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Resource Productivity Dynamics: a Cross-Country Overview and Policies

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Abstract

The paper summarizes recent empirical trends on resource productivity dynamics in a cross-country overview, and it outlines a resource policy that seeks to enhance resource productivity. Main focus is the European Union. The empirical trends underline the well-known trend of decoupling the use of natural resources from GDP and ensuing gains of material productivity and resource productivity. However the dynamics from 2000 – 2007 has slowed down compared to the nineties and falls behind aims of accelerating resource efficiency by 3 %/a. The EU new member states show an annual increase that is slightly higher than in the EU-15 states; however the energy productivity gains outweigh material productivity by far. Interesting to note that the price increases on international raw material markets does not seem to have had much effect on material productivity.

A rational for policies stems from a demand to increase such sluggish material productivity growth as well as from indications on environmental damages occurring along material flows. Increasing Total Material Requirements associated with imports in the EU indicate a burden shifting into countries outside the EU, i.e. a case for international policy approaches. In general, it is both the environmental and the innovation perspective that legitimate policies. The paper outlines a rational for such policies and develops guidelines for policies and a transition management towards resource-efficient economies. It furthermore describes instruments such as a tax on construction minerals, an ecologically differentiated VAT tax, an international covenant for metals and an international convention for sustainable resource management. Such instruments won't be introduced in short term, but may well become a topic at the forthcoming Rio+20 Earth Summit in 2012. For short term policy demand the paper pledges for a technology platform on resource-light construction, a trust funds for eco-entrepreneurship and a programme to speed up eco-innovation and material efficiency across business.

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1. Introduction

In the aftermath of the financial crisis, the markets for raw materials that had been soaring for almost ten years before seemed to relax. Most prices have gone down. Many observers have started to withdraw their attention from what had been perceived as the next gold rush after the IT and dot.com revolution of the late nineties. However three recent events illustrate the need for international economics to pay full attention to the issue of resource productivity:

- The oil disaster in the Gulf of Mexico that has occurred in early 2010 will not only have an impact on the US energy strategy – strengthening the independence from oil – but also on how financial markets will assess oil companies and how those states issuing permits to oil companies will regulate their liability.

- The UNEP's International Panel for Sustainable Resource Management[1] has released its first report on biofuels in late 2009. It presents the severe damages occurring from poor performing first-generation biofuels and calls for more attention to competing land uses between food, feed, biofuel and biomaterial production in light of population growth, food security and climate change.

- The European Commission (2010) has released its long-awaited second report on the criticality of minerals in June 2010 naming some fourteen minerals as „critical", i.e. that the risks for supply shortage and environmental issues as well as their impacts on the economy are higher compared with most of the other raw materials. Though at least some these minerals (Antimony, Beryllium, Cobalt, Fluorspar, Gallium, Germanium, Indium Graphite, Magnesium, Niobium, Platinum Group Metals, Rare earths, Tantalum, Tungsten) are not well-known outside the expert community, the fact that they are essential for steel production and many future technologies make a strong case for economic analysis.

Against this background the following paper has two main purposes: it summarizes recent empirical trends on resource productivity dynamics in a cross-country overview, and it outlines a resource policy that seeks to enhance resource productivity. The main focus is the European Union.

2. International Trends of Material and Resource Productivity

As a general trend, material productivity[2] (GDP generated per ton of DMC) in Europe has improved – economies have been creating more value per ton of resources used. Resource productivity in the EU-27 was highest in the Netherlands, Malta (with some open questions regarding the reliability of data), the United Kingdom, France, Italy and Belgium. It was the lowest in countries such as Bulgaria, Romania, Slovenia, Poland and others (Fig. 1, GDP in US $ PPP per ton DMC). In total, the difference in performance across European economies mounts up to a factor of 17 between top performers and low performers (Schepelmann et al. 2009).

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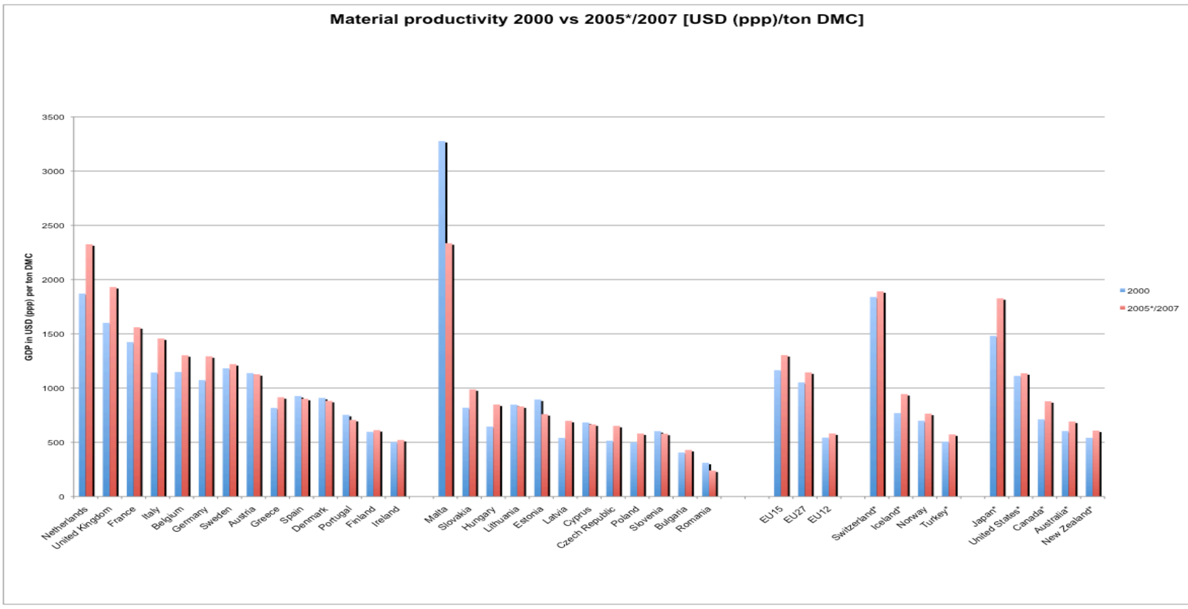
1 http://www.uneptie.org/scp/rpanel/

2 We use the term material productivity if the denominator is DMC or DMI and resource productivity for the more inclusive measurement approaches with TMR or TMC and for general purposes.

Figure 1: Material productivity performance across European economies



Source: European Environment State and Outlook Report 2010, European Environment Agency, 2010 (forthcoming). Compilation by Sören Steger/WI 2010.

The large economies in this group have also experienced a fairly high *increase* in material productivity. All the remaining European countries were either around (Sweden and Austria) or below the EU-27 average of 1,144 USD/ton DMC.

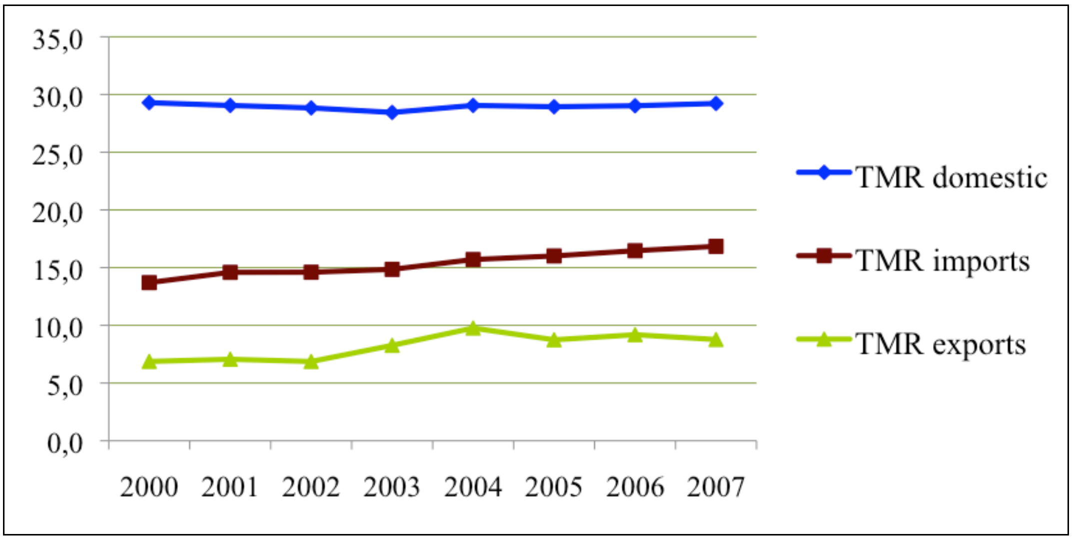
To put this into an international perspective (see also Fig. 5): material productivity in Switzerland was 1892 USD/ton, in Japan 1827 USD/ton, and in Norway 764 USD/ton (in the year 2007). The United States, Canada, Australia and New Zealand had lower material productivity than the EU-27 average - although higher than the average for the EU-12 group.

The growth in material productivity was fastest in the new EU member states, ranging from more than 32% for Hungary, 29% for Latvia, 27% Czech Republic to 122% for Estonia from 1992 to 2007. A strong growth of material productivity between 20% and 30% occurred in the United Kingdom,Netherlands, Italy, Germany, Slovakia, Iceland, Japan and Canada. However in the recent years 2000-2007, annual material productivity has been increasing by 1,01% (EU-12), 1,64% (EU-25) and by 1,44% (EU-27. Thus, material productivity dynamics have been lower than in previous years and fall behind the aim of an annual increase of 3 % / a.

It is interesting to note that the gap in material productivity between the EU's new member states and old member states has not changed significantly between 2000 and 2007. In 2007 material productivity in the EU-12 was only 45% of the average for the EU-15. With the exception of Malta, material productivity in the new member states was well below the EU-27 average. This might offer options for significant future increase.

A second interesting observation relates to the more inclusive indicator Total Material Requirements (TMR) that includes hidden flows and 'ecological rucksacks'. The updated data for the EU show an almost stagnating trend between 2000 and 2007, and increasing TMR associated with imports. This indicates the need to assess the environmental impacts asociated with resource use with great care and to include in particular the international dimension.

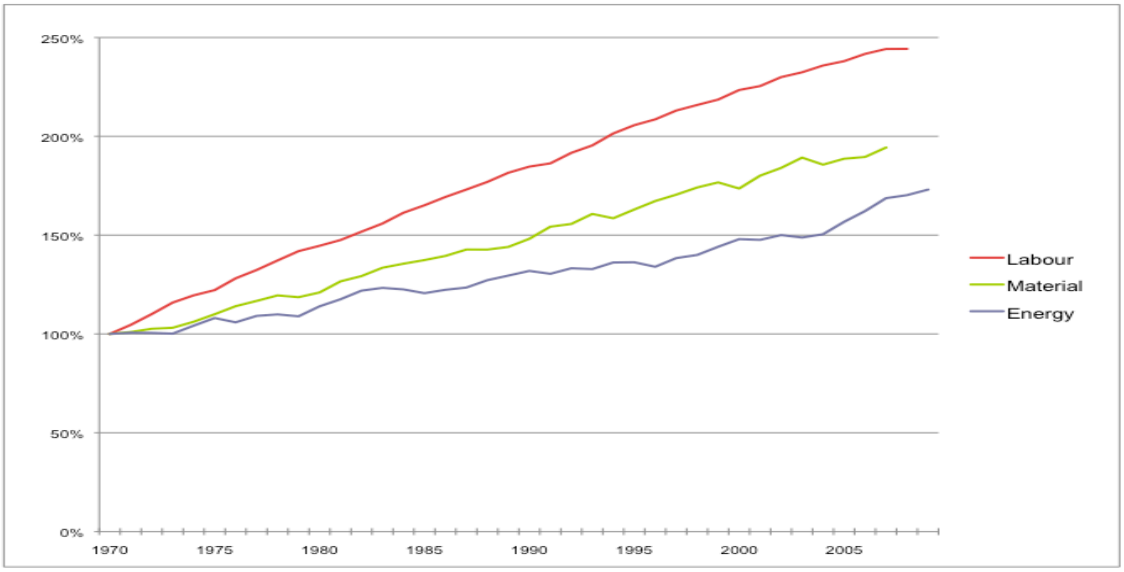
Figure 2: TMR in the EU-27 2000 – 2007



Source: Own compilation made by Helmut Schütz WI 2010.

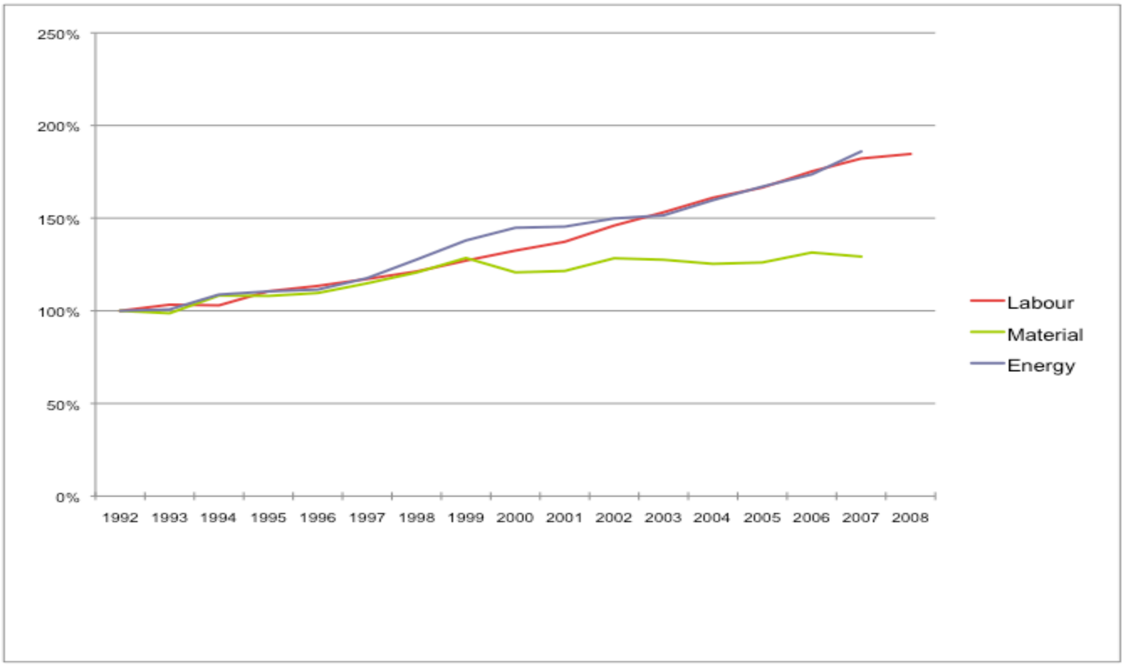
Despite continuous improvements, growth in the productivity of material resources in the EU has been significantly slower than growth in the productivity of labour and, to a lower degree, energy productivity. Over the period 1970-2007 productivity of labour increased by 144% in the EU-15, while productivity of materials grew by 94% and productivity of energy increased by 73% (2009). In the EU-12, where a much shorter time series is available, productivity of materials increased by less than 30% between 1992 and 2007, whereas productivity of energy and labour grew hand in hand increasing by 85%. This surely also reflects also a shift in energy fuels from coal to gas as well as shifts in imports.

Figure 3: Productivity of Labour, Material, and Energy across Countries in EU-15



Source: European Environment State and Outlook Report 2010, European Environment Agency, 2010 (forthcoming). Compilation by Dominic Wittmer/WI 2010.

Fig. 4: Productivity of Labour, Material, and Energy across Countries in EU-12

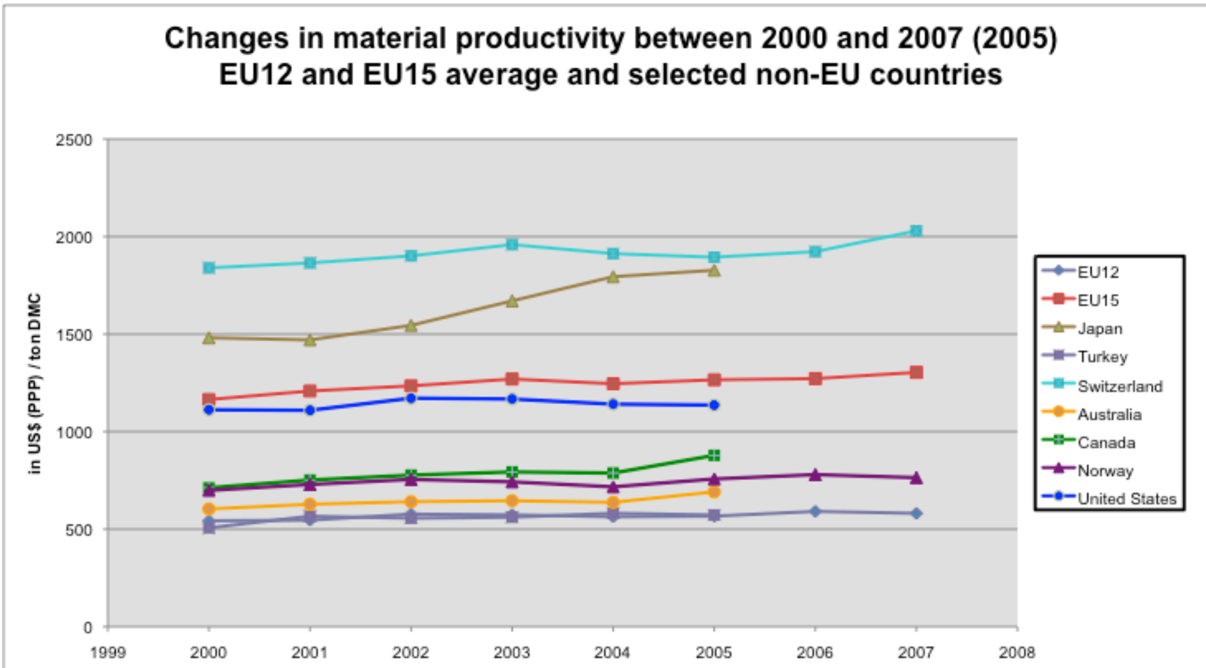


Source: European Environment State and Outlook Report 2010, European Environment Agency, 2010 (forthcoming). Compilation by Dominic Wittmer/WI 2010.

Probably, a main driving force has been the relative pricing of these three inputs and the prevailing tax regimes, which make labour costs more expensive over time and has led to a business focus on managing labour costs. In addition, despite the high potential for improving material and energy productivity, most macro-economic restructuring and fiscal reform programmes in recent years have tended to focus on reducing labour costs. Notwithstanding the pros and cons of this approach, one may conclude that improving material efficiency deserves more attention as a key to reducing total costs and spurring innovation.

During the period 2000-2007 material productivity in the EU as a bloc was markedly and consistently lower than in Switzerland and Japan. There was also a notable gap between the EU-15 and the EU-12, with the material productivity in the latter group lagging behind Australia, Canada and the United States. However, it was very wide spread within the EU itself, with an order of magnitude difference in material efficiency between the Netherlands (ahead of Japan) and Bulgaria and Romania.

Figure 5: Changes in Material Productivity 2000-2007 across Countries



Source: DMC Data from OECD, GDP Data from The Conference Board Total Economy Database, own compilation Sören Steger WI 2010.

Driving forces for such uneven patterns of use and slow productivity dynamics certainly deserve more attention by research. Some general explanatory factors behind such development are the stages of development – in particular the intensity of use during early industrialisation stages – and income. However, major differences also occur across countries with similar levels of industrialization and income. Driving forces for resource productivity[3] thus have to be analysed from a perspective that takes into account relevant socio-economic variables of economies and their innovation systems. This includes:

- Construction activities such as new dwellings completed, road construction, share of construction in GDP,

[3] See the paper written by Steger/Bleischwitz in 'Journal of Cleaner Production' (forthcoming).

- Structure of the energy system (a high share of coal and lignite correlates with higher resource intensity, efforts to increase energy efficiency correlate with resource productivity),
- Imports and international trade: tentative evidence suggests a positive correlation between high imports and material *intensity* for industrialized countries. The reason probably lies in global production chains, where raw materials and intermediate goods are imported, transformed into finished products domestically and also traded globally, i.e. most industrialized countries utilize the international division of labour as net importers of natural resources.[4] By contrast, there is a positive correlation between high imports and resource *productivity* for many less industrialized countries, which is probably due to the competitive pressure on inefficient and resource-intensive industries in those countries.

2. Resource Productivity, Competitiveness and Innovation

Our approach challenges traditional economic analysis that has determined natural resources as a factor of production and, hence, assumes that negative impacts on growth could occur if the supply of natural resources is constrained. In contrast we propose that regions – and in particular resource-poor regions – may benefit from increasing resource productivity, at least with regard to their import dependencies and costs to purchase commodities and probably also with regard to innovation. In line with our approach, research has demonstrated that resource-rich developing countries may experience their abundance of natural resources as a curse that hinders economic diversification, investments in human capital and democracy and, thus, lead to lower growth rates compared to other countries (Gylfason 2009). In line with the chapters above our approach enables research to looking at development across economies and industrial sectors in connection to social, institutional and ecological factors, in particular to emerging markets for eco-innovation.

Our thesis is close to what is called the Porter hypothesis on first mover advantages for countries with an active environmental policy, but focuses stronger on market development and resources. In line with Porter, we also underline the assumption of eco-innovation effects to compensate for related investments. But global analysis of resources and material flows goes beyond Porter's scope because

- It explicitly addresses international distortions resulting from resource constraints and negative externalities namely in the fields of extraction and recycling (see above), and

- It emphasizes the need for international policy approaches rather than assuming an international diffusion of national environmental policies.

Since our approach covers all natural resources used in economies a guiding question for any green growth is whether and to what extent companies, industries and economies can enhance their prosperity through improvements in resource productivity (see also Weizsäcker et al. 2009).

[4] Test statistic for EU-15, 1980-2000: an increase in the import share by 1% would raise the DMC per capita by 0.225%. Research done by Soeren Steger, see Bleischwitz et al. 2009; see also: Dittrich 2009.

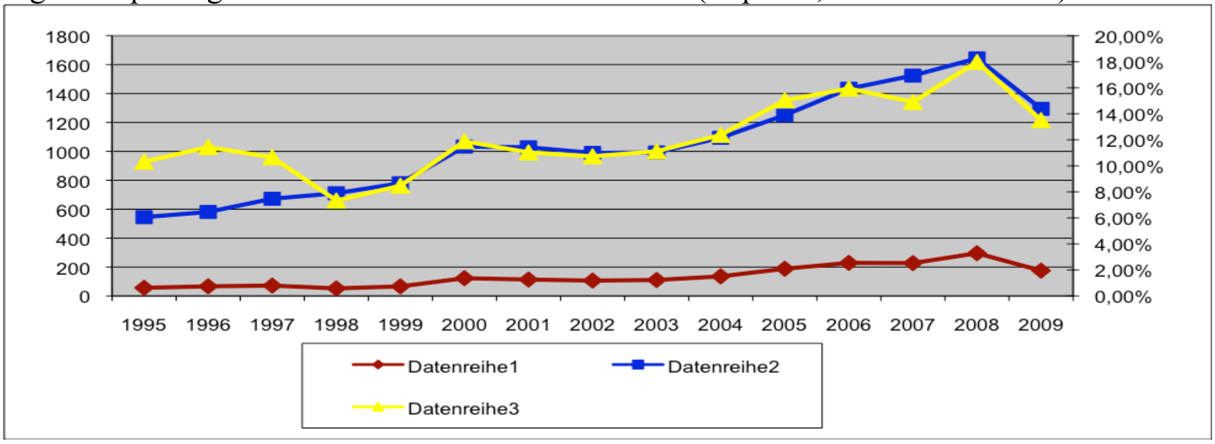
To test our thesis of a positive correlation between resource productivity and prosperity, we use data on the index of competitiveness as measured by the World Economic Forum and on the Domestic Material Consumption for 26 countries. Our results suggest that there is a moderate positive relationship between the material productivity of economies (measured by GDP in purchasing power parity [PPP] US$ per kg DMC) and the score value of the growth competitiveness index (GCI). The higher the level of material productivity the higher the level of competitiveness (R-squared of 0,3). The usual test statistics were performed; both the t-statistics and the F-statistics are in the 95 % significance level, while heteroskedasticity was rejected using the Breusch-Pagan test and the White test. However Finland and Italy illustrate exceptional cases where a high value in one indicator is accompanied by a low value in the other indicator.

Further evidence suggests that the correlation between competitiveness and resource productivity has not been increasing since 2001 on a broad scale, despite high raw material prices and resulting efforts to use resources more efficiently. A strong correlation however has been found between the MEI-index of competitiveness (macro-economic institutions) and European energy productivity performance (R-squared of 0.76, Osnes 2010: 31).

Thus, more research is needed; time series analysis with e.g. co-integrated panel data is probably a suitable methodology to deliver robust results on the causality between different drivers for competitiveness and resource productivity. In such research, critical variables are as follows:

- Relevance of material costs for industry: research needs to clarify the total value of resources and track raw material costs along value chains:
    - Importing costs for raw materials and semi-finished goods is a key macro-economic variable for competitiveness; for the EU, the value based share of the top-ten raw material imports in total imports grew between 1998 and 2008 from around 8% up to 18%.[5] It should be noted however that due to the recession that followed the financial crisis this share has now declinded to 13.1% (2009).

Fig. 6: Importing Costs of Raw Materials into the EU (Top Ten, value based share)



Source:Eurostat statistics, own compilation, WI 2010.

[5] Based on Eurostat and 10 minerals, but no semi-final goods; the share actually is higher than the analysis of de Bruyn et al. (2009) suggests.

- o Data provided by the German Federal Statistical Office reveal that the costs of materials in Germany account for around 40 – 45 % of the gross production value of manufacturing companies (this includes purchased material inputs such as raw materials and intermediate goods). This data is based upon a questionnaire to industry managers and, hence, is relevant for industries but can hardly be added up to an aggregated figure for whole economies.
- o Since most commodities are purchased on a US-Dollar basis, the exchange rate becomes quite relevant. Currently, the financial crisis has weakened the position of the Euro versus the US-$, which may lead to more extreme price increases for energy and metals in Europe compared to the US.
- o The macroeconomic situation – characterized by increasing public debts – increases the vulnerability of economies towards higher commodity prices for raw materials. This may encourage resource savings because such strategy lowers risks of inflation caused by importing fuels and commodities, and it may favour resource taxation in different countries.

- It is also worth mentioning that the competitiveness indicators do not capture negative externalities. Countries investing in eco-innovation might earn the benefits at a later point in time, whereas countries with dumping practices and weak environmental standards can gain short-term benefits by lowering production costs at the expense of others. The fact that the TMR associated with the imports into the EU has been increasing from 2000 – 2007 (see figure ###) may underline the need to analyse any burden shifting in more detail.

- The awareness among managers and companies to pursue material efficiency is still relatively low. Rennings and Rammer (2009) found that just 3 % of German companies have reported significant undertakings to increase material efficiency in their analysis of the EU Community Innovation Survey (CIS).[6] However sales per employee in those companies are approximately 15% higher than in average industries. More recently, a survey done in the UK among 500 companies has revealed that ¾ of those companies have undertaken measures to cut their material purchasing costs (Drury 2010). These findings indicate a gap between traditional measures, current awareness and potential benefits that needs to be tested by more in-depth research at an international scale.

The vast majority of innovation can currently be characterized as process innovation, a strategy that offers affordable risks for companies compared to product innovation or system innovation. Such process innovation becomes visible in material efficiency when companies accomplish strategies such as ‚zero losses', ‚design to costs', or ‚remanufacturing'.

At an international scale however, an advanced process innovation of closing the loops in international value chains remains a challenge especially when end-of-life stages of consumer goods are considered. A 3R strategy for metals, which could be applied in the product groups of mobile phones and vehicles, requires further efforts and interlinkages between different

[6] Innovationpanel as of 2005, survey data from 2002 – 2004 based upon 6600 German firms.

types of innovation, including institutional change and political action in those countries where the used products are imported. According to Eurostat, the EU exports end-of-life vehicles predominantly to countries such Kazakhstan, Guinea, Russia, Belarus, Serbia, Benin.

For that reason it will become important to complement producer responsibility with *materials stewardship*. In this regard and because only a limited number of industrial sectors require a significant share of the total resource requirements of the economy,[7] a sectoral approach to innovation (Malerba 2007) is useful to pursue. In such a perspective, new business models for base metal industries might emerge (Petrie 2007), which could position the industry at the heart of material value chains. This is a horizontal task, which clearly transcends vertical production patterns, for example, along the automotive chain. Within networks and partnerships of integrated material flows management, the base metal industry can demonstrate stewardship and leadership. The challenge is to overcome the business model of a pure primary production company delivering basic materials and develop competencies towards a fully integrated material flow company network, with extended knowledge intensity, customer orientation, worldwide logistics, high-level recycling including critical metals and a long time horizon. Such base metal companies will manage products, flows and stocks.

In total, resource productivity underlines a new category of innovation that can be characterized as "*material flow innovation*". It captures innovation across the material value chains of products and processes that lower the material intensity of use while increasing service intensity and well-being. It aims to move societies from the extract, consume, and dispose system of today's resource use towards a more circular system of material use and re-use with less resource use overall. While the established categories of process, product and system innovation (and organisational and advertising innovation, see e.g. the OECD Oslo Manual on Innovation) have their merits, the claim can be made that given the pervasive use of resources across all stages of production and consumption a new category will have to be established to capture innovation activities which include:

- Developing new materials with better environmental performance;
- Substituting environmentally intensive materials with new materials, functionally new products and functionally new services leading to lower demand;
- Establishing life-cycle wide processes of material efficiency, e.g. by sustainable mining, more efficient production and application of materials and strategies such as
    - Enhancing re-use and recycling
    - Recapturing precious materials from previously open loop systems (e.g. critical metals, phosphorus)
    - Functionally integrating modules and materials in complex goods (e.g. solar cells integrated in roofs)
    - Increasing the lifetime and durability and offer related services
- Transforming infrastructures towards a steady-state stocks society, e.g. via improved maintenance systems for roads and buildings as well as developing new resource-light

7 In Germany, ten sectors induce more than 75% of the TMR; see Acosta et al. 2007.

buildings and transportation systems and other network goods (such as waste water systems) and, in the long run, establishing a solarised technosphere for dwellings and other systems of provision (Bringezu 2009).

Such a perspective on innovation and green growth is also consistent with lead markets worldwide. In distinction to prevailing climate change diplomacy, where it is difficult to engage the emerging economies, our perspective sheds light on attractive lead markets in emerging economies because they can build upon advantages from their natural endowments and allow for the establishment of new development pathways.

4. Resource Policies

The general motivation for resource policies is mainly twofold: Firstly, to address the risks associated with environmental damages that occur throughout the whole life-cycle of using resources (negative externalities) and, secondly, to address the opportunities stemming from potential eco-innovation if material purchasing costs can be reduced and turned into new processes, new products and system innovation. As expressed above, such eco-innovation can also utilize material flow innovation.

Following contemporary analysis of market failures and barriers, however, such attempts are unlikely to be harnessed by markets and business alone. A number of market failures and barriers need to be removed in order to minimize risks and unleash the eco-innovation opportunities towards a green economy. The following categories seem especially relevant with regard to increasing resource productivity at an international scale:

1. Negative externalities: in line with environmental considerations (see above), the existing practices of unsustainable extraction, low environmental standards at production sites for resource-intensive goods and recycling facilities as well as landfilling options will have to be taken into account;

2. Positive Externalities: the current incentives to invest in eco-innovative products and systems (i.e. beyond process innovations) are relatively poor. They are faced with the double externality problem of public costs and benefits.

3. Information deficits at the business level on options to save material purchasing costs and their cost/benefit ratio.[8]

4. Fundamental knowledge gaps on raw material price trends, anthopogenic stocks and asymmetrical information on new green products and systems.

5. Orientation deficits resulting from missing targets and objectives as well as from path dependencies for most capital goods and infrastructures.

Policy analysis can turn these market failures and barriers into guidelines that will facilitate the formulation of efficient resource policies. Following the five categories above, suitable guidelines may look as follows:

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[8] See the experience made in the German DEMEA programme, e.g. Wied (2009).

1. Market order – getting the framework conditions right by establishing the polluter pays principle and the precautionary principle at an international scale and by establishing a competition policy in favour of eco-innovation.

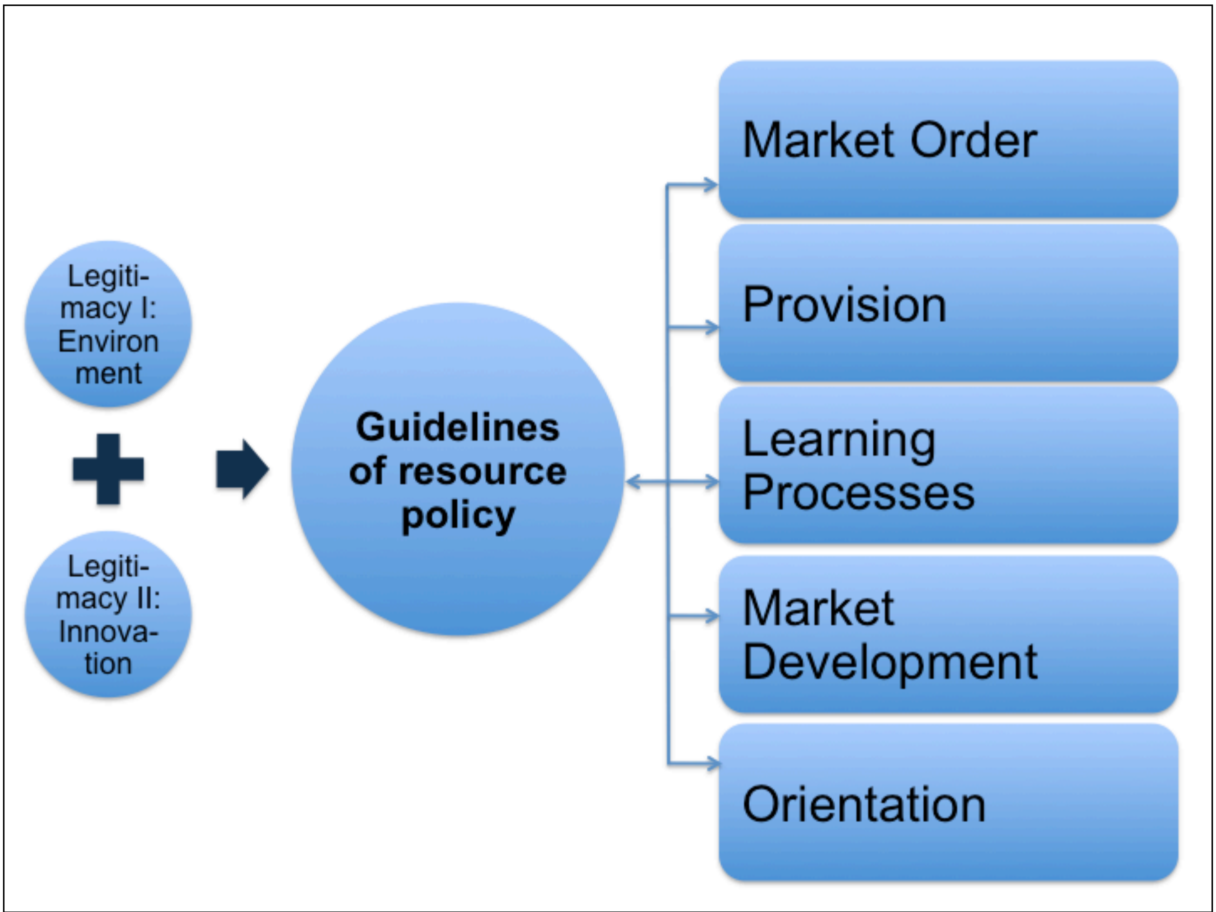
2. Provision – by establishing international open access data sources on resource productivity (including the ecological dimension of resources and trends).

3. Learning processes – facilitate attention and learning through e.g. benchmarking processes, reporting guidelines and diffusion of bst practices.

4. Market development – a sustainable industrial policy that ramps up new and radical eco-innovation and supports the transformation of resource-intensive sectors into new business models as well as international recycling.

5. Orientation – going beyond usual business cycles and even beyond the 2020 perspective will help to develop system innovation and to align resource productivity with the needs of a low carbon society that uses 80 – 90 % less carbon compared to today's level.

Figure 7: Legitimacy and Guidelines for a Resource Policy



Source: Own compilation, Bleischwitz WI 2010.

Setting Targets

Such guidelines can also serve as useful tools when targets and objectives are to be formulated. A challenge compared to e.g. climate policy is that the concept of ‚carrying capacity' will be difficult to apply. The carrying capacity concept allows setting targets derived from (a) a maximum level of tolerable impacts such as the 2° C maximum temperature increase target and (b) a maximum budget of tolerable emissions leading to the target of 80 – 95 % reduction of net carbon emissions by 2050. In the area of resource policy however the environmental science is by far weaker and does not yet allow fixing a maximum amount of resources that can be used in the future. What can be said with high confidence is that the future use of primary materials in industrialized countries and regions such as the EU ought to be reduced compared to today's levels. Such a target, despite the lack of precision which may be seen,[9] can serve functions of orientation for market participants and planners. With regard to indicators, the Total Material Requirements are a more inclusive approach compared to other indicators such as Direct Material Inputs or Raw Materials per se – but research on such indicators is under way.[10]

In line with research on transition management (Grin / Rotmans / Schot 2010), far-reaching innovation can be stimulated by formulating visions about sustainable futures. With regard to the overarching issue of increasing resource productivity, Bringezu (2009) outlines four visions on

- Resource efficient and recycling based industries
- Steady stocks societies
- Solarized infrastructures
- The balanced bio-economy.

Such visions also capture the dimensions of climate change and land use that are not only important but also likely to put constraints on the future availability of biomass and related agricultural goods and renewable resources. In terms of innovation, such visions lead into explorations of carbon recycling and industrial photosynthesis (mineral-based systems) that clearly go beyond today's options of recycling and bio-based products. For sure, this will add to the world market potentials for material efficiency that is estimated to triple by 2020.

As a suitable target, a doubling of resource productivity from 2010 to 2030 should be envisaged. The timeframe reflects the need to get started and to go beyond current business cycles. The dynamics of doubling clearly goes beyond prevailing trends of sluggish material productivity increases (1,4 % / a in the EU-27 from 2000 – 2007 and well below the aim of 3 % / a), i.e. it will require additional action and suitable policies.

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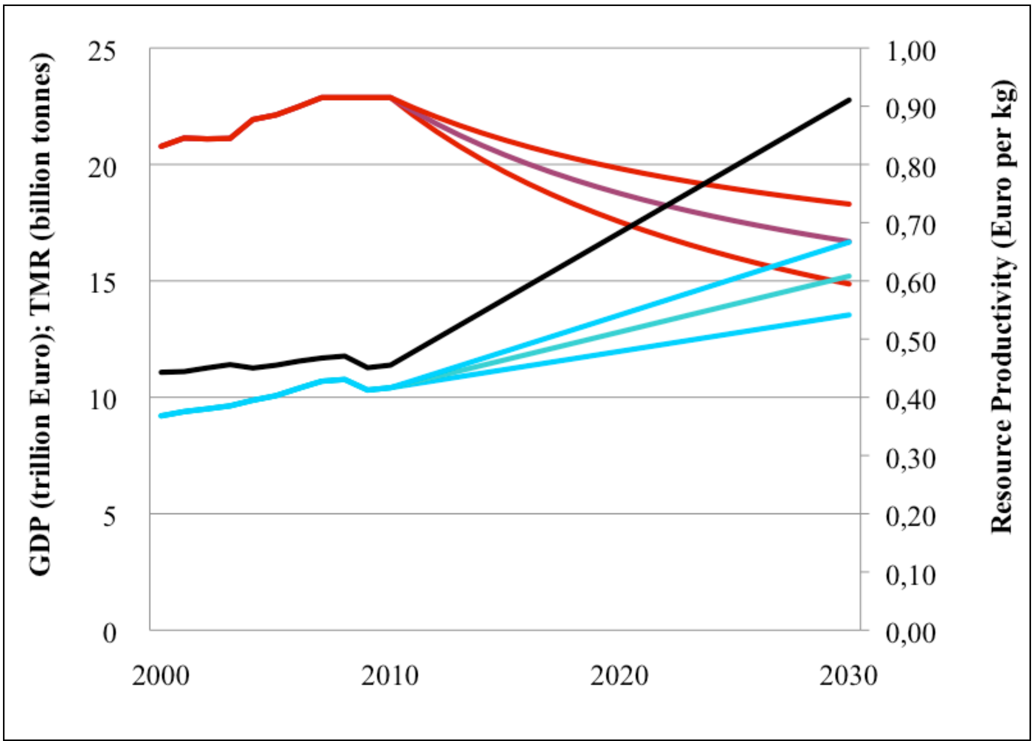
[9] Bringezu (2009: 168) suggests a long-term reduction by 80 %.

[10] See e.g. the EU projects MATISSE, CALCAS, Sustainability A-Test, Measuring Eco-Innovation, the newly established Eco-Innovation Observatory and others.

Figure 8: A Scenario to double resource productivity by 2030



Red line indicates TMR paths, blue line different GDP growth paths, the black line the GDP/TMR ratio.
Source: Own compilation, Schütz / Bringezu WI 2010.

A policy mix of instruments to trigger resource productivity

The complexity of addressing the different barriers and drivers associated with sustainable resource management, the likelihood of trade-offs among different goals, and the different actors involved are not in favour of one single instrument, but rather suggest a policy mix. In line with recent economic analysis (Aghion et al. 2009; Bretschger 2008; Pelikan / Wegner 2003; Welfens 2009: 517), our paper calls for a step-by-step approach to gradually improve the framework conditions for eco-innovation and to enhance the ensuing capacities.

The instruments described below follow a strategic approach that has been outlined elsewhere (Bleischwitz et al. 2009, with suggestions on a European trust fund for eco-entrepreneurship, a technology platform for resource-light industry and a deep renovation programme for existing buildings) and captures the eco-innovation perspective of reducing material costs, disseminating process innovation among businesses, developing lead markets for more radical innovation, transforming industrial sectors and the renewal of infrastructures. It is also worth mentioning that the existing Eco-design Directive could be enlarged to include both energy and material efficiency standards for selected major resource intensive products, taking into account life-cycle resource requirements (material, energy and land).

The following instruments have been analysed in-depth within a German research project called MaRess and seem to capture the main areas of such a resource policy.

Figure 9: A Strategic Approach and Suitable Instruments for a Resource Policy

Source: Own Compilation, Bleischwitz / WI 2010.

A Europe-wide minimum taxation of construction minerals

The rationale for taxing construction minerals stems from their material intensity: it is the most relevant area of any economy with regard to resource productivity, the current recycling rates are low (ranging from roughly 5 % to 25 %), and it has impacts on the environment such as the 45 % share of heavy freight transportation (Bleischwitz/Bahn-Walkowiak 2008). A tax can be seen as a response to the need for economic incentives in that area and as a step towards a more inclusive taxation of resouces in general. Practical experiences with the effect of taxes on aggregates have been gained in some EU member states (in particular in the UK, Sweden, Italy and the Czech Republic), which all levy taxes or charges for sand, gravel and crushed rock (EEA 2008). Drawing on the European Council Directive restructuring the Community framework for the taxation of energy products and electricity (CEC 2003) that was set up in order to harmonise the market conditions our proposal lays the foundation for further expansion and harmonisation of environmental incentives, hence reducing market distortions and the competition that occurs because of different environmental regulations within Europe.

We propose a directive on the structuring of the Community framework for the taxation of construction materials that is applicable to primary aggregates (i.e. sand, gravel and crushed rock) and comprises all European member states. The tax/charge base should be tonnes produced, that is, extracted and purchased (used extraction). The minimum levels could start from €1.5 – 2 per tonne and stepwise increase by e.g. 5 % / a. Based on current production and under the assumption of a low elasticity of demand, this will lead to revenues in countries such as Spain, France and Germany in the order of 800.000 Mill. € each. Tentative scenario results for Germany (Meyer et al. 2010) indicate a reduction of Total Material Requirements in this sector by more than 10 % while the negative impacts are negligible.

The directive should also allow for mechanisms such as border tax adjustments for aggregates imported into the EU, as it could otherwise distort the price mechanism in some local markets. In addition, existing regional schemes such as a stronger differentiation according to the environmental value of extraction sites or land use patterns ought to be integrated.

Politically, the revenues generated could be earmarked and support a resource - efficiency fund or resource-efficiency programmes.

An ecologically differentiated VAT

The rationale of the VAT is that VAT is a large source of revenues in all countries (aprox. 20 % on average in the OECD). It is also an excise tax charged on the end users, since all upstream services are entitled to the deduction of the input tax, provided they have been charged in commercial transactions. Thus it is mainly paid by consumers mainly and allows for a differentiation that targets different lifestyles.

In 2008, the European Commission presented a proposal for a Council Directive amending the VAT Directive 2006/112/EC as regards reduced rates of VAT, which states: "Similarly, the appropriateness of allowing the application of a reduced rate to energy saving materials and to other environmentally beneficial products or services (notably energy saving and energy efficiency related services such as inspections, energy audits and energy performance certifications) is currently being examined by the Commission in accordance with the request formulated by the European Council in March 2008. "This may also apply to the possible eliminatiin of reduced tax rates on polluting products, such as pesticides (COM (2008) 428, see also COM (2007) 380 in a similar wording).

Besides environmental effects, social issues are frequently raised in discussions on reduced VAT rates (Albrecht 2006). The distributional effects of a differentiated VAT are - especially in the public debate - particularly sensitive and shall therefore be briefly discussed here. One criticisism is that other than the income tax the VAT is not based on the financial capacity of the taxpayer. Households with a low income would therefore have to bear a proportionately heavier burden through the VAT than households with a high income.

In light of contemporary analysis (IVM 2008; ##), the following section presents a proposal for advancement of the current VAT sytem:

Repeal of the tax exemption of international flights

In e.g. Germany, the VAT exemption for international flights entails a loss of 1.56 billion euros for the federal and state governments. A possible alternative could be to constitute a staggered ticket tax, e.g. as raised in France, England or the Netherlands (FÖS 2008: 5). The future inclusion of aviation in the EU emissions trading has to be taken into account though.

Repeal of the reduced VAT rate for milk and meat products

In e.g. Germany, the appeal of the VAT reduced rate of these two product groups would lead to additional tax revenues of 5.1 billion €, roughly an equivalent to the current market size for organic products. As a general appeal of the reduced tax rate on food stuff would likely run into opposition in business, government and consumer communities, a normal VAT rate on the most resource-intensive food could be an alternative. These include mainly meat and dairy products. Calculations of IVM (2008) have shown that an increase in VAT for conventional meat and dairy products to the standard rate in all Member States would result in a consumption decrease of 2-7% for meat (1-3 million tonnes) and 2-5% for dairy products (3-6.5 million tonnes) (IVM, 2008, 117). Taking into account possible shifts in organic products and conventional foods this would result in a CO2 reduction of 12-21 million tonnes of CO2 per year. Alternatively, it could be a useful measure to support the organically produced milk and meat products with a VAT reduction.

Introduction of a reduced VAT rate on energy and material efficient white ware (A++)

Household appliances are usually taxed at the standard rate all over Europe. Under the assumption that the introduction of a reduced VAT rate for Class A+ appliances would lead to an increase of a 15% IVM (2008, 58) estimate that 3.4 million tonnes of CO_2 could be saved EU-wide, for refrigerators, freezers and washing machines alone. In the future, the criterion of resource efficiency / material efficiency can be incorporated into legislation of Integrated Product Policy and the Eco-Design Directive.

There are many other possibilities of utilizing the VAT for a resource policy such as a differentiation according to the resource-intensity of key sectors or according to teir service intensity and maintenance of goods. However our proposals are of such character that they offer multiple synergies with other environmental policies and can be implemented rather easily. This also means that more far-reaching options such as to include more products do exist but will require a better information base.

An International Metal Covenant

End of life vehicles (ELV) contain a variety of materials, including steel and copper but also PGM. A high-level recycling could save considerable amounts of resources in comparison to the primary production route. Accordingly, the ELV directive states that manufacturers have to ensure recycling rates of 85%, and this rate will have to be increased up to 95% in 2015. However, most vehicles are exported as pre-used vehicles and end up as waste in countries outside of the EU, where these recycling targets are of no relevance. Usually - if at all - only the main mass flows (particularly steel) are recovered. Such poor management of resources causes a massive material leakage for the EU.

In principle, there should be an economic interest to increasing the recycling rates of these materials: the automotive industry could reduce its dependence on the volatile commodity markets and strengthen their security of supply (e.g. for copper). The recycling industry has developed techniques and infrastructures to recycle ELV profitably, but needs a sufficient amount of available input. In the destination countries of exports illegal waste activities cause significant environmental burdens. At the same time, the development of functioning recycling infrastructures could stimulate local economies while transferring existing schemes of the shadow economy into a legal frame. Despite such common interests, the prevailing policy instruments and incentives are clearly not sufficient to stimulate transactions and to generate the necessary investments that are deemed necessary to put this into action.

Against this background one may start with the negotiation of a legal contract based on private law (a covenant) between suppliers and automotive manufacturers, recycling industry and the relevant public authorities in the export and destination countries. Such a covenant should set long-term goals to increase the resource productivity by high quality recycling of old cars (wrecks). It should define the responsibilities of different actors in terms of operation, implementation, and evaluation. The contractual parties, be it industrial enterprises or their associations, shall commit themselves to ambitious targets for resource protection. In return, the states shall guarantee stable and supportive regulatory framework conditions for the duration of the contract. In distinction to voluntary agreements, the covenant and its compliance should possibly be brought up to a court. However for an effective implementation it should also provide effective dispute resolution and sanctions if contractors fail to meet their obligations. Germany, the biggest car manufacturer and recycling market, could take the initiative for such a covenant within the EU.

Such a covenant does have the potential to establish a framework towards closing material cycles for consumer goods more effectively at an international level. The distribution of the existing costs and benefits along the value chain could be regulated in such contract in a flexible way in order to overcome existing prisoner's dilemmas. New partnerships between industry sectors and public bodies may contribute to the reduction of transaction costs for obtaining information and simultaneously increase the state's regulatory capacity and the industry's acceptance for such arrangements. The extended producer's responsibilities for the physical and financial effects of their products at the end of the use phase – name it material stewardship (ICMM 2007) – would be no longer undermined by exports. This would put real incentives to reinforce design for recycling and solve existing conflicts with other environmental goals, such as the use of plastic for lightweight construction to reduce fuel consumption. But the instrument also shows some practical and legal issues and risks that must be weighed against these potential benefits.

Such an international covenant between selected states and industry sectors is a new area for international law and economics. The theoretical starting point for our considerations of an international covenant is the thesis that especially knowledge problems and transaction costs are responsible for the open loops in international material cycles with end-of-life products. On the one hand market failures exist on recycling markets because of the asymmetrical distribution of information hindering efficient contracts. On the other hand the state has insufficient information to correct market failures for an optimal result by direct regulation. Instruments of direct regulation (prohibitions, standards, etc.) have been very effective in the past and mainly prevented local pollution. Sustainability as a goal of social development increasingly seem to be too complex to be achieved in this way. In particular the uncertainty of sustainable development and the associated principle of precaution overwhelm capacity and capabilities of the political environmental actors to motivate businesses to a behaviour "beyond compliance".

To start with automotive recycling appears potentially interesting for such a covenant: it offers high specific investments in recycling infrastructures, complex coordination processes in the international process with high uncertainty about the evolution of the framework, in combination with a lucrative market with a manageable number of key players and the potential for material efficiency and resource conservation as well as a large number of target countries for the export of used cars, which could be incorporated into a single treaty.

An International Convention for Sustainable Resource Management

In the long run, sound reasons advocate for new legal mechanisms for international resource policy by an international convention on sustainable resource management:

- Existing initiatives and boards are not legally binding; they are based on voluntary participation and uncertain continuity,

- Competitive advantages through material efficiency are thwarted by destructive exploitation, environmental dumping and 'sleazy waste disposal'

- The pressures from problems and therefore the potential for conflicts are growing.

An international convention should be aimed at establishing sustainable and peaceful resource management, as well as principles of resource conservation. Further goals should be the decoupling of welfare from resource use and environmental pressures and the legal codification of criteria of sustainable resource management for resource extraction, refining, manufacturing, use, recycling and final disposal. The way in which sustainable land use is integrated into the convention has to be contemplated.

A convention can codify two fundamental legal principles for a sustainable resource management in international public law:

1. The principle of a *common heritage of mankind*, according to which resources are left to individual states and stakeholders for utilisation, but in the end, in their total geological and anthropogenic stocks, can be viewed as a heritage of mankind and ought to be passed to future generations, at least in their most essential functions. Thereby, resource use is allowed for the sustainability postulate of a constant capital stock and the avoidance of irreversible losses of vital components of the ecosystem. This principle does not contradict private property rights or rights of use and does not exclude the use of non-renewable resources

2. The principle of *materials stewardship*, according to which optimal and sound production and use of raw materials shall contribute to the welfare of society while observing environmental concerns.

In concrete terms, material stewardship in the context of product responsibility would mean that products should be designed, produced and used in such a way that material flows along the production and use chain do not exert undue environmental and social pressures, that subsequent waste recovery and recycling do not impede the recycling of other materials, and that the use of the recycled material provides a net benefit in terms of primary resource requirements. An international convention would underpin efforts and networks towards this end, and give them legal support.

A convention should improve the information base and set incentives for learning processes and the amplification of the knowledge base e.g. through an international data base on extraction, indicators for sustainable resource management and eco-innovation, coefficients for comparing measurements of indirect resource use in internationally traded raw materials, semi-finished products and end products (total resource requirements and global land use, ideally combined with data on global warming potential).

With a vie to resource-rich developing countries, such convention should provide legal support for the establishment and management of national and regional raw material funds. In essence, such funds should include rules that ensure that yields of activities from extraction and the use of natural resources up to recycling and disposal are reinvested in the development of sustainable production and consumption structures, as well as used for the benefit of the population for responsible and effective governance processes.

An international convention should also be designed as a platform under international law for bilateral programmes and arrangements. In this context, cooperatively stipulated 'road maps for sustainable resource management' between G8 and BRIC countries are of special interest. In addition, a legal framework for the realisation of sectoral agreements with material-intensive industries under the roof of such a convention is imaginable. Economic instruments, e.g. the international harmonization of resource taxation and user fees on international goods that are currently not taxed (such as aviation, maritime shipping, international harbours) or resource certificates are also interesting options.

Such a convention, however, will probably be established in a stepwise manner and, in particular, only develop incentives for resource conservation and the legally new area of material stewardship in cooperation with industry. Thus, it is imaginable that initially only information exchange will be undertaken. Furthermore, an international convention is only a means towards global and sustainable resource management. Alternatively, an existing international organisation could take responsibility for information exchange and creating a database, or existing initiatives could be effectively strengthened and implemented.

A short reflection

Our suggested resource policy will make a difference to the prevailing ways of treating construction minerals and metals. Together with the approaches that have been mentioned earlier – a technology platform, a trust funds for eco-entrepreneurship, lighthouse projects – it it will spur innovation in the EU and internationally. It will in particular strengthen the relationship with emerging economies. It needs to be stressed however that such policy does not exclude a special treatment of single substances or selected critical metals if it is deemed to be necessary.

A second reflection should address land use and biomass. So far, our propals have not yet been specific on how biomass should be addressed. In terms of environmental priority, the availability of arable land is of utmost importance. Related areas such as the expansion of cropland at the expense of life-supporting ecosystems and the destruction of forests are clearly issues which need to be addressed. For sure, any shift from non-renewable to renewable resources is not an option. Our VAT proposal targets the problematic of food patterns though, and existing biofuel certification in the EU can also be seen as a starting point towards more comprehensive resource policies in light of the visions mentioned.

5. Conclusions

The empirical analysis underlines the well-known trend of decoupling the use of natural resources from GDP and ensuing gains of material productivity and resource productivity. However the dynamics from 2000 – 2007 has slowed down compared to the nineties and falls behind aims of accelerating resource efficiency by 3 %/a. The EU new member states show an annual increase that is slightly higher than in the EU-15 states; however the energy productivity gains outweigh material productivity by far. Interesting to note that the price increases on international raw material markets does not seem to have had much effect on material productivity.

The trend towards increasing Total Material Requirements associated with imports in the EU indicates a burden shifting into countries outside the EU, i.e. a case for international policy approaches. Thus, any revised EU Thematic Strategy on the Sustainable Use of Natural resources, the envisaged national programmes as well as the forthcoming EU Action Plan for Eco-Innovation are timely and should seek to give appropriate incentives.

The paper outlines a rational for such resource policy and develops guidelines for a transition management towards resource-efficient green economies. In the short term, the paper also pledges for a technology platform on resource-light construction, a trust funds for eco-entrepreneurship and a programme to speed up eco-innovation and material efficiency across business.

However this won’t be enough to remove the barriers and market failures that effectively hinder markets for resource efficiency to flourish. The paper thus develops a strategic approach with grasping the ‘low hanging fruits’ of material efficiency at the business level first, followed by pillars to disseminate process innovation, to develop lead markets, to transform sectors and to establish new infrastructures. In addition, the paper proposes the target of doubling resource productivity by 2030. It furthermore proposes economic instruments such as a tax on construction minerals and an ecologically differentiated VAT. The international markets can be addressed via an international covenant for metals and an international convention for sustainable resource management. For sure, such instruments won’t be introduced in short term, but may well become a topic at the forthcoming Rio+20 Earth Summit in 2012.[11]

After all, more research is needed to understand the dynamics of drivers and barriers as well as the interaction with international economics. Here, a transition management perspective seems appropriate to tackle the different levels of activities and the time dimension.

[11] www.unep.org/greeneconomy/

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