

This PDF is governed by copyright law, which prohibits unauthorised copying, distribution, public display, public performance, and preparation of derivative works.

TITLE

Introduction

AUTHOR(S)

Raimund Bleischwitz, Paul J.J. Welfens and
ZhongXiang Zhang

AVAILABLE IN

*Sustainable Growth and Resource Productivity
Economic and Global Policy Issues* (ed. Bleischwitz,
Welfens and Zhang)

FORMAT(S) Hardback

DATE PUBLISHED September 2009

ISBN 978-1-906093-28-0

MORE DETAILS www.greenleaf-publishing.com/growth

© 2009 Greenleaf Publishing Limited

SUSTAINABILITY • RESPONSIBILITY • ACCOUNTABILITY

Aizlewood's Mill, Nursery Street, Sheffield S3 8GG, UK Tel: +44 (0)114 282 3475 Fax: +44 (0)114 282 3476
info@greenleaf-publishing.com www.greenleaf-publishing.com



Introduction

Raimund Bleischwitz, Paul J.J. Welfens and ZhongXiang Zhang

Natural resources are indispensable for production, consumption and wealth accumulation. From an economic perspective, a crucial distinction concerns renewable versus non-renewable resources. For non-renewable resources the Hotelling rule lets us expect a sustaining rise of the relative price over time, although non-renewables and renewables are to some extent substitutes and the degree of substitutability could change over time, namely in the context of new directions of technological progress. Thus, there is considerable interest not only in demand conditions and supply-side developments but in innovations as well.

For many natural resources, there are a rather limited number of supplier countries, while demand is broadly distributed across countries in the world economy. This raises the problem of strategic natural resources as perceived from the perspective of importing countries. Yet governments and resource stocking agencies narrowly monitor resources that are crucial for economic or military purposes, respectively.

Inventories are naturally large in periods when actors anticipate rising relative prices and when interest rates are low. The beginning of the 21st century can be considered such a period. More than seven years of soaring prices for natural resources between 2000 and 2008 have recalled the economic importance of natural resources for development and sustainable growth.

Taken together, these dynamics raise topics and issues, which are of both specific interest and general relevance. As a mirror phenomenon, the rapid decline of some natural resource prices is also an important analytical challenge and the considerable long-term volatility of relative prices implies both risks for investors in the natural resources sector and problems for a consistent, long-term environmental policy designed to increase resource productivity.

Surely, Robert Solow's essay 'The Economics of Resources or the Resources of Economics' (Solow 1974), published 35 years ago is, by any standard, a seminal contribution to the issue.¹ This essay has done a masterful job of explaining some of the basic principles behind economic growth: the adequate supply of natural resources, the Hotelling rule for efficient extraction of a non-renewable resource, the importance of a proper social discount rate for balancing the present and future, and the possibility of substituting single resources.

Seen from today's perspective, the essay also raises fundamental issues of technological progress and long-term prosperity where the challenges for frontier research in economics have not become smaller. To address but a few of these challenges:

- The availability of natural resources is less of a problem than the limited abilities of ecosystems to absorb the different outputs of economic activities. Climate change, characterised as the greatest market failure in history by Nicholas Stern (2008), is perhaps the most prominent example of those new scarcities. Climate change is caused by many man-made activities, in particular by the use of fossil fuels, deforestation and agriculture
- Using natural resources can thus hardly be separated from environmental pressure. A recent OECD (2008) handbook gives guidance on how the so-called material flow analysis can be used to account for environmental pressure, at least on an aggregated level. It suggests that economics need to take a closer look at the prevailing analytical dichotomy between resources as private commodities and environmental impacts as typical negative externality: the emerging sub-discipline of material flows economics will have to study the environmental dimension of resources in a comprehensive manner. The recently established UNEP panel for sustainable resource management is an important step in this direction
- Traditional and new growth theories have analysed technological progress in its relation to labour productivity and human capital. Less attention has been paid to natural resources and technological progress. For sure, the resource-rich countries have been analysed as being either privileged by these endowments or trapped in a 'resource curse' (Sachs and Warner 2001). But the point stands, that a deeper understanding of how important resources are for long-term prosperity and how innovation and technological progress can be triggered by using resources more efficiently are still lacking

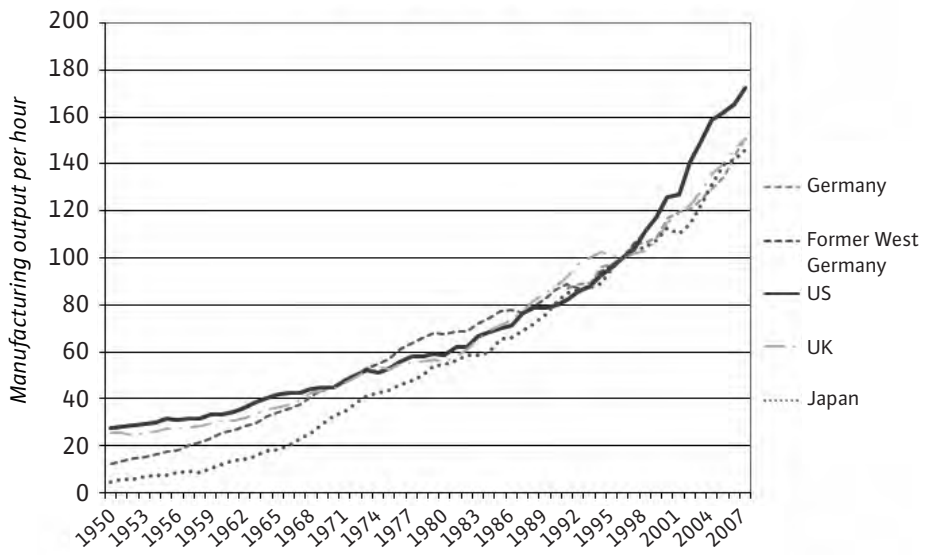
1 See also the reflections on his paper in the newly established *Journal of Natural Resources Policy Research* (Solow 2009).

The economics of resource productivity is a key topic of this book. When we use this term we refer to the relation between economic outputs in monetary terms (Y , numerator) and a physical indicator (M , denominator) for material or resource input. Our notion of resource productivity thus is much broader than a short look at raw material prices or measurement methodologies reveals. For all manufacturing industries, the characteristics of materials as well as the potential quality improvements for products and services matter. Emerging economies have a quest for natural resources to meet their rapidly increasing demand for energy, construction, mobility and food.

A guiding question for economics can be formulated as follows: Can companies and industries spur their competitiveness, and can countries as a whole enhance their prosperity through improving material efficiency and through developing new products and services that lower the overall resource intensity? From such a perspective, resource productivity might become as important for progress and growth as labour productivity. Looking at the increase of labour productivity since 1950—with Japan realising a factor of 40 productivity increase (Fig. 1)—suggests a huge potential for increase in resource productivity.

FIGURE 1 Labour productivity increase of selected OECD countries 1950–2007 (index figures, 1996 = 100)

Source: Own calculations based on US-BLS data



Economics thus will have to shed light on how materials are used in general and how they can be used in a more sustainable manner in particular. This is far from being an easy task. It requires a comprehensive methodology in both

physical and monetary units, which covers the whole life-cycle of materials from extraction through the different stages of production and consumption on to recycling and waste treatment. To that end, a theoretical underpinning on the function of materials for development and well-being is required, backed by empirical analyses and modelling for different economies and industries over time.

This book makes an attempt to fill this research agenda. All the chapters stem from the selected presentations at an international colloquium on ‘Sustainable Growth, Resource Productivity and Sustainable Industrial Policy: Recent Findings, New Approaches for Strategies and Policies’, held from 17 to 19 September 2008 at the University of Wuppertal, Germany. It is the first in a series and accompanies a large research project on ‘Material Efficiency and Conservation of Resources’ coordinated by the Wuppertal Institute with some 30 partners on behalf of the German Federal Ministry for the Environment.

Part I: Raw materials supply and resource use from a global perspective

The first part of this book analyses raw materials supply and resource use from a global perspective. The contributions look at the availability of resources and general drivers such as limited supply, demand from emerging and other economies and the criticality of some materials. The latter is important because a general availability of mass materials such as iron or aluminium does not exclude a critical situation for some metals, which may be necessary as input in high-tech processes and may put certain industries at risk. Moreover, this part addresses the role of plentiful mineral endowments for development. The global perspective is enriched by a new approach that analyses the physical dimension of trade.

Chapter 1 by **Magnus Ericsson** from the Raw Materials Group, Stockholm addresses the question of whether the mining industry will be able to meet the global need for metals. It points to one main challenge: to deliver sufficient volumes of metals and minerals at prices that do not fuel inflation or encourage substitution while ploughing back a reasonable share of profits into local and national host economies. It proposes that only large companies have the necessary financial capabilities to develop new, low-grade, but giant deposits far from markets and existing infrastructure. Such companies are likely to survive the next downturn in the markets. Larger companies are also necessary to fund and pursue increasing volumes of R&D including expanded exploration. Skyrocketing energy, water and environmental costs must be addressed and more

innovative ways of operating must be introduced. On the other hand, proper checks and balances must be in place to ensure that monopolistic powers are not created. It concludes that, whatever the size of a mining company, key concepts such as accountability, governance and transparency must become top priority for all participants.

Christian Lutz and **Stefan Giljum** from the modelling group GWS at Osnabrück, Germany, present an outlook for global resource use in a business-as-usual world in Chapter 2. The chapter contains the updated results from the GINFORS (Global Interindustry Forecasting System) model and analyses the development of global material extraction in a business-as-usual environment until 2030. The analysis is based on the extensive and disaggregated global GINFORS model that explicitly contains 50 countries and two regions and their bilateral trade relations, energy balances, macroeconomic and structural data. Material inputs models are based on a global material extraction dataset. GINFORS is closed on the global level. Preliminary results show for the business-as-usual scenario a strong increase in global material extraction over the next two decades. The bulk of this increase will take place outside the EU and OECD. An increase in global population and high economic growth rates will strongly raise material consumption and necessary extraction, if the world does not run into supply constraints and historic patterns are not changed.

In Chapter 3, **Thorvaldur Gylfason** from the University of Iceland undertakes an analysis on development and growth in mineral-rich countries. His chapter describes some of the ways in which mineral rents and their management influence economic growth and other determinants of growth as well as some of the reasons why many mineral-rich countries have not managed very well to divert their resource rents to furthering economic and social development; that is, why natural capital tends to crowd out human, social, financial and real capital. The empirical evidence of these linkages is presented in two rounds. First, he allows the World Bank data covering 164 countries in 1960–2000 to speak for themselves through a sequence of bilateral correlations that suggest an inverse relationship between natural resource dependence and growth via human capital. He then repeats the exercise for two aspects of social capital, corruption and democracy, suggesting an additional adverse effect of natural resource dependence via social capital on growth. In the second round, he tests for the robustness of natural resource dependence as a determinant of long-run growth by estimating a series of growth regressions for the same 164 countries.

Monika Dittrich from the University of Cologne and Wuppertal Institute, Germany, presents a complementary chapter for Part I. In Chapter 4, she undertakes an in-depth analysis of the physical dimension of international trade between 1962 and 2005. Since it is common to describe trade in monetary terms, her approach can be considered a new contribution to international

economics. Considering, for example, that the trading volume increased from around US\$580 billion in 1970 up to US\$20,000 billion in 2005, research still has not shown anything about the physical dimension of trade—an issue that has been raised by ecological economists or the new geography of trade. This issue can be claimed as important for the following reasons: First, the physical dimension directly points at those countries that are important for supply and demand of raw materials in the world market. Second, the analysis allows quantifying in detail the resource flows between different country groups. Including the so-called ‘ecological rucksacks’ (physically moved but unused materials), the physical dimension of trade gives a general indication of the appropriation of the environment caused by the production of traded commodities. Third, the physical dimension of trade is needed to estimate the resource consumption of single countries. Without neglecting, however, the need for theorising the nexus between trade, resources and the environment, the chapter focuses on empirical realities based on UN Comtrade data.

In Chapter 5, **Thomas Graedel** from Yale University adds to the preceding chapters with an analysis aiming to define critical materials. Starting from the observation that modern technology could not exist without non-renewable resources, it states that the availability of these resources has seldom been a matter of much concern. Indeed, product designers have never been taught to regard materials as anything but commodities to be employed as necessary or convenient. The result is nuclear reactors dependent on the availability of zirconium, catalytic converters dependent on the availability of rhodium, hybrid vehicle batteries dependent on the availability of lanthanum, cellular telephones dependent on the availability of tantalum, and a vast panoply of products with similar needs for very specific resources. The chapter carries out a rigorous analysis and concludes by defining critical materials.

© Copyrighted material. Unauthorised copying or distribution is an offence.

Part II: The economics of resources and sustainable growth

Following these findings, which put resources at the heart of economic analysis, the second part of the book addresses the economics of resources and sustainable growth.

The price dynamics of oil and other non-renewables is a complex field of theoretical and empirical analysis. In Chapter 6, **Paul J.J. Welfens** from the European Institute for International Economic Relations (EIIW) at the University of Wuppertal takes the Hotelling rule as an analytical point of departure—basically relevant for the supply-side dynamics—and also considers resources demand,

which is assumed to depend negatively on the price of oil and positively on net real wealth of the private sector (wealth and real income are, of course, related to each other through the interest rate). The net wealth variable is of particular interest in the approach presented, which emphasises that pricing of non-renewable resources should be considered in the context of portfolio analysis and the role of wealth, respectively. The fairly standard assumption, that the change in the price of natural resources per unit of time is a positive function of the excess demand in the oil market, implies a differential equation, which shows how crucial the role of oil inflation expectations are. If those expectations are below a critical level, there will be stable long-run oil price. If, however, the expected oil inflation rate exceeds the critical value, there will be an ongoing increase of the oil price. From this perspective, it is clear that the long-run price developments of natural (non-renewable) resources are strongly shaped by global expectation dynamics. To the extent that global real demand shocks or restrictive shifts in monetary or credit expansion dynamics occur, oil inflation expectations could switch from a range above the critical inflation expectations to below such a range, which then amounts to a price regime shift. Such a shift obviously has occurred during the transatlantic banking crisis and the following global recession. A somewhat alternative short-term analytical approach considers oil pricing in the context of a broader portfolio model; thus, oil and several standard financial assets are considered (oil could indeed be proxied by stocks of the oil-producing sector while one also considers domestic bonds and money—possibly also non-oil stocks). The chapter concludes that portfolio modelling is appropriate for highlighting short-term dynamics in the non-renewables sector while long-term, supply-side dynamics—this includes Schumpeterian innovation impulses—and the demand side must be considered for understanding medium-term and long-run price dynamics. Policy-makers should consider both volatility issues and the challenges of sustainable growth.

Natalia Merkina from the University of Oslo, Norway, studies the contribution of capital deepening, technological progress and efficiency improvement to economic growth while focusing on cross-country data, and thus finds herself at the crossroads of growth and development accounting. In Chapter 7, she takes a production frontier approach to growth accounting and chooses DEA (data envelopment analysis) as the frontier estimation method. To explore the effects that windfall gains from natural resource use have on growth, output data are corrected for pure natural resource rents: that part of GDP figures not earned by either labour or capital. Taking into account countries' natural resources, she finds that, in the two decades from 1970 to 1990, the average contribution of technological catch-up to per worker output growth was, if anything, negative on the worldwide scale and this trend continued till the mid-1990s. Analysis of efficiency estimates also shows a possible change over the period 1970–1990 in the effect of natural resources on a country's performance.

Erich Hoedl, former Rector at the University of Wuppertal, Germany, and now at the European Academy of Science and Arts, takes a closer look at productivity analysis. In Chapter 8, which is part of a larger study on European sustainability, he discusses the implications of a one-sided augmentation of labour productivity on capital and resource productivities. In contrast, he argues that a stronger augmentation of capital productivity than labour productivity will increase both social and economic sustainability. Natural resources are considered as part of capital inputs and consequently higher resource productivity is identified as a key variable not only for ecological sustainability. It is shown that augmenting resource productivity has simultaneously a considerable positive effect on all three dimensions of sustainability. This chapter, thus, may bridge the gap between productivity analysis and capital theory, on the one hand, and current approaches of measuring material flows (OECD 2008) and wealth accounting (Hamilton and Ruta 2009), on the other. It is interesting to note that the latter now conclude that the signs of genuine savings have become negative in many resource-extracting countries—a clear pledge for proper and in-depth accounting of capital and assets in societies.

If material purchasing costs are relevant and may account for some 40% of overall production costs, **Mario Schmidt** from Pforzheim Applied University, Germany, poses the question: why do companies ignore economic efficiency potentials? In Chapter 9, he analyses real behaviour of firms and the upward trend of material costs in previous years, and compares these findings with standard theories. Given the various barriers, the chapter concludes with the need for more public efficiency awareness focusing on materials and resources.

Part III: Empirical analysis of resource productivity: trends and drivers

Is there an overall trend towards decoupling resource use from economic growth? In Chapter 10, **Sören Steger** and **Raimund Bleischwitz** from the Wuppertal Institute, Germany, analyse the processes of any such decoupling in the EU-27 and its member states as well as Turkey, USA and Japan from 1980 to 2004. The chapter also seeks to test the hypothesis that resource productivity leads to an enhancement of competitiveness through lowering material purchasing costs and through developing new products and services that lower the overall resource intensity. Their empirical analysis reveals that rates of resource productivity increase (2.5% per year for EU-25 and 2.9% per year for EU-15) have fallen behind the aims of the EU's resource strategy. Thus, the EU is only partly on track. Taking the best performing countries as a benchmark,

the ability to improve resource productivity can be estimated in the range of a factor 2–4. In that regard, the data suggest that the current minimum frontier of resource requirements for the best-performing industrialised countries is in the order of 12 t per capita (DMI/DMC [direct material input/domestic material consumption]). The analysis furthermore demonstrates that, in general, there is a positive relation between competitiveness of economies and their resource productivity. More research, however, is required to obtain better insight into drivers for resource productivity and innovation systems.

In a historical analysis in Chapter 11, **Jan Kunnas** from the European University Institute Florence, Italy, and **Timo Myllyntaus** from the University of Turku, Finland, seek to explain the decline of sulphur dioxide emissions in Finland since 1950. The focused approach together with a combination of a historical and economic perspective is used to cut deeper into the controversial environmental ‘Kuznets curve’ hypothesis. They found the main reasons for a downturn in sulphur emissions to be technological development as well as anxiety about possible environmental damage and economic costs related to that. The role of economic growth in creating the downturn was noted to be small or non-existent. The claim is made that the causal connection is straightforward: proper environmental standards and conservation constitute a necessary condition for economic growth in the long run.

Eleni Papathanasopoulou, Sustainable Solutions Greece, formerly at Surrey University, Guildford, UK, looks at ‘Greece’s fossil fuel use in 2006: a production, consumption and supply-chain analysis’. Her chapter rests on input–output analysis and analyses three different perspectives for identification of the industries to target: a production, consumption and a supply-chain perspective. From the production perspective, the two main industries, which consume fossil fuels directly, were seen to be the electricity/gas producing industry (12 Mtoe, million tonnes of oil equivalent) and the transportation industry (8 Mtoe). However, from the consumption perspective (i.e. the production of goods for final demand) the priority target group changed to include food manufacturing (2.2 Mtoe), transportation (2 Mtoe) and the hotels and restaurants sector (1.9 Mtoe). The consumption perspective thus highlights the need to consider the indirect fossil fuel demand of industries when reducing resource demand. The supply-chain analysis carried out for the food production category provided a third set of priority sectors, which would need to be targeted to effectively reduce the fossil fuels attributable to final food products. These were: the agricultural sector (0.8 Mtoe), the electricity/gas producing sector (0.78 Mtoe) and the direct use of fossil fuel by the food manufacturing industry itself (0.24 Mtoe). These findings acknowledge that targeting industries and final products to reduce resource demand is complex. It is concluded from the research that a mix of policies is required in Greece in order to be effective. However, imposing

policies to reduce resource use is not enough. These need to be adequately supported by investments in infrastructure and emerging sectors which will ensure a smoother structural transition to a low-fossil-fuel-dependent Greek economy.

Part IV: Global policy issues

Given these barriers and weaknesses, the policy dimension to sustainable growth and resource productivity is a rich avenue for further studies. The last part of this book looks at the emerging economies and their role in any global governance of natural resources. In Chapter 13, **Jennifer Li** from the Foundation for Environmental Security and Sustainability, Washington, DC, undertakes a critical examination of China and India's resource needs and related impacts on Africa. Along with sustained economic growth, these two economies have continued to witness rapid rises in their energy and resource demands. China will be the world's largest primary energy consumer by 2010, and together China and India will consume 30% of global primary energy demand by 2030. There is a great need for a deeper understanding not only of energy security policy but also of the implications of China and India's rising global procurement of resources and trading of commodities and services for the long-term development of poor countries in Africa, for example. Such an investigation is particularly critical in light of the scale of resource investments (including the special economic zones) that China and India are making in these countries. The development of the manufacturing sector in Africa, for instance, is likely to face more obstacles as a result of the growing exposure of Africa to imports and investments particularly from China.

While this is an issue of international relations, domestic policy issues are of global policy relevance, too. In Chapter 14, **ZhongXiang Zhang** from the East-West Centre, Honolulu, HI, analyses Asian energy and environmental policy. The region is facing a dilemma. On the one hand, continued economic growth is needed to alleviate the poverty of the two-thirds of the world's poor living in this region. On the other hand, this economic growth will further place tremendous strains on the natural environment. This chapter examines a variety of policy responses at national, regional and international levels to deal with growing concerns about the environmental challenges in Asia in order to help to put the region on a more sustainable development path. In the context of national responses, special attention is paid to the following issues: coordination between the central and local governments; market-based environmental instruments and industrial policies; tougher emissions standards for mobile and stationary sources as well as for fuel quality; policies to promote energy efficiency as well

as the use of clean energy and biofuels; the integration of environmental policies with economic and sectoral policies; and engagement of the private sector through, for example, eco-labelling, green government procurement, corporate ratings and disclosure programmes, and gaining the support of financial institutions to promote improved corporate environmental performance. The chapter concludes that having the right policy mix, coupled with strengthened cooperation at national, local and regional levels, will ensure continuing economic growth in the region without compromising its limited ecological carrying capacity and environmental quality.

Paul Ekins from Kings College London reflects on the political economy of sustainable growth by analysing prevailing concepts of management. Stating that human use of the environment and its resources is currently unsustainable, Chapter 15 underlines the requirement for substantial dematerialisation of the economy. A number of policy concepts and principles, such as the waste hierarchy, producer responsibility and integrated product policy, have been introduced to try to stimulate more efficient use of resources, often combined in increasingly complicated packages under such headings as ‘sustainable consumption and production’. However, there is no evidence that these policies are having a substantial and sustained impact on material flows, perhaps because they have not yet had a significant impact on the relative price of materials. One reason for this may be fears about the effect of more stringent policies on economic growth. Economics of dematerialisation, thus, should go beyond the win–win rhetoric and look at a long-term dynamic change.

The international colloquium on sustainable growth is part of the Wuppertal Institute’s (WI) international activities; joint organisation with the European Institute for International Economic Relations (EIIW) at the University of Wuppertal facilitated the logistical and intellectual aspects of this event. For effective and efficient support of this international venture we are particularly grateful to Deniz Erdem (EIIW) and Piet Hausberg (WI).

While the first international colloquium was designated to assemble the state of the art on the subject, the subsequent colloquia in September 2009 and in 2010 will focus on discussion of the technological potentials and business opportunities as well as options for a sustainable industrial policy. Attracting young researchers is part of the strategic effort to enhance capacities in that fascinating field. The international financial market crisis has shown that sustainable development—requiring long-term decision-making—has become undermined by short-termism and inefficiencies in global capital markets. Thus, there is no doubt that sustainable development might raise even more complex challenges at the beginning of the 21st century than at the end of the previous century.

References

- Hamilton, K., and G. Ruta (2009) 'Wealth Accounting, Exhaustible Resources and Social Welfare', *Environmental and Resource Economics* 42: 53-64.
- OECD (Organisation for Economic Cooperation and Development) (2008) *Measuring Material Flows and Resource Productivity: The OECD Guide, Volume I-III + Synthesis Report* (Paris: OECD).
- Sachs, J.D., and A.M. Warner (2001) 'The Curse of Natural Resources', *European Economic Review* 45.4-6: 827-38.
- Solow, R.M. (1974) 'The Economics of Resources or the Resources of Economics', *American Economic Review, Papers and Proceedings* 64: 1-14.
- (2009) *Journal of Natural Resources Policy Research* 1.1 (special issue on 'The Economics of Resources or the Resources of Economics').
- Stern, N. (2008) 'The Economics of Climate Change', *American Economic Review* 98.2: 1-37.

