Resource taxation and resource efficiency along the value chain of mineral resources

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### Glossary – Explanation of key terms in the context of this paper

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<th>Term</th>
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<tr>
<td>Border tax adjustments (BTA)</td>
<td>BTAs aim at eliminating the competitive disadvantage that domestic industries may face as a result of domestic (environmental protection) policy instruments. They include import taxes and export refunds.</td>
</tr>
<tr>
<td>Consumption tax</td>
<td>Tax levied on resources in a final product (e.g. amount of steel in a car) or on a resource intensive final product (e.g. on a car).</td>
</tr>
<tr>
<td>Extraction tax</td>
<td>Tax levied on resources at the point of extraction (e.g. on iron ore).</td>
</tr>
<tr>
<td>Global Raw material tax</td>
<td>“World-wide tax rate on extracted and imported resources” (Ekins et al. 2009). Tax base is the extracted material; if only some countries impose the tax, it is combined with border tax adjustments.</td>
</tr>
<tr>
<td>Material input tax</td>
<td>Tax levied on resources first time they enter into production (e.g. iron ore that is used in steel industry).</td>
</tr>
<tr>
<td>Recycling</td>
<td>“Any recovery operation by which waste materials are reprocessed into products, materials or substances whether for the original or other purposes. It includes the reprocessing of organic material but does not include energy recovery and the reprocessing into materials that are to be used as fuels or for backfilling operations.” Directive 2008/98/EC of the European Parliament and of the council of 19 November 2008 on waste and repealing certain Directives.</td>
</tr>
<tr>
<td>Reserve (in geological context)</td>
<td>Those deposits of a resource, which are geologically identified and can be economically extracted (at current prices within current technology).</td>
</tr>
<tr>
<td>Resource</td>
<td>Material or material flows (raw as well as marginally processed) that can enter into the economy and production processes. Renewable resources include for example water, timber, fertile soil and clean air, while non-renewable resources include metals, minerals, fossil fuels and aggregates. In this paper we use the term resource to denote non-renewable resources, in particular metal and mineral resources.</td>
</tr>
<tr>
<td>Resource (in a geological context)</td>
<td>“A concentration of naturally occurring solid, liquid, or gaseous material in or on the Earth’s crust in such form and amount that economic extraction of commodities from the concentration is currently or potentially feasible.” (Source: USGS Mineral Commodity Summaries)</td>
</tr>
<tr>
<td><strong>Resource efficiency</strong></td>
<td>Relation of a certain result (e.g. a product, service or economic output) to the amount of resource(s) that is used to obtain that result. At the Macro-economic level it can be expressed e.g. by the quotient of Gross Domestic Product / Domestic Material Consumption.</td>
</tr>
<tr>
<td><strong>Resource tax</strong></td>
<td>A tax on resources. The tax base plays a crucial role for the implementation of a resource tax. With respect to the tax base, we make a distinction between extraction, material input, and consumption taxes. The tax base is understood in relation to physical amounts of the resource.</td>
</tr>
<tr>
<td><strong>Royalty</strong></td>
<td>Payment to the owner of the mineral resource in return for the removal of the minerals from the land (Otto et al., 2006). Usually a royalty is designed to skim up the resource rents gained by mining companies, and to compensate the society (as owner of the resource). Different to a tax, the purpose of a royalty is rent extraction, not on setting incentives for changes of behaviour. In practice, however, the effects of a royalty and a tax may be similar. The focus of this paper is on taxes, not on royalties.</td>
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Executive summary

Policy background

Resource efficiency is one of the flagships of the EU 2020 strategy. Resource efficiency is also a key issue in the Raw Material Initiative, the Thematic Strategy on the prevention and recycling of waste, the Thematic Strategy on Sustainable use of Natural Resource, as well as other EU and national initiatives. In its ‘Roadmap to a Resource Efficient Europe’, published on 20th September 2011, the European Commission pointed out the necessity of a resource efficient development of the European economy. “Producing more value using less material and consuming differently” (1) will reduce dependency on resources, economic and environmental costs. The ‘Roadmap to a Resource Efficient Europe’ states that “our economic system still encourages the inefficient use of resources by pricing some below true costs” (2). Therefore “getting the prices right and reorienting the burden of taxation” is considered one of the means for achieving the transformation of the economy (3).

Approach

Some recent analyses suggest the consideration of resource taxation as part of a sustainability strategy(4). Ekins et al. (2009), for example, suggest that a global raw material tax could create an incentive to lower the use as inputs of these materials. Raw material intensive consumption goods will be substituted for by other less material intensive goods as a result of their increasing relative prices. A proportion of the revenues should be used for innovation and resource-efficient technologies and products. Through model-based simulations (GINFORS) of the impact of a resource tax reform in Europe, Barker et al. (2011) suggest that a moderate taxation of all material inputs could lead to a 5% reduction of material consumption in 2020, in particular for construction minerals and ores.

When it comes to the actual implementation of resource taxes, however, it turns out that there are scant prescriptions in the literature and even terms are not used consistently throughout different studies. Meanwhile, the proposals for resource taxes in Europe are few and not fully backed by scientific evidence and policy support.

The aim of this working paper on ‘Resource taxation and resource efficiency along the value chain of mineral resources’ is to shed light on the discussion on resource taxation and to discuss the challenges of introducing resource taxes. The different terms and concepts related to resource efficiency and resource taxation are clarified and the different systems of taxation are analysed with respect to their possible implementation. The scope includes non-renewable and mineral resources only. These resources play a critical role for the European Economy while at the same time Europe is highly dependent on importing them. Non-renewable fossil fuels, as well as other important fixed-amount resources (e.g. water) are excluded from the analysis. The comparison of non-renewable mineral resource taxes with other policy instruments for resource efficiency (including taxes on waste or fossil fuels) is not performed in detail.

1 EC (2011a).
4 The focus of the paper is on metal and mineral resources only.
Rationale for resource taxation

Sufficiently high resource prices would present a powerful incentive to reduce resource use. Resource taxes provide a clearer price signal, as the volatile market prices do not reflect resource scarcity. By supporting resource efficiency, taxes can be a means to reduce dependency on resource producing countries and companies, while also moderate price fluctuations. Beyond the direct economic effect of resource taxation on the price system and the behaviour of economic agents, resource tax revenues can contribute to an environmental tax reform. However, at present, EU member states charge a very low level of taxation on non-renewable resources.

The debate on the necessity to increase resource efficiency is very much based on economic reasons. Scarcity is one argument that combines economic issues with the issue of sustainability. However there is no consensus among experts about how big the problem of scarcity really is. External effects are another important reason for taxation. External effects occur in all stages of the lifecycle of a resource (extraction, use, and disposal). Compared to energy resources, however, where greenhouse gas emissions can serve as a proxy for the environmental harm done and where the effect is a global one, the external effects of the use of non-energy resources are much more complex. External effects are often local in nature and are strongly influenced by the extraction technologies.

Possible taxation schemes

The possible taxes that are considered in this report are: (i) a tax levied on resources at the point of extraction (extraction tax); (ii) a tax levied on resources when they enter into production (material input tax); (iii) a tax levied on resources embodied in a final product or on a resource intensive final product (consumption tax). It turns out that all levels of implementation have their advantages and disadvantages.

An extraction tax, i.e. a tax levied on resources at the point of extraction, may be introduced on a national level. The idea behind an extraction tax is that it influences the price of a resource and therefore the quantity of the resource is extracted at a sustainable level. This is what makes it different to the widely used royalties that aim to tax resource rents without influencing the amount of an extracted resource. On the one hand, such a tax makes mining more costly and creates a competitive disadvantage for the local mining industry. On the other hand, the society has to cope with less external effects caused by mining and more resources can be preserved for future generations. Since most metals used inside the EU are mainly extracted outside the EU, there is only limited option for EU member states for this kind of resource policy. An extraction tax within EU member states is mainly possible for aggregates (as implemented already in some countries) due to the limited international trade and short economic transportation distances. An extraction tax may be complemented by border tax adjustments (BTA) in order to avoid competitive disadvantages for domestic extractive industries and much more to avoid the leakage of resource extraction in mineral and metal exporting countries, since such leakage might lead to zero or negative effects on global resource use and the corresponding environmental damages. An extraction tax together with a BTA will have marginal effects on extractive industries but more impacts on domestic manufacturing industries that have to pay more for both domestic and imported inputs.

A material input tax is applied to materials that are inputs into the production system. Thus, it should be levied on any raw materials from domestic and foreign sources at the first point of industrial use. As raw materials from foreign sources might be processed already abroad, imported intermediate products should be taxed too according to their resource contents. Since intermediate products often

\[5\] Border Tax Adjustments include taxation of imported materials and refund for exported materials (analogous to the VAT system).
contain different raw materials, the determination of the tax base for import is complicated. A tax on copper, for example, may cover all kinds of copper – including intermediate products as metal sheets or even semi-final products. The determination of e.g. copper in car production is even more complicated, since a car contains a considerable amount of copper in kilometres of electrical wires and hundreds of electric and electronic components. Therefore, in practice a material input tax cannot be determined accurately, and may create distortions since not all materials can be included in the tax system. The tax base could be very broad and contain any kind of materials or it could target special materials, e.g. scarce metals.

The main objective of a material input tax should be to create incentives for increased efficiency in production. A material input tax should be applied to both domestic and imported material or intermediate products. Then it does not cause international leakage of resource extraction from the country of tax application. However, when considering the material content of traded intermediate and final goods, further trade-policy adjustments can be necessary to avoid competitive disadvantages for domestic industries.

The advantage of a material input tax is that its implementation is also possible in countries which have a low resources endowment. Compared to an extraction tax it focuses more on use and dependency on resources. It has the potential to spur innovation, increase the resource efficiency of production and alleviate dependency on resources. Depending upon price elasticity and the possibility of material substitution, a material input tax will reduce demand and thus reduce extraction of resources. The disadvantage is that a large amount of data is needed to determine the tax, which will involve high administrative costs.

The taxation of consumption is based on the resource contents of final products. Since final products contain different resources and different resources are also required for their production (depending on their complexity), a consumption tax for targeting resource use is rather inaccurate. The determination of the tax base that reflects resource use is complex and leaves room for much discretion: Questions arise as what characterises a resource intensive product or which amount of resources is needed to produce a certain product. Only if a product is simple and consists mainly of one resource (e.g. fossil fuels) a consumption tax can target resource use directly.

Nevertheless, a resource based consumption tax is expected to influence the behaviour of consumers and depending on the taxation scheme, also the behaviour of producers. Therefore its introduction may be usefully considered, when accepting its limitations.

Conclusions

The taxation of resources other than fossil fuels is possible but much more complicated. The variety of different resources, recycling, international trade, co-production and the long production chains make the determination of the tax base, the implementation of a tax and the calculation of the effects difficult. All existing tax schemes have advantages and disadvantages. Even though a perfect taxation scheme is not available, the introduction of a resource tax – even if not encompassing all resources or products at the beginning – may be useful to direct economies towards a more sustainable direction.
1 Introduction

1.1 Policy background

Several political initiatives with a focus on resource efficiency already exist. Resource efficiency is one of the flagship initiatives of the Europe 2020 strategy. In combination with the Raw Material Initiative, the Thematic Strategy on the prevention and recycling of waste, the Thematic Strategy on Sustainable use of Natural Resource, as well as other EU and national initiatives it provides a new framework for a European resource policy. In its ‘Roadmap to a Resource Efficient Europe’, published on 20\textsuperscript{th} September 2011, the European Commission pointed out the necessity of a resource efficient development of the European economy because “producing more value using less material and consuming differently” \(^6\) can reduce dependency on resources, economic and environmental costs. According to the EEA survey on resource efficiency strategies in Europe \(^7\), most countries include resource efficiency in broad ‘economy-wide’ types of strategies or action plans: national sustainable development strategies; national environmental strategies and action plans; sustainable consumption and production (SCP) action plans; raw materials plans and strategies; strategies and plans related to climate change; and economic reform programmes. Two sectors are more frequently targeted: (i) energy supply, renewable energy and energy efficiency; and (ii) waste management and recycling. Some countries also listed mining and quarrying, agriculture, forestry, industry and fisheries. Many of these strategic sectors are directly or indirectly related to non-renewable and fossil resources. For these resources, Europe is more and more dependent on international markets (see ETC/SCP, 2011).

At the global and the EU level, the use of natural resources is increasing (EEA, 2010; UNEP, 2011). The process of decoupling between resource use and economic drivers that took place in some sectors, and especially in some countries including the EU27, is not sufficient to make the present path a sustainable one. Both current policy and markets signals, e.g. primary commodity prices, are not able to support a further substantial decoupling process and even less an absolute decrease of resource use, even in the EU\(^8\). The EU policy framework for resource efficiency needs additional instruments to become more effective and overcome the main barriers to positive paths.

1.2 Taxation of non-renewable resources: proposals and open issues

A barrier to the achievement of resource efficiency is that “our economic system still encourages the inefficient use of resources by pricing some below true costs” \(^9\). According to the Roadmap, “The EU and its Member States should strive to remove barriers that hold back resource efficiency and so create the right set of incentives for production and consumption decisions”, and this will require: “– Addressing markets and prices, taxes and subsidies that do not reflect the real costs of resource use

\(^{6}\) EC (2011a).
\(^{7}\) See http://www.eea.europa.eu/themes/economy/resource-efficiency
\(^{8}\) The UNEP states: “While different categories of resources have very different kinds of environmental impacts, progress toward decoupling has been made in construction minerals, ores and industrial minerals, fossil fuels, and biomass. But this progress to date has been indicative rather than decisive, and a far greater effort will be required to convince key audiences of the critical importance of decoupling” (UNEP, 2011, page xvi), see also the main conclusions of SOER 2010 on resources and waste (EEA, 2010).
\(^{9}\) COM (2011a), p.2.
and lock the economy into an unsustainable path” (10). Therefore “getting the prices right and reorienting the burden of taxation” is considered one of the means for achieving the transformation of the economy towards higher resource efficiency standards (11). Introducing non-renewable resource taxation schemes can potentially boost the achievement of objectives of the ‘Roadmap to a Resource Efficient Europe’ while delivering multiple benefits from an environmental, industrial, and social point of view.

Recent works suggest the opportunity of considering resource taxation as a fruitful sustainability strategy. According to Baumol (2010), resource taxes are socially useful to rebalance the production costs in favour of environmental services. Ekins et al. (2009) suggest that a global raw material tax can create an incentive on every stage of production to lower the input of materials. Consumption goods that are raw material intensive will be substituted for by other less intensive goods in consequence of their increasing relative prices. Part of the revenues should be used for increasing awareness of resource-efficient technologies and products, so that price signals can encourage behavioural changes.

A few works suggest that resource taxes can have significant effects on material saving. According to the model-based results of the MaRess project (12), the introduction of taxation on building materials in Germany can reduce consumption of non metallic minerals by 15.5% and domestic extraction by 9.7% with respect to business as usual (BAU). Model-based simulations (GINFORS) (13) of the impact of an environmental tax reform in Europe that includes not only energy but also material input taxes of 5% of their price in 2010 and up to 15% of their price in 2020, lead to a 5% reduction of material consumption in 2020, in particular for construction minerals and ores. The model simulations also reveal an increase in material productivity (GDP/domestic material consumption) implying that material intensity decreases (i.e. efficiency gains, see Barker et al., 2011). Uncertainties associated with all modelling exercises must be kept in mind when assessing these findings.

However, at present, EU member states present a very low level of taxation on non-renewable resources except for energy. Furthermore, earmarking of resource tax revenues is very weak. At the same time, the proposals for non-renewable resource taxes in Europe are few and not fully backed by scientific evidence and policy support. In most cases, the issue of how to implement resource taxes is not discussed and is lacking a well-thought-out design.

‘Resource taxes’ actually have various and inconsistent definitions in economic and environmental studies. This report looks at resource taxes in terms of their level of application (extraction, material input, consumption) along the whole material chain. In microeconomic terms, resource taxes can also be classified in terms of their aims, e.g. generating revenue and/or correcting market failures. Furthermore, a classification in terms of their effects on the behaviour of economic agents can be adopted: (i) taxes applied on the marginal unit of value or output, which then should affect producer’s behaviour; (ii) quasi-rent taxes – when aimed at addressing/correcting monopoly power rents due to sunk investment costs, and finally (iii) profit tax / pure rent taxes – which are usually not applied on the marginal unit, and are instead aimed at sweeping away rents; the latter do not in principle affect the behaviour of economic agents, even though in open economies international movements of capital can eventually be influenced (see also Tilton 2004). It is worth noting that when including externality arguments, it could be desirable to achieve a reduced output, and the tax may work as a Pigovian tax. In this case, the social costs (market distortion, reduced output) and benefits (lower extraction and externalities) are accounted for and weighted in order to judge on the ‘properties’ of the tax instrument.

13 Global INterindustry FORecasting System - see for more information Chapter 8 of Ekins and Speck (2011).
The analysis of resource taxation should take into consideration both the complexity in terms of the tax base, of theoretical underpinnings and the practical implementation issues especially with regard to international trade.

1.3 Resource taxes and environmental tax reform

Resource taxes can be seen as a part of a broader environmental tax reform (ETR), which has been extensively studied and practiced in some countries for energy and emissions. ETR policy has been consistently supported by the European Commission and several other major international organisations. SOER2005 claimed that ETR reforms can ‘create more realistic market price signals’ and similar conclusions have been reached by the OECD in many works on ETR (for example OECD, 2006). The Council of Ministers have also endorsed ETR in their review of the EU Sustainable Development Strategy: ‘Member States should consider further steps to shift taxation from labour to resource and energy consumption and/or pollution, to contribute to the EU goals of increasing employment and reducing negative environmental impacts in a cost-effective way.’ (Para 23, Review of the SD Strategy, Council of Ministers, 9 June 2006).

The political and social acceptability of environmental taxes is often very low and the multiple static and dynamic gains for society are not effectively communicated and understood. The way in which revenue recycling is designed and proposed is vital in order to enhance the understanding of both the economic and environmental advantages of ETR. Political economy analyses are needed to support consensus (Aidt, 2010) [14]. The ETR may be a way to put into question the (social) ‘model of development’, generally asking for readdressing growth/development towards equity, quality, wisdom, values, more production of public and collective goods. Earmarking of revenues in negatively affected sectors can increase the trust and the support to ETR.

ETR has thus far largely coincided with energy-related and emission taxation. Taxing these environmental resources can possibly generate revenue at a scale enough to support ‘double dividend’ strategies (i.e. decreasing other distortive taxes) and justify an integrated economic-environmental fiscal reform. However, ETR represents an umbrella under which single or multiple market-based instruments, possibly addressing different sectors, can be designed optimally and implemented consistently. This can also be the case with resource-related taxes, which can be compatible and consistent with other taxes inside an ETR: non-renewable resource taxes are not a substitute for environmental taxes in other sectors; they can even reinforce the effects of other environmental taxes or economic instruments, e.g. coupled with policies for material recycling.

However, given the limited extent of non-renewable taxation schemes aimed at resource efficiency in resource-dependant countries (as opposed to resource taxation for revenue purposes in resource-rich countries, as we shall see), the design of such taxes requires the preliminary examination of their possible features to highlight general as well as specific design issues.

1.4 Aim, scope, and structure

The aim of this working paper on ‘Resource taxation and resource efficiency’ is to shed light on the discussion on resource taxation. The analysis therefore only covers a part of the wider discussion of resource policy issues. The motivation for this focus is that the actual implementation of resource taxes is seldom specified in the literature and that terms are not used consistently throughout different studies. The scope of the analysis is limited to non-renewable mineral resources only. Non-renewable fossil fuels, as well as other important fixed-amount resources (e.g. water) are excluded from the

[14] The evidence for ETR can be found in a range of sources including relevant EEA reports such as three reports on environmental taxes and other market based instruments, (EEA, 2005; 2006, and 2011).
analysis. The comparison of non-renewable mineral resource taxes with other policy instruments for resource efficiency (including taxes on waste or fossil fuels) is not performed in detail.

The general issues of mineral resource taxation are initially discussed (Section 2) to highlight the range of objectives and approaches of resource taxation prevailing in different economic and resource contexts. This analysis can help in distinguishing between resource taxation for revenue purposes and rent re-distribution, which is typical of resource rich/exporting countries, and resource taxation for resource efficiency/saving purposes – which is our focus and the main policy issue in resource-dependant/importing countries, like the EU. This analysis also highlights the differences of taxation schemes depending on: (i) their rationale (reduction of dependency on raw materials, shifting of tax burden from labour to natural resources, reduction of environmental externalities and conservation of natural capital); (ii) the type of resources, in particular those traded in international competitive markets (e.g. metals) and those with ‘local’ markets (e.g. aggregates), and the use of tax revenue. A literature review highlights how the topic of resource taxation for resource efficiency has not been so far a main focus of research (the latter being instead the distribution of resource rents through taxes), thus suggesting the importance of pushing forward this kind of analysis. The issue of ‘border tax adjustments (BTA)’, which arises to make domestic extraction taxes more effective and non discriminatory towards domestic industry, is also considered.

The paper then discusses different resource/material taxation schemes for resource efficiency by highlighting their pros and cons (Section 3). Given the main focus is resource taxation in the EU, i.e. to reduce the use of natural resources both domestically and globally, the paper takes an ‘effectiveness’ perspective. In fact, it does not discuss the cost-efficiency property of different resource tax schemes. It addresses and compares instead the expected effect of a resource tax imposed at different levels of the extraction-production-consumption chain. The stage of application of a tax can be critical for its ability to deliver the expected outcome, as emerging, for example, from the carbon tax literature (\(^{15}\)). Therefore, the paper addresses:

(i) A resource tax levied at the extraction stage; the tax is on the mineral resource extracted (extraction industry); its expected incentive effect is to reduce extraction because of the increasing relative price of the mineral compared to substitutes or other materials; the need of a border tax adjustment associated to this tax is also considered

(ii) A material input tax levied on resources which enter into production; it is levied at the level of manufacturing industry using for the first time the resource-based material as an input, e.g. copper in copper wire production; the international trade issues and the need of border adjustments raised by this kind of tax (e.g. the copper content of imported car components) are also considered;

(iii) A consumption tax levied on final consumption of resource intensive products; the issue of identifying the relative intensity of resources attached to different products is considered as a key issue of implementation.

These different resource tax formulations are examined by describing their rationale, the possible tax base, and the pros and cons that can be encountered in application with respect to their objective of reducing resource use and increasing resource efficiency. A preliminary discussion is also presented on a ‘global’ resource tax, along the lines proposed by Ekins et al. (2009). Although not designed in details by the proponents, such a tax can represent a benchmark because it can avoid – by being global – international competitiveness issues and BTA as arising instead in the national or EU-level schemes we discuss.

\(^{15}\) See different papers presented in Andersen and Ekins (2009) and Ekins and Speck (2011).
The paper thus aims at contributing to the discussion on the application of economic instruments for resource efficiency in Europe but will not come to an ultimate conclusion on which taxation scheme should be implemented and will not detail the technical issues in implementing the schemes themselves.

2 An overview of resource taxation

2.1 Rationale for resource taxation

Resources are not currently being used in an efficient way (\(^{16}\)). Neither do prices accurately reflect external costs and scarcities. Current resource prices are increasingly volatile and do not provide sufficient incentives for an efficient use of resources. Dependency on resources, as well as long-term impacts on the economy, the environment, and society, are in economic decisions not properly reflected.

The need for the taxation of resources is based on a range of different reasons. While in the political context the security of supply and the restructuring of the tax system are very often claimed as priorities, the scientific literature tends to also stress external effects and scarcities (\(^{17}\)). The most important reasons for taxation can therefore be summarised as:

1. Reduction of dependency on raw materials by a reduction of import dependency, promotion of efficiency, substitution or alternative technologies through a provision of price signals and stabilisation of market prices;

2. Restructuring of the tax system through a shift of tax burden from labour to consumption of resources in order to encourage employment and economic growth;

3. Existence of external effects that are not reflected in current resource prices;

4. Inefficient intertemporal allocations (intergenerational equity).

Resource taxes aim at changing price systems and thereby at setting incentives for economic agents to increase resource efficiency and reduce their resource consumption.

2.1.1 Reduction of dependency through an enforcement of efficiency and sufficiency

The EU is highly dependent on imported raw materials. Table 2.1 presents a list of selected raw materials and the EUs import dependency on them (for a complete list see EC, 2010). It shows only direct raw material imports. Import dependency of the EU is even much larger when imports of intermediate and final products are taken into consideration. Table 2.1 points out not only the high import dependency, but also the fact, that this import dependency is not restricted to very special metals like indium. Also the supply of base metals like iron depends very much on import.

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\(^{16}\) See e.g. Dobbs et al. (2011) who state possible savings to society through higher resource efficiency could reach USD 2.9 trillion in 2030 at current market prices or ADL (2005) who found out that in the German manufacturing industry material savings of up to 20 percent are possible.

\(^{17}\) See e.g. European Commission (2011), Garrod and Willis (1999), Turner et al. (1993).
Table 2.1 Import dependence and import sources to the EU of selected raw materials

<table>
<thead>
<tr>
<th>Raw material</th>
<th>Import dependence (2006)</th>
<th>Main EU import sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminum</td>
<td>47%</td>
<td>Russia 27% (2006)</td>
</tr>
<tr>
<td>Antimony</td>
<td>100%</td>
<td>Bolivia 77% (2007)</td>
</tr>
<tr>
<td>Chromium</td>
<td>46%</td>
<td>South Africa 79% (2006)</td>
</tr>
<tr>
<td>Copper</td>
<td>54%</td>
<td>Chile 33% (2007)</td>
</tr>
<tr>
<td>Germanium</td>
<td>100%</td>
<td>China 72% (2007)</td>
</tr>
<tr>
<td>Graphite</td>
<td>95%</td>
<td>China 75% (2007)</td>
</tr>
<tr>
<td>Indium</td>
<td>100%</td>
<td>China 81% (2006)</td>
</tr>
<tr>
<td>Iron</td>
<td>85%</td>
<td>Brazil 51% (2009)</td>
</tr>
<tr>
<td>Magnesium</td>
<td>100%</td>
<td>China 56% (2009)</td>
</tr>
<tr>
<td>Platinum-group-metals (PGM)</td>
<td>100%</td>
<td>South Africa 60% (2006)</td>
</tr>
<tr>
<td>Rare Earth Elements</td>
<td>100%</td>
<td>China 97% (2009)</td>
</tr>
</tbody>
</table>


There are limited possibilities to increase supply for the EU from own sources. Europe’s natural mineral deposits have been heavily exploited over the last centuries. The exploitation of remaining mineral resources is now very costly compared with mining in other countries. With currently relatively high resource prices the opening of some new mines or reprocessing of old tailings is discussed (18). Nevertheless, the barriers are high: large high yield ore deposits are hardly available anymore; environmental standards are high; risks are high as most of the areas are densely populated and the development of new mines takes a very long time.

There is no clear picture of which resources call for policy action most urgently, i.e. which resources should be considered as ‘critical’. Current approaches in the literature are very much focused towards the economic impacts of raw material supply restrictions. The Technology Strategy Board (2008), for example, uses the two dimensions “Impact of Supply Restriction” (as an indicator for economic importance) and ‘Supply Risk’ to determine whether a material should be classified as ‘critical’. If both dimensions show a high value they classify the respective material as ‘critical’. A similar approach is used by the European Commission (see Figure 2.1). Critical materials, according to EC classification include e.g. Indium, Germanium, Niobium, and Rare Earths.

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18 E. g. the Deutsche Rohstoff AG considers different new projects in Germany.
With a broader view the following possible criteria for defining ‘critical’ materials can be taken into consideration (19):

- Geologic scarcity: Scarce materials should be wasted less, i.e. they should either be used less or recycled more. The discussion in Section 2.1 shows, however, that the concept of scarcity is not a trivial one and that it is heavily debated among scientists.

- Oligopolistic market structure and protectionist policies: A scarcity that is caused by firms or countries places the resource user into an unfavourable position (20). Rent shifting or the enforcement of more efficiency may be more advantageous.

- Geopolitical scarcity & conflict: Raw material extraction is often connected with political conflicts (either as a driver or as a result) (21). Such conflicts may lead to an insecure resource supply.

- Negative external effects and environmental restrictions: For environmental reasons not all raw materials that can be extracted from a technical point of view should be extracted. Especially in environmentally sensitive regions such as the Arctic and subarctic regions or rainforests where the loss of nature and biodiversity may far outweigh the gain from resource extraction.

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19 For further details regarding supply restrictions and supply risks see e.g. Smith (2005) or Technology Strategy Board (2008).

20 The ‘classic’ resource cartel is the OPEC. In the 1970s it was able to cause massive disruptions on the oil market. Later on they seemed to be weaker as oil deposits in other parts of the world (e.g. North Sea and Russia) were used much more. With declining resources elsewhere, the OPEC seems to attain new power again. Other resource cartels were not so successful; e.g. the Tin Council collapsed 1985/1986. Currently there is a hot debate on China’s restrictions on rare earth metals.

21 See e.g. Behrendt et. al 2007.
- Land use competition: In densely populated areas, raw material extraction may be difficult. Even when technically feasible, the costs of resource extraction may outpace the gains of it because of damage or risks to the already existing infrastructure.

- Impact of supply restriction: Is the concerned material essential for our society? For what kind of technologies do we need this raw material? Are there substitutes? Resources on which society strongly depends should be handled with much care.

- Recycling: How well is recycling possible from a technical and organisational point of view? The dispersed use of metals is particularly problematic.

- Increasing demand through economic or population growth or technological change requires a more efficient use of resources.

Since the internal supply within the EU cannot be increased significantly, other ways to reduce the dependency on raw materials have to be found, e.g. by substitution, more recycling or increased efficiency. Resource taxes can provide necessary incentives to reduce the use of resources, since they provide clear long-term signals for higher prices. The difference between a simple price increase and a tax is that the latter gives a persistent signal and thus enables long term decisions and investments; prices fluctuate and thus can only give a short term signal (22).

A tax can be an element of a policy mix that aims to reduce resource use in production and consumption and by this reduce the dependency of the economy and the society on this resource. It may as a result contribute to a reduction of vulnerability due to disruptions of supply, raw materials price jumps and fluctuations.

Effects of a resource tax are manifold. As an example, Box 1 illustrates the effects of increased petrol prices which can be caused by an increase in energy taxes. It shows that with a longer time horizon and clear price signals the opportunities for responses and demand reduction will increase.

**Box 1  Effects of increased petrol prices on mobility**

Short term effect:
Increase of costs for vehicle drivers, slight reduction of demand by a reduction of some journeys
Drivers may change the means of transport as far as available and possible

Medium term effect:
Demand for fuel saving cars will increase, car makers try to develop new products
Drivers will buy new fuel saving cars: driving costs will be reduced
Public transport network will be improved: change of means of transport is easier

Long term effect:
Increasing driving costs will change demand pattern:
e.g. consumers will try to reduce commuting e.g. by moving to another house, settlement structure may change in order to reduce the need of transport
Car makers can introduce breakthrough fuel saving innovations

Substitution of petrol:
In case the petrol price reaches an extreme level there will be innovation efforts to replace petrol by other fuels and means of electro-mobility will be developed

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22 EEA (2011) and OECD (2010) highlight the empirical evidence for the positive influence of environmentally related taxation on innovation.
The box illustrates how increased costs by taxes may force the resource user to look for substitutes; how it may spur innovation for new technologies and new products and how it is even able to change consumption patterns and behaviour. The change of demand has the effect that the concerned resource is used less in production and consumption. Thus the economic dependency on this resource will be reduced; probably even a structural change may occur. For potentially scarce resources this is an economic advantage. Furthermore those users, which manage to adjust first, may have a comparative advantage (\(^23\)). However, it has to be noted that the taxation of material resources is much more complex than the taxation of energy.

A tax will not only be a burden to resource users, depending upon price elasticity it may also create a burden on resource suppliers as the supplier has to reduce the price before taxes. For imported raw materials, it means a burden on the rent of the foreign raw material producers that flows as revenue to the domestic government (an example of this are the taxes on oil products). A side effect of a resource tax that is levied nationally is that it may shift income between countries.

Apart from the types of taxes discussed in this report, other taxation schemes levied on resources do exist, namely export and import taxes. Resource suppliers, for example, have the possibility to shift income towards their country by levying a tax on the exported raw material. Such a tax also supports the development of the value added chain in the home country. These import and export taxes are often also part of an industrial policy.

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**Box 2  Export and import taxes**

Resource rich countries frequently levy export taxes on resources. Export taxes are levied on agricultural products but also on minerals (see for a discussion and examples Piermartini, 2004). International trade taxes either levied in the form of import taxes and tariffs or as export taxes are important for the generation of revenues in developing countries (Ayoki, 2007).

When studying different resource taxation schemes it is decisive to assess their application against World Trade Organization (WTO) rules. These rules aiming to reduce protectionism on the import are in general better known than the WTO rules addressing the export side. Article XI:1 of the 1994 General Agreement on Tariffs and Trade (GATT) is the main WTO rule dealing with export restrictions. This article permits the application of export duties (taxes, charges, etc.) but prohibits quantitative export restrictions, such as quotas, bans, etc. (van der Hende et al., 2009).

The issue of export restriction on resources became quite prominent in 2009 when several countries lodged a complaint at the WTO as China toughened their policy stance on exports of minerals and it was claimed that these export restrictions which were implemented in form of export taxes as well as quotas violate WTO rules. The WTO dispute resolution panel ruled in July 2011 that China’s export taxes violate its international obligations as China agreed to eliminate taxes and charges applied to exports when it joined the WTO.

The underlying rationale for imposing import taxes and tariffs is to protect domestic industries, as foreign companies may export goods at prices below the amounts charged by them in their domestic markets in order to capture market shares in the foreign country (dumping). These possible trade discriminations are also dealt with by WTO. Developing countries are complaining that they are facing high tariffs (‘tariff peaks’) on selected products and thereby obstructing their export potentials. Tariff peaks can be found by exporting textiles, clothing, fish and fish products (\(^24\)).

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\(^{23}\) In the environmental literature it is discussed under the notion „Porter-hypothesis“ (see Porter and van der Linde, 1995).

\(^{24}\) See chapter 6 of WTO, 2011.
A resource tax may also contribute to a price stabilisation for the resource user. The tax drives a wedge between the net resource price and the end user price. For a quantity tax (i.e. weight or volume based) this implies that price fluctuations (in relative terms) of the end user price will be lower than without a tax as a quantity tax will not fluctuate with the market price. In other words, the end user will be hit less by price fluctuations and demand patterns will be stabilised based on a high resource price level.

2.1.2 Restructuring of the tax system

Environmental taxes are already applied in many countries. Nevertheless with a view on OECD countries, OECD (2010) makes the following observations:

- Environmental taxes have a rather low share of overall tax revenue.
- During the last decade the importance of environmental taxes stagnated or was even reduced.
- Environmental taxes are currently mostly taxes on energy products (especially fuels), motor vehicles and transport.

On average, environmental taxes accounted for about 2.4 percent of GDP in EU-27 in 2009 (EU, 2011, p.24). This is rather low with regard to the advantages of an environmental tax. There is scope for a shift from direct taxes (especially on labour) to consumption taxes (see e.g. EU, 2011). This is the idea behind a restructuring of the tax system.

Taxes change the price system (e.g. taxes on labour increase cost on labour) and therefore may lead to distortions and a suboptimal equilibrium on the market (e.g. unemployment). On the other hand, there are environmental taxes that make an attempt to correct the price system for external effects. Based on this consideration, a welfare improvement may be achieved by a shift from distorting taxes, e.g. on income, towards environmental taxes. The effect is twofold: Welfare improvements through internalisation of external effects (first dividend) and welfare improvements through a less distortive tax system (second dividend). The German ’Eco-tax’ introduced in 1999 is an example of that. Taxes on energy were increased and the biggest part of this extra revenue was used for the old age pension scheme in order to reduce the contribution rate i.e. levies on labour. Against the background of an aging society, European countries need to adjust their tax and welfare contribution systems. Taxes on resources could be used e.g. to stabilise the welfare system. An environmental tax reform (ETR) can be an essential element in long-term sustainable growth/development and it can support the EU in pursuing the eco-efficient use of energy and resources. The current competitive advantage of the EU in terms of resource efficiency, especially for carbon emissions, is the result of some major drivers such as the technological reaction to past oil crises and the strategies of some (Northern) EU member states in developing strong environmental policies up to implementing complex ‘green fiscal reforms’ (Scandinavian countries in early 1990’s, UK, Germany, see Ekins and Speck, 2011; Andersen and Ekins, 2009).

A further example showing the inter-link between the taxation of resource extraction and a reduction of labour costs can be found in the Norwegian Government Pension Fund. Resource rents are used for securing pensions. What is different to environmental tax reforms is, however, that this pension fund uses the surplus income (actually the resource rent) of the Norwegian petroleum industry and not the revenues of an environmental tax (see Box 3).
Box 3  The Government Pension Fund of Norway

The Government Pension Fund is a fund into which the surplus income produced by Norwegian petroleum industry is deposited. It was previously called ‘The Petroleum Fund of Norway’ until January 2006. As of the valuation in June 2011, it was the largest pension fund in the world. Technically, it is not a pension fund as it derives its financial backing from oil profits and not pension contributions.

The Government Pension Fund comprised of the Fund Norway and Fund Global. Revenues in the Government Pension Fund Global consist of the Government's total income from petroleum activities, and the return on the Fund's investments, while income to the Government Pension Fund Norway consists of the return on the capital under management. The investment strategy of the Global Fund is to achieve high financial returns subject to moderate risk. The Fund is only invested abroad in financial instruments and in real estate. Ethical guidelines for the management of the Fund have been in place since 2004. The strategy for responsible investment encompasses a wide range of tools and activities, including exercise of ownership rights, observation and exclusion of companies. Sound financial return over time is considered to be contingent on sustainable development in economic, environmental and social terms, and well-functioning financial markets.

Norway’s large petroleum revenues have resulted in substantial financial assets in the Fund. Its total value is NOK 3,312 billion (USD 552 bn) according to figures from of 31st December 2011. This equates to the Fund holding 1.1% of global equity markets. With 2.3% of European stocks, it is the largest stock owner in Europe. The value of the fund is much higher than Norwegian GDP, which amounted to NOK 2.710 billion in 2011 (25). The purpose of the petroleum fund is to invest parts of the large surplus generated by the Norwegian petroleum sector, generated mainly from taxes of companies, but also payment for licenses to explore as well as the State's Direct Financial Interest and dividends from partly state-owned Statoil. Current revenue from the petroleum sector is estimated to be at its peak period and to decline over the next decades. The Petroleum Fund was established in 1990 after a decision by the country's legislature to counter the effects of the forthcoming decline in income and to smooth out the disrupting effects of highly fluctuating oil prices. Norges Bank Investment Management (NBIM) manages the Norwegian Government Pension Fund Global.

Source: Norges Bank Investment Management

In many countries, the environmental tax reform has foreseen quantity taxes instead of ad valorem taxes for the taxation of energy. This leads to decreasing (in real terms) eco-tax revenues on GDP in most countries, due to inflation. (26) Environmental taxes do not include a pre-defined ‘escalator’ to preserve their real value, while effective taxes necessarily shrink their same tax base. Their positive impulses are bound to exhaust if there is not a continuous action. The rather low share of environmental taxes, the common environmental destruction and the rather high (tax and social security) burden on labour indicates that there is a scope for an increasing role to be played by environmental taxation (see also EC, 2011).

2.1.3  External effects

The occurrence of external effects is the main justification for environmental taxes. Following economic theory, a Pigovian tax corrects the price system by internalising these external effects. It will increase private costs of environmentally damaging activities until these costs are equal to social costs. Thereby the social optimal level of environmentally damaging activity should be reached, i.e. the damaging activity will become more costly and therefore the demand for it will become smaller. The practical implementation follows more the “price-standard-approach” by Baumol and Oates

26 This can be observed in the EU-27, where a rapid increase in the taxation of energy from 1995 to around 2000 was followed by the fall of energy tax revenues in relation to GDP from 2003 to 2008, see Eurostat (2011).
(Baumol and Oates 1971): The price of an environmental sensitive good will be increased until a certain environmental standard is reached. (27)

Negative external effects of resource use, especially mining, are obvious and manifold (see Figure 2.2). They include such diverse effects as the extensive use of water in regions that suffer of water scarcities, or the contamination of soil and ground water with chemicals that are used in the mining process or heavy metals that are freed during the extraction. Copper or gold mining provide prominent examples for these.

**Figure 2.2 Potential environmental impacts of mining**

<table>
<thead>
<tr>
<th>Environmental impacts</th>
<th>Pollution impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Destruction of natural habitat at the mining site and at waste disposal sites;</td>
<td>- Drainage from mining sites, including acid mine drainage and pumped mine water;</td>
</tr>
<tr>
<td>- Destruction of adjacent habitats as a result of emissions and discharges;</td>
<td>- Sediment runoff from mining sites;</td>
</tr>
<tr>
<td>- Destruction of adjacent habitats arising from influx of settlers;</td>
<td>- Pollution from mining operations in river-beds;</td>
</tr>
<tr>
<td>- Changes in river regime and ecology due to siltation and flow modification;</td>
<td>- Effluent from minerals processing operations;</td>
</tr>
<tr>
<td>- Alteration in water tables;</td>
<td>- Sewage effluent from the site;</td>
</tr>
<tr>
<td>- Change in landform;</td>
<td>- Oil and fuel spills;</td>
</tr>
<tr>
<td>- Land degradation due to inadequate rehabilitation after closure;</td>
<td>- Soil contamination from treatment residues and spillage of chemicals;</td>
</tr>
<tr>
<td>- Land instability;</td>
<td>- Leaching of pollutants from tailings and disposal areas and contaminated soils;</td>
</tr>
<tr>
<td>- Danger from failure of structures and dams;</td>
<td>- Air emissions from minerals processing operations;</td>
</tr>
<tr>
<td>- Abandoned equipment, plant and buildings.</td>
<td>- Dust emissions from sites close to living areas or habitats;</td>
</tr>
<tr>
<td></td>
<td>- Release of methane from mines.</td>
</tr>
</tbody>
</table>


The U.S. EPA analysed 66 mining sites in the United States, covering the extraction of more than 20 raw materials, with regard to the human health and environmental damages caused by management of wastes from mining (extraction and beneficiation) and mineral processing. They find that surface and ground water contamination are the most frequent damages, which occurred in more than 65% of the cases (see Figure 2.3).

27 The ‘incentive’ properties of environmental taxes are still present even if we are not able to directly correlate taxes with externalities values or scarcity in a textbook fashion. Economic instruments maintain their properties even outside the boundaries of strict Pigovian theory (see Baumol and Oates, 1986).
Figure 2.3 Frequency of various types of impacts

<table>
<thead>
<tr>
<th>Type of Impacts</th>
<th>Portion of Damage Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface water contamination</td>
<td>70 percent</td>
</tr>
<tr>
<td>Ground water contamination</td>
<td>65 percent</td>
</tr>
<tr>
<td>Soil contamination</td>
<td>50 percent</td>
</tr>
<tr>
<td>Human health impacts</td>
<td>35 percent</td>
</tr>
<tr>
<td>Flora and fauna damage</td>
<td>25 percent</td>
</tr>
<tr>
<td>Air deposition or fugitive emissions*</td>
<td>20 percent</td>
</tr>
</tbody>
</table>

* Excludes releases associated with air pollution control requirements or devices.


The negative environmental and health impact going out from resource extraction is also pointed out by the Study of the Blacksmith Institute that ranks mining under the most important hotspots of toxic pollution (see table 2.2).

Table 2.2 Top source of toxic pollution hotspots

<table>
<thead>
<tr>
<th>Source Activity</th>
<th>Estimated Global Population at Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Mining and Ore Processing</td>
<td>7,023,000</td>
</tr>
<tr>
<td>2. Metal Smelting</td>
<td>4,955,000</td>
</tr>
<tr>
<td>4. Artisanal Small-Scale Mining</td>
<td>4,233,400</td>
</tr>
</tbody>
</table>

Source: Blacksmith Institute, 2011.

In most countries, mining externalities are regulated by command and control policies which reduce external costs (e.g. through an introduction of pollutant limits). The introduction of a tax may still be valuable, since command and control policies are likely to reduce only a part of the environmental and social costs. In most cases the actual costs of the environmental damage are not fully known because no thoroughly socio-economic and environmental impact analysis is undertaken before mining operations are started. Resource taxes may internalise external effects that can’t be targeted effectively by command and control policy.

The quantification of external costs is not easy from an empirical point of view; in addition external costs may differ strongly depending on the mining site. Evaluations of the damage only exist on a case-by-case basis (28), so even the pursuit of the price-standard approach is difficult. However, a tax can set the right incentives even if the theoretical optimum of resource use cannot be determined (compare e.g. Gawel 2011).

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28 See e.g. the study on the quantification of external effects in bauxite mining and alumina production by Gocht et al. (2001).
2.1.4 Scarcity and intergenerational equity

Is there a scarcity of supply?

Scarcity is a frequently discussed issue in the context of resource use and it is sometimes considered as one of the main reasons for resource policy. However, there is no consensus among experts about how big the problem of scarcities really is.

One main characteristic of exhaustible mineral resources is that, as the name suggests, their availability is limited. Whether this implies that they are scarce is, however, a debate among scientists.

The economic argumentation concerning scarcity of exhaustible mineral resources is based on the central role of the market price in regulating supply and demand. The absolute amount of a resource available in the earth’s crust is fixed, albeit generally unknown. The reserve, however, which denotes resources which could be economically extracted or produced, depends very much on the price of the resource and on the extraction technologies currently available. If the supply of a resource becomes smaller, the price will rise and this will allow for more expensive extraction technologies and for more exploration activities. On the other hand, a higher price will bring about changes on the demand side: it will encourage the substitution of the resource with other materials and/or new ways of using materials. In addition, more efficient resource usage and increased scrap recycling activities can be expected.

The ecological argumentation concerning scarcity of exhaustible mineral resources stresses the environmental and energetic limits to resource extraction activities, taking the position that it will not be possible to continue to extract more of a resource by utilising advanced technology. From some point onwards, further exploitation will require massive amounts of energy, and in addition result in unacceptable levels of pollution and landscape loss. (29)

The point of absolute scarcity of any resource will only be known once the resource has become scarce. In the discussion of the scarcity of oil, for example, the term ‘Peak oil’, i.e. the point in time when the maximum extraction rate of petroleum is reached, is now widely acknowledged. (30) Although scarcity of oil is a rather well analysed topic, it is not possible to precisely determine ex ante the time of ‘Peak oil’ with sufficient accuracy due to the many unknowns associated with oil production and consumption. Thus far, predictions on future production are rather poor. (31) The example of ‘peak oil’ indicates, however, how difficult it is to measure scarcity even in well investigated fields, let alone in fields like mineral resources, on which research has just begun and the peak-concept may not hold in a similar way.

The often referred ‘static range’ indicates how many years under current conditions (supply and reserves) a certain resource will be available. It is not really an indicator of scarcity and since conditions are changing, these numbers can change. Bleischwitz et al. (2009) performed an overview over recent findings on resource scarcity for different fuels and metals. The results are reported in Table 2.3. It must be stressed that the data must be interpreted very carefully. It reflects the current knowledge and situation, but political and economic strategies influence depletion times, as well as criteria such as co-production, recycling, and substitutability.

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29 Especially critical are sensitive areas as rain forest, arctic or subarctic zones or densely populated areas.
30 E.g. OECD /IEA (2010, p.125) presumes that under the “new policies”-scenario the amount of extracted conventional oil will never again obtain its all time peak in 2006.
31 This can be illustrated by the rather drastic revisions of production forecasts and prices in different editions of the World Energy Outlook. See also Energywatchgroup, 2008.
Table 2.3 Predicted peak and depletion of different fuels and metals, and main area of usage

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Peak</th>
<th>Depletion</th>
<th>Main area of usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil</td>
<td>2006–2026</td>
<td>2055–2100</td>
<td>Energy generation</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Chemical industry and pharmaceuticals</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Construction</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Transport fuels</td>
</tr>
<tr>
<td>Natural gas</td>
<td>2010–2025</td>
<td>2075</td>
<td>Energy generation</td>
</tr>
<tr>
<td>Coal</td>
<td>2100</td>
<td>2160–2210</td>
<td>Energy generation</td>
</tr>
<tr>
<td>Antimony</td>
<td>–</td>
<td>2020–2035</td>
<td>Metal alloys</td>
</tr>
<tr>
<td>Copper</td>
<td>–</td>
<td>2040–2070</td>
<td>Energy transport</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Piping</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Electronics</td>
</tr>
<tr>
<td>Gallium</td>
<td>May have passed</td>
<td>–</td>
<td>Electronics (mobile phones, solar cells)</td>
</tr>
<tr>
<td>Indium</td>
<td>–</td>
<td>2015–2020</td>
<td>Electronics (LCDs, solar cells)</td>
</tr>
<tr>
<td>Lead</td>
<td>Passed</td>
<td>2030</td>
<td>Automobile industry</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Chemical industry</td>
</tr>
<tr>
<td>Platinum</td>
<td>–</td>
<td>2020</td>
<td>Electronics (printer, etc.)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Industry (plug, catalyst, glass production)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Medicine (pacemaker)</td>
</tr>
<tr>
<td>Silver</td>
<td>–</td>
<td>2020–2030</td>
<td>Electronics</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Pharmaceuticals</td>
</tr>
<tr>
<td>Tantalum</td>
<td>–</td>
<td>2025–2035</td>
<td>Electronics (mobile phone, automobiles)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Pharmaceuticals</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Chemical industry</td>
</tr>
<tr>
<td>Uranium</td>
<td>–</td>
<td>2035–2045</td>
<td>Energy generation</td>
</tr>
<tr>
<td>Zinc</td>
<td>–</td>
<td>2030</td>
<td>Anticorrosives</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Energy storage (batteries)</td>
</tr>
</tbody>
</table>

Note that out of the variety of different results, the authors derived the time spans with the largest overlaps: For some metals, no information about peak extraction could be found marked with –.

Source: after Bleischwitz et al., 2009, p.19.

Diederen (2009) takes a rather rigorous approach with a long term perspective. He states that only a few elements are really abundant (from the group of metals especially aluminium, magnesium and iron) and geologically available. (32) He recommends in consequence, that society should be built mainly on these “elements of hope”. Following this approach, most of the metals have to be considered as scarce and in the need for political action.

During the last century a decreasing metal content in the extracted ore can be observed (for some examples see Figure 2.4). This means that increasing amounts of energy, water and other resources are needed to extract minerals. As a result economic and environmental costs of resource extraction are increasing.

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32 This assumption is not only based on the absolute abundance of these common metals in the earth crust but also on the presumption that for these minerals the so called mineralogical barrier does not exist. (For further details see e.g. Tilton, 2003, Rankin, 2011 and Diederen, 2009).
Most authors conclude that the absolute scarcity is not a problem, at least not in the short and medium term, but that restriction due to economic, social and environmental constraints are of greater concern (see Section 2.1.1).

**Future demand – a bottleneck that should be anticipated?**

A different approach for dealing with the scarcity question is to look at the demand side. Angerer et al. (2009) focus on key future technologies like photovoltaics or efficient electric motors, and put the global demand of raw materials for the analysed emerging technologies in 2006 and 2030 in relation to today’s world production of each individual raw material. For Gallium, for example, they find that in 2030 the technology-induced demand for this resource will be 6 times higher than its total present worldwide production. For Indium, it will be 3.3 times higher than the total present worldwide production (see Table.2.4). Some of the most critical resources are Gallium and Indium, which are both used for photovoltaics. These numbers can be seen as an indicator for the need of expansion of current mining. They indicate also possible bottlenecks as it might be impossible to expand mining in such a way. Firstly, the expansion of mining requires exploration and mine development, a process that takes many years. Secondly, many of the raw materials are by-products of other elements (see Figure 3.2). Therefore it is not possible to expand their extraction easily, even when they are available in an ore body.
Table 2.4 Global demand of raw materials for emerging technologies in 2006 and 2030 in relation to today’s world production of each individual raw material

<table>
<thead>
<tr>
<th>Raw material</th>
<th>2006</th>
<th>2030</th>
<th>Emerging technologies (selected)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gallium</td>
<td>0.28</td>
<td>6.09</td>
<td>Thin layer photovoltaics, Integrated Circuits (IC), White Light Emitting Diodes (WLED)</td>
</tr>
<tr>
<td>Neodymium</td>
<td>0.55</td>
<td>3.82</td>
<td>Permanent magnets, laser technology</td>
</tr>
<tr>
<td>Indium</td>
<td>0.40</td>
<td>3.29</td>
<td>Displays, thin layer photovoltaics</td>
</tr>
<tr>
<td>Germanium</td>
<td>0.31</td>
<td>2.44</td>
<td>Fibre optic cable, Infrared optical technologies</td>
</tr>
<tr>
<td>Scandium</td>
<td>low</td>
<td>2.28</td>
<td>Solid Oxid Fuel Cells (SOFC), aluminium alloying element</td>
</tr>
<tr>
<td>Platinum</td>
<td>low</td>
<td>1.56</td>
<td>Fuel cells, catalysts</td>
</tr>
<tr>
<td>Tantalum</td>
<td>0.39</td>
<td>1.01</td>
<td>Micro capacitors, medical technology</td>
</tr>
<tr>
<td>Silver</td>
<td>0.26</td>
<td>0.78</td>
<td>Radio Frequency Identification-Systems (RFID), lead-free soft solder</td>
</tr>
<tr>
<td>Tin</td>
<td>0.62</td>
<td>0.77</td>
<td>Lead-free soft solder, transparent electrodes</td>
</tr>
<tr>
<td>Cobalt</td>
<td>0.19</td>
<td>0.40</td>
<td>Lithium-ion batteries, synthetic fuels</td>
</tr>
<tr>
<td>Palladium</td>
<td>0.10</td>
<td>0.34</td>
<td>Catalysts, seawater desalination</td>
</tr>
<tr>
<td>Titanium</td>
<td>0.08</td>
<td>0.29</td>
<td>Seawater desalination, implants</td>
</tr>
<tr>
<td>Copper</td>
<td>0.09</td>
<td>0.24</td>
<td>Efficient electric motors, Radio Frequency Identification—Systems (RFID)</td>
</tr>
<tr>
<td>Selenium</td>
<td>low</td>
<td>0.11</td>
<td>Thin layer photovoltaics, alloying element</td>
</tr>
<tr>
<td>Niobium</td>
<td>0.01</td>
<td>0.03</td>
<td>Micro capacitors, ferroalloys</td>
</tr>
<tr>
<td>Ruthenium</td>
<td>0</td>
<td>0.03</td>
<td>Dye-sensitized solar cells, Ti-alloying element</td>
</tr>
<tr>
<td>Yttrium</td>
<td>low</td>
<td>0.01</td>
<td>Super conduction, laser technology</td>
</tr>
<tr>
<td>Antimony</td>
<td>low</td>
<td>low</td>
<td>Antimony-Tin-Oxide (ATO), micro capacitors</td>
</tr>
<tr>
<td>Chromium</td>
<td>low</td>
<td>low</td>
<td>Seawater desalination, marine technologies</td>
</tr>
</tbody>
</table>

Source: Angerer et al., 2009.

Two of the most important factors driving the demand for a resource are the use of the mentioned future technologies and the growing global economy. Table 2.4 does not capture increases in demand that might be due to economic growth. For resources which are mainly used for a certain purpose or technology, like gallium, neodymium, indium, germanium and scandium, it is the technological development that will primarily determine the demand. For other resources that can be used for a large range of purposes, like iron, steel, copper or chrome, the global economic growth will be the factor that drives the demand. For Platinum-group-metals (PGM), tantalum, silver, titanium and cobalt, both the technological development and world economic growth can be considered to be important for the demand of the resource (Angerer et al., 2009).

The vulnerability of society to the availability of a resource is particularly high when there is no possibility to substitute a material or when substitution is connected with exorbitant high costs.
Optimal intertemporal allocation

The market for non-renewable natural resources possesses some very distinctive features. Firstly, and obviously, the geographic distribution of resources is predetermined by nature. This implies that a country cannot simply decide to engage in extraction activities of a certain resource if that resource is not available in that country. Different strategies have to be employed to reduce dependency on resources. In addition, the formation of prices follow rules that are more complicated than those in standard product markets. For resource markets, it holds that production in any given period is not independent of production in any other period. The resource-extracting industry cannot simply produce more, without affecting the amount of a certain resource that may be extracted in the future. Therefore, each unit of extraction today results in fewer available reserves in the future.

The present value of the lost future profits due to present extraction is often referred to as user costs. Following standard economic models, a resource-extracting firm will in any period expand its output up to the point at which the marginal cost of producing one more unit plus user cost equals the market price \(^{(33)}\). Even though the complex reality prevents a simple application of Hotelling’s rule to resource exploitation, there is one very important implication. If a resource owner has a low valuation of the future and thus uses a high discount factor for decisions on extraction, he may tend to overexploit resources in the immediate present, as he expects less benefit from future extraction. This leads to the following interpretation:

- A resource owner who does not act with a long term perspective discounts strongly, disregards possible future scenarios and tends to overexploit resources. Governments in unstable and under-developed regions are especially prone to that behaviour. Since the supply of many resources flows from such regions, there is a real and likely danger that there currently is an over extraction, oversupply, and consequently an underpricing of certain resources.

- Very often, a difference between the social rate of discount and the private rate of discount can be observed. Private actors tend to have a higher rate of discount than the society; they value the future much less than the present. To compensate for this low valuation of the future, it would make sense to make current resource extraction for private resource owners less attractive in relation to future resource extraction \(^{(34)}\).

Implications

The lack of data, the difficulties to foresee the future, and the limited usefulness of scarcity predictions from the past show how uncertain any forecast on the depletion of resources will be. Nevertheless, in the light of the debate on intergenerational equity one should keep possible scarcities in mind and try to reduce current consumption in order to leave future generations with healthy prospects. The true problem may be not so much the absolute scarcity of some resources, but rather a scarcity due to geopolitical or economic reasons, and the fact that some resources can only be exploited at very high economic, environmental and social costs.

For reasons of scarcity, there is no justification for taxing abundant resources (e.g. Iron, Aluminium), as our economy should substitute potentially scarce resources for those that exist in abundance. The opposite conclusion, however, that a tax should be imposed on resources that are less abundant, may be too simple. In case they are by-products of other elements, there is a danger that taxation may have

\(^{(33)}\) The theory behind the optimal resource extraction path has been introduced by Hotelling (Hotelling, 1931). The Hotelling rule can also be interpreted in such a way, that a resource producer has the choice between
- either resource production now and thus income generation that gains interest in the future
- or waiting and produce later and thus generate income in the future based on future resource prices.

The decision depends upon the rate of interest that can be gained from the current income and the price increase of the resource.

\(^{(34)}\) Cf. Pearce et al., 1989.
the undesired effect of an outcome where extraction is not decreased, but dumping in the tailings (mine dumps) is increased instead. Taxation of resources with the aim to reduce mining now and thereby to postpone scarcity requires thorough calculations and needs further research.

Some governments as well as many companies tend to overexploit resources as they adopt a short term perspective. Governments of resource-producing countries should follow a long term perspective, which takes into account the security of resource supplies for future generations at reasonable prices. These governments should then make a serious effort to slow down the current extraction path.

2.2 Specific features and issues of resource taxation

There are specific features of resource taxes which hinder the direct application of the same approaches adopted for emission and energy taxes.

As opposed to emission externalities, which are mainly global or regional, resource extraction externalities are mainly local. While environmental externality correction is the key to emission taxes, there are several more justifications for resource taxation (see also Section 2.1). According to Garrod and Wills (1999), important issues in resource taxation also include addressing scarcity (and then resource efficiency), ex-post compensation of local extraction externalities (through tax revenue recycling), and rents distribution within a society and worldwide at a given time and over time.

Another of the important differences is the fact that energy resources are consumed, whereas non-energy resources (especially metals) may be recycled and reused, and a high recycling rate is desirable. An extraction tax that leads to a price increase of a resource will increase incentives to more recycling as the virgin material becomes more expensive in relation to the recycled material. Recycling becomes more competitive. Nevertheless, in practice this is not necessarily always true. For example, recycled building materials are often not fully accepted, due to the danger of contamination. The metal price increase may also lead companies to substitute an easily recyclable material with another material that is not (use of carbon fibre instead of metals). Thus, a tax should be complemented by other instruments to ensure that more recycling can be performed, also technically and that no products will be developed that are material efficient in the short term but in the long term difficult to recycle.

However, there is a strong link between energy and mineral resource use. About 7% of global energy consumption is used for extraction, beneficiation and processing of metals (MacLean et al., 2009). An increase of energy taxes is therefore likely to have effects also on the extraction and use of non-energy resources.

Despite of all the challenges related to the introduction of a tax on non-energy resources, such a tax has a number of advantageous features. The tax revenues can be used for public goods provision to local communities and the society at large (35). This allows for the compensation of negative social and environmental effects of extraction activities. Environmental effects are to a large extent site-specific, so in cases where the tax is determined by local planners (mainly for aggregates), there is an option to include at least some of the local externalities into the cost-structures of extraction activities. In addition, tax imposition and collection can act as driving force for better management and planning, including monitoring of extraction activities (see EEA, 2008).

35 This can be observed in some EU member states, especially at the decentralised level of local public good provision (some aggregate related case studies are discussed in EEA, 2008) in federal countries such as Italy, Spain and Germany.
If the aim of taxation is to reduce extraction because of resource scarcity or efficiency reasons, it must be taken into account that there may be a low price elasticity of resource demand, in particular with stable technologies (short run) or limited substitution possibilities in industrial processes. A massive increase in prices (via the tax component) could then have only a small quantity effect. This strategy could have high private costs (high prices of final goods) with relatively low public gains in sustainability. On the other hand, revenue collection may be effective under such conditions: huge revenues are possibly generated to be used for compensation purposes. The economic possibility to apply high taxes due to low demand elasticity is a potential source of ‘shock’ to the economy that concretely produces (i) the possibility of implementing huge sustainability compensation schemes, (ii) enough revenue to fund radical technological shifts (e.g. new materials, energy saving and resource efficient construction processes, etc.). These possible tax revenue recycling schemes can complement the possibly weak effect of prices on innovation and can help to gain a competitive edge regarding resource efficiency. Taxation for resource efficiency can thus embed sustainability objectives that can be reached through both price changes and funding of innovation (using tax revenues).

A possible aim of resource taxation is the reduction of the use of (virgin) resources. Direct taxation of virgin resources is often seen as a theoretical ‘first best’ policy. With respect to the substitution of resources, achieving this effect can be highly complex in the case of non-energy resources. For non-energy resources that do not have renewable substitutes and for which dematerialisation is technically bound, this implies a higher recycling rate and a shift to a different virgin or recycled material mix. To achieve this shift, it would not be sufficient to simply set incentives for a reduction in resource use, it also has to be ensured that the respective product design allows for the recycling of the material and that an appropriate recycling system is implemented. The resource tax scheme could also incorporate incentives to recycling, for example by providing for the use of tax revenue to support recycling industries and processes or by complementing the scheme with a tax on waste that creates incentives to recycle more and thereby reduce the amount of materials that leave the material cycle (see Box 8).

Another very specific issue of non-energy resources is joint production, especially of metals. The composition of resources varies strongly between mines. This also implies that the taxation of any resource is always followed by implications not only on the extraction and use of this resource, but also on the resources that are jointly extracted (see the discussion in Section 3.2.1).

When considering the taxation of mineral resources, a tax on extracted resources would appear to be straightforward (for a general discussion of different taxation schemes see chapter 3). The possibility to implement such a tax in the EU is, however, limited, since the EU has low domestic extraction levels of minerals and fossil energy sources, also compared to the past. Furthermore, Europe is highly dependent on imported resources (see Table 2.1). A taxation of extraction may further lead to a shift from domestic resource extraction to foreign countries. The environmental and social effects of this leakage have to be considered thoroughly.

Figure 2.5 and 2.6 show the monetary value of depletion of minerals (major ferrous and non-ferrous, excluding non-metallic minerals) and energy (oil and gas) in the Euro Area compared to other regions as percent of Gross National Income according to World Bank ‘green accounting’ data (36). The method of calculation is based on unit rents (price minus extraction costs) applied to the quantity produced.

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36 See
Figure 2.5 Minerals value as percent of gross national income

![Minerals value as percent of gross national income](image)

Note: The value of mineral depletion is calculated as the product of net rent and the quantity extracted. Source: own elaboration on World Bank data.

Figure 2.6 Fossil energy resource value as percent of gross national income

![Fossil energy resource value as percent of gross national income](image)

Note: The value of energy depletion is calculated as the product of net rent and the quantity extracted. Source: own elaboration on World Bank data.

In all cases, the basis of the taxation of resource extraction compared to the size of the economy is very low in the EU. According to World Bank data, energy rents in Europe represent 0.3% of Gross National Income (GNI) and minerals rents represent 0.007% of GNI. Mineral and energy rents instead represent a relatively higher share of the GNI of other regions from which the EU import mineral and energy resources. Furthermore, while in some regions the value of resources extracted increased in recent years, it remained stable in the Euro area.
The possibility of introducing (or adding) a tax on minerals and energy in a resource importing region like Europe may raise complex international issues and challenges. While these issues are not so relevant for non-metallic minerals (e.g. aggregates), which are subject to very limited international trade, they are however very important with regard to metallic minerals and fossil energy commodities that are traded globally. This leads us to the concept of a border tax adjustment (BTA) (see Box 4) which would enable the uncoupling of resource prices on the domestic and the world market. This would avoid both competitive disadvantages for domestic industries and the leakage of resource extraction to mineral and metal exporting countries.

**Box 4  Border tax adjustments (BTA)**

Taxes on domestic resource extraction (or use) can make the domestic industry less competitive. In a globalised world this can be a political barrier to impose taxes on resources. To avoid negative impacts on domestic industry, a border tax adjustment can be introduced. It encompasses usually two elements: a tax on import of resources or products embodying resources and a refund to similar exported products. The import tax (or tariff) is to offset additional costs incurred by domestic extractors/manufactures that have to pay the resource tax. The export refund compensates domestic industries for the domestic tax costs they have to incur, so as to level the playing field in foreign markets.

The idea has already been discussed for climate policy measures but could also be applied to other environmental instruments (37). BTA schemes have been proposed in connection to proposals for a European Carbon Tax, as well as to complement the EU Emissions Trading Scheme (EU ETS). In these proposals, the idea of a recently proposed BTA on CO₂ emissions was to protect the working of the EU ETS in front of the threats of carbon leakage and industry migration (due to competitiveness loss) associated to the additional production costs generated by the EU ETS itself. These arguments for BTA in climate policies have been extensively developed by Gros (2009), who argues that, to pursue global welfare, an import tariff based on the external impact of emissions increases global welfare by transferring carbon pricing globally. Already some other works, based on simulations with CGE models, suggested that a compensatory BTA in the EU can improve global welfare and produce a ‘double dividend’ (Majocchi and Missaglia, 2002). While convincing on theoretical grounds, and probably compatible with the WTO rules (see UBA, 2009), the relationships between the EU and less developed producing countries, as well as security-of-supply arguments, also have to be taken into consideration when designing a domestic tax and a BTA.

A contested issue of BTA is its measurement. If the domestic extraction tax is set in terms of resource units (e.g. ton of mineral or its metal content), there is the need to measure the content of embodied resource in imported raw materials, semi-finished, and final products, which raises problems similar to the estimation of CO₂ embodied in imported goods. If the domestic extraction tax is based on the external impacts of mining and energy extraction, the estimation of a BTA on externalities in the site of extraction is much more complicated for natural resources, for which externalities can be site specific, material specific, time specific, compared to CO₂, for which the external costs are global. This difficulty in calculation may pave the way to inefficient determination of the BTA because of either insufficient ‘protection’ of the domestic extraction tax scheme or a discriminatory use of BTA in favour of domestic industry. Thus relevance of international competition and difficulties to implement BTAs may influence resource taxation schemes.

Material resource taxation is much more complicated than energy taxation because the tax base is much more heterogeneous and international trade has a much higher complexity.

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37 For further discussion see e.g. UBA (2009).
2.3 Resource taxation in the literature

Available theoretical and empirical literature on resource taxation is strongly biased towards resource-rich countries and the role of resource exploitation for their economic development.

There are very few works available on resource taxation for resource efficiency in resource-dependant countries, like those in the EU. However, the issues of compensation for extraction externality and the use of rents taxation for social investments are largely dealt with in literature and they may provide suggestions also for resource taxation in Europe. The main works addressing non-renewable resource taxation are discussed here and summarised in the Annex Table 1.

Theoretical and conceptual works

The theoretical literature on resource taxation is huge and goes back to the early years of resource economics and policy. The key issue addressed in this literature is that of capturing and managing the rents from the use of common, private, and public natural resources. In terms of sustainability concepts, this literature on rents from non-renewables brings forward the Hartwick’s rule, according to which rents from non-renewables should be used to compensate for natural capital losses by means of investments in new natural capital, as well as human, and technological capital (38). This rule corresponds to the so called ‘weak sustainability’ principle (see Stiglitz et al., 2009) in which all forms of capital are interchangeable from the economic development point of view (39).

Efficiency and effectiveness of resource taxes are studied at various degrees by works in the literature, which also touch static and dynamic issues. The most significant studies on the theoretical and applied sides are presented below.

Much literature concentrates on the efficiency of resource taxes in terms of efficient rent taxing and an optimal extraction path. In this context, efficiency does not include environmental issues, external effects, or a resource tax as an instrument to enforce efficiency in other parts of the economy. The seminal work by Robinson (1983), in analysing the welfare cost of resource taxation, highlights that scarcity, rent, and inelasticity of supply are strictly interrelated with regard to non-renewable resources and that taxes on such resources should be higher compared to other resources. Taxing rents is often efficient and effective. In fact, taxing rents is ‘price determined’ and not ‘price determining’: a rent does not enter production costs in determining the price, which is why in principle such taxes belong to a family of non-distortionary taxes (Bosquet, 2002). The complex implications of resource taxes are shown by Tilton (2004) who notes that governments should maximise social welfare by capturing rents through resource taxes, and social welfare is linked to the net present value accruing from such fiscal actions. In fact, there is one tax level that maximises net present value of revenues (40), which is bell-shaped with respect to tax rates. It is nevertheless certain that starting at low level, levels of welfare would increase directly as a result of a rise in tax levels.

Moving from a closed economy to open economy also makes the reasoning more complex, as tax inefficiencies may depend upon whether the taxes affect capital movements in the long run. This is related to the ‘pollution haven’ hypothesis argument. The relative abundance of natural stocks is defi-

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38 Hartwick (1977). The paper by Hartwick originated from a discussion on what revenue Canadians could have experienced in 1975 had they invested since 1911 the royalties of resources in assets yielding the normal interest rate, while consuming the interest rate part only.

39 The ‘weak sustainability principle’ is also the basis of ‘Genuine saving’ accounting produced by the World Bank (see par. 2.2).

40 Fraser (2002) notes that both the size of profit margin on extracted resource and the level of riskiness of the resource deposit play a role in determining the relative revenue-generating performance of alternatively structured resource rent taxes (RRTs); the role of each of these factors is mutually re-enforcing in situations which feature either low profit margins and low riskiness, or high profit margins and high riskiness. As a consequence, it can be concluded that no particular structure of RRT is superior at generating tax revenue in all situations.
ninitely a potential source of competitive advantage in resource intense productions. Property right enforcement plays a significant role in this context given that poor enforcement may eventually lead to fast depletion, or excess of supply. In addition, countries could (unsustainably) compete by relaxing property right enforcement and lowering taxes in order to attract investments.

Rents may well be under efficiency levels. Political economy considerations match fiscal and economic reasoning. Van der Ploeg (2010) revisits the Hotelling and Hartwick models including realistic ‘political economic distortions’ such as lobbying and pressures from social groups. First, it demonstrates that it is not sub-optimal for resource rich countries to aim for achieving negative genuine saving performances in the short run, if higher resource prices are expected in the future and extraction technologies are expected to improve (thus waiting for better times). Then, including different social groups and imperfectly defined property rights, political distortions may lead to lower sustainable consumption and lower than optimal accumulation of assets in more fractionalised societies. As expected, economic/political rivalry on the resource determines non optimal outcomes.

Looking at both oil rich and oil poor countries, Bretschger and Valente (2010) theoretically and empirically show (some EU member states are included in the study) that a national tax policy on domestic resource use improves national welfare through rent transfer mechanisms. Amundsen and Schoeb (1999) claim that resource taxation may in some cases affect the international distribution of wealth, without creating clear incentives for consumers to reduce the purchase of resource intensive goods. Theoretically, they start from the fact that coordinated tax policies in advanced resource consuming countries may transfer the tax burden to resource rich countries. This would most likely result in a situation where resource rich countries ‘eat’ up the rents. For example, they cite the parallel increase of real gasoline taxes and the decrease of real producer prices, which has had the historical effect of generating a stable real consumer price.

The above mentioned results are linked to another paper by Schoeb (2003), who, in his extensive paper on double dividends, touches specifically upon the issue of resource taxation in that context and highlights two relevant points. He poses the typical Pigovian argument in a ‘two periods’ model where the resource stock can be consumed over two periods. Firstly, as resource consumption falls, marginal environmental damage decreases, and so should the Pigovian tax. He notes that what matters is the time path of the tax rather than its level. To delay extraction, an action which is welfare enhancing in that model, the tax rate should initially be high and then fall in real terms over time. Pure dynamic efficiency properties could be then satisfied by decreasing tax rates. If innovation were to be introduced as an element of dynamic efficiency (the way taxes affect innovation), it is true on the one hand that a stable policy environment and certain increase of the stringency is shown to influence innovation (OECD, 2011), although on the other hand it is also true that ‘shocking’ the market through an (efficient) tax rate path may stimulate innovation. It is likely the case that different innovation scenarios are stimulated in both cases. We can assume that shocks may well likely stimulate more radical technologies. Many factors, including how agents discount the future, influence nevertheless the way inventions are generated and innovation diffuse in general and as a reaction to policy. Secondly, distributional international issues are again presented as crucial. For example, if resource consuming countries coordinate environmental policy (e.g. a carbon tax), the time path of extraction in producer countries is unaffected. The tax plays the role of a pure rent-capturing tool transferring income from one area to another. Finally, ‘such a tax would have no effect at all on the environment and would thus be a pure rent-capturing tax. If the resource-owning country can exercise market power, by contrast, they may attempt to raise the initial resource price, because this would reduce the environmental tax and allow the resource-owner to capture some of the tax revenues that the resource-consuming countries would otherwise collect’.

Groth and Schou (2007) additionally present results on the role of resource tax reforms for the double dividend idea by showing that resource taxes, and not income taxes and subsidies to capital accumulation, are decisive for growth rates. When resources are a necessary input to the sector where growth is generated, a time-varying tax can increase long run growth. It has been shown that pricing resources
increases productivity and boosts the likelihood of gaining positive per capita GDP growth in the long run state (see Solow, 2010, for a survey of the environmental implications of his models).

Pittel and Bretschger (2010) add further weight in support of the role of *time-varying taxes* and technological change and their interrelatedness. They analyse an economy model in which sectors are heterogeneous with respect to the intensity of natural resource use. Long-term dynamics are driven by resource prices, sectoral composition, and directed technical change- all factors that determine growth and stability conditions. Technical change is found to be biased towards the resource-intensive sector. Resource taxes have no impact on dynamics except when the tax rate varies over time.

The efficiency and effectiveness of a full resource tax reform is a different issue altogether. Revenue generation can be substantial at least in the short run, starting with high tax rates compared to the status quo and low demand to price elasticity. Revenue recycling could be allocated to distributional purposes (giving rent shares to society), sustainable consumption (in cases where resource taxes do not affect consumption choices, but only rent distribution, price changes could be induced by subsidies to resource-light goods), damage compensation (to get at least a zero genuine saving after extraction), and technological purposes (increasing resource productivity is a key point for bringing together growth and sustainability).

**Empirical works**

Even empirical analyses are strongly biased towards resource-rich countries. The main focus is on the management of natural resources, on poor areas exposed to the ‘resource curse’ risk, and lack of investments (negative ‘genuine saving’). A shortage of data appears to have limited the empirical literature; this is even the case in developed countries. In these countries, given that resource taxes have been generally less implemented (besides mining taxes) compared to emission taxes, there is also a lack of policy oriented empirical analysis. Another factor is that the share of resource taxes on GDP in the EU – and even in resource rich countries such as Russia (Bosquet, 2002) – is extremely low. The interrelated analysis of resource curse, sustainability, genuine saving and country’s competitiveness is at the heart of the literature.

Harkness (2009) analyzes the ‘resource curse’ occurrence in an advanced country (US) using data on Kentucky coal counties. The hypotheses are: (1) resource abundance retards growth, while resource rents lead to (2) under-taxation by the government and (3) the diversion of funds away from the provision of public goods, and (4) resource abundance and/or rents increase corruption. He shows that such countries present lower long run economic growth, but it is not true that they under tax rents and under invest in local public goods. This exercise could be well replicated for the case of EU regions with high resource intensity. In a cross section study on US as a whole, Papyrakis and Gerlagh (2004) found that in fact natural abundance reduced the rate of growth (1986-2000) and also decreased investments in public goods/R&D.

Hamilton et al. (2005) address a counter-factual on what would have been the economic growth of countries had they followed a ‘genuine saving’ sustainable policy. They show that following an unsustainable path (i.e. not compensating capital losses, or not reinvesting rents in other assets following the Hartwick rule) can be highly detrimental. If such reinvestment would have taken place, Venezuela and Gabon would now be as wealthy as South Korea, while the per capita GDP in Nigeria would be five times higher than the current level.

In the analysis by Bornhorst et al. (2008), the key hypothesis is that higher resource based taxation reduces the size of other taxation in oil rich countries. Though the allocation in itself can be positive and coherent with ETR rationale (alleviating the burden on labour tax base), excessive substitution may bring about structural losses in tax revenue and debt stress. It could also potentially reduce public pressure on the government, reciprocally decreasing government efforts to tackle tax evasion. In the long term, the fiscal system may be highly undiversified and structurally unstable. Results show that
the two fiscal revenues are associated to a statistically significant negative relation. This evidence does not hamper the ETR properties but highlights a peculiar problem in resource rich countries situated in less advanced areas of the world.

As an example of the international value of a resource tax reform (RTR), Segal (2010) addresses the possibility of reducing poverty at global level by transferring resource rents to citizens through cash flows, a typical distributional aim. This is defined as a ‘resource dividend’. One of the possible dividends (a social one) of a RTR, estimates that taking the 2000-2006 resource rent (World bank data, price of resource – 15 natural resources available – minus the average cost the extraction/production) and income distribution figures, such a transfer could reduce the share of people living under USD 1 per day by 27-66% and the Gini co-efficient is reduced by more than 5 points in 9 out of 17 countries.

Regarding EU member states, Söderholm (2011) reiterates that, from a theoretical point of view, taxing natural resource output or use represents a ‘second-best’ policy, which can be used when, for instance, the monitoring of non-point source emissions is difficult or efficient property rights regimes cannot be established (first best ones). Moreover, by analyzing the aggregate taxation experience in Sweden, Denmark and UK – also exploiting the results of EEA (2008) – the author underlines that the introduction of first-best policies is not possible due to high administration costs or political constraints. The prospects for introducing taxes on virgin natural resources may also be limited on the basis of political acceptability. Proposals for such taxes are likely to be challenged by relatively strong interest groups (e.g. metals or forest industries). In contrast to the heavy industries, the general public may well perceive taxes on natural resources (and on energy) as fair and legitimate. However, natural resources are intermediate goods for which other firms pay a price, and they are ultimately used to produce final goods. Finally, Söderholm suggests the possibility that unless additional policies to increase the supply of recycled materials are implemented, this supply of recycled materials will not increase much, even in the presence of high demand.

Finally, linking to what has just been discussed, a very limited amount of literature exists on the role of taxation in favouring virgin materials vs. recycled materials (or vice versa). Scharf (1999, also based on Chen et al., 1995) provides an empirical assessment of the overall incentives generated by taxes with respect to the choice between extraction and recycling of basic materials in Canada. They calculate measures of the overall impact of the Canadian tax system on the incremental cost of (i) producing virgin material or recycled material that is to be used as an intermediate input in the production of a final product and (ii) producing finished products. The sectors examined include producers of primary virgin material (forestry, mining, oil and gas), producers of recycled material (scrap dealers) and producers of finished products (metal, paper, plastic and glass). The results indicate that the Canadian tax system significantly favours the use of virgin materials rather than recycled materials in the case of metal and glass products, but the reverse is true for plastic products.

Similarly to the theoretical literature, we can note that the (more limited) set of empirical studies stress the possibility of getting high policy value from the international coordination of policies and the use of resource tax revenue for national and also global aims. Though often national in terms of endowments, rights and resource exploitation; production and consumption introduce many international relationships into the picture. Empirical studies stress the crucial role of how revenue is reinvested in advanced and developing countries. Earmarking resource taxation revenues may well improve economic, social and environmental performances. The focus on how the revenue is reinvested is a typical political economy issue, which highlights the often found difficulty of implementing first best policies in the real world (e.g. taxing the source of externality) in order to open space for fiscal policies. Different targets and scenarios may be stimulated by the use of such revenue within a ‘genuine saving’ approach (see above). We cite two possible pillars of earmarking mechanisms, (i) an environmental technological shift, by enhancing green innovation in involved sectors and supporting recycled material markets, and (ii) a development based shift, through investments in education and intangible assets, including innovation. How to mix (i) and (ii) is very much a political economy issue that is difficult to solve for any type of modelling as well as policy making process.
2.4 Existing resource taxation schemes

According to Eurostat (2011), in the EU Member States on average 6.3% of the total tax revenues (equalling to 2.4% of GDP) were from environmental taxes in 2009. The revenues (as % of GDP) however varied between 1.6% and 4.8% among the Member States in 2009. Compared to 1999, when environmental taxes reached their peak level of 2.9% in relation to GDP and 7.0% out of total taxation, the drop is quite significant. Within the environmental taxes, the majority of the revenue is from energy related taxes, followed by transport taxes, while pollution and resource taxes altogether correspond to a negligible share, only about 5% of total environmental taxes (Eurostat, 2011).

Existing taxes on extraction of mineral resources mainly target rent capturing. Royalty taxes are common. Only a few countries use taxes – usually on aggregates – to internalise the external costs associated with mining activities (see EEA, 2005). For example, in the United Kingdom the rate of an aggregates tax (tax on sand, gravel and crushed rock) has been based on an estimate of the external costs. Other countries, for example, Sweden and the Czech Republic introduced taxes on extraction of aggregates with the explicit goal to reduce environmental impacts (EEA, 2008).

An extraction tax can be based either on the physical amount (ad quantum) or on value (ad valorem) of the extracted resources. For example, the aggregates tax in Czech Republic, Italy, Sweden and United Kingdom are based on the physical amount with rates from about 0.1 €/t to 2.4 €/t (EEA, 2008). Other countries like Moldova, Poland and Russia, have implemented ad valorem taxes and charges (EEA, 2005).

In practice, the resource tax rates are usually relatively low. The overall price of the resource does often not change significantly and price elasticity is rather low for aggregates (41) and thus there is no real motivation to change material input. EEA (2008) provides examples where an extraction tax as part of a policy mix (the policy mix may include for example a landfill tax and support of innovation and recycling) leads to some reduction of resource use (Sweden and the UK). Nevertheless, the size of the contribution of the extraction tax to the change of the demand of aggregates is not entirely clear.

Table 2.5 Examples of economic instruments addressing mineral resource use in European countries

<table>
<thead>
<tr>
<th>County and year of introduction</th>
<th>Name of instrument</th>
<th>Minerals and aggregates covered</th>
<th>Purpose of instrument and earmarking of revenues</th>
</tr>
</thead>
<tbody>
<tr>
<td>Czech Republic 1998</td>
<td>Duty on raw materials</td>
<td>Raw material tax on stones; gravel; sand, clay, limestone, chalk, peat, top soil and similar deposits. Tax on mineral phosphorous in feed phosphates.</td>
<td>To provide an incentive to reduce the use of raw materials and, together with the duty on waste, to increase the recycling of construction &amp; demolition waste. Finance activities within the area of the environment and raw materials.</td>
</tr>
<tr>
<td>Cyprus 2005</td>
<td>Payments for mineral extraction</td>
<td>Quarrying charge.</td>
<td>Revenues are used for reimbursements for environmental damages in local communities affected by quarrying (75%), and for support to projects for land and habitat rehabilitation in abandoned quarries (25%).</td>
</tr>
<tr>
<td>Czech Republic 1978</td>
<td>Quarrying charge</td>
<td>Taxes on aggregates (sand, gravel, stone).</td>
<td>Encourage deep mining and preserve landscape.</td>
</tr>
</tbody>
</table>

41 There are many reasons for that; some to mention: construction demand depends very much upon general economic development and state infrastructure projects and building and safety standards give only a limited scope for substitution of materials.
<table>
<thead>
<tr>
<th>County and year of introduction</th>
<th>Name of instrument</th>
<th>Minerals and aggregates covered</th>
<th>Purpose of instrument and earmarking of revenues</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estonia 1991</td>
<td>Mineral extraction tax</td>
<td>Mineral extraction tax on natural gravel, mineral clay, cement limestone, ceramic clay, limestone and dolomite, sand, decorative dolomite, high and low decomposition peat and other mining charges.</td>
<td>To promote the responsible use of natural resources, to ensure they are used effectively and economically. Furthermore, the tax/charge is intended to compensate for public money spent on the investigation of natural resources and for the implementation of measures to ensure their protection. Share of the mining charge that is paid into State Budget is earmarked for environmental protection purposes (under the Act on the Use of Money Accruing from Exploitation of Environment); until 1999, it was revenue of the Environmental Fund.</td>
</tr>
<tr>
<td>France 1999</td>
<td>Extraction of Aggregates</td>
<td>Tax on aggregates (sand, gravel, stone).</td>
<td>Financing labour tax reductions, including working hours cut policy.</td>
</tr>
<tr>
<td>Latvia 1996</td>
<td>Natural resources tax</td>
<td>Tax on extraction of curative mud, dolomite, lime, cement, stones, sapropel, pigmented soil, quartz sand, rock gypsum, sand, gravel, loam, chalk marl, amber, opoka.</td>
<td>To promote the responsible use of natural resources, to ensure they are used effectively and economically. Furthermore, the tax/charge is intended to compensate for public money spent on the exploration of natural resources and for the implementation of measures to ensure their protection. Revenues earmarked for environmental protection and resource management projects, funded through the state environmental fund (receives 40% of the revenue) and municipal environmental funds organised within local governments (receive 60% of the revenue).</td>
</tr>
<tr>
<td>Sweden 1996</td>
<td>Natural gravel tax</td>
<td>Tax on extraction of natural gravel.</td>
<td>Encourage conservation of natural gravel resources and stimulate the use of substitutes (crushed rock) in order to preserve water purification capacities of natural gravel.</td>
</tr>
<tr>
<td>United Kingdom 2002</td>
<td>Aggregate levy</td>
<td>Tax (levy) on extraction of aggregates (natural gravel, sand, stone).</td>
<td>To reduce demand for virgin aggregates, and encourage the use of recycled materials and address the environmental costs associated with quarrying e.g. noise, dust, visual intrusion. Revenues were also recycled via reduction in national insurance contribution.</td>
</tr>
</tbody>
</table>


There are very few countries within the EU that use mineral resource taxes which target environmental purposes.

The purpose of resource extraction taxes (and other economic instruments) is typically fiscal, environmental or both. Among the fiscal reasons, many or most of the revenue from environmental taxes are directed to the state budget. However, there are examples for earmarking the income for environmental purposes such as compensation of the environmental impacts of the extraction activities and/or ensuring the restoration of the landscape after the extraction activity is finished. The environmental motives and reasons may include different aspects (Söderholm, 2006):
1. **Environmental externalities** in the extraction phase, such as waste, noise, air or water pollution, and impacts on landscape, wildlife and ecosystems are one of the most common reasons of resource taxes.

2. **Addressing resource depletion** by raising the price of the extracted material or giving the area of extraction a price (i.e. the aggregate tax in the Czech Republic) in order to create an incentive for the more efficient extraction of the resources.

3. A tax may also encourage the **substitution of certain materials**. For example the gravel tax in Sweden aims at preserving water purification capacities of natural gravel and at encouraging the use of crushed rock instead.

4. Input taxes instead of extraction taxes are also used (mainly on water) in order to strengthen the value of raw material inputs to processing and production industry so to **create incentives for a more efficient and productive use of resources**. Input taxes are to be paid by the consumer of the raw material (i.e. industry) and not by the extractor of the natural resource;

5. To **improve recycling** and use of recyclables instead of virgin raw materials.

### 3 Resource taxes in the context of resource efficiency – can they deliver?

Resource taxes can be levied at different stages of resource use. This leads to different practical, legal and administrative designs as well as different implications on efficiency, resource use and competition. The effectiveness expected from the tax in reducing resource use is likely to be different accordingly: reactions by different stages of resource use and by different industries in terms of saving materials, the use of more recycled materials, or pass through of the tax to other stages will depend on market structure and market power and also on the design of the tax.

We start with a ‘Global Raw Material Tax’ as a benchmark and then look at: (i) an extraction tax (i.e. a tax levied on resources at the point of extraction); (ii) a material input tax (i.e. a tax levied on resources when they enter into production) and (iii) a consumption tax (i.e. a tax levied on resources in a final product or on a resource intensive final product). In order to illustrate how much and how well different types of resource taxes can increase resource efficiency, we present possible tax bases and implementation mechanisms, and discuss their effects, advantages and disadvantages. The most important criteria for the discussion are the effectiveness and the viability of the tax.

#### 3.1 Global tax on resources

A broad based resource tax on (nearly) all material resources is expected to direct the whole economy towards more resource efficiency. Ekins et al. (2009) introduce the idea of a “world wide tax rate on extracted and imported resources”, stressing its advantage of not leading to any negative effects in international trade competition. In this approach, the same tax rate would apply for every unit of weight, independent of the resource (including energy resources) for every material that is brought into the economic system. This approach contains two main elements. (i) all material resources are covered and (ii) the tax is imposed either directly on extraction or on imports from countries that do not (yet) tax the extraction.
3.1.1 Tax base

According to Ekins et al. (2009), the tax base should cover all abiotic and biotic raw materials, in order to reduce overall resource use. The argument for the need of such an overall reduction is that every extraction of resources is in some way harmful for the environment and erodes sustainable development. Therefore, society has to reduce resource use in all areas of life. Given the target that the global use of natural resources should not exceed the current use, and allowing for some growth in developing countries, industrialised countries need to reduce their resource consumption by a factor 10 until 2050 (42).

In 2002, more than 50 billion tons of abiotic and biotic raw materials were extracted worldwide (including fossil fuels), see Figure 3.1. Global resource use is expected to rise up to 80 billion tons in 2020. In a business as usual scenario, the resource use may even amount to 140 billion tons in 2050 (UNEP, 2011). According to UNEP (2011) this “represents an unsustainable future in terms of both resource use and emissions, probably exceeding all possible measures of available resources and assessments of limits to the capacity to absorb impacts”.

Figure 3.1 Global resource extraction

In addition to used extraction, a broad based tax could also cover the so called unused extraction (this is mainly overburden) as this also causes environmental damage. The amount of unused extraction is considerable as can be shown by Table 3.1. For mineral resources the unused extraction adds up to

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42 See e.g. EPA Network, 2006.
more than 1/3 of the amount of the used extraction, for fossil fuels the unused extraction is up to several times higher than the used one. Especially open cast coal mining causes huge amounts of overburden.

Table 3.1 Global used and unused extraction in thousand tons in 2007

<table>
<thead>
<tr>
<th></th>
<th>Used extraction</th>
<th>Unused extraction</th>
<th>Total extraction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minerals</td>
<td>27,921,550</td>
<td>8,505,888</td>
<td>36,427,438</td>
</tr>
<tr>
<td>Fossil fuels</td>
<td>12,210,984</td>
<td>29,249,076</td>
<td>41,460,060</td>
</tr>
</tbody>
</table>

Source: own compilation based on SERI (www.materialflows.net).

There are more or less reliable data on resource extraction on many countries, especially since royalties are often already in place. For a very broad based resource tax (covering all abiotic resources and possibly including unused extraction) there could, however, be a lack of data, in particular related to unused extraction.

3.1.2 Discussion

A global tax will lead to an increase in all resource prices and thereby force an improvement of resource efficiency for all resources, thus reducing human resource consumption and associated impact on the environment. The disadvantage of a tax that relies on a very broad base is that it cannot accurately steer the behaviour of economic agents, neither can it follow specific objectives (as mentioned in Section 2.1), but only the general objective to reduce the resource consumption of society. Box 5 provides calculations as examples for these effects.

Box 5 Example calculations for a global raw material tax

To illustrate the idea of a global raw material tax, the following example outlines its potential dimensions and effects. The world Total Material Requirement (TMR) – that contains used and unused extraction – of mineral resources is about 37 billion tonnes (2007) (see Table 3.1). A global uniform tax of USD 2 per tonne would raise a global revenue of USD 74 billion or about 0.13% of world GDP. This would not disrupt the current economic system as this figure is roughly the magnitude of the current global resource rent for mineral non-energy resources (see Figure 2.5).

What does it mean for the end-user?

The Steel price would be increased by a negligible 7 USD/t (less than 2% of the current world market price). The Copper price would increase by about 600 USD/t, about 7% of the current price, much less than the price fluctuations in the last years. As tin mining requires much material, its price will increase by about 60% (43). Despite the fact that the numbers are based on rough calculations (due to poor data availability for hidden flows), they do show that some sectors and users will be largely unaffected by such a tax while others will be highly affected. Substitutions between different materials may occur. But as the sharp price increase during the last years has shown, demand for material resources has rather low price elasticity, effects on quantity might be negligible: a much higher tax may be required to reach an impact on resource consumption. The example also shows that a uniform tax does not have necessarily equal effects on all sectors.

43 TMR data for steel: 3.66 ton materials per ton of steel, copper: 300 t/t, tin: 6,791 t/t based on Bringezu and Schütz (2001). Current market prices: Steel 527.50 €/t, copper 8,314 USD/t, tin 22,645 USD/t, and a conversion rate of 0.7262 $/€ (September 2011) based on BGR (2011).
A uniform tax on all resources could even aggravate some environmental problems as it focuses only on mass. Mass of resource use does not necessarily correlate with environmental impacts (\(^{44}\)) (even though it might be the case in some circumstances) and unwanted substitution effects may occur (\(^{45}\)). As metals are usually produced jointly (see figure 3.2) a broad based tax may influence the prices especially of by-products and side-products in an unpredictable manner. Thus, a broad based resource tax can only be a supplement to environmental policy, a part of a policy mix to reduce overall resource consumption and environmental pressure from resource use.

### 3.2 Extraction tax

The purpose of an extraction tax is to influence resource prices, thereby reducing the demand and amount of the resource extracted. Extraction should be reduced by this instrument to a level that is sustainable for the society.

#### 3.2.1 Tax base

An extraction tax can be based both on the weight of the used and unused extraction (ore and overburden), alternatively either only on the used extraction (e.g. ore) or the final used material content (e.g. metal content of the ore). It can cover all the resources of a country or region, or be restricted to certain kinds of resources or apply different tax levels to different resources. The coverage of taxed resources should be based on the objectives described in Section 2.1. Moreover, it should be an *ad quantum* tax and not an *ad valorem* tax as the amount of extracted resources is relevant from an environmental perspective (\(^{46}\)).

The joint production of many metals may lead to unintended side effects. Mass metals such as zinc or copper very often determine the profitability of a mine. Other metals are only by-products. Taxation of by-products would not affect the amount of materials extracted provided that the main product is the ultimate purpose of extraction. Furthermore, taxation of a by-product may render the extraction of a by-product uneconomical, resulting in it being disposed of in the tailings; while taxes on mass metals and responses through production reductions may have an effect on the amount of extracted by-products. However, it is difficult to calculate co-production outcomes as the taxation of one metal may also influence the production of all other metals. Figure 3.2 gives an idea of these dependencies.

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\(^{44}\) There is some work to overcome shortcomings of current mass related indicators and measure environmental impact of consumption (Example: Environmentally weighted Material Consumption – EMC, see e.g. van der Voet et al. 2005). Even though these indicators are not really satisfactory yet as they contain much discretion, they indicate that resource use (measured in tons) and environmental impact do not necessarily correlate. See also Giegrich et al. (2012), who show that Cumulated Energy Consumption may be an even better proxy for environmental impact than material consumption.

\(^{45}\) To give an illustrative example: The associated hidden flows to produce tin are about 465 times higher than those for lead (compare Bringezu and Schütz, 2001). A mass based uniform tax would favour the use of lead instead of tin. On the other hand the Restriction of Hazardous Substances Directive directives targets to substitute lead. A typical substitute for use as solder is tin.

\(^{46}\) Nevertheless, an *ad quantum* tax has to be adjusted regularly to correct for inflation.
3.2.2 Implementation

Just as with royalties, an extraction tax is first and foremost a national issue. Since most metals are mainly extracted outside the EU, there could be a limited rationale for adopting such a tax inside in the EU Member States. Therefore, an extraction tax within EU member states could be levied especially on aggregates (as is already implemented in some countries – see Box 6).

Box 6 Taxes on aggregates

Some countries introduced taxes on aggregates with the explicit aim to reduce environmental impacts that emanate from materials extraction (see table 2.5). Where the volume of extracted aggregates is high, there is a need to implement measures to reduce environmental impacts. Often there is a high untapped potential for recycling of aggregates. Compared to taxes on other raw materials, taxes on aggregates are rather simple to introduce. Aggregates are mainly locally traded. Thus, there is only a limited need to introduce border tax adjustments; and international competitiveness of industry is not so much an issue.

As practical experiences show, taxes on aggregates need to be embedded into a policy mix. A tax alone cannot offer enough incentives to reduce consumption of virgin materials as there are many other barriers, for example, a very low price elasticity of construction measures, technical constraints on recycling and material use or a lack of information (47).

47 For further information see e.g. EEA, 2008, or Söderholm, 2011.
An extraction tax influences the price of a resource. So it offers incentives to the resource user to increase efficiency and simultaneously reduce the amount of the extracted resource to a sustainable level. This is what sets it apart from the widely used royalties that aim to tax resource rents without influencing the amount of an extracted resource. However, depending on the concrete implementation, the boundary between an extraction tax and royalties may sometimes be unclear as the following section shows. A high royalty may influence extraction activities, yet a resource tax may also capture resource rents.

3.2.3 Extraction taxes versus royalties

A royalty is to compensate the owner for the extraction (depletion) of a resource. In the scope of the Raw Material Initiative, the European Commission (EC, 2007) has identified the nature of ownership of minerals in different Member States. It was found that higher value minerals, such as metallic ores and energy minerals, plus some industrial minerals are often owned by the State. Other categories of mineral are usually privately owned (mainly by the owner of the land under which they are found). Thus, a royalty usually has to be paid to the State to compensate for the resource extraction. This royalty should capture the resource rent.

There are different designs of mining royalties. They can be unit, value, profit or income based. Hybrid systems that combine several methods are also in use (Otto et al., 2006). According to Kulczycka and Lisowski (2007) and (www.minval.com/royalty_mineral.html), the following four basic forms can be observed:

1. The flat rate unit of production royalty is a fixed sum paid by the extractor for each unit of production of a resource. It appears to be most commonly used for aggregates. It is fairly easy to administer.

2. The gross, or net smelter return (NSR) royalties are a fixed or variable percentage of the sales price, or gross revenue of the resource extractor. It does not allow for deductions for operation costs of the mine. Gross or net smelter return royalty payments are fairly easy to administer.

3. The net revenue, or net proceeds royalty allows for the deduction of some operating costs associated with the on-site mining and processing of the mineral from the gross revenue before calculation of the royalty. The net revenue royalties are usually a fixed or variable percentage of the net revenue. Usually, these allowable production costs are actual direct cash costs at the extraction site and do not include indirect expenses such as costs of exploration or overheads.

4. A net profits royalty is similar to a net revenue royalty, but the allowable cost deductions may include all costs that can be tied to the mining operations, including exploration, corporate overhead, depreciation, depletion, amortization and all other taxes. It will very often be zero.

These different types of royalties show how royalties and resource taxes may be blurred in practice. The flat rate unit of production royalty has some similarities to a resource extraction tax. Similarly, the NSR does not acknowledge costs and thus may influence decisions on mining activities. Only a net profits royalty has no influence on mining decisions. In practice, as the German example shows (see Box 7), a government is able to handle a royalty system in a flexible manner and can thus avoid royalties that may hamper exploration and mining activities. Some countries such as Canada or Australia use flexible royalty schemes that may even negotiate royalty agreements on the basis of unique deposits (Otto et al. 2006).
Mining royalties have a long tradition in Europe. Mining privileges of the sovereigns have been documented since the 12th century. Often everybody had the right to mine and a proportion of the resources mined had to be delivered to the sovereign. The current Federal Mining Act in Germany dates back to 1980. Many resources can be exploited with permission from the authority. There is no requirement to be the land owner in the majority of cases (aggregates are usually an exception). The fees for exploration (‘Feldesabgabe’) are based on \( \text{km}^2 \) with an allowance for exploration expenditures. The revenue is rather low (e.g. in Lower Saxony, a land with high exploration activity, the revenue was EUR 138,845 in 2010, Conrad 2011). The fees for the mined amount of a resource (‘Förderabgabe’) are based on the market value. The royalty rate is 10% of the market price. In certain circumstances, the Bundesländer (the Federated States of Germany) may, however, stipulate a different rate. Many Bundesländer only demand lower rates or exempt certain resources completely from the charge, in order to avoid unduly burden on mining companies. For energy resources e.g. huge differences in tax rates can be observed: on the one hand lignite is exempted from royalties, on the other hand the royalty on oil is comparatively high as present high oil prices generate high resource rents from oil. As the revenues count for the financial equalisation scheme between the Bundesländer, there is only limited incentive for the latter to raise high rates and revenues since the Bundesländer in which the extraction takes place might not benefit from it directly.

### 3.2.4 Effects

An extraction tax has a twofold effect: The net revenue for the mining sector comes under pressure and the price for resource users increases. Price changes will depend upon the price elasticity and the competing supply on the (world) market. The resource price may more or less increase and the demand and supply will change to an extent. An extraction tax will result in a higher cost and/or less profits for the (concerned) mining sector. The following two options mark two extremes. The reality will be somewhere in between as e.g. transport cost, sunk cost for exploration and mine development and/or needed investment will dampen the reaction of economic agents.

- High price elasticity or cheaper foreign supply: 
  
  - domestic resource extraction will decrease,
  - the extracting sector has to bear full tax, profitability will decrease accordingly
  - extraction will be reduced
  (mainly for metals and other high value resources)

- Low price elasticity and no competing cheaper foreign supply: 
  
  - price will increase
  - demand will drop, more or less depending upon price elasticity
  - resource extraction will decrease more or less, profitability will decrease slightly
  (mainly for aggregates because of high transport costs)

Extraction taxes may reduce extraction activity. Two factors will mainly determine the magnitude of the results: 1. International trade will influence the extent to which foreign extractors may compensate and increase their production. 2. Demand elasticity together with the possibilities to increase resource efficiency will determine how much the demand and thus the supply will change.
An extraction tax on mineral resources implemented in the EU without trade measures at the border would reduce extraction activity in Europe without significant global environmental effects, given the low level of domestic extraction and the increasing import that can be expected (leakage via import penetration or industry migration). A resource extraction tax would also have limited effects on innovation because most extraction activities feeding the EU with minerals would take place in other countries, and European industries using minerals as inputs, when faced with a tax, can rely on foreign procurements without increasing their costs (from the tax) and without introducing innovations. The price of the resource may be unaffected and therefore incentives on material substitution and saving will be low. Environmental impacts in the domestic sites of extraction will be reduced, but globally they are likely to be compensated, or even overcompensated (\(^{48}\)), by increased environmental impact in foreign extraction sites. The only exception are aggregates where transport costs are high and therefore a substitution of taxed material by imported material would not be economically viable.

The picture would be different if an extraction tax would be complemented by a BTA. In that case the influence on the domestic extraction sector would be marginal but the resource using industry would be concerned. In fact such a tax scheme would resemble more a hybrid scheme of an extraction tax and a material input tax (see section 3.3); the tax would be levied on the extraction sector but the resource using sector would be affected mainly. The design of the BTA should also be similar to the import tax design of the material input tax, i.e. it should include intermediate products. If the tax were only limited to imported minerals and not to intermediate goods, there is the danger of international relocation of economic activity without any global environmental gain and also without effects on prices and resource efficiency.

The low economic value of mineral extraction in the EU is relevant for the possibly low incidence of an extraction tax in terms of the size of the sectors involved and then the size of the tax revenue compared to the size of the European economy.

The revenue recycling of such a small amount alone cannot be expected to support an environmental tax reform having a relevant macro-level incidence. On the micro-level revenue could be used very well to compensate for negative environmental effects of extraction or to support resource efficient or recycling friendly technology. Tax revenue could thus contribute to a broader policy mix that supports resource efficiency.

### 3.2.5 Discussion

An extraction tax at the national or EU level is difficult to implement and its effectiveness is limited as most resources are imported. Nevertheless, resource taxation within the EU can be effective at least for aggregates. Extraction taxes can be instead very relevant in mineral resource rich countries. There they can be effective in reducing resource extraction to a sustainable level. This is also important for economic reasons: in resource rich and especially resource exporting countries, the economy depends very much upon resource extraction and there is the danger that this hampers the development of other sectors (‘Dutch disease’ \(^{49}\)). Resource taxation may reduce this dependency upon the extracting sector. A further aspect of resource taxation is that it is relatively easy to administrate. Especially in developing countries with a weak tax base, a more extensive use of extraction tax may improve state financing and social development. The support of a proper implementation of an extraction tax in resource rich countries could become a useful part of development policy. We cannot discuss this issue in detail here, but we would like to mention that a long term supply of resources depends upon conditions that enjoy a stable social and economic framework in the extracting countries. Extraction taxes may also contribute to this.

\(^{48}\) Overcompensation may occur when environmental standards and technologies abroad are weaker than domestic standards.

\(^{49}\) This describes the fact that the currency of a heavy resource exporting country will become stronger because of the resource export revenues and thereby decrease the competitiveness of other sectors.
Concerning the practical implementation of an extraction tax, it may also be possible to assign different tax levels to different mines according to scarcity of the resource or external effects, etc. In cases where the external effects are very high or at least have a potential risk of becoming high, command and control systems are more advantageous than taxes. A tax may reduce extraction, but it does not provide any incentives for precautionary measures. For example one of the environmental problems with gold mining, is the use of chemicals (in particular cyanide) which is released into the water and harms not only rivers, but also the ground water. In such a case mining standards can be more efficient in reducing the external effects than a tax on the resource. A tax that is based on the amount of mined ore, or even includes the overburden and not only the metal content, may give some incentives to increase efficiency during extraction and the beneficiation process.

In spite of these possible advantages of resource taxation in resource rich countries, the EU has limited possibilities in influencing their decisions and behaviour. Development or trade policy could contribute in future to a more advantageous taxation in resource rich countries.

### 3.3 Material input tax

A material input tax or sometimes also called a ‘material tax’ addresses the materials that are inputs into the production system. The main objective of a material tax should be to create incentives for increased efficiency in production through dematerialisation and material substitution.

#### 3.3.1 Tax base

A material input tax could be levied on any material that enters into domestic production for the first time. Thus, it should be levied on any raw materials from both domestic and foreign sources. As raw materials from foreign sources entering domestic production might be processed already abroad, imported intermediate and semi-finished products should be taxed too according to their material content. Since imported intermediate products often contain different raw materials, the determination of the tax base is complicated. A tax on refined copper input, for example, can simply be applied at the gate of the first domestic copper user, be the refined copper produced domestically or imported. However, to avoid production leakage to foreign countries, it must be also applied on all imported copper as embodied in all intermediate products (as sheet metal) or semi-final products (as power supply lines), or final goods (as imported cars that can contain a considerable amount of copper in electrical wires and electronic components). The exact determination of the copper fraction of a car needs to include a copper bookkeeping for the complete value added chain, including the value chain of production abroad of imported goods. A more practical approach for a material input tax would require simplifications of the tax base. This will have the disadvantage of being somewhat discretionary and as a result may create distortions if not all materials are included equally in the tax system. Therefore, in practice a material input tax cannot be determined accurately. The tax base should reflect the goals of a material input tax: it could be very broad and contain different materials (e.g. simply tonnes of materials) to reach an overall higher material efficiency or it could target special materials, e.g. scarce metals or building materials.

#### 3.3.2 Implementation

A material input tax may be levied on weight of materials when it enters the manufacturing production chain. The taxation of materials entering the production (first user) within the national economy is straightforward. However, imported raw materials or semi-final goods should be taxed according to their material ‘rucksack’. Otherwise, there would be incentives to shift material intensive process steps abroad to avoid taxation. With a material input tax applied at the country level, domestic industries will have higher production cost than their foreign competitors. The protection of domestic in-
dustries may thus require some form of border tax adjustment. To establish international level playing field, it could be useful to complement the tax with the addition of an export refund. This refund should be designed in a way to match the material ‘rucksacks’ of the tax on the domestic as well as imported materials (see Box 4 on border tax adjustments).

While the consideration of material ‘rucksacks’ of traded goods makes the determination of the tax base difficult, it is more straightforward to implement a tax on intermediate products that do not contain too many dispersed materials. Cement that is used as an input into production could be an example (products made of cement contain usually not many other materials). A determination of the tax base is, with some smaller constraints, possible in such a case (e.g. Danish gravel tax, see Section 3.3.5). On the other hand, a tax on a material such as copper that is used in millions of products in higher or smaller concentration cannot be implemented adequately as there is too much room for discretion or simply lack of data. A material input tax could be concentrated therefore, on materials that are not subject to dispersed use or only in sectors that are rather small and resource intensive. Otherwise, the administrative costs to adequately determine the tax rate equitably would be too high.

A further practical issue of implementation is the preparation of the material balance for recycled metals. As one important strategy to improve resource efficiency is the increase of the recycling rate, a taxation of recycled materials should be avoided. However, since virgin and recycled metals are physically and chemically identical, intensive book keeping of material flows would be required when they are imported or exported.

### 3.3.3 Effects

A material input tax makes the input of that material for the production sector more expensive, thereby creating incentives for a more efficient resource use (e.g. material-saving innovations), substitution by other (renewable) resources, and more recycling. The industrial user of the material is the actor best positioned in giving rise to the resource efficiency effects through substitution and innovations. He/she can (i) introduce new technology to save the taxed material (likely if all non-renewable resources are taxed); (ii) substitute the material with non taxed materials via product design and making (likely if just some materials are taxed); (iii) pass through the additional cost to subsequent stages thus reducing the competitiveness of the material intensive product (likely if he/she has market power, makes differentiated products, or the share of the specific material taxed in total cost is not so high). Instead, the producer of raw materials (see the extraction tax in Section 3.2) has no substitution possibilities; he can only decide if and how to pass through the tax on the mineral in the price of the metal. If he passes through the tax completely, it is the same as taxing the metal at the manufacturer gate but he can also decide not to pass through the tax and accept to reduce his profit to avoid that the metal price increases and the metal is substituted for by other materials, or used less.

Depending upon the price elasticity, consumption may also be affected when a material input tax leads to increased product prices.

When BTAs are effective, the production sector abroad is affected as far as it exports the material in countries with taxes: exporters to the taxing country have to face a tax equivalent to the one applied in the country. The domestic production sector improves its resource efficiency, while the BTAs enable an international level playing field for domestic industries, thereby preventing competitive disadvantages for domestic industries while transmitting internationally the resource saving incentive. Thus, a material input tax focused on the domestic market coupled with a BTA can improve resource efficiency globally. Aachener Stiftung Kathy Beys (2005), shows in a simulation for Germany the impacts of a material input tax up to EUR10 per tonne of all materials. The overall resource consumption would be reduced by 5.5% against the base scenario. The economic impacts are marginal. They show in another example, that a material input tax can have a stronger impact if it is complemented by additional instruments. Assuming that measures such as consulting and information services in addition to the tax lead to a material efficiency of about 20%, the authors show that income will increase,
the use of resources will be reduced by 18% and employment will increase by more than 2%. This illustrates how the increase of material efficiency can have positive impacts on employment and the competitiveness of an economy in addition to increased resource efficiency.

Depending on price elasticity and the possibility of material substitution, a material input tax may reduce demand and thus reduce the level of resource extraction. A material input tax may influence the behaviour of consumers as resource-intensive products may become more expensive, thus reducing the demand for products including taxed raw materials. When BTAs are effective the foreign resource consumption will not be directly affected by the tax.

It may also have unintended side effects if substitution, change of design or processes for reducing the tax burden unintentionally increases the consumption of other non-taxed resources, materials or products.

3.3.4 Discussion

The advantage of a material input tax is that its implementation is also possible in countries that are not rich in resources but use large amounts of materials, as is the case with the EU. It is an instrument for resource policy that has the potential to spur innovation, increase resource efficiency of production and reduce resource dependency from abroad.

However, since implementation is extremely difficult because of data availability, the material input tax can be determined only inaccurately. On the practical side, the determination of the tax base (for imported materials) requires information that is currently not fully available. In addition, the implementation of border tax adjustments needs extensive discussions of the international context and administrative costs for this are also likely to be very high.

Recycling makes it difficult to determine the tax base. For some non-renewable resources, e.g. metals there are high rates of recycling and for a sustainable resource use a high recycling rate is needed. Therefore, recycled metals should not be covered by a material input tax. As recycled metals are physically the same as virgin metals, an extensive tracing and bookkeeping of material flows would be necessary when they cross borders.

As for an extraction tax, recycling is likely to increase, if there is a tax on the virgin metal but not on the recycled one. It may, however, be necessary to complement the tax with other instruments to ensure that the necessary infrastructure for higher recycling rates is provided. For example, the revenue of the tax can be used to support recycling. It has to be ensured that the material input tax does not counteract long term efficiency by a sparse but recycling unfriendly use of material.

A broader material input tax may have varied effects on different sectors. Price and substitution elasticities differ, while technical alternatives to improve resource efficiency vary between sectors. Consequently, different sectors/industries/production processes/products may be affected in different ways. A price increase may result in high private costs with relatively low public gains in sustainability if demand elasticity is low.

Still the simulation of the Aachener Szenario and also the example of the Danish gravel tax show that a material input tax is nevertheless a useful instrument if embedded into a mix of different instruments and measures that target other issues, such as the lack of information, or offering additional incentives, as in the case of a waste tax.
3.3.5 Example: Danish gravel tax

In Denmark, a tax on raw material extraction has been in effect since 1977. In 1990, it was replaced by a tax on raw materials following the implementation of the landfill taxation in 1987. The objective of the raw material tax, in combination with the waste tax, was to promote the reduction of raw material consumption and the reuse of building and construction waste.

The tax rate is since 1990 set at DKK 5 per m³ for selected extracted raw materials, including aggregates (stone, gravel and sand), clay, limestone, chalk, peat, top soil and similar deposits. The tax burden increased prices between 3-33% percent depending on material, but the overall tax is small in relative values.

The tax is levied both on raw materials that are extracted for domestic use and on imports to Denmark for domestic consumption. Therefore, imports are taxed, but no tax is levied on exports in order to ensure that domestically and imported raw materials are treated equally. In other words, a BTA is in place to ensure that exported resources are untaxed and unaffected, allowing competition to continue without disruption.

The raw materials tax was complemented with other measures to reduce the use of resources and encourage substitution to recycled materials such as a landfill tax, voluntary agreements, and a regulation on the separation of construction and demolition waste. The importance of this policy mix especially of the waste tax (see Box 8) is shown also by Söderholm (2011).

In a 2001 report (ECOTEC, 2001) it was concluded that the tax has had small impacts on raw materials extraction in Denmark. The derived demand for raw materials (in construction activities) combined with a low own-price elasticity of demand most likely explains this meagre effect (Söderholm, 2011). ECOTEC, 2001, concludes that the waste tax – that is also in place in Denmark – is a much stronger economic incentive than the tax on materials. As such, the tax on raw materials combined with the tax on landfilled waste and the scheme for separate collection of demolition materials provides a strong incentive for aggregates users in Denmark to employ recycled materials, rather than extracting virgin materials and disposing of old ones (Söderholm, 2011).

**Box 8 Landfill tax as part of a policy mix**

18 European countries currently already have a tax on the land filling of waste. The tax is charged on waste types such as construction and demolition waste and inert waste: residues, hazardous and non-hazardous waste and biodegradable waste. The tax seems to be a driver in diverting waste from landfills and it seems to be especially useful for homogenous waste types like construction and demolition waste. The overall revenue of EUR 2.1 billion in 2009/2010 contributed to both the general state budgets as well as environmental and waste management initiatives. This is in average 0.07% of total tax revenue (ETC/SCP, 2012).

The aim of a waste tax is mainly to reduce the amount of land filled waste. Re-use and recycling and thus the substitution and reduction of virgin material input contribute to this. Thereby, a landfill tax has a positive impact on resource efficiency. As the examples of aggregates taxes further show, best effects can be reached by a policy mix containing different tax incentives and prudent tax recycling.

The example of the Danish gravel tax shows, that although the classification of resource taxes used in this report (extraction, material input, and consumption tax) seems straightforward, mixtures of these arise in reality. The Danish gravel tax is an extraction tax that is complemented by an import tax and tax exemptions for exports. These border tax adjustments protect the Danish extraction industry and allow competition to continue without disruption.

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50 Special regulations regarding the taxation of cement make this particular tax even more a hybrid case.
therefore the effects of the tax resemble more those of a material input tax as they increase the price for the input into production.

3.4 Consumption tax

The taxation of consumption is based on non-renewable resources embodied in final products. Here we consider a consumption tax aimed at reducing resource use. A consumption tax can only address resource use indirectly, since final products contain different resources, while different resources are also needed for their production depending on technology.

3.4.1 Tax base

As products usually contain different resources, it is necessary to develop criteria to decide which products are to be taxed. They could e.g. reflect the issues mentioned in Section 2.1. Based on these considerations it is conceivable to tax products such as (the following list is not exhaustive and the given examples could be challenged for different reasons):

- Products that contain a considerable amount of a critical resource (e.g. electronic equipment or natural fertilizer that contains phosphorus);
- Products containing a certain amount of a critical resource that is used in a dissipative way, and is therefore not conducive to efficient recycling (e.g. mobile phones);
- (Luxury) products that contain more resources than necessary to fulfil the purpose of the product (e.g. extra large automobiles).

This list shows that there can be different approaches and thus different possible tax bases. A weight-based tax might work in cases where the final product is traded in units of weight (e.g. fertilizer). A tax could also be based on a classification of resource use (e.g. size classes of cars). It could also be levied on all products that contain a certain resource or a certain amount of a resource. A practical but not very targeted approach would be to base the tax on the value of a product. This would make sense when the value is correlated with resource use. All approaches have their shortcomings and contain discretion to a certain extent. As the different approaches show, there is no simple all-purpose approach.

3.4.2 Implementation

Implementation on a national level is in most cases possible as it does not directly touch international trade rules. Nevertheless, in some cases consumption taxes can be interpreted as discriminatory (51). Consumption taxes for different purposes are common in many countries (52). A further reason for taxing could be environmental impacts. There are many approaches for a consumption tax. To keep administrative costs down, it should focus on few, very resource intensive products. In any case, the criteria for classifying the resource intensity of products can be very disputable.

A consumption tax that aims at the reduction of resource use could also be tied to the existing tax system; this would keep administrative costs low. A frequently discussed proposal is a modification of the VAT system. Resource intensive products could be taxed with a higher VAT or vice versa resource efficient products could be taxed with a lower VAT (53). Such a model is theoretically easy to

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51 Take as an example a country that produces only small cars and taxes extra large cars that are imported.
52 Excise duties e.g. for alcohol and tobacco are common. Traditionally these duties have pure fiscal reasons. Price elasticities for these products are low. Nowadays taxes are also based on health reasons (alcopop tax in Germany, France, Swiss and Denmark or fat tax in Denmark).
53 For proposals see e.g. Bahn-Walkowiak et. al (2010).
implement (besides probably some legal restrictions as imposed by the Council Directive 2006/112/EC on the common system of value added tax) but practically, lobbying and the inevitable discretion when choosing certain products make implementation difficult (54). Furthermore, it can only roughly target the issue of resource efficiency. In practice there is rather a tendency to simplify the VAT system and not to differentiate more (55). Thus, an extension of the existing VAT system towards more resource efficiency would be administratively rather simple, but overall not very effective. A consumption tax that is not tied to the value but instead to the amount of resources used for the product would be more effective but it will raise all the issue of measurement on material content of both imported and domestically produced final goods, already noted for the material input tax.

### 3.4.3 Effects

A consumption tax makes consumption more expensive for the relevant products. Depending upon the price and substitution elasticity the gross price of the product will be increased more or less and producers or consumers have to bear the tax. In case of low price elasticity it could place a heavy extra burden on society without having much effect on resource consumption. Many luxury goods are resource intensive. Thus a consumption tax on resource intensive goods may have some distributional effects. The right choice of the tax base is crucial for effectiveness. Taxes should be designed in such a way to fulfil at least one of the following points at low social and economic costs (56):

- Allow the consumer for substitution by less resource intensive products;
- Allow for reduction of consumption without problematic social impacts;
- Allow the producer for a change towards less resource intensive products or production patterns.

### 3.4.4 Discussion

Similarly to a VAT, a consumption tax is (usually) not problematic for international competition and it touches not much international law if it does not discriminate between domestic and imported goods. From this point of view implementation would therefore be easy. Practically, implementation is difficult as much lobbying and discretion regarding the tax base and the classification is possible and to a certain extent unavoidable. Furthermore social problems may arise as poorer people could be affected. In that case compensation schemes are necessary.

For simple cases where the tax base correlates strongly with resource use, a consumption tax can be considered. In other cases, when the tax base needs proxies for resource use and intensity, consumption taxes do not allow for a highly targeted resource policy. With a carefully designed tax base at least some effects in reducing resource consumption and increasing resource efficiency might be obtained.

Furthermore, a consumption tax has a psychological effect; it will signal to consumers what are ‘good’ and what are ‘bad’ products. The existence of the tax itself could give information (somewhat similarly to a label) on the resource-use implications of consuming a product and then contribute to the development of green consumption.

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54 Copenhagen Economics (2008) is rather sceptical regarding reduced VAT rates for energy efficient products. They see it problematic that the tax reward is tied to the price but efficiency correlates not necessarily to the price and there are too many conflicting designing issues.

55 For the current discussion see e.g. COM (2011b). In this document the commission propose to abolish reduced VAT rates for environmentally harmful products.

56 Theoretically the cost of introduction of the tax should be lower than the benefit by reduced resource consumption. As costs and benefits are difficult to count practically this requirement cannot be quantified satisfactorily.
4 Conclusions

Environmental taxes are used as a policy instrument in many countries. The most common are taxes on energy use and transport. Pollution and resource taxes only make up a negligible share of overall revenues from environmental taxes. The ratio of environmental tax revenue to total taxation has, however, declined over recent years, especially within the Euro zone, even though their use has shown several advantages in terms of economic efficiency (57). Taxes on the extraction of minerals and fossil fuels are usually implemented with the purpose to capture resource rents, and are implemented in a few resource rich countries where they can even be a major source of government revenue.

Environmental tax reform, which means a shift from taxes on production factors such as labour towards taxes on environmentally harmful activities, promises a combination of combating negative environmental externalities and introducing positive economic stimuli. During the last two decades many countries started to implement this concept through taxation of energy and fuels. It seems to be straightforward to extend this concept to other non-renewable resources. But when it comes to the taxation of non-energy resources and materials, the application of this instrument turns out to be not trivial and many implementation issues arise.

In this working paper we have identified and discussed the most important issues related to mineral resource taxation.

Among the reasons for mineral resource taxation, external effects and scarcities as well as the reduction of resource dependency, the enforcement of resource efficiency and the overall reduction of resource consumption are the most important. External effects occur in all stages of the lifecycle of a resource (extraction, use and disposal). Compared to energy resources, however, where the greenhouse gas emissions can serve as a proxy for the environmental harm done and where the effect is to a large extent a global one, the external effects of the use of non-energy resources are much more complex. A large part of externalities are local in nature. Scarcity is a geological problem and much debated among scientists. The necessity of a reduction of resource dependency for economic and political reasons, on the other hand, is generally acknowledged, but it is not easy to agree on concrete targets for the many different resources. Recommendations for optimal taxation schemes are therefore not straightforward.

In order to reduce global resource consumption, a global resource tax that is charged per unit of weight of all raw materials from non-renewable resources, has been suggested. Even leaving aside the global politics dimension of such a global tax, its implementation raises different technical issues, such as the fact that the extraction method strongly influences the environmental effects and that environmental damages do not correlate to the weight of the material extracted. In addition, by-products are a substantial complication for the taxation of mineral resources. In order to increase resource efficiency, the tax level should therefore be differentiated for every site according to the concrete local situation. This approach, however, lacks practicability.

From the scarcity point of view, there is no justification to tax resources that are obviously abundant (e.g. Iron, Aluminium). The opposite conclusion, however, that a tax should be imposed on resources that are less abundant, may be too simple, as they are often extracted as by-products. The taxation of resources that are by-products of the extraction of other material might have the adverse effect that their extraction is not decreased but only their dumping increased instead.

57 Note that taxes on oil and gas extraction are excluded from the definition of environmental taxes by Eurostat.
In order to achieve high resource efficiency, **recycling** has to be intensified. It is not trivial to design a tax in a way that it necessarily leads to increased recycling. Even though a tax on virgin materials makes recycling more competitive, the realized recycling potential depends upon additional, especially technical conditions and recycling friendly product design. A resource tax should be therefore complemented by other instruments that support recycling. Another complication lies in the fact that primary and secondary metals are indistinguishable. This will require intensive **material accounting**, in particular for tax schemes that include a border tax adjustment.

Resource taxes can be levied at extraction, at the time of input into a certain process or region or at final consumption of goods. All these levels of applications have advantages and disadvantages.

The straightforward idea is the **taxation of extraction**. In Europe, only a few mineral resources, mainly aggregates, are extracted, and the EU dependency on foreign resources is huge. Therefore there are only few possibilities within the European jurisdiction to influence resource use by purely domestic taxation: import would increase thus creating leakage of impacts abroad. A border tax adjustment (BTA) scheme, i.e. a tax on resources that enter Europe and a tax refund for exported products to create a level playing field would be needed to complement the domestic tax: domestically extracted and imported resources would have an equal commercial treatment and the incentive to save resources can be transmitted internationally. This approach can, of course, raise international trade issues, as in the case of recently proposed BTA for the CO₂ content of imported goods. However, in case of high negative external costs of resource extraction with limited international trade, as in the case of aggregates, a domestic resource tax can be useful and efficient.

An extensive impact on resource efficiency could be expected by a **material input tax** that is imposed the first time a resource enters an industrial use. Being referred to the first use of the material it does not discriminate between domestic and imported primary materials. However, it should be complemented by a BTA on the material content of imported intermediate inputs. Even though this idea is theoretically straightforward, practically it is extremely difficult to implement, especially for the BTA. There are many of products that contain different materials in different concentrations: an efficient BTA requires an exact registration of all products that contain taxed materials, which is, however, not too different from implementing a BTA on CO₂ content of imported goods. An additional issue is the need to avoid taxation of recycled metals, which cannot be easily distinguished from virgin metals. Nevertheless this approach could be of some interest as it could target some especially resource intensive industries. Further research is needed to identify possible resources and possible industries (products).

Another possibility would be the **taxation of consumption**. From the point of view of efficiency this seems to be the least preferable as it is difficult to impose a tax on consumption that properly reflects resource use. The data are usually not available in the necessary quality. Therefore only rough proxies seem to be possible (e.g. taxing of extremely resource intensive products) that could be controversial and prone to lobbying. On the other hand, a consumption tax could be relatively easy implemented form a technical point of view and resource consumers are targeted directly. Within certain limits even a single country within the EU could implement such a taxation scheme.

The taxation of resources other than fossil fuels is possible but much more complicated. The variety of different resources, recycling, international trade, co-production and the long production chains make the determination of the tax base, the implementation of a tax and the calculation of the effects difficult. All the possible tax schemes have advantages and disadvantages. Even though a perfect taxation scheme is not available, the introduction of a resource tax – even if not encompassing all resources or products at the beginning – may be useful to lead the EU economy towards higher resource efficiency.
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<th>Policy Option</th>
<th>Tax base</th>
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<td>Extraction Tax</td>
<td>Tax on extracted resource</td>
<td>National</td>
<td>– Tax on extracted resource</td>
<td>– Tax on input into production</td>
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<td>– Tax base difficult to determine, due to use/import of materials in different processing stages, e.g. iron ore, iron and iron in products (+ products may be produced with different resource intensity)</td>
<td>– Can be implemented nationally</td>
<td>– Tax base difficult to determine, will have to be based on rough approximation of resources in raw material and intermediate products</td>
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<td>– Tax base difficult to determine, will have to be based on rough approximation of resources in raw material and intermediate products</td>
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<td>Purpose: Reduction of domestic extraction</td>
<td>Tax may be levied on weight, e.g. €/t iron ore</td>
<td>International coordination should be preferable</td>
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<td>Purpose: Increase of resource efficiency in production</td>
<td>May be restricted to “critical” resources or implemented as a broad tax to any resources</td>
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<td>Pro</td>
<td>Easy to implement, as data is available (in most EU member states)</td>
<td>May contribute to the desired reduction of extraction</td>
<td>May contribute to increased recycling</td>
<td>Tax base difficult to determine, will have to be based on rough approximation of resources in raw material and intermediate products</td>
<td>Implementation of BTAs problematic (legal and administrative issues)</td>
<td>High administrative costs</td>
<td>Price increase may lead to high private costs with relatively low public gains if substitution possibilities and material use innovations are limited</td>
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<tr>
<td>Con</td>
<td>Most resources (except aggregates) are mined outside EU</td>
<td>Price increase may lead to high private costs with relatively low public gains if substitution possibilities and material use innovations are limited</td>
<td>May contribute to increased recycling</td>
<td>Tax base difficult to determine, will have to be based on rough approximation of resources in raw material and intermediate products</td>
<td>Implementation of BTAs problematic (legal and administrative issues)</td>
<td>High administrative costs</td>
<td>Price increase may lead to high private costs with relatively low public gains if substitution possibilities and material use innovations are limited</td>
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<td>Policy Option</td>
<td>Only applicable for resources mined within national boundaries</td>
<td>BTA schemes can be applied to avoid resource extraction leakage abroad</td>
<td>Not easily applicable, due to complex determination of tax base</td>
<td>BTAs necessary to take into account resources embodied in imported intermediate/final products</td>
<td>Not easily applicable, due to complex determination of tax base</td>
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<td><strong>Purpose:</strong> Increase sustainability of consumer behavior</td>
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<td>− Relatively easy to implement</td>
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<td>− Depending upon tax base design and price elasticity it may change consumption and production patterns</td>
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<td>− Very general, no consistent pursuit of issues such as scarcity, external costs or general reduction of resource use possible</td>
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<td>− Price increase may lead to high private costs with relatively low public gains if demand elasticity is low</td>
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<td>− Debates and lobbying on which products are “resource intensive” are likely to arise</td>
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<td>− Introduction might be comparable to the ongoing discussions regarding the reduced VAT for environmentally friendly goods and services</td>
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<td>− No need for BTAs</td>
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References

Aachener Stiftung Kathy Beys, 2005 Ressourcenproduktivität als Chance – Ein langfristiges Konjunkturprogramm für Deutschland, Aachen,


Behrendt, S., Kahlenborn, W., Feil, M., Dereje, C., Bleischwitz, R., Delzeit, R., Scharp, M., 2007, Rare metals - Measures and concepts for the solution of the problem of conflict-aggravating raw material extraction - the example of coltan, UBA Texte 23/2007, Dessau

BGR. 2011, Commodity prices September 2011


Bleischwitz et al. – ITRE, 2009, Eco-innovation - putting the EU on the path to a resource and energy efficient economy, European Parliament’s committee on Industry, Research and Energy


Bringezu, Schütz, 2001, Total material requirement of the European Union Technical part, EEA


Chen D. et al., 1995, Taxation of virgin and recycled materials: Analysis and Policy, mimeo, University of Toronto.

COM (2011a) 571 final, European Commission, Roadmap to a resource Efficient Europe.

COM (2011b) 851 final, European Commission, Communication on the future of VAT.


ECOTEC, 20001, Study on Environmental Taxes and Charges in the EU.


EPA Network, 2006, Delivering the sustainable use of natural resources


European Commission, 2005, Thematic Strategy on the sustainable use of natural resources, COM 2005, 670 final


Gocht et al, 2001, Quantifizierung externer Effekte im Bauxitbergbau und bei der Tonerdeherstellung, in Erzmetall 54 Nr. 5, S. 255 ff.


Mudd, Gavin, 2005, Accounting for Increasing Mine Wastes in the Australian Mining Industry


OECD, 2008, Environmental Outlook to 2030, Paris


OECD, 2011, Invention and transfer of environmental technologies, Paris.


Rankin, 2011, Minerals, Metals and Sustainability: Meeting Future Material Needs


Tilton J.E., 2004, Determining the optimal tax on mining, Natural Resources Forum 28, 144–149.


UBA, 2009, Border Tax Adjustments for Additional Costs Engendered by Internal and EU Environmental Protection Measures: Implementation Options and WTO Admissibility Climate Change Nr. 07/2009

UNEP, 2011, Decoupling Natural Resource Use and Environmental Impacts from Economic Growth.


Van der Voet, Ester et al., 2005, Policy Review on Decoupling: Development of indicators to assess decoupling of economic development and environmental pressure in the EU-25 and AC-3 countries

World Trade Organization (WTO), 2011, Understanding the WTO, Geneva, Switzerland.
### Annex 1 Tables

#### Annex table 1– Resource taxation studies

<table>
<thead>
<tr>
<th>Work</th>
<th>Main contents</th>
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<tr>
<td>Butlin, 1983, Enhanced recycling through a material tax, Resources Policy</td>
<td>The study concludes that a consumption tax based on the exhaustible resources and energy used in the production of a good is likely to create more savings for fossil fuels than for other exhaustible resources.</td>
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<tr>
<td>Fraser, 2002, An evaluation of the relative performance of alternatively structured resource rent taxes, Resources Policy</td>
<td>Both the size of profit margin on extracted resource and the level of riskiness of the resource deposit play a role in determining the relative revenue-generating performance of alternatively structured resource rent taxes (RRT); the role of each of these factors is mutually reinforcing in situations which feature either low profit margins and low riskiness, or high profit margins and high riskiness. As a consequence, it can be concluded that no particular structure of RRT is superior at generating tax revenue in all situations.</td>
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<td>John E. Tilton / Natural Resources Forum 28 (2004) 144–149</td>
<td>A resource tax increase is easier to justify if the interests of society are focused largely on the present generation and in particular its welfare over the next several years. In this case, tax revenues in the more distant future are heavily discounted. However, if the welfare of the current generation beyond the next few years and the welfare of future generations are of concern as well, then the longer-run negative effects of an increase in the tax rate arising from the reduction in exploration and new mine development become important. In this case, the short-run gains in tax revenues are less likely to offset the longer-run losses sufficiently to enhance the welfare of society revenues — or more generally the net present value of the social benefits — that an increase in the tax rate would produce.</td>
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<td>Hung, Quyen 2009, Specific or ad valorem tax for an exhaustible resource?, Economic letters</td>
<td>Notwithstanding the equivalence in static framework between an ad-valorem and a specific sale tax, this paper shows in the dynamic Hotelling model for an exhaustible resource that the ad valorem tax is definitely welfare-superior to the specific tax.</td>
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<tr>
<td>Boadway and Keen, 2009, Theoretical Perspectives on Resource Tax Design, mimeo.</td>
<td>This paper reviews the challenges for tax policy in dealing with the resource sector, the principal instruments used, and some of the central design issues.</td>
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<td>Boadway, Robin &amp; Flatters, Frank, 1993. &quot;The taxation of natural resources: principles and policy issues,&quot; Policy Research Working Paper Series 1210, The World Bank.</td>
<td>Natural resources are typically subject both to taxation under the income tax system and to special resource taxes. Properly designed income taxes attempt to include capital income on a uniform basis. But in most countries the income tax treats resource industries more favourably than most other industries - through favourable treatment of such capital expenses as depletion, exploration and development, and the cost of acquiring resource properties. The authors discuss three alternative ideal ways for the government to divert a share of rents to the public sector: levy a tax on rents, ideally in the form of a cash flow tax; require firms to bid for the rights to exploit resources; and take a share of equity in the firm. They discuss these options in terms of their implications for the ability of firms to obtain finance, the allocation of risk, the share of rents accruing to the public sector, the extent of involvement of foreign firms, and other factors. The time has come in many countries, they say, when gains from further refinement of imperfect existing taxes on resources are less than replacing them with simpler, more efficient forms of pure rent taxes.</td>
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<td>Garrod and Willis, 1999, Externalities from extraction of aggregates Regulation by tax or land-use controls, Resources</td>
<td>Quarries create externalities such as noise, dust, and visual disamenity in the production of minerals. Externalities can be regulated by taxes, or land-use controls specifying externality levels not to be exceeded. This article shows how stated preference methods can be used to estimate the value to local residents of avoiding different externality levels from a quarry. From this a tax value per tonne is de-</td>
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<td><strong>Lund, 2009, Rent Taxation for Non-renewable Resources</strong>, Annual review of environmental resources</td>
<td>Introducing uncertainty into the analysis of the effects of different taxes opens a range of challenges and leads to results that cast doubt on the relevance of studies that neglect uncertainty. According to the author, there are some situations in which the same tax policy may be beneficial in relation both to neoclassical companies and others. The companies that behave as risk averse, i.e., not taking advantage of diversification possibilities in capital markets, will typically under exploit investment opportunities and take on too little unsystematic risk. The Do-mar-Musgrave effect means that a Brown cash flow tax with full, immediate loss offset will encourage investment by these companies. At the same time, this tax is neutral in relation to companies that are well diversified. Although the information needed to implement an exactly optimal tax rate may be difficult to obtain, this is at least an example that all is not dark.</td>
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<td><strong>Groth and Schou, 2007, Growth and non-renewable resources: The different roles of capital and resource taxes</strong>, Journal of environmental economics and management</td>
<td>We contrast effects of taxing non-renewable resources with the effects of traditional capital taxes and investment subsidies in an endogenous growth model. In a simple framework we demonstrate that when non-renewable resources are a necessary input in the sector where growth is ultimately generated, interest income taxes and investment subsidies can no longer affect the long-run growth rate, whereas resource tax instruments are decisive for growth.</td>
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<td><strong>Amundsen and Schob, 1999, Environmental taxes on exhaustible resources</strong>, Eur. J. Of political economy</td>
<td>Environmental problems are tied to the use of exhaustible resources. A resource tax extracts rents from the resource owning countries, without creating significant incentives for consumers to reduce their resource consumption. The placement of the tax burden on resource owners affects the international distribution of wealth</td>
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<td><strong>Peery Cover and Pasten, 2009, Does the Chilean Government Smooth Taxes? A Tax-Smoothing Model with Revenue Collection from a Natural Resource</strong>, SSRN</td>
<td>Does the Chilean government smooth taxes? This paper argues that the answer is yes, but only if one takes into account royalties from copper</td>
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<td><strong>Bornhorst et al., 2008, Natural Resource Endowments, Governance, and the Domestic Revenue Effort: Evidence from a Panel of Countries SSRN</strong></td>
<td>The recent development literature stresses that countries that receive large revenues from natural resource endowments typically raise less revenue from domestic taxation, and that this creates governance problems because the lower domestic tax effort reduces the incentive for the public scrutiny of government</td>
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<td><strong>Maldonado, 2010 28th April, mimeo</strong></td>
<td>Revenues and bribery-based corruption in Peru. The author find that after the increase of prices of mineral resources the predicted probability of being asked to provide a bribe by public officials in local governments benefited with Mining Canon transfers reduces by 1.5-1.8 percentage points. This effect is large since represents a reduction in the average probability of being required to pay a bribe by local civil servant of 52%. This effect is larger in producer districts (a reduction of 2.0-2.7 percentage points).</td>
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<td><strong>Pittel and Bretschger, 2010, Sectoral Heterogeneity, Resource Depletion, and Directed Technical Change: Theory and Policy, CER-ETH Working Paper No. 08/96 and Canadian Journal of Economics</strong></td>
<td>We analyze an economy in which sectors are heterogeneous with respect to the intensity of natural resource use. Long-term dynamics are driven by resource prices, sectoral composition, and directed technical change. We study the balanced growth path and determine stability conditions. Technical change is found to be biased towards the resource-intensive sector. Resource taxes have no impact on dynamics except when the tax rate varies over time. Constant research subsidies raise the growth rate while increasing subsidies have the opposite effect. We also find that supporting sectors by providing them with productivity enhancing public goods can raise the growth rate of the economy and additionally provide</td>
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<td>Reference</td>
<td>Summary</td>
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| Ekins et al. (2011), Environ Resource Econ | The paper reports the results of a major modelling exercise to gain insights into the possible economic and environmental effects of a large-scale environmental tax reform (ETR) in the UK. Main conclusions are the following:  
  - High world market fossil fuel prices reduce GHG emissions, but at high cost to the economy.  
  - Environmental tax reform (ETR) also reduces GHG emissions, but at effectively no cost to the economy and with increased employment. The reduction of other polluting emissions associated with energy use, though not calculated here, is a further benefit of the ETR policy which should be taken into account when the policy is being considered.  
  - Using some of the tax revenues from an ETR to invest in eco-innovation can further reduce GHG emissions without adverse consequences for the economy. It may also develop new economic sectors with export potential (as, for example, Denmark and Germany have found with investments in wind energy), but that is outside the scope of this modeling. |
| Soderholm, 2011, Resources, Conservation and Recycling (forthcoming) | An analysis of the empirical experiences of aggregates taxes in three European countries, i.e., taxes on, for instance, gravel, rock, stone etc. The selected countries include Sweden, Denmark and the United Kingdom. The analysis has illustrated that before specific taxes on natural resources are introduced for environmental reasons: (a) the relevant market failure that the tax should correct for must be clearly identified; (b) the impacts of the tax on environmental quality and economic efficiency should be assessed; and (c) these impacts should be compared with those resulting from the use of other regulatory approaches. Overall the paper recognizes that taxing outputs or use typically represents a “second-best” policy alternative, which can be used when, for instance, the monitoring of non-point source emissions and/or efficient property rights regimes are hard to implement. |
| Scharf (1999), Tax Incentives for Extraction and Recycling of Basic Materials in Canada | An empirical assessment of the overall incentives generated by taxes with respect to the choice between extraction and recycling of basic materials in Canada. The sectors examined include producers of primary virgin material (forestry, mining, oil and gas), producers of recycled material (scrap dealers) and producers of finished products (metal, paper, plastic and glass). The Canadian tax system significantly favours the use of virgin materials rather than recycled materials in the case of metal and glass products, but the reverse is true for plastic products. |