

Preface

In the aftermath of the financial crisis, the challenges for international economics have not become less demanding. Financing innovative business ideas and new technologies need to overcome adjusted risk portfolios. While the crisis alleviated temporary concerns about a tight balance between supply and demand for energy and resources and led to a first time reduction in global CO₂ emissions in 2009, rising tides of higher raw material prices are soon to sweep through all economies as they recover from the economic crisis. Indeed, the Eastern Asian economies have recovered early and strongly from the economic crisis. While the recoveries of the European Union and the U.S. have been sluggish, they are emerging from the worst recession since the Great Depression. In the post-crisis era, all countries are going to be increasingly focused on sustainable growth, most notably the emerging economies where people more than ever demand clean air, healthy sanitation systems and affordable mobility.

However, an Asian-led growing demand for natural resources and the related impacts cannot be underestimated. Not many international forecasts exist on future supply and demand of natural resources, however a doubling of demand between 2000 and 2030 is a reasonable estimation (Lutz and Giljum 2009: 38), thus underlining the need to analyze markets in more detail as well as to establish international market intelligence on the issue.

There are many fundamental uncertainties involved in those forecasts for natural resources and materials on the future markets and their impacts. However three latest news illustrate the need for international economics to pay full attention to this issue:

- The UNEP's International Panel for Sustainable Resource Management¹ released its first report on biofuels in late 2009 that states unanimously the severe damages occurring from poor performing first-generation biofuels and calls for more attention to competing land uses between extraction, agriculture and other purposes.

¹<http://www.unep.org/scp/rpanel/>

- The oil disaster in the Gulf of Mexico that occurred in early 2010 will not only have an impact on 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 European Commission (2010) 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 an expert community, the fact that they are essential for steel production and many future technologies make a strong case for economic analysis.

In total, the issue of scarcity that has been looked at as somewhat old-fashioned needs to be reconsidered: it is an essential driver for the green economy and the low-carbon society – and it should become a centerpiece of economic analysis (Bleischwitz et al. 2009). Though obviously many minerals are almost abundantly available, the aforementioned future risks call for more profound economic analysis that is international in scope and aligns innovation with environmental and resource economics – definitely an issue for the Rio+20 conference of the United Nations in 2012.

This is also a strong pledge for international macroeconomics of resource management. The financial crisis has demonstrated the vulnerability of economies resulting from international dependence on weakly coordinated financial institutions; in its aftermath, increasing public debt is likely to stimulate an over-exploitation of natural resources in resource-extracting regions. On the other hand, combating the public debts will require further cuts in expenditures. Here, cutting the costs for importing commodities could become a key strategy in the majority of resource-dependent countries – if strategies of resource efficiency are promoted. Indeed, these two strategies do not match. Hence, analyzing public policies in relation to optimal pathways for both resource-exporting countries and importing regions and industries is of paramount relevance.

The upcoming Rio+20 conference in 2012 – 20 years after the Earth Summit in Rio de Janeiro 1992 – will probably deal with fostering green growth and launch a program on a green economy.² This book seeks to make a contribution to this goal. It addresses the challenge of turning the aforementioned risks into opportunities and forward-looking policies. The chapters included have undergone a rigorous discussion and review process during and after the Second International Wuppertal Colloquium on sustainable growth and resource productivity.³

²<http://www.unep.org/greeneconomy/>

³http://www.wupperinst.org/en/projects/proj/index.html?projekt_id=313&bid=138

The basic message is simple and straightforward: Resource efficiency offers tangible economic benefits. Our understanding of resource efficiency captures all efforts to enhance the sustainability of using resources along their full life cycle from extraction to transformation into materials and production, transportation, consumption on to recycling and disposal. Indeed, this definition underlines all kinds of cost-saving measures that include improving operational efficiency and reducing the use of raw materials and consumables, as well as minimizing water, energy, transportation and waste.⁴ In addition to such evident resource efficiency benefits for business, it seeks to explore different kinds of innovation as well as efforts to internalize negative externalities.

Material Flow Analysis (MFA) was created a few years ago as an attempt to analyze the use of natural resources in societies. It is associated with concepts such as “industrial ecology” and “socio-industrial metabolisms”⁵ – and may not yet have fully explored the economic dimension of material flows. Integrating the stages of production, consumption and recycling, it goes beyond traditional resource economics and offers a comprehensive perspective for resource policy. Since Eurostat and OECD have provided handbooks on the measurement of material flows, and do in fact promote the collection of data and applying concepts, there are many opportunities for international economics and economic policy to integrate MFA in their models and empirical analysis.

A comprehensive perspective for how economies use materials and increase their total resource productivity – a notion that is seen as inclusive and captures indirect flows as well as ‘ecological rucksacks’ (OECD 2008; Bringezu and Bleischwitz 2009) – will however need to look at many barriers and some persisting bottlenecks of transforming currently resource-intensive patterns of production and consumption. It would be naïve to believe in a self-sustaining growth promoted by green technologies alone. Rather, economic analysis reveals that more factors ought to be taken into account, such as

- The structural change from resource-intensive industrial patterns to services as it has occurred in many OECD countries since the 1970s and will soon be on the agenda in most emerging economies
- A structural change within resource-intensive industries establishing new business models on e.g. clean mobility and sustainable construction
- The setting up and maintenance of infrastructures for electricity, heating, mobility, telecommunication, water, and housing
- Accounting for education and knowledge, a factor emphasized by the new growth theory and e.g. UNESCO
- Accounting for negative externalities (such as environmental damages) and for informal activities such as private households’ care systems

⁴A survey of 500 UK businesses shows that almost three-quarters of the respondents had developed a more detailed knowledge on their resource use as a result of the downturn; see: Drury (2010).

⁵See e.g. the web pages of the International Society for Industrial Ecology: <http://www.is4ie.org> and <http://www.materialflows.net> on data.

Thus, it is clear that the program of such international economics of resource efficiency can be labeled as “no green growth without innovation” (Aghion et al. 2009). Referring to insights of Joseph Schumpeter, however, it should also become apparent that mechanisms of “creative destruction” will also be part of such an agenda (i.e., the industrial transformation of currently unsustainable patterns within a timeframe that is sufficient to (a) allow essential ecosystem services to adapt and (b) to develop and to disseminate suitable eco-innovation to replace them).

Not surprisingly, the related debate on growth, well-being and environment as well as on transitions from today’s status to sustainable development has accelerated. Van den Bergh (2010) spotlights a “GDP paradox”, meaning that economists and other researchers feel increasingly uneasy with GDP as a measure of social progress while politicians and many others critiquelessly support it and call for unconditional GDP growth. This conflict will become politically controversial when economic models offer alternative policy packages with implications such as “lower CO₂ emissions, higher resource productivity, higher employment and slightly lower GDP growth compared to business as usual”. Indeed, some relaxation about GDP growth as such and more emphasis on key progress indicators will need to be backed by in-depth economic analysis supplemented with a convincing communication strategy.

Some circles have started to advocate a “De-Growth” – a downscaling of production and consumption – as a response to these challenges (Schneider et al. 2010).⁶ This is in sharp contrast to business consultants advocating the merits of win-win and green market opportunities. Seen from a Schumpeterian and transition management point of view, however, it may be less provocative than it seems at a first glance for a number of reasons. Firstly, a decline of some industries has accompanied the history of market economies since its very beginnings. Secondly, the need for industrial transformation is widely accepted. Thirdly, the weak identity between GDP growth and well-being has become a standard lesson. Fourthly, the opportunities of greening the progress that appear today are just the tip of the iceberg and will become more important when ecosystem services are fully incorporated into business agendas and a future accounting system. Fifthly, international cooperation with emerging economies will probably be easier to strengthen if a new paradigm is closer to a “green economy” than to any “de-growth”.

The scope of this book follows the debate as outlined above. It includes 18 chapters. *Lucas Bretschger* provides an overview of sustainability economics and sheds light on the nexus between resource use and economic performance from both a theoretical and an empirical perspective. Moreover, his chapter addresses a possible “Green New Deal” that would help boost investments in eco-innovation.

The international sustainability discussion has focused greatly on CO₂ emission reductions, but this focus is rather narrow and not really adequate when the long-run sustainability dynamics are to be assessed. The broader role of green innovativeness

⁶See therefore the website of De-Growth: <http://www.degrowth.eu>

has to be considered as well. Aimed for a broader innovation-oriented sustainability, *Welfens, Perret and Erdem* have developed the Global Sustainability Indicator. The new indicator set is in line with OECD recommendations for composite indicators and uses weights from factor analysis. Reflecting environmental pressures, economic performance and capabilities for eco-technologies, the Global Sustainability Indicator shows a compact way of assessing global sustainability. Illustrating the outcomes on a global scale, their chapter also addresses the relevance of policy.

Paul Ekins discusses concepts, policies and the political economy of system innovation for environmental sustainability. His paper reviews a number of theories of technological transition, which make clear that such transitions have complex political, institutional and cultural, in addition to technological and economic, dimensions. This is similarly true for processes of environmental and eco-innovation, the nature of which the chapter explores, together with how they can be measured. His paper supports a strong role in policy and also advocates the role of the law, in a policy mix with the undoubtable success of the economic incentives. The chapter concludes that such policies will need to become much more stringent if eco-innovation is to drive an adequately far-reaching technological transition to resolve pressing environmental challenges. Crucial in the political economy of this change will be that eco-industries, supported by public opinion, are able to counter the resistance of established industries which will lose out from the transition, in a reformed global context where international treaties and co-operation prevent the relocation of environmentally destructive industries and encourage their transformation.

Raimund Bleischwitz and Stefan Brinzeu analyze why concern over natural resources requires a sustainability perspective; they give evidence on some critical metals that are needed for a green economy and the resulting trade-offs. The empirical part of their chapter compares resource productivity performances across countries. Introducing the notion of “material flow innovation”, they discuss the innovation dynamics and issues of competitiveness. In conclusion, they make a case for effective resource policies that should provide incentives for knowledge generation and to get prices right.

Phillip Crowson provides an overview of the economics of current metal markets and gives analytical insights from stock market experience on the issue. He concludes that markets have learned to deal with rapid price increases and scarcities, but some business models need to be reconfigured and policies ought to improve regulation.

Rainer Walz discusses competences for green development and leapfrogging in Newly Industrializing Countries (NICs). His approach underlines necessary absorptive capacities and technological competences in the sustainability technologies. The general framework conditions for innovations are analyzed for various newly industrializing countries using different data sources. International patents and successes in foreign trade indicate to what extent a country is already able to “open up” internationally. The resulting pattern shows various strengths and weaknesses of the analyzed NICs, and seems to support a lead market perspective.

The differences within the countries imply that the analysis must proceed on a technology specific level. Furthermore, there is a strong need for strategic positioning of the countries and for coordination of the various policy fields involved.

ZhongXiang Zhang analyzes trade policy implications of the proposed carbon tariffs in the US as well as China's responses to it. Scrutinizing the emissions allowance requirements proposed in the US congressional climate bills against WTO provisions and case laws, his paper recommends what is to be done on the side of the US to minimize potential conflicts with WTO provisions in designing its border carbon adjustment measures and provides suggestions for China on how to deal with its advantage effectively while being targeted by such proposed measures. Given the fact that, in volume terms, energy-intensive manufacturing in China values 7–8 times that of India, and thus carbon tariffs have a greater impact on China than on India, the chapter questions whether China should hold the same stance on this issue as India as it does now, although the two largest developing countries should continue to take a common position on other key issues in international climate change negotiations.

Dajian Zhu and Yi Wu discuss modernization patterns of the Chinese economy. They argue that the critical issue is whether China can free itself from the traditional modernization model based on the relatively abundant natural capital, and innovatively create a developmental model of a big country under the scarcity of natural capital. This thinking explains why China advocates the circular economy and resource efficiency. They point out the strategic choice for China's future development, emphasizing that China needs to enhance the new industrialization, new urbanization and new modernization and discussing the technological and mechanistic support required to realize development under the scarcity of natural capital.

René Kemp analyzes the innovative Dutch Energy Transition approach, which is characterized by dialogues and cooperation among actors rather than a top-down policy. Explaining how it has worked in the past and what theories support the transition approach, his chapter makes an interim assessment and discusses implications for a policy mix.

Renata Dagiliute addresses physical growth of society and related environmental burden in a country study on Lithuania, a typical transition country. The results show that growing economy, demand of life quality outweighed overall efficiency gains, and have led to an increase in resource consumption. Both material and energy consumption have started to increase after the transitional decline. Nevertheless, since per capita consumption values are still lower than the EU-15 average, there might be a window of opportunity to not follow Western consumption patterns and thereby gain from the efficiency improvements and savings in both material and energy consumption. The chapter suggests that more attention should be paid to driving forces of consumption and production patterns and to the strategies like awareness rising, information, eco-efficient products and services, CSR, modern technologies and others.

Jonas Nässén and John Holmberg analyze the rebound effect. The magnitude of such effects is crucial to whether energy efficiency should be a strategy for environmental policy or not. This chapter aims at deriving a general expression

of the rebound effects of household consumption in a parameterized form where available data can be tested. The chapter analyses how different parameter assumptions affect the quantification of rebound effects and what may be reasonable ranges. Income effects are quantified using data from the Swedish Household Budget Survey of different goods and services split on income classes. The changes in consumption patterns with increasing income are used to establish the composition of marginal consumption. Combined with energy intensities derived from input–output analysis, this gives a model of how money saved on energy use in one sector may lead to increased energy use in other sectors. The total rebound effects of energy efficiency improvements appear to be in the range of 5–15% in most cases. Finally, comments on rebound effects of improved materials efficiency are added.

Ronald Schettkat provides a survey on the rebound effects and concludes that prevailing research does not yet provide clear results. His chapter aims at clarifying the theoretical basis of various analytical approaches which lead to widely different estimates of rebound effects.

Wolfgang Irrek differentiates between direct and indirect rebound effects and discusses its magnitude, which can be influenced by policy makers. As a second step the chapter addresses the more ambitious question as to which conditions may foster absolute decoupling of resource use from economic growth.

In the subsequent part on modeling, *Frank Beckenbach* takes a dynamic system perspective and presents findings from an agent-based, multi-level approach on innovation, growth and mitigating emission impacts. His simulation reveals the time dependency of incentives and the usefulness of target group-specific approaches.

Christian Lutz also presents findings from a modeling exercise. Using the dynamic input-output model GINFORS, the chapter reveals the economic impacts of reducing CO₂ emissions and increasing resource productivity in the EU. His analysis is based on the extensive and disaggregated global GINFORS model that contains 50 countries and two regions and their bilateral trade relations, energy balances, material, macro-economic and structural data. The model is applied in the petrE project to analyze the impacts of major environmental tax reforms (ETR) and the EU ETS to reach the EU GHG reduction targets until 2020. The ETR includes a carbon tax for all non-ETS sectors and a material tax. Scenarios look at unilateral EU action and at international cooperation by all OECD countries and the major emerging economies. The results show a positive impact on emissions and employment, though a slightly lower GDP growth compared to business as usual scenarios. The results clearly demonstrate that only global action with substantial carbon prices may lead to an emission path still in line with the 2° target. But even if a far-reaching global climate agreement is reached later in 2010, global resource extraction will continue to increase without additional international measures.

Holger Rohn, Michael Lettenmeier and Nico Pastewski approach the tapping of potentials for an increase in resource efficiency and their evaluation. A summary of existing knowledge on resource efficiency is given. The chapter presents the state of work and the interim results as it has been done within the Germany-based

project “Material Efficiency and Resource Conservation” in 2009. The purpose of this step was to identify innovative lead products, lead technologies and lead markets increasing resource efficiency. The concluding section outlines the next step, in which approximately 20 selected lead technologies, products and strategies will be evaluated in depth.

Christian Ott, Andreas Windsperger, Brigitte Windsperger and Marcus Hummel take a look at the Austrian pulp and paper industry as well as the wood processing industry, which are actually two major platforms in the use of biomass in this economy. The aim is to develop an object oriented functional model of the integrated production system of wood processing and paper production to analyze the recent situation and the effect of different technology improvement scenarios and structural changes on the economic and ecological performance. Parameters like comprehensive key data for evaluating the overall performance are suggested. Target figures within that goal are resource and energy efficiency, ecological characteristics, and the value of the single process chains concerning technical innovation, changed framework requirements and structural changes. Problematic issues for the results like carbon intensity of products, export and import of products and intermediates etc. are addressed and discussed. In a concluding section, guidelines and recommendations for future development in technological and organizational respect are derived.

Christian Hagelücken analyses special and precious metals that are key ingredients for high tech applications like information technology, electronics, or car-catalysts, and emerging clean technologies. With a relatively recent use in mass applications, 80% or more of the cumulative mine production for e.g. the Platinum Group Metals (PGM), gallium, or indium took place just in the last 30 years. A future sufficient access to these “technology metals” is essential. Their primary production is often coupled with base metals and concentrated in few mining regions of the world, causing a complex demand-supply balance and high price volatility. Hence it is necessary to secure their resource efficient use along the lifecycle and to establish effective recycling systems to “close the loop”, preserving limited resources. Appropriate management at the product’s end-of-life however is characterized as challenging. Most consumer products are characterized by an “open cycle” with non-transparent global flows and multiple owners along the lifecycle, a complex material composition, and demanding collection and recycling chains. The chapter elaborates the system interdependencies and potential ways of improvement. It demonstrates that in many cases effective recycling technologies exist – however the majority of consumer products do not enter in such recycling chains so far and, hence, policies are needed to establish recycling for consumer products at an international scale.

Tomoo Machiba introduces the OECD’s work on green growth and the underlying analytical approach. His chapter also discusses new policy at crossroads after the financial crisis.

From the analysis of the underlying issues in the book, it is clear that Resource Economics, International Economics and Policy Analysis should be linked more closely in the future. For a future research agenda empirical findings should be

included on green innovativeness as well as on the progress in the field of resource efficiency. There is also great need to get more empirical studies on the issue of external effects of production, consumption and waste disposal. Moreover, sustainability research as well as transition management (Grin et al. 2010) will have to develop new visions ranging in scope from product design to new models of wealth for different societies, to develop tools for assessing experiments with suitable strategies as well as to give scientific advice to learning processes and institutional change at international levels. In that regard, we are entering a fascinating new field.

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