Chapter 2
Global Economic Sustainability Indicator: Analysis and Policy Options for the Copenhagen Process

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2.1 Introduction

In the post-Kyoto process, it will be very important to face the global climate challenge on a broad scale: simply focusing on the OECD countries would not only imply the restriction of attention to a group of countries, which around 2010 will be responsible for less than 50% of global greenhouse gas emissions; it would also mean to ignore the enormous economic and political potential which could be mobilized within a more global cooperation framework. The Copenhagen Summit 2009 will effectively set a new agenda for long-term climate policy, where many observers expect commitments to not only come from EU countries, Australia, Japan and Russia, but also from the USA and big countries with modest per capita income, such as China and India. The ambitious goals envisaged for long-term reduction of greenhouse gases will require new efforts in many fields, including innovation policy and energy policy. If one is to achieve these goals, major energy producers such as the USA, Russia, Indonesia and the traditional OPEC countries should be part of broader cooperation efforts, which could focus on sustainability issues within a rather general framework:

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- Sustainable development, in the sense that the national and global resource efficiency strongly increases over time, so that future generations have equal opportunities, as present generations, in striving for a high living standard.
- Sustainable investment dynamics in the sense that investment in the energy sector should be long term – given the nature of the complex extraction and production process in the oil and gas sector and in the renewable sector as well (not to mention atomic energy, where nuclear waste stands for very long-term challenges); investment dynamics will be rather smooth when both major supply-side disruptions and sharp price shocks can be avoided. The current high volatility of oil prices and gas prices – with both prices linked to each other through some doubtful formula and international agreements – is largely due to instabilities in financial markets: Portfolio investors consider investment in oil and gas – in the respective part of the real sector in some cases, in many cases, simply into the relevant financial assets – as one element of a broader portfolio decision process, which puts the focus on a wide range of assets, including natural resources.
- Sustainable financial market development: If one could not achieve more long-term decision horizons in the banking sector and the financial sector, respectively, it would be quite difficult to achieve rather stable long-term growth (minor cyclical changes are, of course, no problem for the development of the energy sector). With more and more countries facing negative spillovers from the US banking crisis, more and more countries will become more interested in more stability in global financial markets. At the same time, one may not omit the fact that emission certificate trading systems established in the EU have created a new financial market niche of their own. With more countries joining international Emission Trading Schemes (ETS approaches), the potential role of financial markets for the world's efforts in coping with climate policy challenges will become more important over time. It may also be noted that stable financial markets are required for financing investment and innovation in the energy sector. From this perspective, overcoming the international banking crisis is of paramount importance, however, the progress achieved within the G20 framework is rather modest – not the least because there is still weak regulation for big banks (for which, the problem of too big to fail is relevant) and because more competition, as well as better risk management, has been hardly achieved in 2009; transparency is still lacking, not the least because the IMF has not yet published the Financial Sector Assessment Program for the USA, which is now overdue for many years. Without more stability in financial markets and banks, there is considerable risk that the creation of new financial instruments associated with emission trading will simply amount to creating a new field of doubtful speculation activities with massive negative international external effects.

Sustainability so far has not been a major element of economic policy in most OECD countries and in major oil exporters and gas exporters, although sustainability policy may be considered to be a key element of long-term economic and ecological modernization; sustainability implies a long-term perspective and such a perspective is typical of the oil and gas industry. The use of fossil fuels, in turn, is of key importance for climate change and sustainable development, respectively – and the use of such primary energy sources in turn causes CO_2 emissions. In contrast to general discussions in the international community, which typically puts the focus on CO_2 emissions per unit of GDP (or per capita), it is adequate to consider CO_2 emissions per unit of GDP at purchasing power parities (PPP); otherwise, there would be a crucial bias in the comparison of CO_2 emission intensities. The PPP figures look quite different from the emission intensities based on nominal $ GDP per capita data; e.g., China's performance on a PPP basis is not much worse than that of Poland.

Greenhouse gas emissions, toxic discharges in industrial production and deforestation are among the key aspects of global environmental problems. Long-term economic growth in the world economy will intensify certain problems; at the same time, growth is coupled with technological progress, which in turn could allow for a decoupling of economic growth and emissions. It is not clear to which extent countries and companies contribute to solving environmental problems, although some countries – e.g., Germany, Switzerland and Austria – claim that exports in environmental products strongly contribute to overall exports and also to the creation of new jobs (Sprenger 1999).

While certain fields of environmental problems have seen some improvement over the past decades – e.g., the quality of water in many rivers within Europe improved in the last quarter of the twentieth century – other challenges have not really found a convincing solution. In the EU, the European Environmental Agency (2008) reports on various fields of economic improvement. The BP report (2009) also presents progress in a specific field, namely the reduction of CO_2 emission per capita in OECD countries. The global picture is different, however. Greenhouse gases have increased over time, and while emission trading in the EU has made considerable progress, the global dynamics of CO_2 and other greenhouse gases have been strong.

While global political interest in sustainability issues has increased over time, the recent transatlantic financial market crisis has undermined the focus on sustainable development. It is also fairly obvious that financial markets shaped by relatively short-term decision horizons – and short-term oriented bonus schemes – are undermining the broader topic of sustainability. It is difficult to embark on more long-term sustainable strategies in companies and households, if both banks and fund managers mainly emphasize short- and medium-term strategies.

For the first time, energy consumption and greenhouse gas emissions were larger outside the OECD than in the OECD countries in 2008. This partly reflects the dynamics of successful economic globalization, namely that countries such as China, India, Indonesia, Brazil, etc. have achieved high, long term growth, which goes along with rising emissions. Economic globalization has several other aspects, including:

- Enhanced locational competition which reinforces the interest in foreign direct investment and multinational companies.
- Higher global economic growth (disregarding here the serious short-term adverse effects of the transatlantic financial crisis and the world recession) which correspond with stronger competition and a broader international division

of labor on the one hand, and with potentially fast rising emissions and growing trade in toxic waste on the other.
- Fast growth of transportation services and hence of transportation related emissions which particularly could add to higher CO_2 emissions.

From a policy perspective, it is useful to have a comprehensive assessment of the pressure on the environment. Several indicators have been developed in the literature, which give a broader picture of the environmental situation. The EU has emphasized the need to look not only at GDP but at broader measures for measuring progress (European Commission 2009).

Most sustainability indicators are mainly quantitative (e.g., material flow analysis, MFA) which to some extent is useful for assessing the ecological burden of the production of certain goods and activities. Total Material Requirement is an interesting indicator when it comes to measuring resource productivity since it considers all materials used for a certain product, including indirect material input requirements associated with intermediate imports. A very broad indicator concept – with dozens of sub-indicators – has been developed by researchers at Yale University and Columbia University (Yale/Columbia 2005) which derive very complex indicators for which equal weights are used. Very complex indicators are, however, rather doubtful in terms of consistency and the message for the general public, industry and policymakers is often also opaque. Thus one may raise the question whether a new indicator concept – following the requirements of the OECD (2008) manual and taking into account key economic aspects of green innovation dynamics – can be developed. Before presenting such a new approach a few general remarks about the System of National Accounts are useful to make clear the analytical line of reasoning developed subsequently.

The most common indicator used to assess both economic performance and economic well-being is gross domestic product (GDP: in line with the UN Systems of National Accounts), which indicates the sum of all newly produced goods and services in a given year. If one wants to consider long term economic development perspectives one would not consider gross domestic product, rather one has to consider Net Domestic Product (Y') which is GDP minus capital depreciations. Taking into account capital depreciations is important since an economy can maintain its production potential only if the stock of input factors – capital K, labor L and technology A – are maintained; ultimately one is only interested in per capita consumption C/L which is the difference of per capita production ($y = :Y/L$) and the sum of private gross investment per capita (I/L) and government consumption per capita (G/L). However, in reality natural resources R – consisting of renewable and non-renewables – also are input factors in production. Therefore, "Green Net Domestic Product" may be defined here as net national product minus depreciations on natural resources. To indeed consider such a GNDP is important for many countries which are used to heavily exploiting their respective natural resources. Exploiting nonrenewable resources comes at considerable costs for long term economic development since running down the stock of non-renewables implies that future production will decline at some point of time t.

The World Bank has highlighted the role of depreciations on natural resources, namely by calculating genuine savings ratios S'/Y where S' is standard savings S minus depreciations on capital minus depreciations on natural resources (and also minus expenditures on education which are required expenditures for maintaining the stock of human capital; and minus some other elements which are detrimental to sustained economic development – see the subsequent discussion). One should note that there is some positive correlation between gross domestic product per capita and subjective well-being as is shown in recent analysis (Stevenson and Wolfers 2008). Policymakers thus have a strong tendency to emphasize that rising GDP per capita is an important goal. At the same time, it is fairly obvious that the general public is not aware of the difference between Gross Domestic Product and Net Domestic Product (NDP) – let alone the significance of NDP and Green Net Domestic Product (Sustainable Product). The problem is that the UN has not adopted any major modernization of its System of National Accounts in the past decades although there have been broad international discussions about the greening of national accounts (see e.g. Bartelmus 2001). The UN has developed an approach labeled System of Integrated Economic Environmental Accounts (SEEA) which, however, has not replaced the standard Systems of National Accounts. SEEA basically considers depreciations on natural capital, but the system is rather incomplete as appreciations of natural resources are not taken into account – e.g. the SEEA does not adequately consider improvements of the quality of natural resources (e.g., water quality of rivers which has improved in many EU countries over time). An interesting indicator to measure the quality of life is the UN Human Development Index which aggregates per capita income, education and life expectancy. Life expectancy is related to many factors where one may argue that the quality of life is one of them. Another indicator is the Index of Sustainable Economic Welfare (ISEW), based on John Cobb [COBB (1989)], who basically has argued that welfare should be measured on the basis of per capita consumption, value-added in the self-service economy (not covered by the System of National Accounts) and consumer durables, but expenditures which are necessary to maintain production should be deducted (e.g., expenditures on health care, expenditures for commuting to work). The elements contained in the ISEW are not fully convincing, and the policy community has not taken much notice of this.

In the subsequent analysis, it will be argued that one should focus indeed on broader concepts of Global Sustainability: A broader concept should take into account the role of international competitiveness and technological progress adequately. Section 2.2 takes a look at traditional approaches to environmental damaging, and Sect. 2.3 presents results for the new composite indicator on global sustainability, the final section presents policy conclusions. The main results are also presented in form of a global map.

2.2 Traditional Approaches to Environmental Damaging and Innovation Theory

Standard approaches to environmental damaging emphasize much of the issue of non-renewable resources. This focus is not surprising, as some vital resources used in industry are important non-renewable inputs. However, one should not overlook the fact that innovation dynamics and technological progress typically can mitigate some of the problems in the long-run – here, the focus is on both process innovations, which economize on the use of resources, as well as product innovations, which might bring about the use of different non-renewable or of synthetic chemical inputs. At the same time, one may argue that until 2050 there will be considerable global population growth and most of the output growth will come from Asia – including China and India. In these countries, emphasis on fighting global warming is not naturally a top priority, rather economic catching-up figures prominently in the political system are; and economic analysis suggests that China and India still have a large potential for economic catching-up and long term growth, respectively (Dimaranan et al. 2009). Nevertheless, one may emphasize that economic globalization also creates new opportunities for international technology transfer and for trade with environmental (green) goods. If there is more trade with green goods and, if certain countries successfully specialize in the production and export of such goods, the global abilities in the field of environmental modernization might be sufficient to cope with global warming problems: This means the ability to fight global warming, on the one hand, and on the other hand, the ability to mitigate the effects of global warming. A potential problem of putting more emphasis on innovation dynamics is that a wave of product innovations could trigger additional emissions, which would partly or fully offset the ecological benefits associated with higher energy efficiency that would result in a generally more efficient way to use natural resources.

Sustainability means the ability of future generations to achieve at least the same standard of living as the current generation has achieved. If one adopts a national sustainability perspective this puts the focus on sustainable economic development in every country of the world economy. Analytical consistency in terms of sustainability imposes certain analytical and logic requirements:

- As a matter of consistency one may expect that if there is a group of countries which represents – according to specific sustainability indicators – sustainable development other countries converging to the same structural parameters of the economy (say per capita income and per capita emissions as well as other relevant parameters) will also be classified as sustainable.
- If all countries are sustainable there is sustainability of the overall world economy. What sounds trivial at first is quite a challenge if one considers certain indicators as we shall see.

An important approach to sustainability has been presented by the World Bank which calculates genuine savings rates. The basic idea of a broadly defined savings rate is to take into account that the current per capita consumption can only be maintained if the overall capital stock – physical capital, human capital and natural capital – can be maintained. To put it differently: an economy with a negative genuine savings rate is not sustainable. The genuine savings rate concept is quite useful if one is to understand the prospect of sustainable development of individual countries. Figures on the genuine savings rate basically suggest that OECD countries are well positioned, particularly the USA (World Bank 2006). This, however, is doubtful, because it is clear that in case the South would converge to consumption patterns of the OECD countries – and would achieve economic convergence in terms of per capita income – the world could hardly survive because the amounts of emissions and waste would be too large to be absorbed by the earth. For example, the CO_2 emissions would be way above any value considered compatible with sustainability as defined by the IPCC (Intergovernmental Panel on Climate Change) and the Stern report.

The World Bank approach is partly flawed in the sense that it does not truly take into account the analytical challenge of open economies. To make this point clear, let us consider the concept of embedded energy which looks at input output tables in order to find out which share of the use of energy (and hence CO_2 emissions) are related to exports or net exports of goods and services. For example, the USA has run a large bilateral trade deficit with China – and indeed the rest of the world – for many years and this implies that the "embedded genuine savings rate" (EGSR) of the USA has to be corrected in a way that the EGSR is lower than indicated by the World Bank. Conversely, China's EGSR is higher than indicated by the World Bank. To put it differently: While the genuine savings rate indeed is useful to assess sustainability of individual countries at first glance, a second glance which takes into account the indirect international emissions and indirect running down of foreign stocks of resources (e.g., deforestation in Latin America or Asia due to net US/EU imports of goods using forest products as intermediate inputs) related to trade represents a different perspective; EGSR should not be misinterpreted to take the responsibility from certain countries, however, EGSR and the genuine savings rate concept – standing for two sides of the same coin – might become a starting point for more green technology cooperation between the USA and China or the EU and China.

Considering the embedded genuine savings rate helps to avoid the misperception that if all countries in the South of the world economy should become like OECD countries the overall world economy should be sustainable. According to the World Bank's genuine savings rate, the USA in 2000 has been on a rather sustainable economic growth path. However, it is clear that if all non-US countries in the world economy had the same structural parameter – including the same per capita income and the same emissions per capita – as the USA there would be no global sustainable development. If, however, one considers embedded genuine savings rates, the picture looks different. For instance, if one assumes that the embedded genuine savings rate for the USA is lower by 1/5 than the genuine savings rate, it is clear that the US position is not as favorable as the World Bank data suggest.

The ideal way to correct the World Bank genuine savings rate data is to consider input-output and trade data for the world economy so that one can calculate the embedded genuine savings rate; however, such data are available only for a few countries, but in a pragmatic way one may attribute China's depreciations on natural resources and the CO_2 emissions to the USA and the EU countries as well as other countries vis-à-vis China runs a sustained bilateral trade balance surplus. A pragmatic correction thus could rely on considering the bilateral export surplus of China – e.g., if the ratio of total exports to GDP in China is 40% and if ½ of China's export surplus of China is associated with the USA then 20% of China's CO_2 emissions can effectively be attributed to the USA. One might argue that considering such corrected, virtual CO_2 emissions is not really adequate since global warming problems depend indeed on the global emissions of CO_2, while individual country positions are of minor relevance. However, from a policy perspective it is quite important to have a clear understanding of which countries are effectively responsible for what share of CO_2 emissions in the world economy. As sources of CO_2 emissions are both local and national, it is indeed important to not only consider the embedded genuine savings rate but also to know which country are responsible for which amount of CO_2 emissions.

In the literature, one finds partial approaches to the issue of global sustainability. The concept of the ecological footprint (Wackernagel 1994; Wackernagel and Rees 1996) – as suggested by the WWF (see e.g. Wiedmann and Minx 2007) – is one important element. Ecological footprint summarizes on a per capita basis (in an internationally comparative way) the use of land, fish, water, agricultural land and the CO_2 footprint in one indicator so that one can understand how strong the individual's pressure on the capacity of the earth to deliver all required natural services really is. At the same time, one wonders to which extent one may develop new indicator approaches which emphasize the aspects of sustainability in a convincing way. The Global Footprint indicator calculated by the World Wildlife Fund and its international network indicates the quantitative use of resources for production, namely on a per capita basis (Global Footprint Network). It thus is a rather crude indicator of the pressure on the global biosphere and the atmosphere. However, it has no truly economic dimension related to international competition and competitiveness, respectively. If, say, country I has the same global per capita footprint as country II, while the latter is strongly specialized in the production and export of green goods – which help to improve the quality of the environment and to increase the absorptive capacity of the biosphere of the importing countries, respectively – the Global Footprint approach does not differentiate between country I and country II.

If the general public and the private sector as well as policymakers are to encourage global environmental problem solving it would be useful to have a broadly informative indicator which includes green international competitiveness – see the subsequent analysis. One may argue that a positive revealed comparative advantage (RCA) for certain sectors is economically and ecologically more important than in other sectors, however, we consider the broad picture across all sectors considered as relevant by the OECD. Modified RCAs (MRCA) are particularly useful indicators since they are not distorted by current account imbalances – as is the traditional RCA indicator which simply compares the sectoral export import ratio with the aggregate export import ratio (Comtrade data base of the United Nations and World Development Indicators/WDI (2008) are used in the subsequent calculations).

As regards as adjustment dynamics, it is clear that a static view of the economy and world ecological system is not adequate; rather Schumpeterian innovation perspective is required.

2.2.1 Growth and Exhaustible Natural Resources

Natural resources, pollution and other environmental issues are not considered in the classical growth model of Solow. Many economists – from Malthus (1798) to Hotelling (1931) and Bretschger (2009) – have argued that the scarcity of land and natural resources, respectively, could be an obstacle in obtaining sustainable growth. Nordhaus (1974) described the impossibility of an infinite and long-term economic growth based on exhaustible energy; he has basically emphasized that non-renewable resources are critical long-run challenges, along with three other aspects:

- Limitations of resources: certain key resources are non-renewable and substitution through alternative exhaustible resources is often complex.
- Environmental effects – the use of resources causes emissions or effluents and dealing with those is costly.
- There will be rising prices of the exhaustible energy resources.

With connection to this, back-stop technologies or innovations have a crucial role for the long-term economic perspective and for the optimal energy price level. The effect of a back-stop technology[1] on the resources price path can be presented in a straightforward way (Fig. 2.1):

A standard insight – on the assumption of a perfect competition and a linear demand curve – is that the price will rise in the long run due to rising extraction costs. With the use of a new technology (lower marginal costs bc_1) one will have a lower price until the exhaustion of a new substitute. It would, however, be inefficient not to use up new resources completely. In this context, one should emphasize that the initial price must remain below $bc_1 < \bar{p}$. Due to the new attractive supply, the demand will increase, and the resource will be exhausted earlier (T_1). With a more innovative technology, and more favorable extraction costs (bc_2), one

[1]One can mention the following back-stop technologies concerning today's knowledge level: Solar power and hydrogen and other renewable energy technologies, possible nuclear fission systems on the basis of the breeder reactors or light-water reactors with uranium production, new nuclear fusion techniques (Hensing et al. 1998).

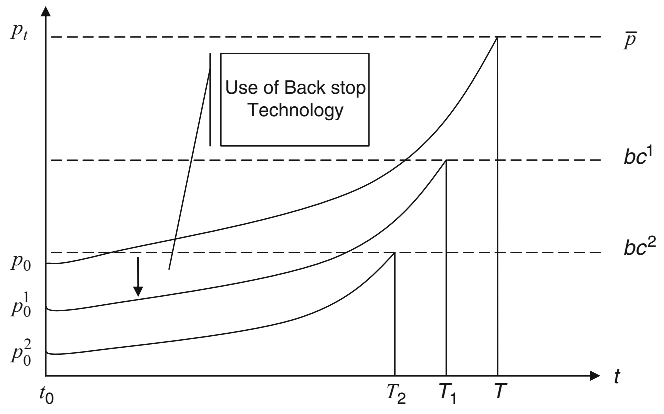

Fig. 2.1 Use of back-stop technology. Source: (Wacker and Blank 1999)

achieves an even earlier extraction time (T_2) (Wacker and Blank 1999: 43). In a similar way, Levy (2000) shows that a decrease of the initial average costs by one dollar leads to a decrease of the spot prices by somewhat less than a dollar.

With regards to the promotion of these technologies, governments are faced with two different approaches:

– "Technology Push" refers to the identification of a potential technology and the support of the research and development (R&D), in order to bring a competitive product on the market. "The Technology Push"-approach basically argues that the primary focus should be on the development of Green House Gas reduction technologies: via public R&D programs and not via obligatory regulations, such as restrictions on emission. Obligatory restrictions may be used only if the innovations would sufficiently lower the costs of green house gas emissions.
– The opposite "Market Pull"-approach stresses that technological innovation must come primarily from the private sector. In this context, the economic interaction of changing needs and shifts in technologies (supply side) bring about new appropriate products. The focus of this approach lies in the fact that the obligatory restrictions could force the enterprises to innovations in search for cost reduction (Grubb 2004: 9; Hierl and Palinkas 2007: 5).

The origins of environmental problems and the various solutions proposed by businesses and institutions in innovative green technologies, have been often examined since the 1980s and 1990s: The concepts, as well as the conditions for the emergence and diffusion of technological and institutional innovations are based on so-called nonlinear system dynamics, a theory partly introduced by J. A. Schumpeter, stating that unforeseeable innovative processes with positive externality stand in close relationship with knowledge and learning processes (Farmer and Stadler 2005: 172). For most countries, foreign sources of technology account for 90% or more of the domestic productivity growth. At present, only a handful of rich countries account for most of the world's creation of new technology. G-7 Countries accounted for 84% of the world's R&D, but their world GDP share is 64% (Keller 2004). The pattern of worldwide technical change is, thus, determined in large part by international technology diffusion.

Aghion et al. (2009) argue that radical innovations are needed to bring about strong progress in CO_2 emissions: Given the fact that the share of green patents in total global patents is only about 2%, one cannot expect that incremental changes in technologies will bring about strong improvements in energy efficiency and massive reductions of CO_2 emissions per capita; while the generation of electricity is a major cause of CO_2 emissions the share of R&D expenditures in the sector's revenues was only 0.5%.

2.3 New Indicator Concept

Basically, one could build indicators based on the individual, which often is a good way to motivate individuals to reconsider their respective style of living. Alternatively (or in a complementary way), one may develop indicators with a focus on individual countries so that the focus is more on political action, including opportunities for international cooperation. A consistent theoretical basis for a global sustainability indicator is useful and it is therefore argued here that one should focus on three elements for assessing global sustainability. Here an indicator set will be suggested where the main aspects are:

- Ability to maintain the current standard of living based on the current capital stock (broadly defined). Hence "genuine savings rates" – including the use of forests and non-renewable energy sources – are an important aspect. To the extent that countries are unable to maintain the broader capital stock (including natural resources) there is no sustainable consumption to be expected for the long run.
- Ability to solve environmental problems: If we had an adequate sub-indicator – related to innovation dynamics – the composite sustainability indicator would then have a true economic forward-looking dimension. If countries enjoy a positive revealed comparative advantage in the export of environmental products ("green goods": [OECD OSLO MANUAL 2008; WTO 1999; OECD 1999]), one may argue that the respective country contributes to global solving of environmental problems. As it has specialized successfully in exporting environmental products, it is contributing to improving the global environmental quality; also, countries which have specialized in exports of green goods may be expected to use green goods intensively themselves – not least because of the natural knowledge advantage in producer countries and because of the standard home bias of consumers. Countries will be ranked high if they have a high modified RCA (MRCA) in green goods: The MRCA for sector i is defined in such a way that the indicator is zero if the respective sector's export share is the same as that of all competitors in the world market and it is normalized in a way

that it falls in the range -1, 1 (with positive values indicating an international competitive advantage).

- Pressure on the climate in the sense of global warming. Here CO_2 emissions are clearly a crucial element to consider. The share of renewables could be an additional element, and a rising share over time would indicate not only an improvement of the environmental quality – read less pressure for global warming – but also reflect "green innovation dynamics".
- The aggregate indicator is based on the sum of the indicator values for relative genuine savings rate (s' of the respective country divided by the world average s'^W), the relative CO_2 per capita indicator (CO_2 per capita divided by the average of global average CO_2 per capita). In principle aggregation of sub-indicators should use a weighing scheme based on empirical analysis.

A synthetic indicator can conveniently summarize the various dimensions to be considered, and this indeed is done subsequently.

For a group of countries, the genuine savings rate and the gross domestic savings rate are shown for the year 2000. The definition of net national savings is gross national savings minus capital depreciations (consumption of fixed capital); if we additionally subtract education expenditures, energy depletion, mineral depletion, net forest depletion, PM10 damage (particulate matter) and CO_2-related damage on has the genuine savings rate.

Sustainability (defined in a broad sense) is weak – based on standard World Bank data – if the genuine savings rate is relatively low. Comparing data from the World Bank on this topic it can be seen that the genuine saving is generally smaller than the gross domestic saving. This is particularly the case for Azerbaijan, Kazakhstan, Iran, Saudi Arabia and Russia. While all of them report negative genuine savings rates, the latter two are in a very weak position since the genuine savings rate exceeded -10%. Moreover it is also noteworthy that for many countries there is a large gap between the standard savings rate and the genuine savings rate. This suggests that with respect to economic sustainability there is a veil of ignorance in the broader public and possibly also among policy makers.

A crucial dimension of global sustainability is CO_2 emissions per capita; this indicator mainly is related to the use of energy for production and consumption, respectively. The share of renewable also is a crucial element for climate policies. The energy sector, however, is subject to considerable relative price shifts over time and indeed has reacted with innovations to strong price shocks. High and rising oil prices have undermined global economic dynamics in the period from 2006 to 2008, and representatives of industry and OECD countries have raised the issue as to how, why, and how long such price increases will continue. While it seems obvious that sustained relative price changes should stimulate innovation – see the analysis of Grupp (1999) for the case of the OPEC price shocks of the 1970s – as well as substitution effects on the demand side and the supply side, it is rather unclear which mechanisms shape the price dynamics in the short-term and the long run. The following analysis takes a closer look at the issues, presents new approaches for economic modeling and also suggests new policy conclusions.

In the wake of the two oil price shocks of the 1970s – each bringing with it a quadrupling of the oil price – the economics of exhaustible resources became an important research field (e.g. Stiglitz 1974; Dasgupta and Heal 1979; Sinn 1981). Oil and gas are particular examples of non-renewable resources, and they are politically sensitive since the main deposits are concentrated regionally, in the case of oil in politically rather sensitive Arab countries as well as Iran and Russia. In addition, major oil producers have established OPEC, which became a powerful cartel in the 1970s when it controlled about 60% of the world market for oil. As transportation costs for oil are very small, the oil price is a true world market price since equilibrium is determined by world oil supply and global oil demand. There is considerable short-term oil price volatility in the short run, and there have been major shifts in oil prices over the medium term. Changes in market structure will affect the optimum rate of depletion of resources (Khalatbari 1977).

The oil and gas sector has a long history of high Schumpeterian dynamics, where analysis by Enos (1962) suggests there is a time lag of about 11 years between invention and innovation. By implication, R&D promotion in this industry will go along with considerable time lags with respect to innovation – this is also a challenge for policy makers, who would have to apply a relatively long time horizon. As regards R&D Promotion, Furtado (1997) found that differences in the degree of appropriability between upstream and downstream of the oil industry had a great impact on effect of R&D promotion. There are regional case studies on the dynamics of innovation in the oil and gas industry – concerning Stavanger and Aberdeen (Hatakenaka et al. 2006) – which show that different approaches to R&D promotion can have similar effects. It is also noteworthy that the energy sector has been a leading early user of information technology (Walker 1986).

A rising relative price of non-renewables is often considered inevitable, since there is long-term global population growth and also high aggregate output growth since the 1990s in the world economy. The use of fossil energy sources does not only have economic issues at stake, but it is also relevant in terms of global warming issues. The Stern Report (Stern et al. 2006; Nordhaus 2006; Latif 2009) has raised international attention about the dynamics of the use of energy and the associated CO_2 emissions as have the policy activities and UN reports with a focus on the Kyoto Protocol. There is long term concern that high economic global growth will strongly stimulate the demand for energy and hence raise emissions. At the same time, there are also medium term concerns about the potential negative impact of oil price shocks. While higher real oil prices might be useful at encouraging a more efficient use of energy resources, there could also be inflation and unemployment problems linked to sudden rises of nominal oil prices.

As regards CO_2 emissions per capita we see a well known picture in which the USA was leading with a relatively poor performance up to 2000 (Fig. 2.2).

As regards the consistent composite indicator (with adequate centering) a positive position is strictly defined as a favorable global position, a negative value reflects ecological weakness and to some extent lack of green innovativeness or inefficiencies in the use of energy-intensive products (as mirrored in the CO_2 per capita indicator); more and better innovations can improve the position of the

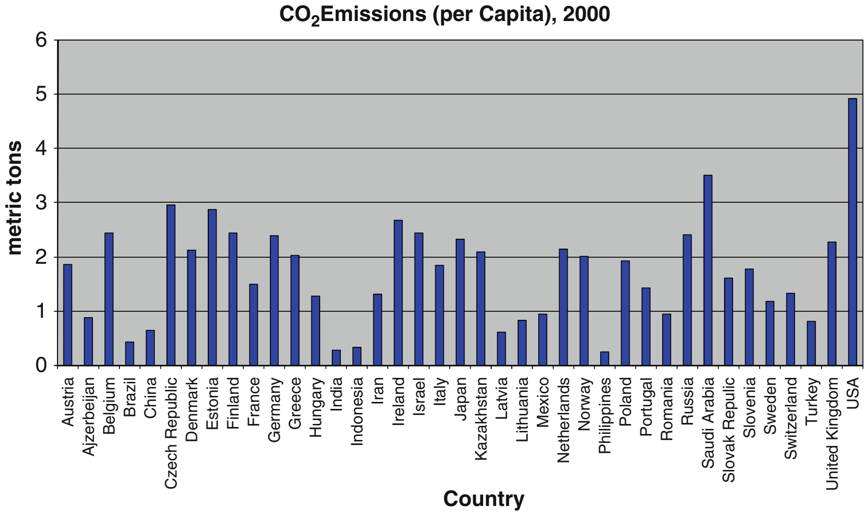

Fig. 2.2 CO_2 emissions. Source: WDI 2008

composite indicator so that the main message is that green innovation dynamics matter – thus government should encourage green Schumpeterian dynamics, particularly if there are positive national or international external effects. Specialization in green knowledge-intensive industries and positive green RCAs could go along with national or international positive external effects, however, there are hardly empirical analyses available here. The aggregate indicator shows results which, of course, are somewhat different from the simple aggregation procedure; we clearly can see that careful standardization is required for consistent results.

As already mentioned, from a methodological point the weights attached to the individual components of the indicator could be determined through empirical analysis. Factor loadings are useful starting points for a valid approach. It should be emphasized that the new indicator set proposed (even disregarding the weighing issue) puts the analytical and policy focus on the issue of global sustainability in a new way. The indicator emphasizes long term opportunities and global sustainability. While this approach is only a modest contribution to the broader discussion about globalization and sustainability, it nevertheless represents analytical progress. There is little doubt that specific issues of sustainability – e.g., global warming (see Appendix) – will attract particular interest from the media and the political systems. At the same time, one may emphasize that the new broad indicators developed are useful complements to existing sustainability indicators such as the global footprint from the WWF.

The indicator presented is complementary to existing sustainability indicators. However, it has two specific advantages:

- It emphasizes within the composite indicator a dynamic view, namely the Schumpeterian perspective on environmental product innovations.
- It is in line with the OECD handbook on composite indicators.

The indicator for SO_2 emissions can be easily aggregated for global emissions, while the genuine savings indicator cannot easily be aggregated if one wants to get a global sustainability information. However, as regards the genuine savings indicator one may argue that if the population weighted global savings indicator falls below a critical level there is no global sustainability. One might argue that the global genuine savings rate – a concept which obviously does not need to focus on embedded (indirect) use of materials and energy – should reach at least 5% because otherwise there is a risk that adverse economic or ecological shocks could lead to a global genuine savings rate which is close to zero; and such a situation in turn could lead to economic and political international or national conflicts which in turn could further reduce genuine savings rates in many countries so that global sustainability seems to be impaired.

There are many further issues and aspects of the indicator discussion which can be explored in the future. One may want to include more subindicators and to also consider robustness tests, namely whether changing weights of individual subindicators seriously changes the ranking of countries in the composite index.

Since the global warming problem refers to CO_2 emissions and other greenhouse gases from a worldwide perspective, it is not efficient to reduce emissions of greenhouse gases in particular countries through particular national subsidies. A global approach to establishing an ETS would be useful. However, one may emphasize that stabilization of financial markets should be achieved first since otherwise a very high volatility of certificate prices is to be expected; future markets for such certificates also should be developed carefully and it is not obvious such markets necessarily will be in the USA; the EU has a certain advantage here as the EU has taken a lead in the trading of emission certificates. There are policy pitfalls which one should avoid in setting up ETS; e.g. the German government has largely exempted the most energy-intensive sectors in the first allocation period – those sectors would normally have rather big opportunities to achieve cuts in energy intensity and CO_2 emissions, respectively; Klepper/Peterson (2006) have calculated that the welfare loss of emission trading could have been 0.7% of GDP in the first German National Allocation Plan while in reality the welfare amounted to 2.5% of GDP.

Government incentives on renewables could be a useful element of environmental modernization. As regards the share of renewable in the use of energy generation the following tables show that there are large differences across countries. Following the general approach presented here – with the world average set at zero [and the indicator normalized in a way that it falls in the range $(-1, 1)$] – we can see that there are some countries which are positively specialized in renewable energy: Austria, Brazil, Finland India, Italy, Latvia, Philippines, Portugal, Sweden, Switzerland and Turkey have positive indicators. It is noteworthy, that the position of Azerbaijan, Iran, Kazakhstan, Netherlands, Russia and the UK are clearly negative. Comparing 2000 and 2006 the worsening position of China is remarkable, at the same time the UK has slightly and Germany has strongly improved its respective position. There is no doubt that countries such as Russia and China could do much better in the field of renewable provided that government encourages innovative firms and innovations in the renewable sector on a broader scale (Fig. 2.3).

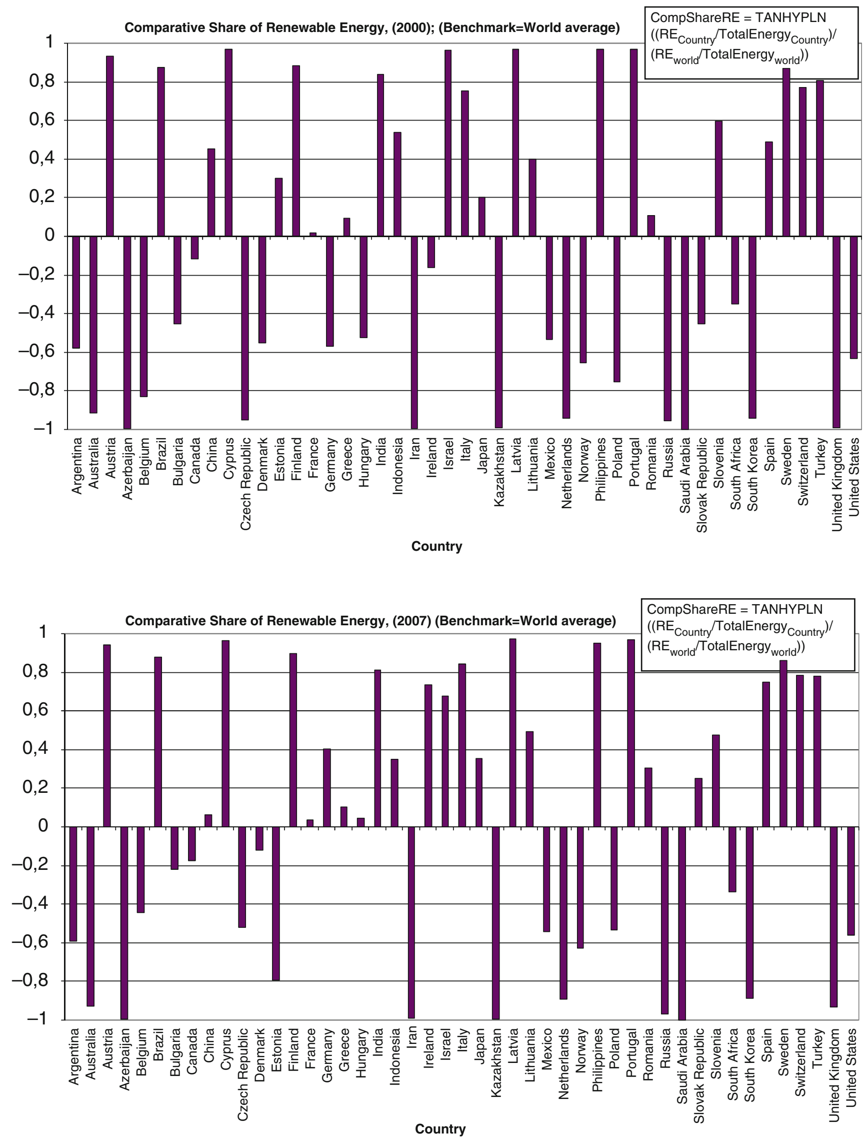

Fig. 2.3 Normalized indicator on the share of renewables in selected countries: 2000 vs. 2007. Source: IEA Database, EIIW calculations

2.3.1 *Basic Reflections on Constructing a Comprehensive Composite Indicator*

In the following analysis, a composite indicator measuring global sustainability in energy consumption is presented. In the first step, the influence of different partial indicators on the composite indicator is discussed by analysing sets of composite indicators with fixed identical weights. In the second step, the weights are allowed to be flexible/different and are estimated using factor analysis. Building on the insights gained in these two steps, a specific composite indicator is developed.

However, to begin with, the partial indicators will be introduced and it will be argued in how far they differ from the standard approaches in the literature. Additionally, the modes in which the partial indicators are transformed into centralized and normalized versions are presented.

2.3.1.1 Points of Departure: Revealed Comparative Advantage

There is a long history of using the revealed comparative advantage (RCA) as an indicator of international competitiveness, which can also be an indicator for assessing the specialization in green environmental goods. The standard Balassa indicator considers the sectoral export-import ratio (x/j) of sector i relative to the total export-import ratio (X/J) and concludes that an indicator above unity stands for international competitiveness in the respective sector. It is useful to take logarithms so that one can calculate ln(x/j)/ln(X/J): If the indicator exceeds zero, there is a positive successful specialization, if the indicator is negative, the country has a comparative disadvantage. Minor deviations from zero – both positive and negative – will normally be considered as a result of random shocks (to have a positively significant sectoral specialization, a critical threshold value has to be exceeded).

Since this indicator takes existing goods and services into account, there is a natural bias against product innovations, particularly in new fields; innovative countries that have many export products that stand at the beginning of the product cycle, will typically only export a few goods at relatively high prices – only after a few starting years will exports grow strongly. Foreign direct investment might also somewhat distort the picture, namely to the extent that multinational companies could relocate production of green products to foreign countries. To the extent that foreign subsidiaries become major exporters over time, – a typical case in manufacturing industry in many countries – the technological strength of an economy with high cumulated foreign direct investment outflows might contribute to a relatively weak RCA position, as a considerable share of imports is from subsidiaries abroad.

A slight modification of the Balassa RCA indicator is based on Borbèly (2006): The modified RCA indicator for export data (MRCA) is defined as:

$$\mathrm{MRCA}_{c,j} = \mathrm{tanhyp}\left(\ln\left(\frac{x_{c,j}}{\sum_{j=1}^{n} x_{c,j}}\right) - \ln\left(\frac{x_{I,j}}{\sum_{j=1}^{n} x_{I,j}}\right)\right) \quad (1)$$

where $x_{c,j}$ gives the exports in sector j of region/country c and $x_{I,j}$ gives the exports in sector j of the reference market I (in this case the EU 27 market).

In this context, the index uses data for exports and calculates the ratio of the export share of a sector – in this case, the sector of environmental green goods – in one country to the export share of that sector in a reference market (e.g. EU27 or the world market). In most cases, it is adequate to use a reference market with a homogenous institutional set-up, such as the EU27 market; an alternative is the world market, which stands for a more heterogeneous institutional setting than the EU27. The selected countries make up most of the world market (about 80%), but not the whole world economy. Therefore, for practical purposes, – e.g. avoiding the problem of missing data – we have decided that the reference market used is the market consisting of the countries observed in the analysis.

Furthermore, it is important to mention that the modified RCA indicator, as presented above, allows to be applied to a much broader range of data than just export data. While it is possible to use the indicator for the relative position of macroeconomic data, such as labor or patents, in the present case, it is also applied to the share of renewable energy production in countries instead of the export data – the idea is to consider the relative renewables position of a given country: The resulting RCA-indicator (SoRRCA) gives the relative position of one country, regarding renewable energy production in comparison with the share of renewable energy production in the reference market, which in this case is the total world market. It can be shown that for this case, the results will not be influenced much by either the world market or the market consisting of all observed countries.

In addition to the traditional and modified RCA indicators, as introduced by Balassa (1965) and Borbèly (2006), respectively, we also test for volume-weighted RCAs. In this case, the modified RCAs (MRCAs) are calculated and multiplied by the countries' absolute exports, resulting in the volume-weighted RCA (VolRCA). The results for the year 2000 are shown in Fig. 2.4. Here, the basic idea is not only to look at the relative sectoral export position for various countries, but to emphasize that a country whose green sector has a positive specialization in green export goods adds more to the global environmental problem solving, the higher the

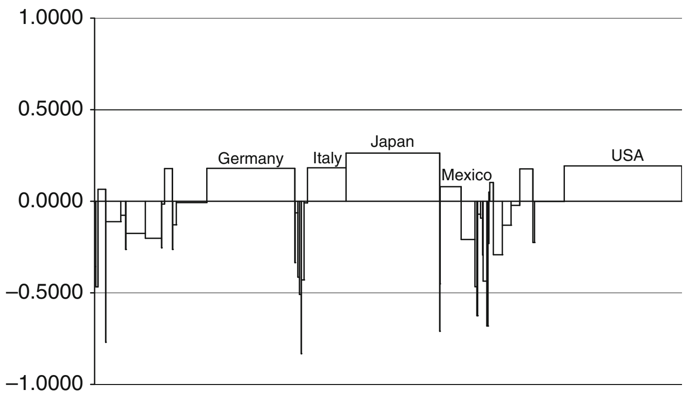

Fig. 2.4 Volume-weighted RCAs for the year 2000

absolute volume of green exports. From this perspective, large countries with a high positive green export specialization stand for a particularly favorable performance.

Figure 2.4 shows that the indicator modified in such a way allows for discrimination between those countries which are leading in weighted green RCAs, and those that fall behind, either in absolute volume or in green specialization. Leading countries, like Germany, Italy, Japan, Mexico or the USA, not only export a high volume of environmental goods, but also hold a significant advantage compared to the other countries. In contrast to that group of countries, the countries that show a comparative disadvantage can be divided into a group that has a green export advantage but a small export volume; and into a group that has a relatively high volume but no strong comparative advantage. The latter countries are mostly larger countries that are major international suppliers of green goods, but compared to their other industries, the environmental goods do not play a very important role. These countries have a potential to become future leaders in the area and a more detailed analysis of the countries and the dynamics would allow an insight into the way comparative advantages and growing sectoral leadership positions are established – an issue left for future research.

2.3.1.2 Standardization

All indicators, except MRCA or SoRRCA, are neither centralized around zero nor have they clearly defined finite and symmetrical boundaries, especially not in the same way as the RCA indicators, whose results lie in the interval $[-1, 1]$. If the intention is, therefore, to combine the partial indicators additively, as will be done in the present approach, it is necessary to ensure that the indicators are concentrated around zero and that their values do not exceed the above stated interval. Furthermore, it is necessary to ensure that the best possible result is +1 and the worst possible result is equivalent to -1.

Centralization is easily achieved by calculating the mean for an indicator and subtracting it from the individual indicator value. Alternatively, a given average (like the world average) can be taken and used as an approximate mean. The resulting indicator ensures that the number of countries with a negative value is equal to the number with positive values.

The problem in this context is the temporal stability of the calculated means. If the means do not stay relatively constant over time, a problem arises, where a positive or negative position does not depend so much on the values of a single country but mostly on the values of other countries.

It can be shown that, while the means of the genuine savings rate and the CO_2 output remain mostly on the same level, the mean of the total exports is monotonically rising. This will be a problem, especially in the construction of the volume weighted RCA indicator, VolRCA.

Even if the VolRCA indicator is inherently relative in nature, this effect solely takes the absolute volume into account, neglecting the sectoral structure; nonetheless, this trade-off is necessary to combine export-volumes and sectoral advantages, and until now, no alternative approach is known that could take care of this trade-off.

The second part of the standardization process is the normalization of the data. It is possible to take different approaches. The most common one is to divide the indicator values by the range given by the difference between the maximum and the minimum value. This approach is also the one that is implemented in this analysis. In the table below it is referred to as “normalized(linear)”.

An alternative is the “normalized(arctan)” approach. Here, the centralized data is normalized using the function $f(x) = 2/\pi \arctan(x)$. A useful effect of this approach is the fact that the result is not influenced by very large or very small outliers. Furthermore, the basis of the calculation stays the same and does not differ with the respective data used. Using the arctan-functional form also means to work with a functional form that is relatively steep for small values. Therefore, the results are very often nearing unity or -1, and it is very hard to distinguish between them. Additionally, the arctan-function is skewed and will lead to skewed results, which means that distances between values are no longer relatively constant. The linear approach will be used in the following chapters, considering both of the alternative approaches.

2.3.1.3 Fixed Weights vs. Free Weights

The following table provides the partial indicators used in the following analysis. As only linearly normalized variables will be used, only those are mentioned (Table 2.1).

The composite indicators that will be constructed and discussed below all have the form:

$$\text{CompositeIndicator} = \sum_{i=1}^{n} w_i \cdot \text{PartialIndicator}_i \tag{2}$$

It is assumed in the following section that all weights are identical.

$$w_i = w_j = \frac{1}{n} \quad \forall i, j = 1, \ldots, n \tag{3}$$

Table 2.1 Partial indicators used

Partial indicator	Abbreviation
MRCA	(1)
MRCA*Exports (centralized + normalized; volume weighted): VolRCA	(3)
Genuine savings rate [centralized + normalized (linear)]	(7)
CO_2 generation [centralized + normalized (linear)]	(9)
Share of renewables	(A)
SoRRCA (normalized, centralized)	(B)

By contrast, in a later section, where the weights are estimated, it is generally true that weights differ:

$$w_i \neq w_j \; \forall i \neq j = 1, \ldots, n \tag{4}$$

In this context it is discussed, whether situations arise where two or more weights are identical.

2.3.1.4 Fixed Weights

The following Fig. 2.5 show a composite indicator that is constructed from the partial indicators for the genuine savings rate, the SoRRCA (Share of Renewables RCA) and in the first case the MRCA and in the second case the VolRCA, for the years 2000, 2006 and 2007.

The basic of the following Fig. 2.5 is to highlight to which extend there is a difference between our "ideal" preferred composite indicator consisting of (3), (7), (9), (A), (B) namely compared two alternative indicators.

The difference between the two indicators lies in the way the comparative advantages in the field of environmental goods are introduced. The first indicator uses the traditional MRCA while the second one uses the volume weighted MRCA. It can be seen that the second indicator is in most cases more pronounced, meaning that positive advantages report higher values and negative advantages report lower values.

The first insight gained from Fig. 2.5 is that in most cases both indicators point in the same direction, meaning that if the first one indicates a comparative advantage, the second one does so as well. Furthermore, it seems that the second one is somewhat less harshly accentuated. Additionally, in the area were the first indicator is insignificantly close to zero, the second one gives a clear indication as to whether an advantage is present or not. The last fact that is worth mentioning is that, over time, the indicators stay mostly similar. While this does not influence the decision concerning the choice of the export RCA, it is, nonetheless, worth mentioning as it shows that not only the composite indicators both stay stable, but also that there has been rather few dynamics in the last years concerning sustainability in the majority of countries.

Conclusively, it can be said that both partial indicators can be used for the creation of a composite indicator, as there is no discernable difference between the effects the two have. We decide in favor of the VolRCA since it distinguishes best between advantages and disadvantages and, as it will be shown in the following sections, using the VolRCA will result in better weights when they are allowed to deviate from each other (across subindicators).

Following the same procedure as above, a composite indicator constructed from the partial indicators of the VolRCA, the genuine savings rate and the SoRRCA are compared to an indicator additionally containing the CO_2 output indicator (Fig. 2.6).

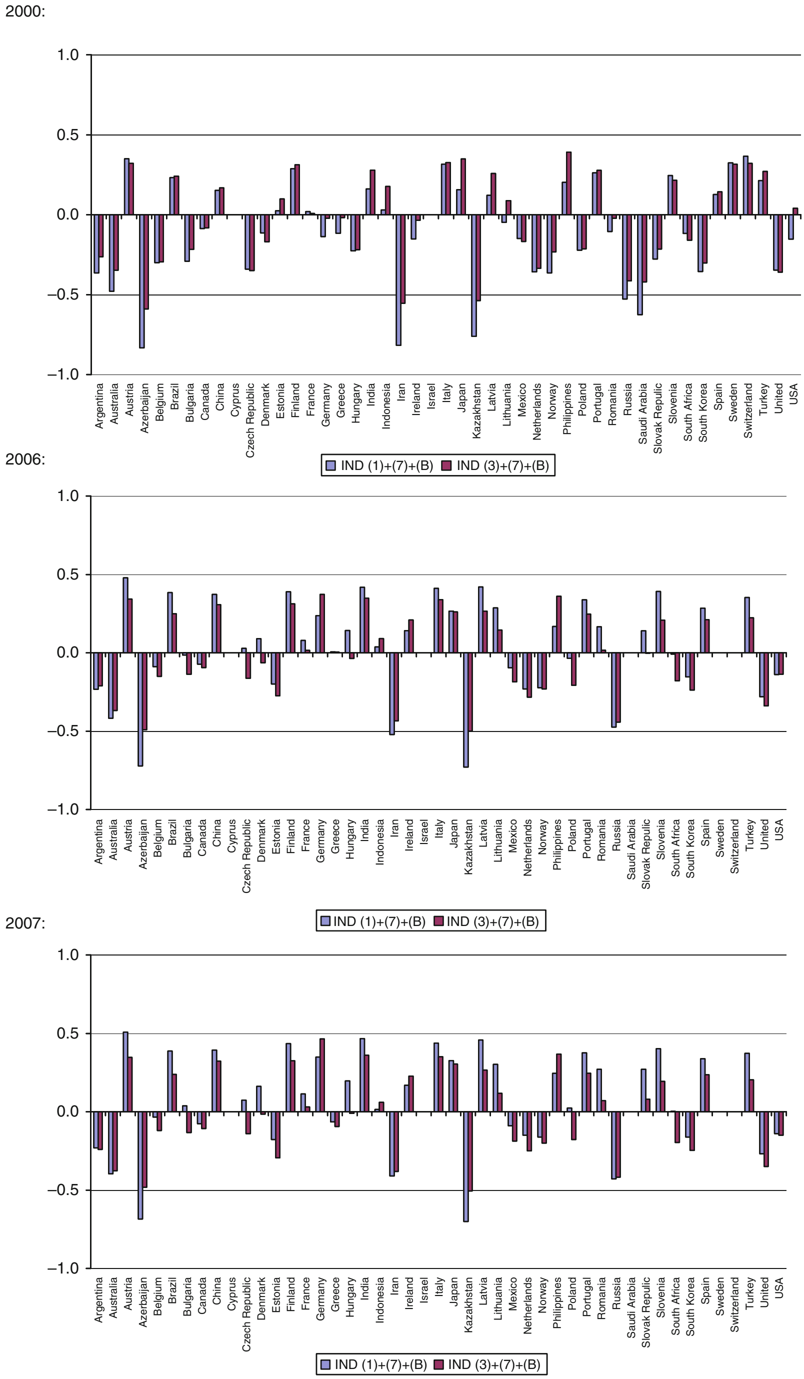

Fig. 2.5 Indicators showing the influence of the standard RCA indicator vs. the volume-weighted RCA indicator

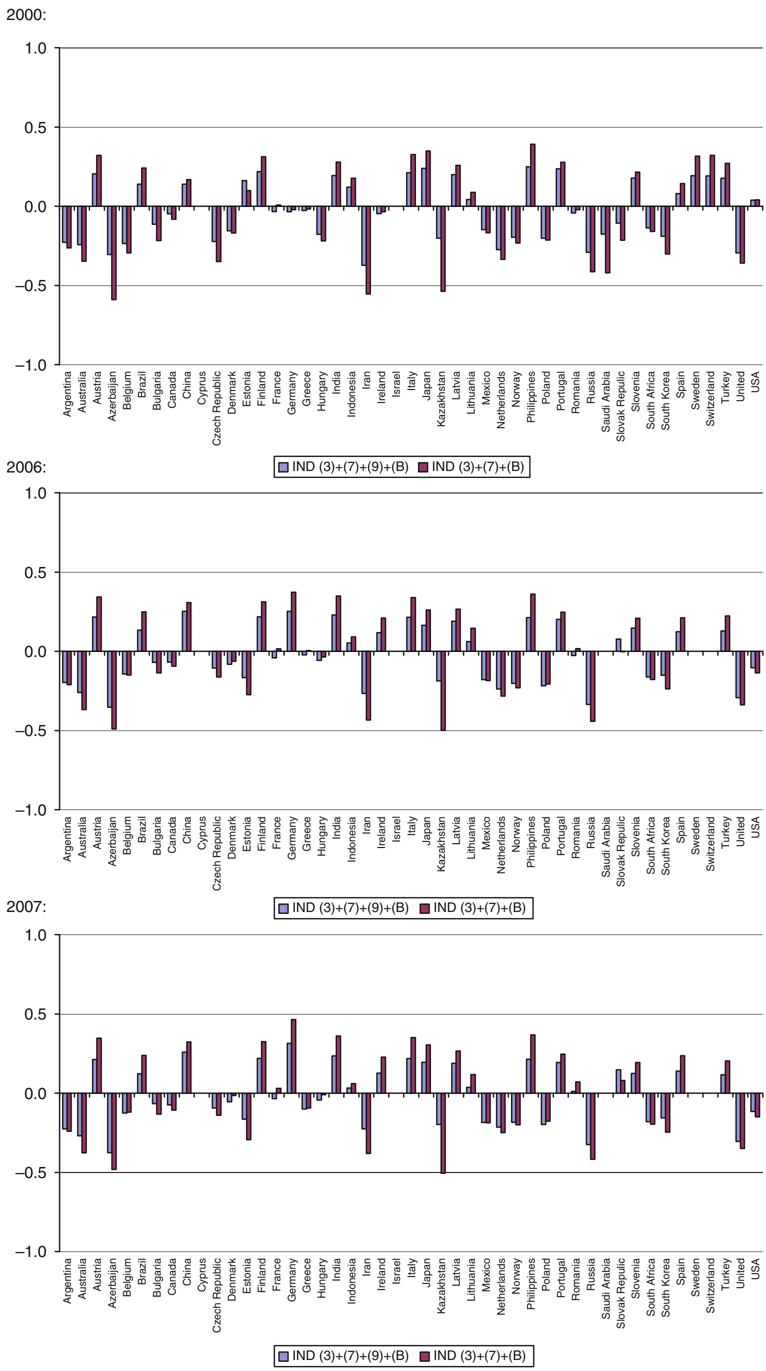

Fig. 2.6 Indicators showing the influence of the CO_2 indicator. Own calculations

In almost all cases, the indicator without the CO_2 emissions is more accentuated (positive values are higher and negative values and lower) than the indicator including them. Combined with the effect that, as shown below, inclusion of the CO_2 emissions indicator leads to redundancy problems in the composite indicator, it is prudent to abstain from using the CO_2 emissions indicator. Similar to Fig. 2.5, the two composite indicators compared here stay relatively stable over time, and in the rare occasions where the results change, at least the relations of the two indicators to each other are kept.

Finally, in the third part of this analysis, the influence of the share of renewable energy production in the energy mix of the countries is observed. Here, the composite indicator is calculated from the VolRCA and the genuine savings rate. Additionally, the three cases of no inclusion of the share of renewable energy, the absolute share of renewable energy and the SoRRCA are considered.

2.3.2 Weights from Factor Analysis

In the following part, the weights are no longer fixed to the number of partial indicators used. Instead, a factor analytical approach is used to estimate the values for the weights.

Factor Analysis is a mathematical method from the field of dimension reducing algorithms. The goal is to start from a row of observations for different indicators and estimate weights for aggregation of the indicators into one or more composite indicators. The number of resulting composite indicators will be less than the number of indicators to begin with. The method also offers decision support on how many indicators will result from the process. In contrast to the traditional application of the factor analysis, the number of resulting indicators in this case is fixed, but not the number of resulting eigenvalues exceeding given bounds.

Nevertheless, the eigenvalues play an essential role in constructing the composite indicator. In traditional factor analysis, the desired result would be for one eigenvalue to dominate all other eigenvalues. The sum over all eigenvalues equals the number of partial indicators; traditionally, the ideal result would be for the largest eigenvalue to be equal to this sum, whereas all other eigenvalues would be zero. This would be the case if all partial indicators were measuring exactly the same concept.

In constructing the present composite indicator, it is desirable to combine different concepts around the idea of sustainability. Therefore, it would be best for every partial indicator to describe a different concept. The degree to which this goal is achieved can be seen from the eigenvalues. If all eigenvalues have values near unity, it indicates that all partial indicators measure independent concepts.

This is also the way in which the final decisions on the usage of partial indicators of the preceding chapter have been reached. If more than one indicator is possible, the one that has the more evenly distributed eigenvalues for all years is chosen.

The second aspect that is used as a decision criterium is the sign of the resulting components, e.g. the resulting weights. It can be seen that the expected signs for the weights of all but the CO_2 emissions indicator are expected to be positive. This condition is, with the exception of two cases, met by the present data, so that it does not offer a reliable means to distinguish between feasible partial indicators and non-feasible ones. So, the main decision is made using the distribution of eigenvalues. Finally, the resulting components are normalized by dividing them by their sum, thus, resulting in weights summing up to unity. An overview of the resulting eigenvalues and the components, e.g. weights, is given in the appendix.

Combining the insights from this and the preceding chapter, an ideal global indicator can be motivated, which is constructed from the VolRCA, the genuine savings rate and the SoRRCA. Figure 2.7 gives a broad overview of this composite indicator for the years 2000, 2006 and 2007. A clear finding is that Austria, Brazil, Cyprus, Finland, Germany (in 2006 and 2007, not in 2000), India, Ireland, Italy, Japan, Latvia, the Philippines, Portugal, South Africa, Sweden and Switzerland have considerable positive indicators; by contrast, Australia, Azerbaijan, Iran, Kazakhstan, Russia, Saudi Arabia, the UK and – less pronounced – the USA, the Netherlands and Mexico and some other countries – have a negative performance. The countries with relatively weak indicator values for sustainability are often rather weak in terms of renewable energy; this weakness, however, can be corrected within 1 or 2 decades, provided that policymakers give adequate economic incentive and support promotion of best international practices. To the extent that countries have low per capita income, it will be useful for leading OECD countries to encourage relevant international technology transfer in a North-South direction. At the same time, successful newly industrialized countries or developing countries could also become more active in helping other countries in the South to achieve green progress.

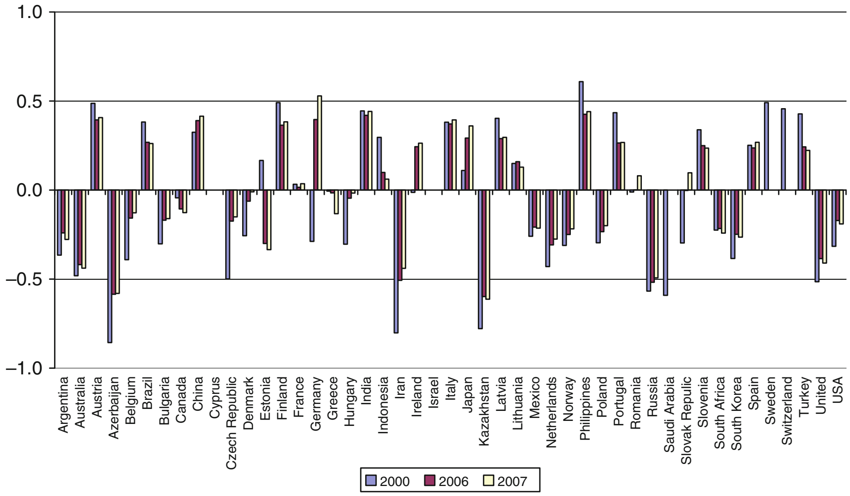

Fig. 2.7 EIIW-vita global sustainability indicator

To the extent that international technology transfer is based on the presence of multinational companies, there are considerable problems in many poor countries: these countries are often politically unstable or have generally neglected the creation of a framework that is reliable, consistent and investment-friendly. Countries in the South, eager to achieve progress in the field of sustainability, are well advised to adjust their economic system and the general economic policy strategy in an adequate way. Joint implementation in the field of CO_2-reduction could also be useful, the specific issue of raising the share of renewable energy should also be emphasized. Solar power, hydropower and wind power stand for three interesting options that are partly relevant to every country in the world economy. With more countries on the globe involved in emission certificate trading, the price of CO_2 certificates should increase in the medium-term that will stimulate expansion of renewables both in the North and in the South. While some economists have raised the issue that promotion of solar power and other renewables in the EU is doubtful, – given the EU emission cap – as it will bring about a fall of CO_2 certificates, and ultimately, no additional progress in climate stabilization. One may raise the counter argument that careful nurturing of technology-intensive renewables is a way to stimulate the global renewable industry, which is often characterized by static and dynamic economies of scale. With a rising share of renewables in the EU's energy sector, there will also be a positive effect on the terms of trade for the EU, as the price of oil and gas is bound to fall in a situation in which credible commitment of European policymakers has been given to encourage expansion of renewables in the medium-term. Sustained green technological progress could contribute to both economic growth and a more stable climate. One may also point out that the global leader in innovativeness in the information and communication technology sector, offers many examples of leading firms (including Google, Deutsche Telekom, SAP and many others) whose top management has visibly emphasized the switch to higher energy efficiency and to using a higher share of renewable energy.

Given the fact that the transatlantic banking crisis has started to destabilize many countries in the South in 2008/2009, one should keep a close eye on adequate reforms in the international banking system – prospects for environmental sustainability are dim if stability in financial markets in OECD countries and elsewhere could not be restored.

There is a host of research issues ahead. One question – that can already be answered – concerns the stability of weights over time used in the construction of the comprehensive composite indicator. While the weights for every year have been calculated independently, one could get further insights if a single set of weights over all years is calculated. Considering the results shown in the table below, it is not straightforward that it is possible to calculate such a common set of weights for the available data. Making such a calculation, this results in weights with a distribution similar to those for the years 2006 and 2007.

In 2000, the main weight in the construction of the indicator lies in the savings rate and the SoRRCA, whereas the VolRCA only plays a marginal role. By contrast, in 2006/2007, all three indicators show similar weights, with a slight dominance by

Table 2.2 Estimated weights from factor analysis

	2000	2006	2007
(3)	0.01	0.29	0.30
(7)	0.50	0.39	0.38
(B)	0.50	0.32	0.31

Own calculations

the savings rate. In light of these findings, one might conclude, – based on exploitation of more data (as those are published) – that the empirical weights converge to a rather homogenous distribution. There is quite a lot of room left for conducting further research in the future. However, the basic finding emphasized here is that the variables used are very useful in a composite indicator (Table 2.2).

With the weights derived from factor analysis we can present our summary findings in the form of two maps (with grey areas for countries with problems in data availability). There is a map for 2000 and another map for 2007 – with countries grouped in quantiles (leader group = top 20% vs. 3 × 20% in the middle of the performance distribution and lowest 20% = orange). The map shows the EIIW-vita Global Sustainability Indicator for each country covered which is composed of the following subindices:

- Genuine savings rate (3)
- Volume-weighted green international competitiveness (7)
- Relative share of renewable in energy production (B)

Indonesia has suffered a decline in its international position in the period 2000–2007 while Germany and USA have improved their performance; compared to 2000, Iran in 2007 has also performed better in the composite indicator in 2007. China, India and Brazil all green, which marks the second best range in the composite indicator performance. The approach presented shifts in the analytical focus away from the traditional, narrow, perspective on greenhouse gases and puts the emphasis on a broader – and more useful – Schumpeterian economic perspective. While there is no doubt that the energy sector is important, particularly the share of renewables in energy production, a broader sustainability perspective seems to be adequate (Fig. 2.8).

2.4 Policy Conclusions

There is a broad international challenge for the European countries and the global community, respectively. The energy sector has two particular traits that make it important in both an economic and a political perspective:

- Investment in the energy-producing sector is characterized by a high capital intensity and long amortization periods, so adequate long-term planning in the private and the public sectors is required. Such long term planning – including financing – is not available in the whole world economy; and the Transatlantic

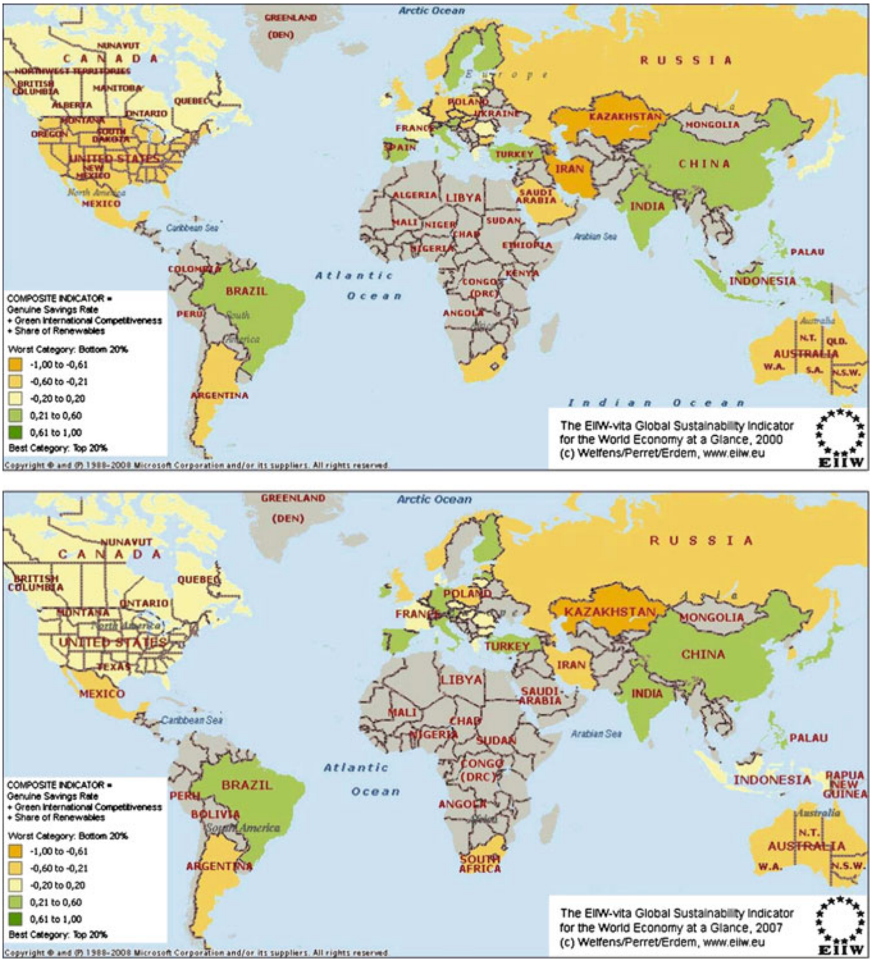

Fig. 2.8 The EIIW-vita global sustainability indicator (see http://www.eiiw.eu)

Banking Crisis has clearly undermined the stability of the international financial system and created serious problems for long term financing. Thus, the banking crisis is directly undermining the prospects of sustainability policies across many countries.

- Investments of energy users are also mostly long-term. Therefore, it takes time to switch to new, more energy-efficient consumption patterns. As energy generation and traffic account for almost half of global SO_2 emissions, it would be wise to not only focus on innovation in the energy sector and in energy-intensive products, but to also reconsider the topic of spatial organization of production. As long as transportation is not fully integrated into CO_2 emission certificate trading, the price of transportation is too low – negative external global warming effects are not included in market prices. This also implies that international trading patterns are often too extended. Import taxes on the weight of imported products might be a remedy to be considered by policymakers, since emissions in the transportation of goods are proportionate to the weight of the goods (actually to ton kilometers).

One key problem for the general public as well as for policymakers is the inability of simple indicators to convey a clear message about the status of the quality of environmental and economic dynamics. The traditional Systems of National Accounts does not provide a comprehensive approach which includes crucial green aspects of sustainability. The UN has considered several green satellite systems, but in reality the standard system of national accounts has effectively remained in place so that new impulses for global sustainability could almost be derived from standard macroeconomic figures. The global sustainability indicators presented are a fresh approach to move towards a better understanding of the international position of countries, and hence, for the appropriate policy options to be considered in the field of sustainability policies. International organizations, governments, the general public as well as firms could be interested in a rather simple consistent set of indicators, that convey consistent signals for achieving a higher degree of global sustainability. The proposed indicators are a modest contribution to the international debate, and they could certainly be refined in several ways. For instance, more dimensions of green economic development might be considered, and the future path of economic and ecological dynamics might be assessed by including revealed comparative advantages (or relative world patent shares) in the field of "green patenting". The new proposed indicators could be important elements of an environmental and economic compass, that suggest optimum ways for intelligent green development.

The Global Sustainability Indicator (GSI) provides broad information to firms and consumers in the respective countries and thus could encourage green innovations and new environmental friendly consumption patterns.

The GSI also encourages governments in countries eager to catch up with leading countries to provide adequate innovation incentives for firms and households, respectively. This in turn could encourage international diffusion of best practice and thereby contribute to enhanced global sustainability in the world economy.

The Copenhagen process will show to what extent policymakers and actors in the business community are able to find new international solutions and to set the right incentives for more innovations in the climate policy arena. There is no reason to be pessimistic, on the contrary, with a world-wide common interest to control global warming there is a new field that might trigger more useful international cooperation among policymakers in general, and among environmental policies, in particular. From an innovation policy perspective there is, however, some reason for pessimism in the sense that the Old Economy industries – most of them are highly energy intense – are well established and have strong links to the political system while small and medium sized innovative firms with relevant R&D activities in global climate control typically find it very difficult to get political support. Thus one should consider to impose specific taxes on non-renewable energy producers and use the proceeds to largely stimulate green innovative firms and sectors, respectively. Competition, free trade and foreign direct investment all have their role in technology diffusion, but without a critical minimum effort by the EU, Switzerland, Norway, the USA, China, India, the Asian countries and many other countries it is not realistic to assume that a radical reduction of CO_2 emissions can be achieved by 2050. Emphasis should also be put on restoring stability in the financial sector and encouraging banks and other financial institutions to take a more long term view. Here it would be useful to adopt a volatility tax which would be imposed on the variance (or the coefficient of variation) of the rate of return on equity of banks (Welfens 2008, 2009).

It is still to be seen whether or not the Copenhagen process can deliver meaningful results in the medium-term and in the long-run. If the financial sector in OECD countries and elsewhere remains in a shaky condition, long-term financing for investment and innovation will be difficult to obtain in the marketplace. This brings us back to the initial conjecture that we need a double sustainability – in the banking sector and in the overall economy. The challenges are tough and the waters on the way to a sustainable global economic-environmental equilibrium might be rough, but the necessary instruments are known: to achieve a critical minimum of green innovation dynamics will require careful watching of standard environmental and economic statistics, but it will also be quite useful to study the results and implications of the EIIW-vita Global Sustainability Indicator.

2.5 Appendix: Eigenvalues and Components (Fig. 2.9)

	2000											
	RCA normal						MOD RCAVOL					
	with CO2			without CO2			with CO2			without CO2		
	without SoR	with SoR	with SoRRCA	without SoR	with SoR	with SoRRCA	without SoR	with SoR	with SoRRCA	without SoR	with SoR	with SoRRCA
EV1	2.151	2.252	2.427	1.516	1.602	1.786	1.682	1.856	2.033	1.014	1.283	1.432
EV2	0.520	0.969	0.796	0.484	0.969	0.792	0.996	1.044	1.008	0.986	1.006	1.000
EV3	0.328	0.451	0.449		0.429	0.422	0.323	0.777	0.636		0.711	0.568
EV4		0.328	0.328					0.323	0.323			
VolRCA	0.796	0.746	0.731	0.871	0.784	0.754	0.163	0.081	0.097	0.712	-0.148	0.015
SavingsRate	0.867	0.869	0.863	0.871	0.882	0.869	0.904	0.872	0.867	0.712	0.783	0.846
SoRRCA		0.412	0.628		0.457	0.681		0.564	0.719		0.805	0.846
CO2emissions	-0.876	-0.878	-0.868				-0.915	-0.878	-0.869			
	2006											
	RCA normal						MOD RCAVOL					
	with CO2			without CO2			with CO2			without CO2		
	without SoR	with SoR	with SoRRCA	without SoR	with SoR	with SoRRCA	without SoR	with SoR	with SoRRCA	without SoR	with SoR	with SoRRCA
EV1	1.701	1.791	2.004	1.378	1.441	1.621	1.621	1.519	1.730	1.236	1.243	1.387
EV2	0.693	0.942	0.794	0.622	0.939	0.759	0.759	1.112	0.998	0.764	1.071	0.937
EV3	0.605	0.677	0.629		0.620	0.620	0.620	0.708	0.682		0.686	0.676
EV4		0.590	0.573					0.662	0.590			
VolRCA	0.782	0.738	0.721	0.830	0.785	0.771	0.771	0.434	0.407	0.786	0.726	0.590
SavingsRate	0.743	0.715	0.679	0.830	0.803	0.756	0.756	0.757	0.704	0.786	0.821	0.795
SoRRCA		-0.430	0.684		0.425	0.675	0.675	0.454	0.708		0.207	0.638
CO2emissions	-0.733	-0.742	-0.745					-0.743	-0.753			
	2007											
	RCA normal						MOD RCAVOL					
	with CO2			without CO2			with CO2			without CO2		
	without SoR	with SoR	with SoRRCA	without SoR	with SoR	with SoRRCA	without SoR	with SoR	with SoRRCA	without SoR	with SoR	with SoRRCA
EV1	1.635	1.743	1.974	1.386	1.468	1.667	1.439	1.502	1733.000	1.279	1.288	1.458
EV2	0.760	0.927	0.808	0.614	0.918	0.722	0.883	1.109	0.987	0.721	1.053	0.897
EV3	0.605	0.727	0.621		0.614	0.611	0.678	0.732	0.679		0.658	0.645
EV4		0.603	0.598					0.658	0.601			
VolRCA	0.785	0.742	0.725	0.832	0.792	0.776	0.664	0.521	0.482	0.800	0.750	0.633
SavingsRate	0.746	0.705	0.679	0.832	0.789	0.755	0.780	0.753	0.707	0.800	0.826	0.798
SoRRCA		0.472	0.716		0.467	0.703		0.434	0.717		0.211	0.649
CO2emissions	-0.679	-0.687	-0.690				-0.624	-0.689	-0.698			

Fig. 2.9 Eigenvalues and components

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