Bettina Bahn-Walkowiak, Henning Wilts, Mark Meyer, Martin Distelkamp

Conceptualising a tax policy mix for resource efficiency

Selected results from a three-transition pathways approach

This is a draft chapter. The final version is available in:

In: Weishaar, S. et al. (eds.) The Green Market Transition - Carbon Taxes, Energy Subsidies and Smart Instrument Mixes - Critical Issues in Environmental Taxation Series, Vol. XIX. Cheltenham: Edward Elgar, pp. 174–192.
doi: 10.4337/9781788111171.00024

Wuppertal Institut

*Bettina Bahn-Walkowiak, a**
Henning Wilts, a
Mark Meyer, b
Martin Distelkamp, b

Conceptualising a tax policy mix for resource efficiency: selected results from a three-transition pathways approach

a Wuppertal Institute, Germany

b Institute of Economic Structures Research, Germany

* Corresponding author:
Bettina Bahn-Walkowiak
Wuppertal Institut für Klima, Umwelt, Energie gGmbH
Döppersberg 19
D-42103 Wuppertal
Germany

E-mail: bettina.bahn-walkowiak@wupperinst.org
Phone: +49 202-2492 276
Fax: +49 202-2492 138

Wuppertal Institut

Abstract

Against the background of the question which role tax based instruments have to play in policy mixes to counteract the unbroken growth trend of global resource use, this chapter initially describes how the insights from a country comparative study on national resource policy frameworks could be linked to instruments for the internalisation of external environmental costs at European scale. On the basis of a project specific but substantiated resource use vision and potential governance principles for three transition processes to reach the goals, the tax concepts are subsequently connected to simulation scenarios in order to illustrate the resource impacts that could be achieved by those policy reforms. Conclusively, barriers to such fundamental change of framework conditions are briefly reflected upon and some conclusions are drawn.

1 Introduction

Future projections show an exorbitant increase of global material use within the next decades (by 2050) under business as usual conditions, reaching up to 183 billion tonnes of extraction per year (UNEP 2016). The growing dependencies, volatile prices and the increasing scarcity and criticality of raw materials that are associated with this challenge shall be answered with a transformation of the economy in order to radically increase resource efficiency, inter alia, by 'a major shift from taxation of labour towards environmental taxation [that] will lead to a substantial share of environmental taxes in public revenues' (European Commission 2011).

The following chapter describes a segment of a comprehensive research process within the project 'Policy options for a Resource-efficient Economy' (POLFREE) commissioned by the European Commission. It links results from a comparative country study on resource policy frameworks and subsequent analyses on potential resource efficiency tax instruments to the environmental and economic impacts of a modelled policy reform in three transition scenarios. Finally, barriers for such a fundamental change of framework conditions are briefly touched upon. The guiding research questions were:

- Which role can tax based instruments play in policy mixes for resource efficiency?
- Which resource reductions could be achieved by these policy mixes?

2 Real world policies: lessons from trends and policies in a country study

There is substantial variation across Member States concerning their environmental performance and their resource policies. A recent study (Bahn-Walkowiak et al. 2014) examined and assessed the fulfilment of selected criteria, such as direct financial support, green elements in economic recovery programmes and innovation policies, support for small and medium sized enterprises, the phasing out of environmentally harmful subsidies (for meat and cars), coordination of policies and environmental and resource taxes. The figure below shows exemplary configurations of the governance patterns of the four selected countries: Austria, Germany, Hungary and the Netherlands.

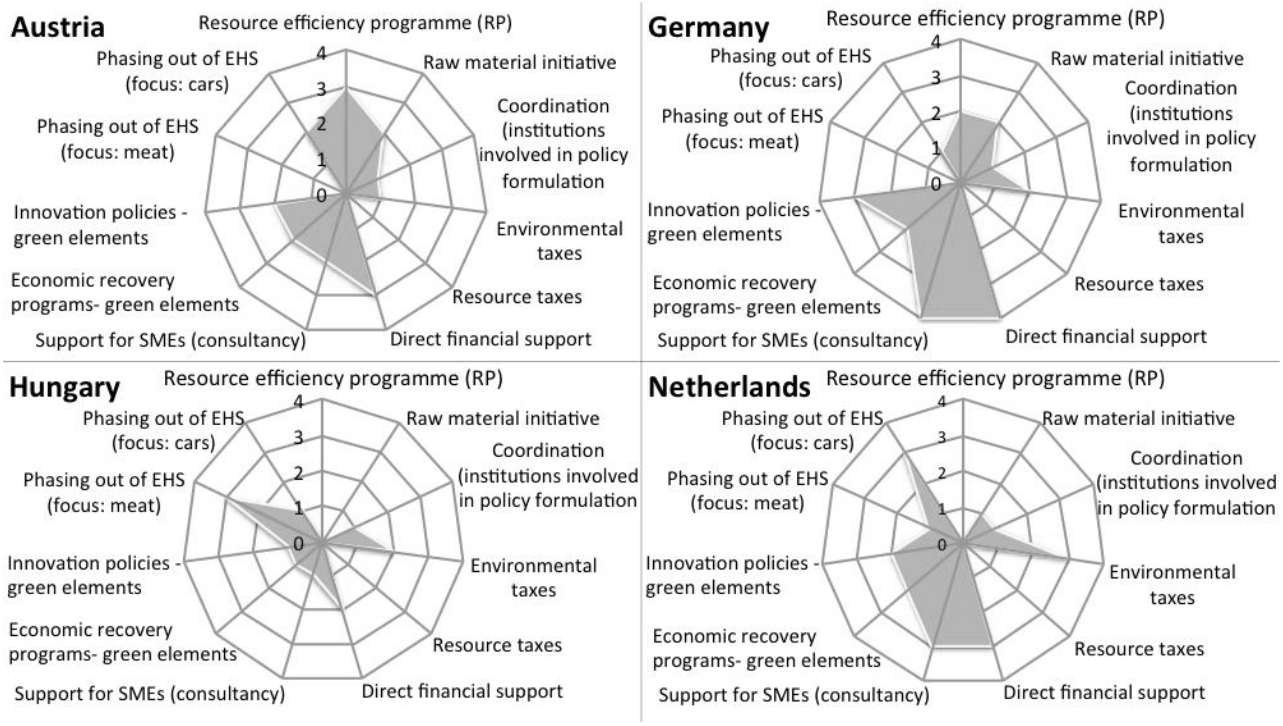

Figure 1 Governance patterns of resource efficiency policies of four exemplary countries with respect to requirements of the EU Roadmap to a Resource Efficient Europe; Source: Bahn-Walkowiak et al. 2014.

Strong shortcomings are depicted in the policy design, inter alia, missing targets and objectives not fit for purpose, a lack of policy coherence, conflicting policy objectives, counter productive exemptions, as well as non-integration of rebound effects and international implications (Fedrigo-Fazio et al. 2014). Further deficits stem from largely unexploited potentials for innovation and investments and lack of regulation and mainstreaming of eco-innovation as well as lack of knowledge on the environmental impacts of key sectors (Bahn-Walkowiak et al. 2014).

A key weakness in the policy frameworks with direct effect on the environmental performance is the low level of environmental and resource taxation. The majority of environmental taxes come from energy (76.5 per cent) and transport (19.9 per cent), with pollution and resource taxation representing only 3.6 per cent of the total environmental tax revenue in 2014. This constitutes a marginal contribution of 0.1 per cent from resource and pollution taxes to the Gross Domestic Product (GDP) in the EU compared to any other types of taxes (such as those on labour) (Eurostat 2016a). At the same time, the EU average resource consumption in 2014 was 13.9 tonnes of Raw Material Consumption (RMC) per capita and year (Eurostat 2016b), whereas the numbers vary considerably among the countries: Spain and Italy are presently the most modest consumers with approximately 8 tonnes of Domestic Material Consumption (DMC) per capita; Finland consumes more than 3 times as much with 30 tonnes per capita (Eurostat 2016c).[i] The global average per capita consumption is 10

tonnes while here too 'per-capita consumption levels are very uneven, with a factor of more than 60 between the country with the lowest and highest consumption in 2009' (Giljum et al. 2014).

3 The vision: reduction of resource use

Guided by the issue of fair and safe conditions of a future global material use, the project developed a 'Vision' for a resource-efficient economy in the EU by 2050 by providing key qualitative and quantitative characteristics that such an economy should exhibit (O'Brien et al. 2014). An essential output of this process was the development of quantitative headline targets for the environmental characteristics concerning the four major categories: material use, carbon emissions, land and water use (Drummond 2016). Due to space constraints and the complexity of the topic, this chapter focuses on materials/resources and will only present the approach with regard to materials and the taxation of materials. The headline target for a resource-efficient economy is qualified as 5 tonnes of RMC per capita and year in order to return to a level of global raw material extraction equivalent to the year 2000, and distribute this level equally among the expected world population in 2050. A further complementing condition specifies that the European demand for primary materials is reduced to the point that it can be nearly all sourced within the built environment through, for example, urban mining, recycling and the use of secondary resources (that is, no net addition to stocks). This also implies a reduced land take and much higher levels of renovation of the existing building stock (Jäger 2014 based on Bringezu 2014, BIO Intelligence Service 2012).

Considering this ambition, resource-related taxes obviously have to be an integral part of any policy mix for resource efficiency – in view of the distance-to-target between an average consumption of about 14 tonnes today (Eurostat 2016b) and a vision of 5 tonnes in 2050 (Jäger 2014).

4 The concept: internalisation of external costs

It is often argued that internalisation of costs by taxes or any other measure, first needs a proper estimation of the damages and pollution. [ii] Accounting methods for externalities are, inter alia, life cycle assessment, life cycle costing, green accounting, cost-benefit analysis and the impact pathway approach. Due to the complex issue of an economic valuation of environmental damages and pollution, a precise and comprehensive internalisation of external effects is hardly possible yet. [iii] The 'polluter pays' principle has to serve as a heuristic model, supplemented by the precautionary principle, in order to steer the allocation of the societal costs of nature consumption to the users and polluters.

Besides an overall vision and concrete targets that were developed for the four major categories: materials, emissions, land and water use (Jäger and Schanes 2014), three

alternative pathways to achieve a resource-efficient European economy in 2050 were designed, each related to a specific governance principle (O'Keeffe et al. 2014):

- Strong Global Cooperation – All countries co-operate through international agreements and harmonised economic and regulatory policy instruments to pursue decarbonisation and a resource-efficient global economy
- Europe Goes Ahead – The EU pursues the development of a low-carbon, resource-efficient economy unilaterally through strong EU-level economic and regulatory policy instruments instituted by Member States. The rest of the world fails to increase the ambitions
- Civil Society Leads – Civil society, non-governmental organisations and businesses drive resource-efficiency and decarbonisation through voluntary changes in preferences and behaviour. Policies are introduced to facilitate such changes (Meyer, et al. 2015).

Three types of instruments were analysed for each policy field. [iv]

A first instrument type grasps for low hanging fruits of resource efficiency that could be described as a win-win situation for the actors by leading to quick resource savings (or quality improvements and cost savings) within short amortisation periods. A second type requires severe market interventions by public actors that especially force the supply side of raw materials and products to increase the resource efficiency of production processes. These instruments often follow the idea of technology forcing – assuming the existence of technologies that should be rationally introduced – from a social and long-term point of view, not from the perspective of a single firm. A third type aims at a systematic transformation of production and consumption patterns towards resource efficiency directly impacting consumption or consumer preferences. From the viewpoint of politics, these instruments presuppose a high level of awareness for the urgency of resource efficiency within the population (and thus among voters).

Against the background of the analytical framework (consisting of the policy context, specific design features, specific implementation issues of the instruments, existing experiences on national/regional levels, multi-level issues, dynamic and static effects and impacts, implementation barriers and relevant winner, losers and veto actors) (Wilts et al. 2015), the next section will summarise the main results of this analysis.

4.1 EU-wide harmonisation and introduction of (construction) minerals taxes

Construction material taxes can be a first step to more comprehensive environmental tax reforms all over Europe. Although the extraction of construction materials does not have the largest environmental impact in terms of pollution along the life cycle, it has considerable relevance in relation to material use and intensity and long-term life-cycle effects, in particular if one looks at investments in path-dependent infrastructures (Usubiaga et al. 2011). A construction minerals tax can expand the hegemonic energy-based taxation, which is the most established instrument of resource

taxation by now (Withana et al. 2014; Ekins and Speck 2011). The Energy Taxation Directive (2003/96/EC) can provisionally be regarded as a prototype of a resource taxation. It expanded the scope of the minimum rate system for energy products, until then limited to mineral oil, to all energy products (coal, natural gas, electricity). In line with this directive and its objectives, a further expansion of the tax base would be a consistent and logical consequence.

From a social sustainability perspective, a construction minerals tax can generate funding for environmental programmes and research while relocation processes are rather unlikely, due to a limited cross-border trade of the transport-sensitive material. Strong regressive effects are not to be expected because of a low material price in relation to the price of a complete building. In the short term, demand is rather inelastic. In the long term, the tax can strongly contribute to resource efficiency by promoting competitiveness in the field of resource-efficient construction.

A European Directive on Construction Minerals Taxation would be a two-tier legal act comprising (1) a directive, initiated and issued by the European institutions, followed by (2) national implementing measures, initiated and carried out by the Member States within a certain timeframe.

Practical experiences with the effects of taxes on construction minerals have been collected in several EU countries. Among the countries that achieve verifiable income by taxes on mineral resources are Bulgaria, the Czech Republic, Denmark, Lithuania, Latvia, Sweden, the United Kingdom and others. Not only are different mineral resources taxed or charged with fees, but different tax bases are also applied (for example, extraction amounts, surface mining, market values). Similarly, the measurable effects are diverse and do not only depend on the level of price incentives, but also on a possible inclusion in a consistent policy bundle such as an implementation of a landfill tax. Other aspects are matters of tax beneficiaries (local, state, federal) and the legal ways to use the revenue gained, for example, earmarking for environmental purposes. Especially in those countries where taxes are part of a wider policy mix, success is achieved (for example, the UK, Denmark, Sweden) and consumption of the taxed resource decreased significantly. Overall, one can indeed speak of a certain policy diffusion of the instrument, but there are no standardised instruments, nor harmonisation efforts at the EU level (Bahn-Walkowiak et al. 2014).

4.2 RMC-based material input taxes

According to the ‘polluter pays’ principle, both the producer and the consumer should bear the responsibility for the pollution and external effects generated by the producer to manufacture the goods demanded by the consumer (Proops et al. 1994). Based on a harmonised European approach in the areas of energy and construction minerals, the second pathway is a scenario of introducing RMC-based environmental taxes across all resources, including strong market interventions. It aims at a full cost pricing of resource extraction, utilisation and the associated hidden flows. A targeted

relief of the production factor labour will lead to balancing the lopsided taxation of production factors until 2050.

A European-wide harmonised taxation on materials starting at the beginning of the value chain would not lead to distortions of competition in European but would require border tax adjustments in the form of import taxes on materials not extracted domestically (Behrens et al. 2005). It would also require calculating the amount of material content in imported semi-finished and finished goods. In addition, generalisations and credible life-cycle analysis assessment and certification systems are to be developed to reward above-average environmental standards in mining and processing (Sachverständigenrat für Umweltfragen 2012). The tax has to be complemented by, for example, CO2 taxes and other pollution taxes but exempt secondary materials from taxation (Sachverständigenrat für Umweltfragen 2012). This is ecologically considered essential because material-intensive sectors are burdened overproportionally by those taxes. The taxable entity is the company that directly deploys materials to produce certain products. For the material input, which is included in downstream intermediate goods (semi-finished goods), the tax is only paid indirectly through the higher purchase prices (Omann and Schwerd 2005). With the introduction of an RMC-based material tax, a revenue-neutral reduction of other taxes (for example, income tax) should take place to avoid any additional tax burden.

There are no practical experiences with such a comprehensive material tax at any national or regional level. The theoretical effects encompass a more expensive material input for the production sector, thus creating incentives (depending on the tax rates) for a more efficient resource use, material-saving innovations and technologies, substitution by other (renewable) resources, more recycling, reuse and input of secondary resources. The material costs are passed on along the subsequent stages to the consumer who will have an incentive to switch to other products for which the share of material content taxed is not so high. At the sectoral level, the RMC-based material tax provides an incentive for all industries to change to a more environmentally friendly production. However, the structural change caused by the tax does not have a positive effect on all industries, because sectors with a higher material input are more affected than the others. At the same time, a trend towards more services is expected, which should lead to overall positive employment effects in this sector. Less material-intensive product design and technologies will become more common. Services, in particular services for reuse and repair, will become more important (Omann and Schwerd 2005). If the additional revenue generated is raised for a relief of labour costs, the disposable income and wealth will remain at the same level. An RMC-based material tax should be initiated either by the EU or by several like-minded countries (Ekins et al. 2009).

4.3 LCA-based Value Added Taxes

Consumption taxes based on non-renewable resources can only indirectly address resource use or environmental pressures. Eckermann et al. differentiate several concepts of tax bases: a weight-based tax when the final product is traded in units of

weight (for example, fertilisers), a tax based on a classification of resource use (for example, size classes of cars) which is levied on all products containing a certain resource or a certain amount of resource, and a tax based on the value of a product, appropriate when the value is correlated with the resource use (for example, air flights) (Eckermann et al. 2012). The basic idea is that value added taxes (VAT) rates depend on the environmental product performance, thus implementing incentives to support consumer choices and producer action in favour of resource efficiency.

Morrison (2007) proposes a plan for an ecological value added tax to be phased in to replace all income tax (personal, corporate and payroll) with an average 18 per cent ecological value added tax, so-called E-VAT, that could replace all US government taxes on income, fund the federal budget and get the prices right by raising taxes on more polluting goods and services. 'The more polluting, the higher the E-VAT tax rate, and the lower the rate of profit' (Morrison 2007). The regressive effects of ecological consumption taxes shall be avoided through a negative income tax concept. [v]

A different concept suggests a combination of the VAT system and life cycle assessment (LCA)-based data. De Camillis and Goralczyk (2013) discuss several methodologies capable of determining variable VAT rates depending on the environmental product performance based on LCA indicators. They simulate a case study that shows considerable potential to deliver significant impacts on unsustainable consumption and production patterns. Another proposal calls for a reform of the current VAT system by introducing differentiations between sectors, products and services, and product and service groups, which are identified as particularly resource and carbon intensive and sets out how a harmonisation of the overall system and an ecological differentiation in single consumption areas could contribute to support the transition to a low-carbon and resource-efficient economy (Bahn-Walkowiak and Wilts 2015). Depending on the choice of concept, the approach could either be initiated at national level or by the EU and could be applicable at national or EU level.

There are no practical experiences with a comprehensive ecological consumption tax at national or regional level. Brazil has experienced an ecological value added tax by implementing rules for a reallocation of certain shares of consumption tax revenues upon ecological criteria as compensation for restricted economic activities of local governments due to conservation activities (May et al. 2002). This led to the fact that conservation became the principle industry in some municipalities. It has to be noted though that the concept refers to allocation principles and therefore differs from other concepts of ecological value added taxes. At a theoretical level, there are various econometric studies calculating the effects of consumption taxes or changes to consumption tax rates of specific products, such as meat and dairy products (Institute for Environmental Studies 2008, Säll and Gren 2012), and showing remarkable positive steering effects.

5 The scenarios: adapted tax measures in a policy mix

As described above, the exploration of policy fields and the corresponding instruments, as well as the modelling work, were embedded in a scenario framework (Jäger and Schanes 2014) which hypothesised different ways of cooperation and governance (O'Keeffe et al. 2014) with and in countries of the world, and that allocated plausible policy mixes (Wilts et al. 2015) in addition to the EU targets. Further, a business-as-usual (reference) scenario was developed in which an increasing focus or ambition towards decarbonisation and resource efficiency in both EU and non-EU countries fails to materialise (Meyer et al. 2015).

The economic models (GINFORS, EXIOMOD) that were used for the modelling belong to the family of Environmentally Extended Global Multi Regional Input-Output (EE-GMRIO) models. Such models assess the interconnections between the environment and the economy (energy use, emissions, resources) with a multi-region/multi-country perspective, and are characterised by global coverage and the ability to analyse impacts on economic sub-sectors and specific resource products. Two key differences may be found between the GINFORS and EXIOMOD. First is the main source of historical data. GINFORS is based on the WIOD database, a global multiregional time-series of input-output tables with accompanying socio-economic and environmental data. EXIOMOD is based on EXIOBASE, which provides more sectoral detail but reports only for one historical year. Second, and most important, is the different theoretical and empirical foundation of the behavioural functions the models consider. GINFORS has a Neo-Keynesian theoretical background and all parameters of the model, like price elasticities and technical progress, are estimated econometrically based on historical observations. EXIOMOD in contrast is a Computable General Equilibrium Model (CGEM) with neoclassical theoretical foundations. The parameters of the model (elasticities, efficiency gains) are taken from literature or set by assumptions (Drummond 2016).

The project intensively discussed opportunities to include policy mixes in such highly aggregated macro-economic modelling approaches as GINFORS and EXIOMOD. Firstly, this required a partial reformulation of instruments in order to achieve clearer and more easily modellable assumptions (in terms of mandatory recycling rates, for example). Secondly, additional instruments and targets became necessary, especially with regard to climate change mitigation in order to fulfil the boundary conditions of the POLFREE scenarios. As a last step a set of 20-30 different policy instruments (informational, economic and regulatory instruments) was allocated to the three alternative scenarios with the different governance and international cooperation assumptions.

For example, the pathway Global Cooperation encompassed a carbon tax, an extraction tax of fossil fuels and metal ores, a tax on metal ores and non-metallic minerals and a tax on meat. The pathway EU Goes Ahead integrated a carbon tax, an RMC-based tax on metal ores, a tax on water withdrawal and the taxation of meat. The

pathway Civil Society Leads simulated a carbon tax with direct compensation and further autonomous reduction of other materials (Meyer et al. 2015, Hu et al. 2015).

In order to radically decouple economic development and the use of raw materials, all simulated tax measures were flanked by further assumptions on, inter alia, a regulation for recycling and public innovations funds for material efficiency. In the scenario EU Goes Ahead they were designed in a way that would not endanger international competitiveness (for example, through taxes on final demand instead of upstream taxes or by the implementation of direct compensation). In contrast, the Global Cooperation scenario foresaw an environmental tax reform in which the tax revenues were used for the reduction of taxes on goods and services with low carbon and resource contents. The Civil Society Leads scenario however assumed bottom-up changes overwhelmingly driven by a high intrinsic motivation to behave more resource efficient.

The following figure shows the potential deviation from a business-as-usual scenario for the indicator RMC as well as the deviation from 2015 levels, under the assumptions of a comprehensive implementation of a policy mix within a strong Global Cooperation scenario.

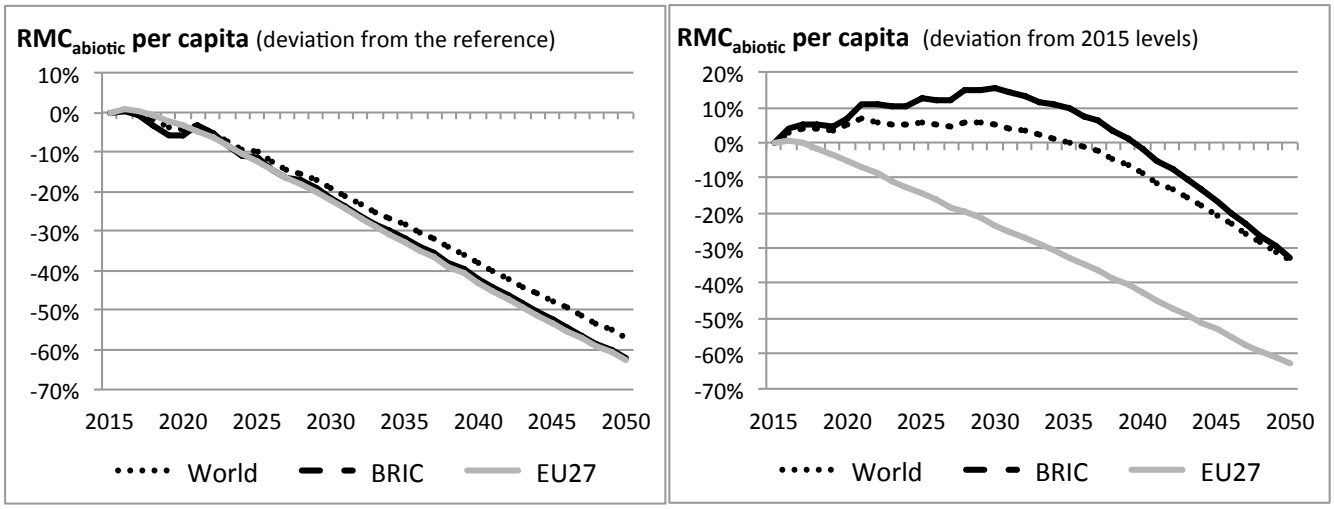

Figure 2 Raw material consumption of EU-27 in a scenario of global cooperation – Deviation from reference and 2015 levels (GINFORS results); Source: Distelkamp 2015 and Distelkamp and Meyer 2016.

Scenario EU Goes Ahead shows that for the EU a lead position in the transition process would be profitable while Scenario Civil Society Leads shows that behavioural changes of European citizens towards a post-growth economy can substantially contribute to the compliance of planetary boundaries (Distelkamp 2015).

In the EXIOMOD Model, the scenario Global Cooperation has the best balance between resource efficiency and economic performance but the scenario EU Goes Ahead seems to be more realistic in terms of policy implementation. Due to trade and

international dependencies the full potential of the measures on resource efficiency is not reached. 'However, households will benefit the most from ETR [environmental tax reform] in this scenario. In Scenario Global Cooperation ETR is smaller in size because there are less resource taxes and in Scenario Civil Society Leads the positive ETR effect is offset by a reduced working week and reduced final consumption' (Hu et al. 2015).

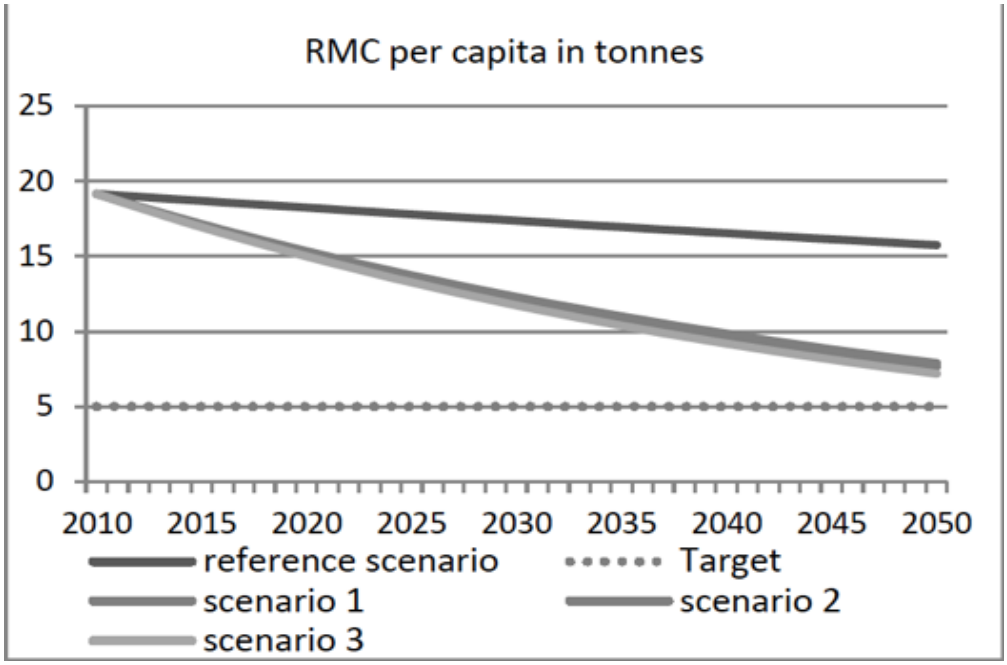

Figure 3 Raw material consumption in the EU-27 by scenario, 2010-50 (EXIOMOD results); Source: Hu et al. 2015, p. 47.

The complex and comprehensive use of different instruments sets, including particularly tax instruments, for the – at least partial – target attainment emphasise that radical changes are needed in the institutional and policy setting for the achievement of key environmental targets of the EU by 2050. For complex detailed results from the modelling of the whole policy mix, particularly the differences and similarities between the two models, it is referred to Meyer et al. 2015, Distelkamp and Meyer 2016 as well as Hu et al. 2015.

6 Barriers: winners, losers and veto players

The winners, losers and veto players in the context of incremental and radical internalisation measures can be easily sketched. Resource-efficient housing technologies and infrastructures, the maintenance and recycling industry, construction materials substitutes and urban development can be expected to benefit from a Construction Minerals Tax Directive while the mining sector, construction industry and the associated employment may be losers if they were not able to adapt to the new mechanism

in a timely manner. It can be assumed that the mining sector and construction industry are main veto players. In a similar vein all resource-efficient industries and investors in resource-efficient technologies most likely profit from RMC-based material taxes while primary industry, importing companies and their employment, and exporting countries might oppose such an approach, while the World Trade Organization in particular would be an important veto player. Depending on the classification scheme chosen, different environmentally friendly products and sectors could benefit from an ecological VAT while resource-intensive and inefficient products and technologies would be sanctioned this way. Possible conflicts may arise with the current EU regulation scheme and national governments as soon as competitive disadvantages are expected. In general it can be stated that innovators and early adopters will be the winners of such a transition process, but innovation laggards and Member States with low investment capacities may be losers, motivating European and other national governments and their finance ministers to plead against a fundamental reform (Wilts et al. 2015).

The introduction of comprehensive tax schemes with the aim to radically shift the tax objects and bases inevitably brings many resistors into the arena and generates winners and losers. Weizsäcker (2014, pp. 108ff.) reflects on at least seven main objections that will be raised in the context of any ecological tax reforms:

- Fiscal policy argument: Which is the dominant motive – governance or revenues? Effective taxes will destroy their tax base.
- Social policy argument: Taxes are regressive (but so are environmental pressures, at least to a certain extent).
- Environmental policies: Taxes are not targeted enough, and should be linked to purpose, second-best policies.
- Economic policy: Taxes are a burden on the economy and bear the danger of relocation of businesses; growth and employment have priority.
- Voters: No extra burden – tax matters are always unpopular.
- Experts: Taxes are imprecise, accounting methods are immature.
- EU harmonisation issue: Distorting effects of national differentiations; smooth functioning of internal market has high priority.

The research process has made clear that the merging of microanalysis and macromodelling is not easy. It is therefore most important to further develop such methodological combinations to allow for better projections of resource efficiency and other environmental instruments and obtain better insights regarding the distribution of winners and losers in the context of a conversion of tax systems. This will contribute to constructively channelling a mainly tax-adverse discourse.

7 Concluding remarks

While the idea of internalising external costs through tax measures is quite simple – and the modelling underlines the theoretical capability of those instruments – design and implementation remain to be a challenge. First, the valuation and thus monetization of nature and its services appears to be only achievable in parts for the time being (and from some respects perhaps not even desirable). Second, the market-based pricing of today's provenience is strongly influenced by the (infra-)structure of current taxation systems. Third, many economic effects and side-effects have to be considered. Last but not least, taxation systems are proven structures that must be considered to be cumbersome and path-dependent. Their reorganisation would deeply impact economic and social framework conditions, raise multi-level, regional and competition issues and require new socio-technical configurations and alliances with respect to the interplay and mutual dependence of national, European and global key sectors and key players.

The third European Resources Forum hosted by the Federal Environment Agency in Germany in 2016 however recently called for a European VAT reform for resource-efficient products, binding environmental and social standards for raw materials along the entire value chain and secondary materials for the construction sector that should be cheaper if less or no primary raw materials were used. These important proposals underline the research results presented here that show that tax policy mixes have to be a fundamental element for the radical reduction of raw material consumption and substantial increases of resource efficiency, even in different governance pathways of future economies.

Notes

[i] 'The total weight of raw material extractions needed to produce manufactured products is usually several times greater than the weight of the products themselves. Eurostat has developed a model to estimate the raw material equivalents of imports and exports for the aggregated EU economy and the results are presented in an article on material flow accounts — flows in raw material equivalents' (Eurostat 2016) but it does not display RMC-figures at national scale yet. We therefore use DMC here for illustration purposes. POLFREE used the term Raw Material Consumption, that is, directly and indirectly used resources without those embedded in the exports of the country.

[ii] There are different forms of externalisation of environmental costs. The three most important are: 1. The externalisation to the future and future budgets: measures are carried out or products are manufactured leaving environmental costs incurring years later (for example, pesticides which need approximately 20 years until they are detected in the groundwater); 2. The externalisation to the public: a project is carried out or the product is prepared so that incidental or consequential costs are paid by the public, not the polluter (for example, hazardous waste); 3. The externalisation to other countries: activities are organised or a product is manufactured so that incidental or consequential costs incur in another country (for example, feed production for European cows on fields in developing countries).

[iii] There are few estimates of how high the externalised costs of the environment actually are. One of the few examples is 'Earth Politics' where the rate of the external costs of resource use and environmental degradation is considered to be approximately 5–10 per cent of GDP (von Weizsäcker 2014), in this way giving a proxy of the potential magnitude of the necessary internalisation efforts. Another example is the famous Stern-Report (Stern 2006) bringing the economic costs of climate change non-mitigation to a broader audience and pointing to the 'discounting' issue by shifting disbenefits and cost into the future. The report estimated each tonne of CO_2 emitted caused damage worth at least $85, thus firstly and forcefully providing an image of the neglected costs.

[iv] Wilts et al. (2015) examined nine policy fields altogether: Internalisation of external costs, phasing out of environmentally harmful subsidies, resource efficient electricity production and distribution, resource efficient mobility, resource efficiency in the building sector, minimisation of food losses and waste, resource efficiency by product service systems, from waste disposal to a resource-efficient circular economy, and resource efficiency by industrial symbiosis.

[v] Weizsäcker considers the taxation of consumption not to be an appropriate instrument in the context of an ETR. Morrison and Daly argue for this as a replacement for the income tax. This concept has been developed in the US, where there is no federal VAT on goods or services, but a sales tax is common in most US states.

References

Aachener Stiftung 2011, Factsheet Measuring Resource Extraction. Sustainable Resource Management Needs to Consider both Used and Unused Extraction. Aachener Stiftung Kathy Beys, Aachen. Available from http://wupperinst.org/ uploads/tx_wupperinst/Factsheet_Measuring_Resource_Extraction.pdf. [31 December 2016].

Bahn-Walkowiak, B, von Gries, N, Wilts, H, Schefer S 2014, 'Comparing Trends and Policies of Key Countries: Report about Drivers for Resource Decoupling and the Role of National Policies', *POLFREE - Policy Options for a Resource Efficient Economy,* Deliverable D1.3, funded by the European Commission, University College London, London. Available from https://www.ukcmb.org/polfree/publications [11 November 2016].

Bahn-Walkowiak, B and Wilts, H 2015, 'Reforming the EU VAT System to Support the Transition to a Low-Carbon and Resource Efficient Economy' Kreiser, L et al. (eds) 2015, *Carbon Pricing - Design, Experiences and Issues*, Critical Issues in Environmental Taxation Series, vol. XV, pp. 111-126. Edward Elgar, Cheltenham. DOI:10.4337/9781785360237.

BIO Intelligence Service 2012, 'Assessment of Resource Efficiency Indicators and Targets', Final report prepared for the European Commission, DG Environment. BIO IS, Paris. Available from http://ec.europa.eu/environment/enveco/resource_efficiency/pdf/report.pdf [17 December 2016].

Bringezu, S 2014, 'Targets for Global Resource Consumption', Angrick, M et al. (eds) 2014, *Factor X, Policies, Strategies and Instruments for a Sustainable Resoure Use*, Eco-Efficiency in Industry and Science **29**, pp. 41–64. Springer, Dordrecht, DOI:10.1007/978-94-007-5706-6_3.

De Camillis, C and Goralczyk, M 2013, 'Towards Stronger Measures for Sustainable Consumption and Production Policies: Proposal of a New Fiscal Framework Based on a Life Cycle Approach'. *The International Journal of Life Cycle Assessment,* vol. **18**, no. 1, pp. 263–272. DOI:10.1007/s11367-012-0460-5.

Distelkamp, M 2015, 'On the Road to a Resource-Efficient Europe - Recent findings from POLFREE Research', Presentation at the World Resources Forum 2015, Davos, Switzerland, 12 October 2015. Available from http://www.wrforum.org/wp-content/uploads/2015/10/SS1-Distelkamp.pdf [21 December 2016].

Distelkamp, M and Meyer, M 2016, *Quantitative Assessment of Pathways to a Resource-Efficient and Low-Carbon Europe,* GWS Discussion Paper 2016/10. Gesellschaft für Wirtschaftliche Strukturforschung, Osnabrück, Available from http://www.gws-os.com/discussionpapers/gws-paper16-10.pdf [31 December 2016].

Drummond, P 2016, 'Conclusions & Policy Insights', *POLFREE - Policy Options for a Resource efficient Economy*, Deliverable D4.6., funded by the European Commission. University College London, London. Available from https://www.ukcmb.org/polfree/publications [14 December 2016].

Eckermann, F, Golde, M, Herczeg, M, et al. 2012, *Resource Taxation and Resource Efficiency along the Value Chain of Mineral Resources*, ETC/SCP Working Paper 3/2012. European Topic Centre on Sustainable Consumption and Production, Copenhagen. Available from

http://scp.eionet.europa.eu/wp/wp2012_3 [15 December 2016].

Ekins, P, Meyer, B and Schmidt-Bleek, F 2009, *Reducing Resource Consumption: A Proposal for Global Resource and Environmental Policy*, GWS Discussion Paper 2009/5. Gesellschaft für Wirtschaftliche Strukturforschung mbH, Osnabrück. Available from http://papers.gws-os.com/gws-paper09-5.pdf [17 December 2016].

Ekins, P and Speck, S (eds) 2011, *Environmental Tax Reform (ETR): A Policy for Green Growth*. Oxford University Press, Oxford.

European Commission 2011, *Roadmap to a Resource Efficient Europe*, COM(2011) 571. European Commission, Brussels.

Eurostat 2016a, *Environmental Tax Statistics - Statistics Explained*. Available from http://ec.europa.eu/eurostat/statistics-explained/index.php/Environmental_tax_statistics#Environmental_taxes_by_category [31 December 2016].

Eurostat 2016b, *Material Flow Accounts - Flows in Raw Material Equivalents - Statistics Explained*. Available from http://ec.europa.eu/eurostat/statistics-explained/index.php/Material_flow_accounts_-_flows_in_raw_material_equivalents [31 December 2016].

Eurostat 2016c, *Material Flow Accounts and Resource Productivity - Statistics Explained*. Available from http://ec.europa.eu/eurostat/statistics-explained/index.php/Material_flow_accounts_and_resource_productivity [31 December 2016].

Giljum, S, Dittrich, M, Lieber, M and Lutter, S 2014, 'Global Patterns of Material Flows and Their Socio-Economic and Environmental Implications: A MFA Study on All Countries World-Wide from 1980 to 2009', *Resources*, vol. **3**, no. 1, pp. 319–339. DOI:10.3390/resources3010319.

Hu, J, Moghayer, S and Reynes, F 2015, 'Report on Integrated Scenario Interpretation - EXIOMOD / LPJmL results', *POLFREE - Policy Options for a Resource Efficient Economy,* Deliverable D3.7b, funded by the European Commission under Grant 308371. University College London, London. Available from https://www.ukcmb.org/polfree/publications [11 November 2016].

Institute for Environmental Studies 2008, *The Use of Differential VAT Rates to Promote Changes in Consumption and Innovation*, commissioned by the European Commission, DG Environment, Brussels.

Jäger, J 2014, 'A Vision for a Resource Efficient Economy', *POLFREE - Policy Options for a Resource Efficient Economy,* Deliverable D2.2, funded by the European Commission. University College London, London. Available from https://www.ukcmb.org/polfree/publications [11 November 2016].

Jäger, J and Schanes, K 2014, 'Report on Scenario Formulation', *POLFREE - Policy Options for a Resource Efficient Economy,* Deliverable D3.5, funded by the European Commission. University College London, London. Available from https://www.ukcmb.org/polfree/publications [11 November 2016].

May, PH, Veiga Neto, F, Denardin, V and Loureiro, W 2002, 'Using Fiscal Instruments to Encourage

Conservation: Municipal Responses to the "Ecological" Value-Added Tax in Paraná ´ and Minas Gerais, Brazil'. Pagiola, S (ed) 2002, *Selling Forest Environmental Services: Market-Based Mechanisms for Conservation and Development*, pp. 173–199. Earthscan, London.

Meyer, B, Distelkamp, M and Behringer, T 2015, 'Report about Integrated Scenario Interpretation GINFORS / LPJmL Results'. *POLFREE - Policy Options for a Resource Efficient Economy,* Deliverable D3.7a, Project funded by the European Commission under Grant 308371 University College London, London. Available from https://www.ukcmb.org/polfree/publications [14 December 2016].

Morrison, R 2007, *Markets, Democracy & Survival: How to Be Prosperous Without Being Self-Destructive*. Writer's Publishing Cooperative, Warner NH.

O'Brien, M, Hartwig, F, Schanes, K et al. 2014, 'Living within the Safe Operating Space: A Vision for a Resource Efficient Europe', *Eur J Futures Res* **2** (48), pp. 1-11. DOI:10.1007/s40309-014-0048-3.

O'Keeffe, M, Jäger, J, Hartwig, F et al. 2014, 'Report on Global Governance for Resource-Efficient Economies'. P*OLFREE - Policy Options for a Resource Efficient Economy,* Deliverable D2.5, funded by the European Commission. University College London, London. Available from https://www.ukcmb.org/polfree/publications [14 December 2016].

Omann, I and Schwerd, J 2005, 'Die Materialinputsteuer, Ein neues Instrument nachhaltiger Entwicklung. Konzeption, Realisierung, Wirkung', Spangenberg, JH (ed) 2005, *Vision 2020. Arbeit, Umwelt, Gerechtigkeit - Strategien für ein zukunftsfähiges Deutschland*, pp. 203-222. Ökom, Munich.

Proops, J, Steele, P, Ozdemiroglu E and Pearce, D 1994, *The Internalization of Environmental Costs and Resource Values - A Conceptual Study*, UNCTAD/COM/27. United Nations Conference on Trade and Development Geneva. Available from http://unctad.org/en/Docs/pocomd27.en.pdf [20 December 2016].

Sachverständigenrat für Umweltfragen 2012, *Umweltgutachten 2012: Verantwortung in Einer Begrenzten Welt*. Erich Schmidt Verlag, Berlin.

Säll, S and Gren, IM 2012, *Green Consumption Taxes on Meat in Sweden*, Working Paper 10/2012. Swedish University of Agricultural Sciences, Department of Economics, Uppsala. Available from http://pub.epsilon.slu.se/9294/1/sall_s_121214.pdf [17 December 2016].

Stern, N 2006, *The Economics of Climate Change: The Stern Review*. Cambridge University Press, Cambridge.

UNEP 2016, 'Resource Efficiency: Potential and Economic Implications. A report of the International Resource Panel. Ekins, P., Hughes, N. et al. Nairobi, United Nations Environmental Programme. URL: http://www.resourcepanel.org/reports/resource-efficiency [23 May 2017]

Usubiaga, A, Schepelmann, P, Bahn-Walkowiak, B et al. 2011, *EU Subsidies for Polluting and Unsustainable Practices: Study*. European Parliament, Policy Department Economic and Scientific Policy, Brussels. Available from http://www.europarl.europa.eu/RegData/etudes/etudes/join/2011/457359/IPOL-ENVI_ET(2011)457359_EN.pdf [31 December 2016].

Weizsäcker, EU von (ed) 2014, *Ernst Ulrich von Weizsäcker*, SpringerBriefs on Pioneers in Science

and Practice vol. 28. Springer International Publishing, Cham.

Wilts, H, von Gries, N, Bahn-Walkowiak, B. et al. 2015, 'Policy Mixes for Resource Efficiency'. *POLFREE - Policy Options for a Resource efficient Economy,* Deliverable D2.3, funded by the European Commission under Grant 308371. University College London, London. Available from https://www.ukcmb.org/polfree/publications [11 November 2016].

Withana, S, ten Brink, T, Illes, A et al. 2014, *Environmental Tax Reform in Europe: Opportunities for the Future*. Report for The Netherlands Ministry of Infrastructure and the Environment. Institute for European Environmental Policy (IEEP), Brussels. Available from http://www.ieep.eu/assets/1397/ETR_in_Europe_-_Final_report_of_IEEP_study_-_30_May_2014.pdf. [20 December 2016].