firms in the region. As investment barriers are bound to differ across countries and sectors, insights from such surveys could be critical for tailoring future interventions.

Project-specific data: To convince firms and banks of the commercial viability of resource efficiency investments, it is also important to document the performance of past projects.

Which kinds of projects are likely to deliver resource efficiency gains and commercial profits under which conditions? Empirically, what are the main obstacles to different resource efficiency projects? Transparent information on such project details as well as their outcomes can improve the perceived commercial attractiveness of resource efficiency projects (as showcases).

#### 6.4. Developing indicators for resource efficiency gains

One major bottleneck for investing in resource efficiency is a lack of consistent and meaningful indicators to measure success. The difficulty in formulating such indicators is partly due to the heterogeneity of resource-inputs: Material indicators are often weight-based and single-category measures. However, one tonne of sand and one tonne of gold differ in many ways, including their monetary value and environmental impacts. Thus, indicators measuring resource efficiency gains using only one weight-based category fall short of making such crucial distinctions between different materials.

The German Federal Environmental Agency suggests a rather complex approach for an indicator capturing resource efficiency in production, by taking into account the ‘cumulative raw material expense’ (Umweltbundesamt, 2013). This indicator is the sum of all materials (in tonnes) being used throughout the value-chain of a product (including production, transport, energy). In order to measure efficiency gains, an *ex ante* and *ex post* ratio of the weight of a specific material or product and its own ‘cumulative raw material expense’ are compared. It is possible to extend the ratio and include environmental impacts associated with the material or product.

There are several resource efficiency indicators for individual firms available (e.g. monetary value based, several subcategories for each material, ‘conversion rates’ among different materials, etc.) – all with their respective shortcomings. Therefore, an in-depth evaluation of such indicators is crucial for monitoring resource efficiency gains at the firm level.

## 7. Concluding Remarks

This report analyses the rationale for investments in resource efficiency, and considers their implementation in practice. It provides an evidence base for the notion that such investments are not only profitable from a commercial perspective, but can also address major externalities, such as the environmental impacts from excessive industrial waste. However, resource efficiency investments can be difficult to implement in practice as firms face multiple investment barriers due to market distortions and failures. Thus, helping firms to overcome these barriers, and thus enabling resource efficiency gains, is the key rationale for market interventions and proactive support schemes.

Focussing on the ECA and MENA regions, macroeconomic data on material consumption suggests that resource efficiency in these regions is significantly lower compared to high-income countries, even when taking into account the industrial share of GDP (Chapter 2). This gap indicates the potential for investments in resource efficiency in the ECA and MENA regions.

Furthermore, this report provides a comprehensive analysis of potential costs and benefits from investing in resource efficiency, as well as the implications of inaction. While it is impossible to draw universal conclusions, such a cost benefit framework (Chapter 3) suggests that resource efficiency investments are likely to offer positive net present values, especially when including non-monetary dimensions.

However, in practice resource efficiency investments are often obstructed by inefficiencies. Based on this insight, this report investigates the causes of inefficient resource use and the key investment barriers, which prevent for instance the modernisation of production plants and processes (Chapter 4). The report draws from empirical evidence on how such investment barriers have been overcome in the past, and suggests measures for targeted interventions, which help to improve the conditions for resource efficiency investments. Going forward, the analytical framework in this report can be used to assess specific investment projects and complement purely commercial investment appraisals.

Overall, the lessons of this report are clear: Inefficient resource use has wide range of causes, which require a wide range of complementary policy measures. Commercial investment appraisals of specific resource efficiency projects need to be complemented by a comprehensive assessment of costs and benefits (including externalities), as well as investment barriers. Policy makers, regulators, investors, banks, and firms are all critical actors and carry an important role within a comprehensive strategy towards a more resource efficient economy. This comprehensive resource efficiency strategy includes financial and technical support measures at the micro and macro levels aiming to address both the ‘symptoms’ (e.g. excess waste, externalities) and structural causes of inefficiencies. External entities, such as international financial institutions can play a key role in supporting such a comprehensive resource efficiency strategy, especially by providing technical assistance, financing and impulses for policy reform. In summary, while resource efficiency investments are by no means a *free lunch*, concerted action can overcome investment barriers and unlock substantial efficiency gains and the associated economic, environmental and social benefits.

## Bibliography

- Allwood, J. M., Ashby, M. F., Gutowski, T. G., & Worrell, E. (2011). Material efficiency: A white paper. *Resources, Conservation and Recycling*, 55(3), 362–381.
- Aghion, P., Bloom, N., Blundell, R., Griffith, R., & Howitt, P. (2002). Competition and Innovation: An Inverted U Relationship. *NBER Working Paper Series*, No. 9269 .
- Allwood, J. M., Cullen, J. M., & Milford, R. L. (2010). Options for achieving a 50% cut in industrial carbon emissions by 2050. *Environmental Science & Technology*, 44(6), 1888–94.
- AMEC, & Bio IS. (2013). *The Opportunities to Business of Improving Resource Efficiency*.
- Anderson, S., & Newell, R. (2004). Information programs for technology adoption: . *Resource and Energy Economics* , Vol. 26, pp. 27–50.
- Arthur, W. (1989). Competing Technologies, Increasing Returns, and Lock-In by Historical Events. *The Economic Journal*, 99(394), 116–131. Retrieved from
- Atkinson, G., & Hamilton, K. (2003). Savings, Growth and the Resource Curse Hypothesis. *World Development*, 31(11), 1793–1807.
- Bahn-Walkowiak, B., Bleischwitz, R., Distelkamp, M., & Meyer, M. (2012). Taxing construction minerals: a contribution to a resource-efficient Europe. *Mineral Economics*, 25(1), 29–43.
- Barbier, E., Markandya, A., & Pearce, D. (1990). Environmental sustainability and cost-benefit analysis. *Environment and Planning A*, 22(1), 1259–1266.
- Barker, T., Ekins, P., & Foxon, T. (2007). The macro-economic rebound effect and the UK economy. *Energy Policy*, 35(10), 4935–4946.
- Barnes, W., Gartland, M., & Stack, M. (2004). Old habits die hard: path dependency and behavioral lock-in. *Journal of Economic Issues*, 38(2), 371–377.
- Barrett, J., & Scott, K. (2012). Link between climate change mitigation and resource efficiency: A UK case study. *Global Environmental Change*, 22(1), 299–307.
- Bleischwitz, R. (2010). International economics of resource productivity – Relevance, measurement, empirical trends, innovation, resource policies. *International Economics and Economic Policy*, 7(2-3), 227–244.
- Bleischwitz, R. (2012). Towards a Resource Policy - Unleashing Productivity Dynamics and Balancing International Distortions. *Mineral Economics*.
- Bleischwitz, R., Johnson, C. M., & Dozler, M. G. (2013). Re-Assessing resource dependency and criticality. Linking future food and water stress with global resource supply vulnerabilities for foresight analysis. *European Journal of Futures Research*, 2(1), 34.

- Bleischwitz, R., Welfens, P., & Zhang, Z. (2009). *Sustainable Growth and Resource Productivity: Economic and Global Policy Issues* (p. 360). Greenleaf Publishing.
- Bloom, N., & van Reenen, J. (2007). Measuring and Explaining Management Practices Across Firms and Countries. *Quarterly Journal of Economics*, Vol. 122(4), pp. 1351-1408.
- Bringezu, S., & Schütz, H. (2001). *Total material requirement of the European Union*.
- Brunner, P., Baccini, P., Deistler, M., & Lahner, T. (1998). *Materials accounting as a tool for decision making in environmental policy: Mac TEmPo summary report*.
- Brunner, P., & Rechberger, H. (2004). *Practical Handbook of Material Flow Analysis. The International Journal of Life Cycle*.
- Bruyn, S., Markowska, A., de Jong, F., & Blom, M. (2009). Resource Productivity, Competitiveness and Environment Policies, (December).
- Calcott, P., & Walls, M. (2005). Waste, recycling, and “Design for Environment”: Roles for markets and policy instruments. *Resource and Energy Economics*, 27(4), 287–305.
- Cavalcanti, T. V. D. V, Mohaddes, K., & Raissi, M. (2011). Commodity Price Volatility and the Sources of Growth, (January).
- Cellini, S. R., & Kee, J. E. (2010). Cost-Effectiveness and Cost-Benefit Analysis. In *Handbook of Practical Program Evaluation* (pp. 493–530).
- Chatham House. (2012). *Resources Futures*.
- Clift, R., & Wright, L. (2000). Relationships Between Environmental Impacts and Added Value Along the Supply Chain. *Technological Forecasting and Social Change*, 295, 281–295.
- Conway, P., Lysenko, T., & Barnard, G. (2009). Product Market Regulation in Russia. *OECD Economics Department Working Paper 742*, Organisation for Economic Co-operation and Development, Paris.
- Corrigan, C. C. (2014). Breaking the resource curse: Transparency in the natural resource sector and the extractive industries transparency initiative. *Resources Policy*, 40, 17–30.
- Crivelli, E., & Gupta, S. (2014). Resource Blessing, Revenue Curse? Domestic Revenue Effort in Resource-Rich Countries. *European Journal of Political Economy*.
- Da Rosa, C. D., Lyon, J. S., & Hocker, P. M. (1997). *Golden Dreams, Poisoned Streams: How Reckless Mining Pollutes America's Waters, and How We Can Stop It*. Mineral Policy Center.
- Dahlstrom, K., & Ekins, P. (2005). Eco-efficiency Trends in the UK Steel and Aluminum Industries and Resource Productivity, 9(4).
- Davis, G. a. (1995). Learning to love the Dutch disease: Evidence from the mineral economies. *World Development*, 23(10), 1765–1779.

- DeCanio, S. (1993). Barriers within firms to energy-efficient investments. *Energy Policy* , pp. 906-914.
- DeCanio, S., & Watkins, W. (1998). Investment in Energy Efficiency: Do the Characteristics of Firms Matter? *The Review of Economics and Statistics* , Vol. 80(1), pp. 95-107.
- DeCanio, S., Dibble, C., & Keyvan, A.-A. (2000). The Importance of Organizational Structure for the Adoption of Innovations. *Management Science* , Vol. 46 (10), pp.1285-1299.
- Dimitropoulos, J. (2007). Energy productivity improvements and the rebound effect: An overview of the state of knowledge. *Energy Policy*, 35(12), 6354–6363.
- Distelkamp, M., Meyer, B., & Meyer, M. (2010). *Quantitative und qualitative Analyse der ökonomischen Effekte einer forcierten Ressourceneffizienzstrategie Abschlussbericht zu AP5*. [epub.wupperinst.org](http://pub.wupperinst.org).
- Dodman, D. (2009). Blaming cities for climate change? An analysis of urban greenhouse gas emissions inventories. *Environment and Urbanization*, 21(1), 185–201.
- Duflou, J. R., Sutherland, J. W., Dornfeld, D., Herrmann, C., Jeswiet, J., Kara, S., ... Kellens, K. (2012). Towards energy and resource efficient manufacturing: A processes and systems approach. *CIRP Annals - Manufacturing Technology*, 61(2), 587–609.
- Ebrahim, Z., Inderwildi, O., & King, D. (2014). Macroeconomic impacts of oil price volatility: mitigation and resilience. *Frontiers in Energy* , Vol. 8(1), pp. 9-24.
- Eco-innovation Observatory. (2012). *Closing the Eco-Innovation Gap An economic opportunity for business*.
- EBRD. (2010, October 19). *EBRD Management, Organisation, and Innovation (MOI) Survey*. From European Bank for Reconstruction and Development: <http://www.ebrd.com/pages/research/economics/data/moi.shtml>
- EBRD. (2013). *Transition Report 2013*. London: European Bank for Reconstruction and Development.
- Ecorys. (2011). *Study on the Competitiveness of the European Companies and Resource Efficiency*.
- Ecorys. (2012). *Mapping resource prices : the past and the future Final report*.
- ECSIP Consortium. (2013). *Treating Waste as a Resource for the EU Industry. Analysis of Various Waste Streams and the Competitiveness of their Client Industries*.
- Ericsson, M., & Larsson, V. (2013). Annual Survey of Global Mining Investment. *Engineering and Mining Journal*.
- Eurobarometer. (2011). *Attitudes of European entrepreneurs towards eco-innovation*.
- Eurobarometer. (2012). *SMEs, Resource Efficiency and Green Markets*.

- Eurobarometer. (2013). SMEs, Resource Efficiency and Green Markets, (September).
- European Commission. Analysis associated with the Roadmap to a Resource Efficient Europe Part I (2011).
- European Commission. Analysis associated with the Roadmap to a Resource Efficient Europe Part II (2011).
- European Commission. (2011). Roadmap to a Resource Efficient Europe. *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions* .
- European Commission. (2014). *Study on Modelling of the Economic and Environmental Impacts of Raw Material Consumption. Technical report 2014-2478*.
- European Commission JRC. (2012). *Global Resources Use and Pollution, Volume 1 / Production, Consumption and Trade (1995-2008)* (Vol. 1).
- European Environmental Agency. (2011a). *Earnings, Jobs and Innovation: The Role of Recycling in a Green Economy*.
- European Environmental Agency. (2011b). *Resource efficiency in Europe - Policies and approaches in 31 EEA member and cooperating countries*.
- European Environmental Agency. (2012a). *Environmental Indicator Report 2012 - Ecosystem Resilience and Resource Efficiency in a Green Economy in Europe*.
- European Environmental Agency. (2012b). *Material Resources and Waste — 2012 Update*.
- European Environmental Agency. (2013). *Environmental Pressures from European Consumption and Production - A study in integrated environmental and economic analysis*.
- European Resource Efficiency Platform. (2014). *Manifesto & Policy Recommendations*.
- Eurostat. (2001). *Economy-wide material flow accounts and derived indicators*.
- Feng, Y. (1997). Democracy, Political Stability and Economic Growth. *British Journal of Political Science*, 27(3), 391–418.
- Fh-ISI, Wuppertal Institute, & Arthur D. Little GmbH. (2005). *Studie zur Konzeption eines Programms für die Steigerung der Materialeffizienz in mittelständischen Unternehmen. Abschlussbericht*.
- Frishammar, J., & Hörte, S. (2005). *Managing External Information in Manufacturing Firms: The Impact on Innovation Performance. The Journal of Product Innovation Management* , Vol. 22(3), pp. 251-266.
- Giglio, S., Maggiori, M., & Stroebel, J. (2014). Very Long-Run Discount Rates.
- Gollier, C. (2002). Discounting an uncertain future. *Journal of Public Economics* , pp. 149-166.

- Gorodnichenko, Y., & Schnitzer, M. (2010). Financial Constraints and Innovation: Why Poor Countries Don't Catch Up. *NBER Working Paper No. 15792* .
- Gunningham, N., Kagan, R., & Thornton, D. (2004). Social License and Environmental Protection: Why Businesses Go beyond Compliance. *Law & Social Inquiry*, 307.
- Gylfason, T., Herbertsson, T. T., & Zoega, G. (1999). A Mixed Blessing - Natural Resources and Economic Growth. *Macroeconomic Dynamics*, 3, 204–225.
- Hallegatte, S., & Rentschler, J. (forthcoming). Risk Management for Development – Assessing Obstacles and Prioritizing Action. *Risk Analysis* , accepted 06/16/2014.
- Hallegatte, S., Shah, A., Lempert, R., Brown, C., & Gill, S. (2012). Investment decision making under deep uncertainty -- application to climate change. *World Bank Policy Research Working Paper* , WPS6193.
- Hamilton, K., & Hartwick, J. (2005). Investing exhaustible resource rents and the path of consumption. *Canadian Journal of Economics/ ...*, 38(2), 615–621. 1
- Hartwick, J. (1977). Intergenerational Equity and the Investing of Rents from Exhaustible Resources. *American Economic Review*.
- Howarth, R., & Andersson, B. (1993). Market Barriers to Energy Efficiency. *Energy Economics* , pp. 262-272.
- Hyytinen, A., & Toivanen, O. (2005). Do financial constraints hold back innovation and growth? Evidence on the role of public policy. *Research Policy* , Vol. 34(9), pp. 1385–1403.
- IFC. (2013a). *Municipal Solid Waste Management: Opportunities for Russia*. Washington DC: International Finance Corporation.
- IFC. (2013b). *Municipal Solid Waste Management: Opportunities of Ukraine*. Washington DC:: International Finance Corporation.
- International Institute for Environment & Development, & World Business Development Council for Sustainable Development. (2002). *Breaking New Ground: Mining, Minerals and Sustainable Development. New directions for youth development* (Vol. 2014).
- IMF. (2013). *Energy Subsidy Reform: Lessons and Implications*. Washington DC: International Monetary Fund.
- Inverto. (2014). INVERTO Raw Materials Survey 2014 Raw material cost management – why businesses need to act now to mitigate risks.
- Jaunky, V. C. (2013). A cointegration and causality analysis of copper consumption and economic growth in rich countries. *Resources Policy*, 38(4), 628–639.

- Kempton, H., Bloomfield, T. a., Hanson, J. L., & Limerick, P. (2010). Policy guidance for identifying and effectively managing perpetual environmental impacts from new hardrock mines. *Environmental Science & Policy*, 13(6), 558–566.
- KfW Bankengruppe. (2009). *Perspektive Zukunftsfähigkeit – Steigerung der Rohstoff- und Materialeffizienz*.
- KfW Bankengruppe. (2013). *BMU-Umweltinnovationsprogramm: Neuer Förderschwerpunkt „Materialeffizienz in der Produktion“*. From Kreditanstalt für Wiederaufbau.
- Kimura, O. (2010). Japanese Top Runner Approach for Energy Efficiency. *SERC Discussion Paper* , SERC09035.
- Krishna, P., & Mitra, D. (1998). Trade liberalization, market discipline and productivity growth: new evidence from India. *Journal of Development Economics* , Vol. 56(2), pp. 447-462.
- Layard, R., & Glaister, S. (1994). *Cost-benefit analysis* (pp. 1–56). Cambridge University Press.
- Legeida, N. (2002). The Economic Implications of Government Support for the Steel Industry: The Case of Ukraine. *Association for Studies in Public Economics - The Fifth International Conference on "Public Sector Transition"*.
- Leicester, A. (2012). *Environmental taxes: economic principles and the UK experience*. London: Institute of Fiscal Studies.
- Lieberman, M., & Montgomery, D. (1988). First-Mover Advantages. *Strategic Management*
- Ma, Y. (2013). Iron ore spot price volatility and change in forward pricing mechanism. *Resources Policy*, 38(4), 621–627.
- McKinsey Global Institute. (2011). *Resource Revolution: Meeting the world's energy, materials, food, and water needs*.
- McKinsey Global Institute. (2013a). *Resource Revolution - Tracking global commodity markets*.
- McKinsey Global Institute. (2013b). *Reverse the curse: Maximizing the potential of resource-driven economies*.
- Mehlum, H., Moene, K., & Torvik, R. (2006). Institutions and the Resource Curse. *The Economic Journal*, 116(508), 1–20.
- Meyer, B. (2011). *Macroeconomic modelling of sustainable development and the links between the economy and the environment* (Vol. 49).
- Meyer, B., Meyer, M., & Distelkamp, M. (2011). Modeling green growth and resource efficiency: new results. *Mineral Economics*, 24(2-3), 145–154.

- Morriss, J., Phillips, P., & Read, A. (1998). The UK Landfill Tax: an analysis of its contribution to sustainable waste management. *Resources, Conservation and Recycling* , Vol. 23(4), pp. 259–270.
- Moss, R. L., Tzimas, E., Kara, H., Willis, P., & Kooroshy, J. (2013). The potential risks from metals bottlenecks to the deployment of Strategic Energy Technologies. *Energy Policy*, 55,
- Nicolli, F., Johnstone, N., & Söderholm, P. (2012). Resolving failures in recycling markets: the role of technological innovation. *Environmental Economics and Policy Studies*, 14(3), 261–288.
- Oakdene Hollins. (2011). *The Further Benefits of Business Resource Efficiency*.
- OECD. (2004). *Principles of Corporate Governance*. Paris: OECD.
- OECD. (2007). Measuring material flows and resource productivity, *I*.
- OECD. (2011). *Resource Productivity in the G8 and the OECD A Report in the Framework of the Kobe 3R Action Plan*.
- Onischka, M., Liedtke, C., & Jordan, N. (2012). How to sensitize the financial industry to resource efficiency considerations and climate change related risks. *Journal of Environmental Assessment Policy and Assessment* , Vol.14 (3).
- Pamukcu, T. (2003). Trade Liberalization and Innovation Decisions of Firms: Lessons from Post-1980 Turkey. *World Development* , Vol. 31(8), pp. 1443-1458.
- Pasqual, J., & Souto, G. (2003). Sustainability in natural resource management. *Ecological Economics*, 46(1), 47–59.
- Pearce, D. (1998). Cost benefit analysis and environmental policy. *Oxford Review of Economic Policy*, 14(4), 84–100.
- Perman, R., Ma, Y., Common, M., Maddison, D., & Mcgilvray, J. (2011). *Natural Resource and Environmental Economics* (p. 744). Addison Wesley; 4 edition.
- Pindyck, R. (1990). Irreversibility, uncertainty, and investment. *NBER Working Paper No. 3307* .
- Pindyck, R. (2006). Uncertainty in Environmental Economics. *NBER Working Paper, No. 12725*.
- POLFREE. (2013). *DI.1 Analytical Framework of Drivers and Barriers to Resource Efficiency* (pp. 1–50).
- Rennings, K., & Rammer, C. (2009). Increasing energy and resource efficiency through innovation: an explorative analysis using innovation survey data. *ZEW Discussion Paper*, 09(056).
- Rodrik, D. (1988). Closing the Technology Gap: Does Trade Liberalization Really Help? *NBER Working Paper Series, No. 2654* .

- Rohdin, P., Tholander, P., & Solding, P. (2007). Barriers to and drivers for energy efficiency in the Swedish foundry industry. *Energy Policy*, Vol. 35(1), pp. 672-677.
- Sachs, J. D., & Warner, A. M. (2001). The curse of natural resources. *European Economic Review*, 45(4-6), 827-838.
- Satterthwaite, D. (2008). Cities' contribution to global warming: notes on the allocation of greenhouse gas emissions. *Environment and Urbanization*, 20(2), 539-549.
- Schleifer, A. (1998). State versus Private Ownership. *NBER Working Paper Series, No. 6665*.
- Schliephake, K., Stevens, G., & Clay, S. (2009). Making resources work more efficiently – the importance of supply chain partnerships. *Journal of Cleaner Production*, 17(14), 1257-1263.
- Schmidt, M., & Schneider, M. (2010). Kosteneinsparungen durch Ressourceneffizienz in produzierenden Unternehmen. *Umweltwirtschaftsforum*, 18(3-4), 153-164.
- Schoer, K., Giegrich, J., Kovanda, J., & Lauwigi, C. (2012). *Conversion of European Product Flows into Raw Material Equivalents. Methodology*.
- Schoer, K., Wood, R., Arto, I., & Weinzettel, J. (2013). Estimating raw material equivalents on a macro-level: comparison of multi-regional input-output analysis and hybrid LCI-IO. *Environmental Science & Technology*, 47(24), 14282-9.
- Schreyogg, G., & Sydow, J. (2011). Organizational Path Dependence: A Process View. *Organization Studies*, 32(3), 321-335.
- Schröter, M., Lerch, C., & Jäger, A. (2011). Materialeffizienz in der Produktion: Einsparpotenziale und Verbreitung von Konzepten zur Materialeinsparung im Verarbeitenden Gewerbe. *Fraunhofer-Institut Für System- Und Innovationsforschung ISI*.
- Schütz, H., Moll, S., & Bringezu, S. (2003). *Globalisierung und die Verlagerung von Umweltbelastungen*.
- SERI. (2013). *Global Material Flow Database - Technical Report*.
- Söderholm, P., & Tilton, J. E. (2012). Material efficiency: An economic perspective. *Resources, Conservation and Recycling*, 61, 75-82.
- Sorrell, S. (2007). *The Rebound Effect: an assessment of the evidence for economy-wide energy savings from improved energy efficiency*. *Australian family physician* (Vol. 42, p. 169).
- Sorrell, S. (2009). Jevons' Paradox revisited: The evidence for backfire from improved energy efficiency. *Energy Policy*, 37(4), 1456-1469.
- Sorrell, S., & Dimitropoulos, J. (2008). The rebound effect: Microeconomic definitions, limitations and extensions. *Ecological Economics*, 65(3), 636-649.
- Sorrell, S., Dimitropoulos, J., & Sommerville, M. (2009). Empirical estimates of the direct rebound effect: A review. *Energy Policy*, 37(4), 1356-1371.

- Spitz, K., & Trudinger, J. (2008). *Mining and the Environment: From Ore to Metal* (p. 900). Taylor & Francis.
- Sutherland, R. (1991). Market Barriers to Energy-Efficiency Investments. *The Energy Journal* , Vol. 12 (3), pp. 15-34.
- Statistisches Bundesamt. (2011). *Statistisches Jahrbuch 2011*.
- Tietenberg, T. (2009). *Environmental Economics and Policy* (p. 560). Pearson; 6 edition.
- Todorova, N., Worthington, A., & Souček, M. (2014). Realized volatility spillovers in the non-ferrous metal futures market. *Resources Policy*, 39, 21–31.
- Transatlantic Academy. (2012). *The Global Resource Nexus The Struggles for Land, Energy, Food, Water, and Minerals*.
- Tversky, A., & Kahneman, D. (1986). Rational Choice and the Framing of Decisions. *The Journal of Business* , Vol. 59(4).
- UNEP. (2014). Sustainable Consumption and Production - Targets and Indicators.
- UNEP IRP. (2010). *Assessing the Environmental Impacts of Consumption and Production - Priority Products and Materials*.
- UNEP IRP. (2013). *Environmental Risks and Challenges of Anthropogenic Metals Flows and Cycles*.
- UNEP IRP. (2014). *Decoupling 2 - Technologies, Opportunities and Policy Options*.
- UNIDO. (2011). *UNIDO Green Industry Initiative for Sustainable Industrial Development*.
- UNIDO, & AFD. (2013). *Green Growth - From Labour to Resource Productivity*.
- United Nations. (2009). *System of National Accounts 2008*.
- US Dept. of Commerce. (2001). Report to the President. Global Steel Trade: Structural Problems . *International Trade Administration* .
- Valiante, D., & Egenhofer, C. (2013). *Price Formation in Commodities Markets: Financialisation and Beyond. Report of an ECMI/CEPS Task*.
- Varian, H. (2010). *Intermediate Microeconomics: A Modern Approach* (p. 740).
- Voet, E., Oers, L., & Nikolic, I. (2005). Dematerialization Not - Not Just a Matter of Weight. *Journal of Industrial Ecology*, 8(4), 121–137.
- Walz, R. (2011). Employment and structural impacts of material efficiency strategies: results from five case studies. *Journal of Cleaner Production*, 19(8), 805–815.
- West, J., & Schandl, H. (2013). Material use and material efficiency in Latin America and the Caribbean. *Ecological Economics*, 94, 19–27.

- Whitley, S. (2013). *Time to change the game - Fossil fuel subsidies and climate*. London: Overseas Development Institute.
- Wiedmann, T. O., Schandl, H., Lenzen, M., Moran, D., Suh, S., West, J., & Kanemoto, K. (2013). The material footprint of nations. *Proceedings of the National Academy of Sciences of the United States of America*.
- World Bank. (2006). *Corporate Governance Country Assessment - Ukraine 2006*. Washington DC: The World Bank.
- World Bank. (2004). *Corporate Governance Country Assessment : Moldova*. Washington DC: World Bank.
- World Bank. (2004). *Corporate Governance Country Assessment: Romania*. Washington DC: World Bank.
- World Bank. (2014). *Diversified Development - Making the most of natural resources in Eurasia*. Washington DC: The World Bank.
- World Bank. (2013). *World Development Report 2014 - Risk and Opportunity: Managing Risk for Development*. Washington DC: The World Bank.
- World Bank. (2013). *World Development Report 2014 - Risk and Opportunity: Managing Risks for Development*. Washington DC: : The World Bank.
- World Economic Forum . (2013). *Global Competitiveness Report 2013-2014*. Geneva:: World Economic Forum.
- Yeo, M., Partner, Steptoe, & Johnson. (2010). *Natural Resource Subsidies*. Geneva: World Trade Organization.