THE SIGNIFICANCE OF GLOBAL RESOURCE AVAILABILITY TO SWISS COMPETITIVENESS

Final report

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Executive Summary

This study was commissioned by the Federal Office for Spatial Development (ARE), as lead agency, in collaboration with the Federal Office for the Environment (FOEN), the Swiss Federal Statistical Office (SFSO), the Federal Office for Agriculture (FOAG), the Swiss Agency for Development and Cooperation (SDC), and the State Secretariat for Economic Affairs (SECO).

The objective of this study is to establish, in general terms, the importance to Swiss competitiveness of current global trends in resource consumption and reserves. The relevance of the declining availability of natural resources to Switzerland, as a business location, is examined from both a biophysical and an economic perspective. The study is intended as an input paper for the *Dialog Nachhaltige Entwicklung Schweiz* ("Dialogue on Sustainable Development in Switzerland") event in September 2014. With this in mind, it does not constitute a conclusive treatment of the subject, but instead is intended to spark debate.

From the biophysical perspective, the availability of resources is measured in terms of ecologically productive area (biocapacity), a measure which syntheses the supply and consumption of resources for a given country. The analysis of global resource trends shows that, since the 1970s, human demand for resources has exceeded the supply which the earth's ecosystem is able to replenish, resulting in a biocapacity deficit at the global level. Resource availability is thus declining world-wide.

Many countries are likely to experience natural resource-related problems in the not-too-distant future, especially low-income countries. Compared to 13 other countries, Switzerland itself is not as "best-in-class" as is often assumed. The country faces risks which must be taken seriously. Firstly, Swiss citizens' share of global income is falling, owing to the much sharper rise in incomes in emerging markets, reducing Switzerland's relative purchasing power on resource markets. Secondly, the country is also affected by risks stemming from dysfunctional global resource markets. In this respect Switzerland, as a small power refraining from political alliances, may find itself on a difficult path in a more conflict-stricken world. And such a world may come earlier than expected because of the increasing biocapacity bottleneck.

In view of its robust economic position, its resource-efficient technologies and its trading options, Switzerland can be seen as less vulnerable than other countries to resource shortages. That said, it is heavily dependent on import and exports on both the production and consumption sides, and currently trades primarily with countries which are also running biocapacity deficits. If resources become less available on global markets, the Swiss economy may face growing risks in both its supplier and its export markets. Global expansion in the overall carbon footprint also increases the danger of reaching tipping points, i.e. changes which may have a fundamental effect on the earth's climate.

From the economic perspective, the study examines resource use and efficiency at sector level, as well as the quality of Switzerland's locational factors in an international comparison.

The sector analysis concentrates on the availability of energy, CO_2 and critical materials. CO_2 is regarded as a good with limited availability, because statutory thresholds or guidelines effectively limit the environment's capacity to absorb emissions and waste products. Compared with its peer group, the Swiss economy is in an excellent position with regard to energy intensity and CO_2 emissions. This means that, at present, the various sectors of the Swiss economy are likely to be more resistant to problems with the availability of natural resources than economic sectors in other countries. In contrast, the availability of critical materials, such as rare earths, has the potential to threaten Swiss competitiveness. Critical materials are essential components of modern technologies in sectors which are expected to become increasingly important within the Swiss economy as a whole.

Switzerland is also highly competitive when it comes to locational appeal (the availability of natural resources, infrastructures, innovation and efficiency, regulation and quality of life and the environment), but this applies first and foremost to competitiveness in the here and now. A peer comparison of changes in individual indicators over time shows that Switzerland has made less progress in recent years, especially on innovation and efficiency. The picture deteriorates still further when expenditure on foreign raw materials is factored in. There are indications that Switzerland has outsourced particularly raw material-intensive production stages abroad. However, this does not ultimately improve its raw material productivity.

All in all, it becomes clear that a nuanced view must be taken of Swiss competitiveness. Switzerland currently enjoys an excellent competitive situation, which is reflected in its robust economic position, its resource-efficient technologies, its trading opportunities, its efficient sector mix, and its outstanding locational factors. The country will therefore continue to succeed for longer than other countries as resources become scarcer. Significantly faster progress – on efficiency, for example – is nonetheless required to secure this competitiveness in the long term. Furthermore, as a small and open economy, Switzerland depends heavily on imports and exports. It will be able to maintain its high level of competitiveness in the long term only if it works alongside importing nations and export markets, along the entire length of the value chains concerned, and in doing so factors in grey energies and emissions. This would require reengineering on a broader scale to create a green economy for Switzerland.

The efficient management of natural resources can be achieved only over a long time horizon, and is thus very much path-dependent. Switzerland must invest considerable time and energy in examining the options for the future, so that it chooses the right path. There are essentially six options for how Switzerland might act: "business as usual", "retreat from the world", "engage in hypergrowth", "hedge your bets", "extreme reengineering right now", and "sustainable economic practices and global responsibility – the green economy". All of these options have far-reaching consequences. Some of them are mutually exclusive, while others might be combined. Switzerland has a number of paths open to it. The challenge is to find a forward-looking, feasible policy for handling limited natural resources.

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1 Introduction

Rising resource use world-wide means that the availability and scarcity of those resources is increasingly becoming an issue in the national and international political arenas, as well as in the business community (Federal Council 2009, Federal Council 2013A, Federal Council 2013B, Federal Council 2013C). For example, as the debate on climate change has highlighted, resource consumption in many areas has increased to levels which are no longer ecologically harmless. This problem is being exacerbated by continued growth in demand for energy and materials around the world. There are no signs at all so far of a reversal in this trend. There are a number of reasons behind the rising global need for natural resources: an expanding global population; rapid economic growth in emerging economies, and many low-income countries playing a resource-intensive game of catch-up; technical progress and new product developments, in particular; and resource-intensive lifestyles and economic practices in industrialised nations.

This study asks: what effect might current trends in resource consumption and reserves have on the competitiveness of the Swiss economy?

Several political and scientific discussions about resource policy and economic output are currently ongoing. These can be summarised as follows (cf. Jacob et al. 2012): resource policy to ensure raw material supplies; resource policy as a driver of ecological modernisation; resource policy to respect the natural limits of the planet; and resource policy as a criticism of the prevailing economic system.

These debates reveal the spectrum of different – sometimes contradictory – assessments and expectations with regard to future economic developments and the corresponding resource policies: from securing access and the availability of "cheap" resources, to increases in resource prices to stimulate innovation (resource consumption management), and the vision of a reduction in consumption in absolute terms.

In market economies, prices serve as instruments of valuation and allocation. In the case of natural resources, a variety of problems – such as exogenous effects, or the nature of those resources as public goods, etc. – result in price distortions and thus the misallocation of those resources. There is broad debate, and many academic works, about the economic consequences of this misallocation, or about how it might be remedied by environmental conservation measures, for example. Beyond this, the literature examines the effects that individual measures might have on global economic growth, or on a specific country. They generally focus on a single measure or resource, such as crude oil, the climate, biodiversity, raw materials, etc.

However, to date there has been no comprehensive study on the importance of resources to the competitiveness of the Swiss economy overall. There is also a general lack of concepts of competitiveness which factor in natural resources. A further problem is that there is no standard, generally recognised tool with which to measure the supply and the consumption of resources. Considerable difficulty is also attached to forecasting the supply and consumption of resources in the future.

This study addresses the problems described above in a number of ways:

- It considers the different perspectives and opinions on the resource problem in the business, political and research spheres, by looking at the relevance of natural resources to Swiss competitiveness from both the biophysical and the economic points of view.
- It uses the concept of the Ecological Footprint as a synoptic measure of biophysical resource supply and consumption both globally and in Switzerland. There are a number of approaches to estimating resource consumption and its impact on the environment, each with different methods and areas of focus, and each with its own pros and cons (cf. Frischknecht et al. 2013). The Ecological Footprint is one of these metrics, and it has earned itself a high reputation in recent years. The Footprint is verified by a number of different countries, including Switzerland, and has been adopted by the Swiss Federal Statistical Office as part of the MONET system of indicators for sustainable development. The concept of the Ecological Footprint is therefore used in this study as a

measure that will permit biophysical resource supply and consumption in Switzerland and worldwide to be examined. Furthermore, the Footprint permits an international comparison of resource availability and resource use.

- Applying a concept of competitiveness which factors in natural resources, Global Footprint Network documents trends in the resource situation, and interprets their possible consequences at the macroeconomic level. BAKBASEL uses this model to study Switzerland's competitiveness at the sector level, as well as the quality of the country's locational factors, in the international context.

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The report is structured as follows:

Section 2 introduces the key terms associated with the field of natural resources, and presents the concept of competitiveness that is applied in this report. It also introduces the peer countries used in the international comparison, and explains the reasons for selecting these countries.

Section 3 discusses the importance of resource availability to past economic growth in Switzerland and in an international context. It also examines the decline in resource availability in the future.

Section 4 documents global resource trends using biocapacity as a measure, and discusses their potential impacts on Switzerland. It looks into the way in which ecological limitations change conditions on the market, and the extent to which these changes will affect Switzerland.

Section 5 examines Swiss competitiveness in relation to resource availability at the sector level. It focuses primarily on three "resources": energy, emissions (CO_2), and critical materials. It then goes on to discuss the quality of the factors which make Switzerland an appealing business location, and compares these with other countries. This section concludes with a detailed synopsis of the results of a SWOT analysis of Swiss competitiveness.

Section 6 summarises the findings of the previous two sections.

Finally, Section 7 sets out possible options for Switzerland as natural resources become ever more scarce. It should be regarded as a basis for future discussion on how to deal with declining reserves of such resources, and thus covers a broad spectrum of possibilities.

2 Terms and concepts

2.1 Natural resources in the economy

In both classical and neoclassical economic theory, natural resources form global natural capital, which is the basis of all economic activity and the foundation for daily life, and thus welfare. Natural resources include both tangible goods such as raw materials, land and water, and "intangibles" such as clean air, fertile soil and, above all, biodiversity (Federal Council 2013B). The economy needs, and consumes, natural capital (renewable and non-renewable resources such as raw materials, soil/land area, water, air, foodstuffs and energy) to generate value. The use of natural resources in production or consumption also impacts on the environment, by releasing greenhouse gases, causing noise and pollutant emissions into the air, water and soil, and by damaging ecosystems and biodiversity.

Natural capital is one of the inputs into national value-creation. It can be distinguished from human capital, physical capital, and the level of technical advancement. All four capital stocks are important input factors in to country-specific production functions:

$$Y = f(K, L, N, A),$$

where Y = output,

K = capital stock,

L = human capital,

N = natural capital, and

A = level of technical advancement.

Economic output thus depends not only on natural capital, but also on other capital stocks such as human and financial capital, for example. There is at least a limited degree of substitutability between these capital stocks. It is also assumed that the individual stocks can be increased through investment. For example, investment can raise the level of technical advancement. Innovation, and process-related innovations, in particular, may reduce the consumption of resources. Consequently, declining resource consumption does not necessarily have to go hand in hand with a decline in economic output. Human and physical capital, as well as the level of technical advancement, can be substituted at least to some extent for natural capital.

Scarcity is not a problem in economic theory. If the supply of a good falls, its price rises, resulting in its efficient usage and optimum resource allocation. The exhaustion of a resource in its entirety is an extreme form of scarcity. Whether and within what time frame a resource will be exhausted depends on the price trend for the individual resource, how and to what degree it is recycled, the availability of alternative technologies and substitute resources, and on global growth.

Certain conditions must nonetheless be met for a natural resource to be used in the optimum way (Bretschger et al. 2010). If the market is to manage the use of natural resources efficiently, there must be perfect markets (complete information and pure competition), and the resources must actually be traded on these markets as private goods. This is not always the case, neither can this model be applied to all types of natural resource. That is why markets may fail in a variety of ways where natural resources are concerned, often resulting in overshoots and losses of welfare.

2.2 Competitiveness and natural resources

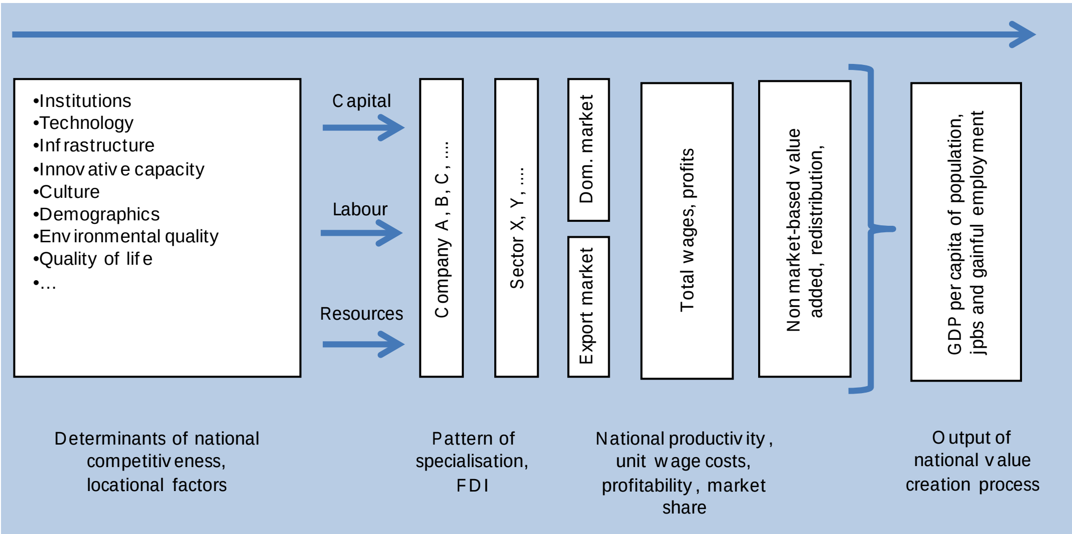
A new approach is required to evaluate Switzerland's competitiveness from the particular perspective of the significance of natural resources. This report first presents a model of competitiveness, and then explains the role that natural resources play within it.

A country is regarded as competitive if it is able to ensure a high degree of, and growth in, prosperity, especially when compared to other countries. Thus, competitiveness is not an end in itself, but rather a concept used to synthesise a large number of different determinants of economic success. It centres on the level and momentum of national economic value-creation in comparison with other countries (cf. Fig. 2-1).

Actual success, i.e. economic prosperity and growth, is ultimately determined by the sum of individual enterprises within a given country: the microeconomic perspective. How well an enterprise can assert itself on the market, not least in comparison with (potential) competitors, is thus one of the first key questions that must be asked. A company is highly competitive either if it is able to produce comparable products at a much lower cost than other providers (competitive advantages from efficiency and productivity), or if it is able to offer the market products for which there is a particularly high demand (competitiveness through innovation).

At the meso level, competitiveness is determined by the sector structure of a country's national economy, i.e. that economy's pattern of specialisation. Since competitiveness also differs from sector to sector, a country's specific sector mix forms the basis of its national competitiveness overall.

Fig. 2-1 Competitiveness as a value-creation process at national level



Source: BAKBASEL, modelled on Cambridge Econometrics (2002)

In principle, it is possible to increase the competitiveness of a nation's economy by working more (and more productively), by employing more capital or by using the factors of labour, capital and natural capital more efficiently as a result of technical advancement. Overall, a country's competitiveness at the macroeconomic level is a product of the "efficient use of all factors of production" (Weder 2001). A country's competitiveness can thus also be measured in terms of the productivity of these individual factors of production. There are also other factors which determine national competitiveness. These determinants, or locational factors, characterise the specific qualities of individual locations within their geographical contexts (Kulke 2009). This refers to the aggregate of all material and immaterial influences on a particular location. These can be divided into hard factors – influences quantifiable in monetary units which have a direct bearing on companies' costs and income (taxes, availability of resources, etc.) – and soft factors, which are qualitative influences with an indirect effect on businesses and those who work in them (cultural offer , available education, etc.)

Locational factors, or determinants of competitiveness, may be understood collectively as the pros and cons of a given country as a base for economic activity. They determine the availability of, restrictions on, and quality of capital, labour and natural resources as factors of production. While capital is highly mobile, and labour mobility has also increased, it may be assumed that both of these factors of production depend very much on the prevailing investment climate and the appeal of a given country, so that enterprises and workers relocate, and remain. A country's investment climate rests on a whole series of factors. The main ones in this context are infrastructure and accessibility, the availability of labour, and a productive environment. These conditions depend in turn on a range of softer factors such the institutional framework, the degree of internationalisation, technology and innovation, and quality of life and the environment.

In summary, a nation's competitiveness depends on a number of different influences which determine economic success, i.e. the level and growth of gross value added. A country's economic capacity in comparison with that of others rests on the quality of its locational factors, and that country's specific sector mix.

What role do natural resources play in competitiveness?

The use of natural resources plays a key role in the use of capital in the production process. A country's economic capacity can be increased through the greater and/or more efficient use of factors of production. Resource scarcity can therefore impact negatively on the production process, while improvements in resource efficiency can release new growth potential.

To ensure a country's long-term competitiveness, it is therefore important to secure its economic capacity by using resources more efficiently, rather than depleting its capital stocks. This is also in line with the sustainability ethos, which is why it may be referred to as "sustainable competitiveness" (cf. WEF 2013B) or "sustainable industry" (cf. EU Member States' Competitiveness Performance and Policies 2012). Switzerland's competitiveness will be discussed from this perspective in Section 4, using the concept of the Ecological Footprint.

A national economy's particular pattern of specialisation tends to determine the intensity of its demands on natural resources. An economy that is strongly geared to heavy industry will use more natural resources than an economy which has become specialised in the service sector. In addition to the pattern of specialisation, the various sectors of the economy also display differing levels of productivity and efficiency in their use of natural resources. When natural resources are factored in, patterns of specialisation and the resource efficiency of individual sectors thus play a key role in the competitiveness of the country concerned. The pattern of specialisation and its effect on Swiss competitiveness are examined in Section 5.1.

These are not the only factors, however. The efficient use of factors of production also demands functioning, flexible labour, capital and resource markets. If these do not exist, resources will be misallocated, and competitiveness impaired. The determinants of competitiveness – locational factors and operating framework – are key in helping to ensure optimum resource allocation and thereby securing competitiveness. Natural resources are the foundation of human life and economic activity, provide services for humans, the economy and society, and thus constitute an important locational factor in themselves – that of the environment. Natural resources also play a prominent part in countless other locational factors. Regulation of the product, labour and resource markets, as well as state action on environmental conservation, both feed in to the "state and regulation" locational factor. Accessibility is a major element of infrastructure as a locational factor. Meanwhile, access to and the availability of factors of production covers access to natural resources, the level and stability of resource prices, as well as the availability of human capital. This latter factor is dependent in turn on quality of life. One aspect of quality of life is environmental quality. The quality of Switzerland as a business location is discussed in Section 5.2.

2.3 Switzerland and its benchmarking regions

Switzerland can be divided into three large regions, each with its own characteristic landscape: the Jura, the densely-populated *Mittelland*, and the Alps and their foothills. At the end of 2013, the country had a permanent resident population of 8,136,689 in total. Counting 201 inhabitants per km^2, Switzerland is one of the more densely populated countries in Europe. Its gross domestic product (GDP, adjusted for purchasing power) of USD 47,863 per capita, puts it in eighth place world-wide[1].

The key aspect of any benchmark study is the selection of the peer group. This report covers regions with similar socio-economic indicators (population density, GDP per capita), regions displaying a variety of economic systems (very liberal, more heavily regulated, and very heavily regulated with a strong emphasis on welfare), and regions covering a certain spectrum of geographical features (size, resource-availability). In addition to the countries shown in the table below, Norway and Chile are included additionally in the biophysical analysis owing to their biocapacity surpluses.

Tab. 2-1 Benchmarking regions in Switzerland

Region	Selection criterion: similar features
Belgium	Size, economic system
Denmark	Size, economic system, population density, GDP per capita
Germany	Economic system, population density
United Kingdom	Economic system
Ireland	Size, population density, GDP per capita
Italy	Population density
Netherlands	Size, economic system, population density, GDP per capita
Austria	Size, economic system, population density, GDP per capita
Sweden	GDP per capita
Czech Republic	Size, population density
United States of America	GDP per capita, economic system

Source: BAKBASEL

[1] International Monetary Fund, World Economic Outlook Database, April 2014, PPPPC

3 Future resource availability and bottleneck factors

3.1 Economic growth and the decline in resource availability since 1950

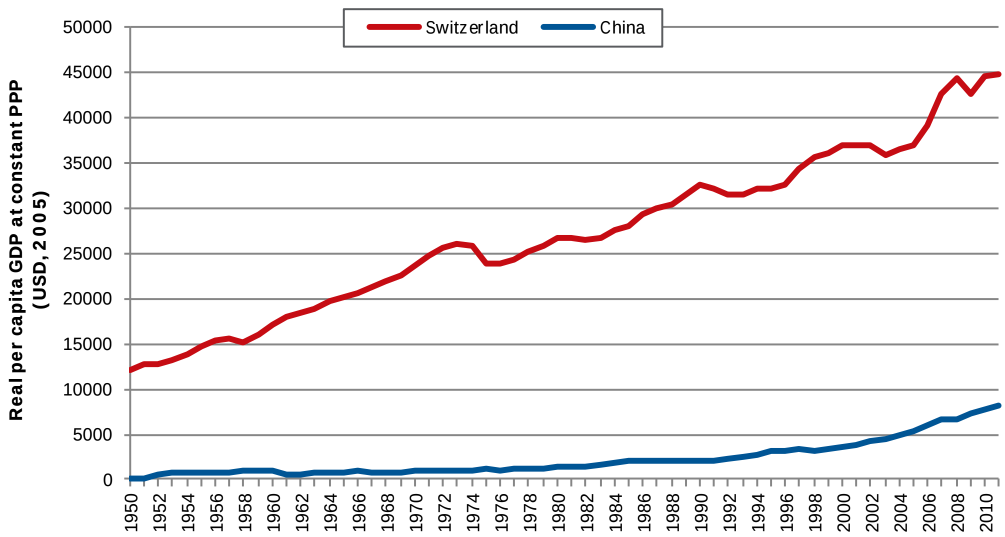
Abundance in available natural capital enabled industrial economies to expand rapidly following World War II. Can we expect resource abundance in the future? Or might future economic expansion be hampered by less available natural capital?

Access to bioproductive resources – food, fibre, and timber – has been a limiting factor to humanity in the past. Extreme cases of protracted resource shortages brought about the collapse of entire civilisations, including old Eurasian empires, as well as the Mayan and Easter Island civilisations (Turchin and Nefedov 2009, Diamond 2008, Chambers, Simmons and Wackernagel 2000). In contrast, the coal-driven first Industrial Revolution, in the mid-18th century, and the oil-driven second industrial revolution, from the mid 19th century, almost set aside resource limitations. Ever since, humanity has consistently overcome the constraints of local ecosystems, escaping the common predator-prey, rise-and-decline population dynamics of the past (Motesharrei et al. 2014). The world order created after World War II further expanded global trade. This trend has been even more marked since the end of the Cold War, dramatically easing access to distant resources. As a result, resources ceased to be a limiting factor for most economies.

Building on Ricardo's propositions, standard economics suggests that a country can make up for a lack of resources on its home soil by trading with other, better-endowed countries, to the final advantage of both. In the case of repeated resource shortages, commodity prices would increase so that the frontiers of extraction are expanded by replenished economic reserves and new technologies. The process of industrial substitution, by means of innovative solutions, is taking place in parallel. According to standard economic theory, the aforementioned mechanisms will keep an ever-increasing flow of natural resources moving through international markets and fuelling the global economic engine (Ridley and Ganser 2010). In Schumpeterian terms, this is creative destruction, keeping the economy in a state of flux (Schumpeter 1942).

The promise of neoclassic economics delivered handsomely in the less populated, less affluent world of that time, frozen by the Cold War. The fall of the Berlin Wall then reset globalisation. However, a variety of sources suggest that the consequences of undervaluing the ecological cost of resources, and even accelerating their use in the form of fossil fuel subsidies, have yet to come.

Fig. 3-1 Economic boom after WWII exemplified by average incomes in Switzerland and China



Source: Feenstra et al. (2013)

Per-capita 2010 GDP in Switzerland is four times that of 1950. In China, it is 30 times higher. Rising incomes have been driving the materials throughput of both economies.

Switzerland capitalised on these favourable international circumstances and experienced unprecedented economic expansion until the first global oil crisis. There have been regular resurgences of resource insecurity ever since, such as the 2008 price hikes in agricultural commodities, accelerated by increased biofuel production in the US and the EU (Mitchell 2008). Despite this, issues surrounding resource availability still remain at the margins of discussions on national competitiveness, even though the World Economic Forum recently acknowledged ecological constraints and resource access as a growing global risk (WEF 2014). Sometimes, as in the case of Switzerland, conventional wisdom even construes the absence of substantial natural resource endowments as a blessing in disguise, since it leads to additional, compensatory investment in human capital (Straumann 2014).

With national accounts for natural resources now receiving increased attention in the light of mounting international pressures on land, it is suggested that foresight in resource management will become an increasingly critical issue in the discussions surrounding national competitiveness. After all, the customary definition of competiveness is *"the total factor productivity of a nation, including natural resources*".

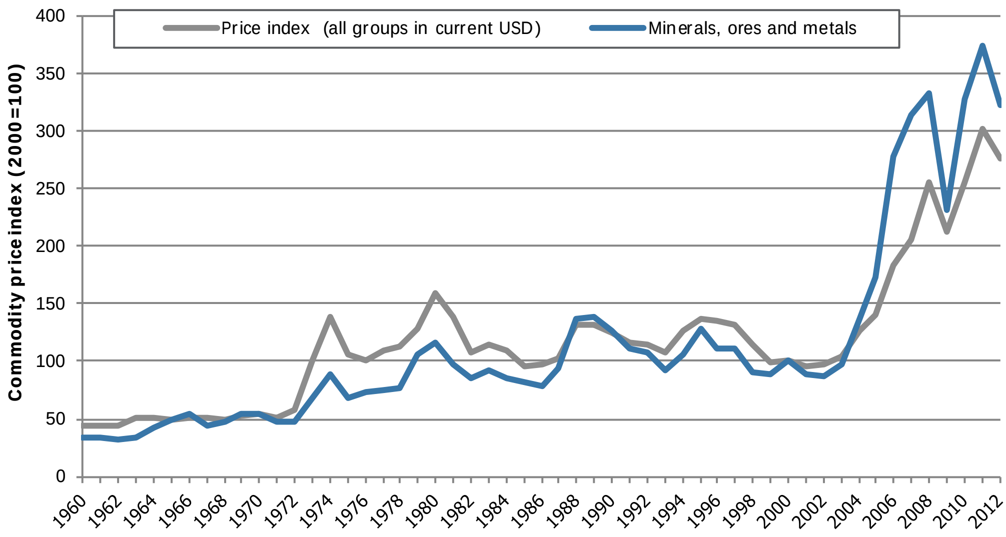
3.2 The next era is likely to be defined by ecological constraints

Human demand for natural capital now exceeds what ecosystems can renew, and the trends are not slowing down. Ever more countries are relying on resource trade. Will this new context define a new economic era? Is resource depletion economically insignificant after all?

Recognising nature's physical limits in economic assessments would be necessary only in a world defined by tightening ecological constraints, and if economies were unable to reverse or counteract these constraints. Are ecological constraints indeed defining a new world? Converging clues point in this direction.

Fig. 3-2 shows a persistent increase in commodity prices after 2001, when China entered the WTO and put all its strength into international trade**.** Soaring resource prices in the 21st century are interpreted by economic agents, if not by the academic literature in general, as mounting evidence of the growing economic scarcity of resources, and of impending shortages. This is not the first time this has happened in the recent past. The 1970s were characterised by a similar sense of emergency about the future availability of natural resources. At that time, resource economist Julian Simon, a figurehead of the Cornucopian school of thought, and the famous population ecologist Paul Ehrlich, often associated with the neo-Malthusian school, made a scientific wager on the development of the prices of an agreed basket of resources over the decade ending in 1990. Ehrlich eventually lost the bet, because the price of the five selected metallic commodities of copper, chromium, nickel, tin, and tungsten, went down during the 1980s, as predicted by Simon. However, despite this earlier victory, it is unlikely that such a wager would be proposed today, even by a seasoned Cornucopian. The bet would be even less likely if the basket included fossil fuels, water and agricultural land.

Fig. 3-2 Commodity price index



Source: UNCTAD (2014)

Meanwhile, consumption trends worldwide are not decoupling in absolute terms from resource throughput, although higher-income economies have achieved considerable progress on resource efficiency thanks to dedicated investment, as well as less resource-intensive spending owing to higher incomes. However, this is still not taking place at a sufficient scale and pace, so overall resource use is not shrinking, or even plateauing, as a result (Lawn and Clarke 2010).

The over-arching question remains whether or not resource depletion is genuinely economically significant in the here and now. Has it ever been so in recent history? One may wonder in hindsight because, for instance, global GDP has resumed growth after two global oil crises, despite increasing evidence and awareness of environmental depletion. Furthermore, global trade volumes have expanded 3.5-fold since the end of the Cold War (WTO 2013), undeterred by mounting signs of ecological scarcity and natural resource depletion.

Some would construe global economic slow-downs, such as the recession that began in 2008 and is still keeping the world behind its economic growth potential, as a type of integrated temporary mechanism which has the beneficial outcome of easing human pressure on scarcer natural resources. This reduced pressure, it is contended, buys time for technological efficiency gains to become stronger and to outpace growing human demand, leading eventually to lower resource throughput. Indeed, were it possible to rely on such apparently self-regulating slumps at the end of each business cycle, it might be claimed that the solution is built into the very framework of market economics. But are these slumps in resource demand the corrections we want, and do they address resource constraints meaningfully enough? Can or should we – for want of better options – rely on these “self-regulating” mechanisms in the decades to come?

Mainstream economics acknowledges market failures in the treatment of public goods, but does not concern itself with whether or not the global economy is operating safely within planetary boundaries (Rockström et al. 2009). This indifference may last until economic analysis sees the world economy as embedded in an finite overall environment with finite fossil fuel deposits. Natural resources cannot be stretched forever. Evidence that the biophysical view is not yet fully acknowledged by mainstream economists is abundant. For instance, William Nordhaus, a prominent figure in economic policy and economic theory in the USA, is not in the least a climate change denier nor a Cornucopist like Julian Simon. However, he foresees only minor natural resource constraints on economic growth up to 2100 (Nordhaus 2013). He believes that the benefits of economic expansion over the next 90 years will far exceed and compensate for the losses climate change might impose. So, what new lenses and risk assessments are needed to more fully map the production factors of an economy, and help identify pathways out of this conundrum?

National Footprint Accounts, a macro database spanning the last half-century, are an attempt to bridge this gap in today's economic assessments. These accounts of natural resources measure the biologically productive area of the earth, or of any country or region, in a given year, and compare it with the biologically productive area demanded by people to maintain their consumption of materials in the same year. This demand includes the food, fibre, and biomass they consume, as well as capacity to absorb waste, specifically CO_2 emissions from the use of fossil fuels. We might could say that this accounting tool provides a form of profit and loss statement of the earth's ecological services.

Box 1: Biocapacity explained

GRAZING LAND

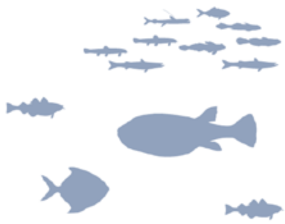
The area of grassland used, in addition to crop feeds, to raise livestock for meat, dairy, hide and wool products.

CROPLAND

The area required to produce food and fiber for human consumption, feed for livestock, oil crops and rubber.

FISHING GROUNDS*

The area of marine and inland waters used to harvest fish and other seafood.



FOREST LAND

FOR PRODUCTS

The area of forest required to support the harvest of fuel wood, pulp and timber products.

FOR SEQUESTRATION

The forest area required to sequester human-produced CO_2 emissions, primarily from fossil fuels burning, that are not absorbed by oceans.

BUILT-UP LAND

The biologically productive areas covered by human infrastructure, including transportation, housing and industrial structure.

Biocapacity is a measure of the amount of biologically productive land and sea area available to provide the ecosystem services that humanity uses. We might refer to it as the supply side of our ecological budget. It is nature's regenerative capacity (Borucke et al. 2013). Biocapacity varies over time, driven by changes in management practices, agricultural inputs, water supply, climate and soil conditions. Overuse can also degrade biocapacity. The amount of biocapacity available per person declines as populations increase more rapidly than ecosystem productivity. For centuries, we have treated biocapacity as a provider of an essentially limitless flow. Today, however, humanity's demand for biocapacity outstrips global supply by more than 50 percent.

Five components of biocapacity serve six human demands, or Footprint components:

FISHING GROUNDS
The area of marine and inland waters used to harvest fish and other seafood.

GRAZING LAND
The area of grassland used, in addition to crop feeds, to raise livestock for meat, dairy, hide and wool products.

CROPLAND
The area required to produce food and fibre for human consumption, feed for livestock, oil crops and rubber.

FOREST LAND serve two demands:

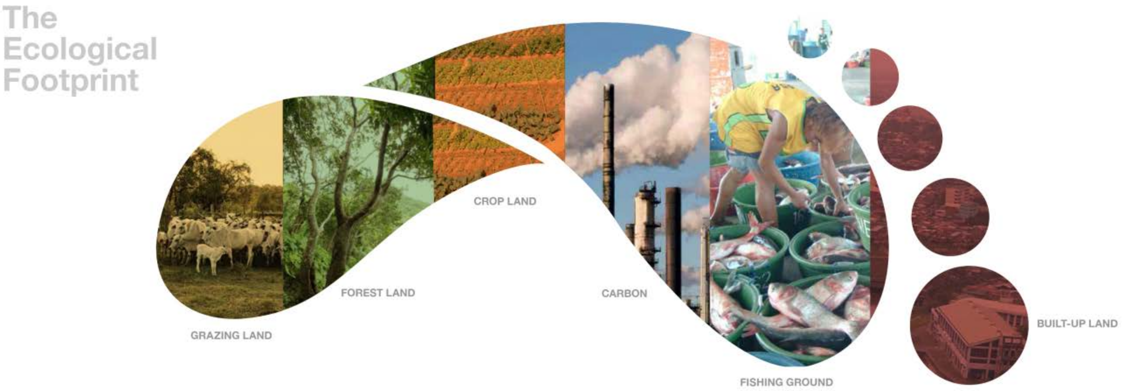
FOREST PRODUCTS FOOTPRINT
The area of forest required to support the harvest of fuel wood, pulp and timber products.

CARBON FOOTPRINT
The forest area required to sequester human-produced CO_2 emissions, primarily from fossil fuel-burning, which are not absorbed by oceans.

BUILT-UP LAND
The biologically productive areas covered by human infrastructure, including transportation, housing and industrial structures.

In a world of growing ecological overshoot – in which humanity's demand for nature's products and services exceed the planet's ability to renew them – this dependence on external biocapacity becomes a significant risk. It means that humanity's economic activities are fuelled by depleting the planet's ecological assets – a strategy that is not sustainable. Cities and countries trapped in energy and resource-intensive infrastructures and economic activities will become fragile. If they cannot minimise their dependence, they will not be able to adapt in time to meet emerging challenges.

Box 2: The Ecological Footprint explained



Biocapacity measures the supply of ecological assets that provide services. In contrast, the Ecological Footprint measures humanity's demand for those assets. The Ecological Footprint is an accounting tool that aggregates this demand. It measures the amount of biologically productive land and sea area required to produce the renewable resources a population (or an activity) consumes and absorb the waste it generates, using prevailing technology and management practices. Because of a lack of globally consistent data sets on waste generation and waste absorption, current national calculations take only carbon dioxide into account on the waste side.

A population's Ecological Footprint can be compared with the biocapacity that is available domestically or globally to support that population, just as expenditure is compared with income in financial assessments. As with financial flows, resources too can be "overspent". If a population's demand for ecological assets exceeds the country's supply, that country is running a biocapacity deficit. Conversely, when demand for ecological assets is less than the biocapacity available within a country's borders, the country has a biocapacity reserve.

A national biocapacity deficit means that a country is importing embedded biocapacity through trade, liquidating its own ecological assets, or turning to the global commons. In contrast with national biocapacity deficits, the global biocapacity deficit cannot be compensated for through trade or by using distant commons. Therefore, by definition global biocapacity deficits are the same as overshoot.

The Ecological Footprint has six components, as explained in the biocapacity box above:

- Crop Footprint
- Grazing Footprint
- Forest products Footprint
- Carbon Footprint
- Fish Footprint
- Built-up Footprint

The idea floated above – that recurrent economic recessions combined with technological improvements create an uncanny mechanism to adjust the global economy to ecological constraints – does not stand up to examination through the Ecological Footprint lens. The total Ecological Footprint of most nations has not contracted sustainably over recent decades. The few cases in which it has contracted have been a reflection of economic calamity, not proactive foresight and adjustment. The *Energiewende*, or shift to renewable energies, in Germany and Switzerland, may be one of the few counter-examples. Declines caused by economic slowdowns rebound following recovery. Even increased efficiency does not seem to generate a lasting reduction in resource demand, mirroring the Jevons paradox (Jevons, 1906). So, indeed, sourcing material inputs worldwide while keeping natural resource amenities at a sufficient level for sustained economic activity is going to be an intricate challenge (Rockström et al. 2009).

The discovery and increased utilisation of fossil fuels temporarily set aside material throughput constraints on ecosystem services (Day et al. 2013, Catton 1982). Emerging climate concerns, as well as increasing efforts to access fossil fuels, point to the possibility of revisiting an age in which ecosystem service constraints are the overarching limitation. Global Footprint Network believes that the future availability of natural resources, i.e. commodities and ecosystem services, will become a far more obvious limiting factor than recognised in the prevailing economic theory during the second half of the 20th century. The reasons are twofold a) biocapacity constraints are masked by the availability of cheap energy (fossil fuels) and b) the impact of carbon emissions from fossil fuel burning and from ecosystem overuse may well jeopardise future biocapacity.

3.3 Which resources might become bottleneck factors for Switzerland?

As emerging economies continue to advance in the future, it is to be expected that their demand for resources will continue to rise. The OECD, for example, predicts that China will be the world's largest importer of crude oil by 2020, and that India will be the largest importer of coal (cf. IEA International Energy Outlook 2013, for example). It may therefore be assumed that prices for energy resources, among others, will increase further. Energy prices are of key importance in particular for sectors such as metals, cement, paper, glass and the oil industry.

Mildner (2011) sets out the factors which may result in resource scarcity. These can be broken down into endogenous (physical characteristics of the resource) and exogenous (economic, social and political) factors, as well as factors on the supply and demand sides.

The concentration of extraction or production on individual countries or companies, as well as political and economic risks affecting those countries, are often cited in the literature as supply-side factors which may result in resource scarcity. The risks associated with resource-extracting countries may also be exacerbated by the "carbon sink problem", i.e. the lack of CO_2 absorption capacity, as a limiting factor. For example, rules and legislation on environmental conservation may restrict the depletion of resources. The EU's MaRess (Material Efficiency and Resource Conservation) project also considers environmental relevance (material costs, raw material costs and energy costs of resource depletion), as well as dissipative usage (heterogeneity in fields of use and products which make recycling more difficult), and reclassifies as problematic raw materials that were once deemed non-critical (Hennicke et al 2009).

In addition to supply challenges, whether or not a raw material is to be classified as critical is also determined by the demand side. A rough estimate of the importance of a resource to the economy may be made in terms of the cumulated share of gross value added generated by those sectors in which the resource is used (cf. EU 2010).

Platinum-group metals (platinum, ruthenium, rhodium and palladium), rare earths, niobium, antimony, tungsten and magnesium are some of the raw materials most often classified as critical or highly critical (cf. Section 5.1.3).

However, current methods are essentially able to evaluate the availability of non-renewable resources only. Soil, air and water, as well as electrical power, for example, are not taken into account. Where the latter resource is concerned, the availability problem is a different one entirely. In theory, electricity from non-renewable resources could be substituted entirely with electricity from renewable sources. Here, however, the availability problem is a weather-dependent one, and is also associated with capacity problems in the power grid.

Company surveys are another, frequently used method of determining the availability risks attached to natural resources. According to a study by Credit Suisse (CS 2012), 42 percent of almost 2,000 participating small and medium-sized enterprises (SMEs) regard natural resources (energy and raw materials) as a significant or even very significant factor influencing their business activities. Companies in the secondary sector see themselves as more heavily affected than those in the service sector. Interesting, in a slightly older survey (CS 2011), it was two areas from the tertiary sector – tourism and entertainment – which took the most negative view of resource scarcity. These two sectors are heavily dependent upon mobility, which in turn is influenced directly by the availability of energy. Surveys in countries neighbouring Switzerland (cf. Commerzbank 2011, for example) and among industrial companies (cf. SWISSMEM 2008 or the *Volkswirtschaft* 2012 report) come to similar conclusions.

Yet these surveys also fail to include the natural resources of soil, water and air, which are not generally marketable. The availability of water to the Swiss economy is judged to be unproblematic. Indeed, the problem may well be too much water (in the form of flooding), rather than too little (Federal Council 2009).

Soil, meanwhile, is regarded as problematic in the public perception. Increasing scarcity creates difficulties for certain sectors, such as agriculture, which is facing a decline in agricultural land area, or tourism, which sees its foundation – Switzerland's stunning landscape – being eroded by urban sprawl. An analysis on the basis of the Ecological Footprint shows that soil (land) is a limiting factor not just in Switzerland, but world-wide. Unfortunately, differences in the availability and scope of data make it impossible to produce a detailed picture that offers an international comparison.

There is scarcely any quantitative information available on biodiversity. There has been no halt to the loss of species, habitats and genetic diversity in Switzerland, however, so that now only isolated communities exist of once-common domestic plants and animals (Umwelt 2013). This loss of diversity of both habitats and species, and thus genetic diversity generally, has far-reaching consequences. The concept of resilience is becoming increasingly important here. Biodiversity loss weakens the general ability of flora and fauna alike to thrive and to regenerate. Robustness, i.e. the ability to withstand stress, is also impaired as biodiversity declines.

Availability risks in connection with air and the climate are emerging primarily as a loss of carbon sinks to absorb emissions. It is almost impossible to calculate the impact of overloading the air and the climate, so the availability of clean air is evaluated indirectly, via the available sinks, i.e. absorption capacity limits determined politically through legislation and restrictions.

The 2013 Global Risks report (WEF 2013A) cites water scarcity, failure to adapt to climate change, and rising greenhouse gas emissions, as the greatest global risks. Three resource-related issues therefore lead the risk rankings. Only major systemic financial failures, chronic fiscal imbalances in national budgets, and the diffusion of weapons of mass destruction are rated as similarly serious.

In summary, it can be said that there may be bottlenecks in a wide range of natural resources in the future. The analysis in this report concentrates first and foremost on the following "resources": biocapacity, energy, carbon sinks ($C0_2$) and raw materials/critical materials.

4 The significance of natural resources to Swiss competitiveness – the biophysical perspective

4.1 The biophysical view of natural resources

Ultimately, biocapacity represents the resource bottleneck in the human economy. How does it relate to fossil fuels and other resources? What have been the demands on biocapacity?

The Ecological Footprint rests on the premise that human and non-human life on this planet is fully dependent on, and limited by, the biosphere's regenerative capacity. This capacity in turn is limited by the planet's surface area. "Limited" in this sense does not mean that technology, inputs or management practices cannot increase (or reduce) this regenerative capacity. Clearly there is some scope for expansion, at least temporarily. Nevertheless, it is increasingly acknowledged that failing to live within nature's budget – the actual amount that nature can regenerate in a given year – will eventually lead to ecological bankruptcy and social collapse (Wackernagel et al. 2002).

This limitation concerns far more resources than just the annually regenerated biomass that is useful to mankind, including the ecological service of anthropogenic carbon uptake. It also indirectly controls access to resources which may be extracted from the lithosphere, i.e. the outer part of the Earth, consisting of the crust and upper mantle, approximately 100 km thick. Indeed, the use of fossil fuels will be more restricted by the planet's biocapacity to cope with its waste than by the underground reserves of such fuels.

For instance, humanity may not only recognise the biocapacity constraints on sequestration, but also act and therefore proactively restrict emissions, and with them fossil fuel use, as advocated by the Secretary General of the OECD[2]. Or it may not, and wait for the time when the physical effort involved in extracting fossil fuels outweighs their benefits. If humanity were to opt for the latter and burn all of the extractable fossil fuels that have already been discovered, the greenhouse gas concentration in the atmosphere (measured in CO_2 equivalent) might rise beyond 1700 ppm (UK Institution of Mechanical Engineers[3], 2009) unleashing unmanageable self-reinforcing feedback loops. Such a path would mean fewer constraints in the short term, but far more limiting constraints in the long term as potentially significantly weakened biocapacity must meet possibly greater demands, with no support from fossil fuels. Or conversely, if CO_2 emissions were to be limited to avoid exceeding the 450 ppm CO_2 concentration threshold in the atmosphere[4], humanity would have to find ways of forcing itself not to burn 80 percent of the fossil fuels reserves that have already been discovered (Leaton 2012). In this case, will existing biocapacity be sufficient to substitute the energy currently generated from fossil fuel? Will we have the willpower, economic capacity or coercive force to guide humanity into refraining from this fossil fuel use?

Whichever path we choose, the role of biocapacity as both the ultimate income source and the ultimate constraint becomes apparent. It is this divergence between the burnable carbon that humanity has found in the lithosphere and the carbon that can be "safely" released into the atmosphere, which illustrates that waste absorption – not fuel supply – is the most significant bottleneck in sustainable fossil fuel use. In other words, biocapacity to absorb greenhouse gases is more limiting to the human economy than fossil fuel reserves.

Ores are another resource from the lithosphere. They are used largely to provide society with metals, including rare earths for specialist electronics. Are these metals, and particularly the most precious rare

[2] http://www.oecd.org/about/secretary-general/the-climate-challenge-achieving-zero-emissions.htm

[3] In its 2009 Climate Change Adaptation Report, it states: "The report's point of departure is that we are unlikely to be far more successful at curbing our CO_2 emissions in the near future than we have been over the past decade or so. And even with vigorous mitigation effort, we will continue to use fossil fuel reserves until they are exhausted. However by then, atmospheric CO_2 levels may have risen to about 1700ppmv compared to an average of 383ppmv today."

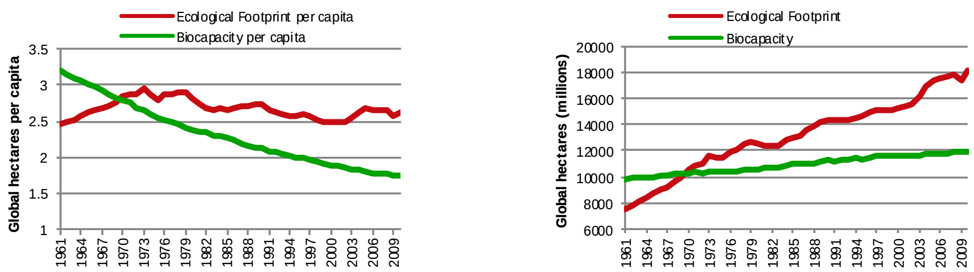
[4] Many climate scientists already consider this too high for ecosystem stability (Hansen et al. 2008, Lovejoy 2008)

earths, the most limiting factor for the human economy, as sometimes suggested in the popular media? Unlike fossil fuels, metals are used, not used up. Society may need more metals, or metals that are in use may erode and become dispersed. Therefore, the use of metals depends on humanity's ability to concentrate their elements. Given existing technology, this ability is limited primarily by energy inputs, whether on the recycling side or the mining side. With much of the industrial energy use currently being sourced from fossil fuels, the limiting factor thus ultimately becomes biocapacity, as explained above. In other words, the use of metals, even rare earths, is also ultimately limited by biocapacity.[5]

As a result of this systemic view, overstretched biocapacity may be considered a generic marker of the availability of a large range of natural resource commodities and amenities. This also offers an indicator of the threats to biodiversity and the associated financial risks of lost habitats, extinct species, and depleted genetic stock (Mulder UNEP-FI 2010). Biocapacity is a common bottleneck that summarises and approximates the overall material dynamic of the human economy.

Fig. 4-1 Interpreting humanity's consumption trends

A: Per-capita biocapacity and Ecological Footprint **B: Total biocapacity and Ecological Footprint**



Source: Global Footprint Network (2014)

As shown in Fig. 4-1A, the biocapacity per capita trend, i.e. the earth's regenerative capacity available annually to each person, has continued to shrink in recent decades as population growth has been faster than the increase in biological productivity. Technological advances and increased input from agriculture have increased yields, but not enough to outpace the overall demand on natural systems. Combined with ad-hoc assessments of the increasing human pressure on local ecosystems, the overall productive biocapacity time series can be interpreted as an early warning of a metabolism mismatch between human demand and resource availability.

With regard to the per-capita Ecological Footprint in recent decades, the only protracted declines have been due either to the oil crisis (1973 and 1979) or to the collapse of inefficient centrally planned economies (after 1991). 2001 marked a rebound in per-capita Ecological Footprint, as mass consumption began to increase in emerging economies. This was corrected again for a time by the 2009 global recession.

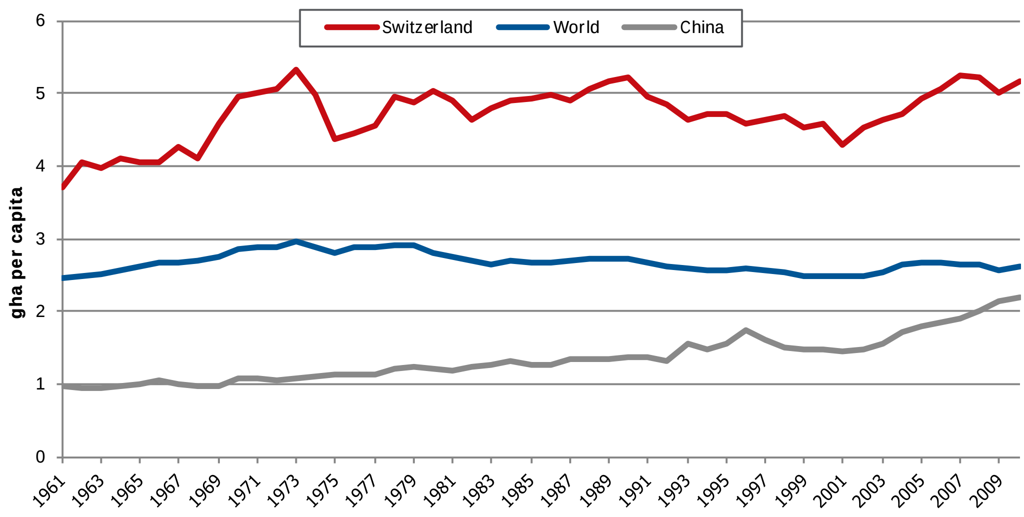
Yet global biocapacity – the flow of productive biomass the earth can regenerate in a given year – is only one side of the coin: the supply side or the "ecological income" side. The other side is the global Ecological Footprint, which measures the competing demands of humanity in terms of land use year after year. This represents how much of biocapacity's services people expend.

Fig. 4-1B – which now factors in population growth – hints at global ecological constraints. The overall take of renewable resources now exceeds what the earth can regenerate in one year. According to the 2014 edition of the National Footprint Accounts (NFA), humanity's Ecological Footprint has surpassed biocapacity since the 1970s. With growing human demand, this gap has been widening. This deficit accu-

[5] In addition to energy for concentrating metals, mining itself can also affect biocapacity, both through the loss of potentially productive areas, and through mining refuse and other waste products.

mulates over time into an ecological debt, manifested as erosion of underlying ecological assets such as soil, forests, and fish populations, or the filling up of sinks such as carbon accumulation in the atmosphere. That said, in spite of this debt accumulation, increased inputs into agriculture have been able to increase crop yields up to now, making the strain less obvious. Further studies would be needed to determine the extent to which this ecological debt accumulation may reduce future biocapacity.

Fig. 4-2 Per-capita Ecological Footprint of consumption: Switzerland and China vs the World



Source: Global Footprint Network (2014)

Fig. 4-2 shows that overall per-capita resource consumption seems to be constant, but that demand for resources from emerging economies such as China is catching up. There is no hint whatsoever of convergence between high-income and emerging economies, if Switzerland and China are any indication. Although China has come closer to the world average, Switzerland has widened its 1961 gap. World average income and global resource consumption have been increasing steadily since 1961. The almost-flat world per-capita Ecological Footprint line therefore means that the rise in resource consumption permitted by higher incomes towards the middle of the income distribution is being offset by a) a shift towards the consumption of less resource-intensive goods such as health services, at the higher end of the income distribution, and b) stagnating or even declining per-capita resource consumption in many densely populated low-income countries. Worth noting is a 37% increase in Swiss per-capita resource consumption over the period (as measured by the Footprint), to be compared with a 133% increase in China, yet from a much lower base. Indeed, the average biocapacity consumed by a Swiss citizen has increased by almost one and a half global hectares (gha) over the period, which still exceeds that of the average Chinese (+ 1.2 gha).

Fig. 4-3 shows a sample of the most populated and/or largest countries of the world within their continental contexts. They are arranged by geographical neighbourhood. While scrolling down these country clusters, it is natural to look for similarities, be they across continents or arising from contiguity, as if the result of parallel histories or a continental destiny. Countries are either ecological creditors – if their national biocapacity exceeds their Ecological Footprint, or ecological debtors – if their Ecological Footprint exceeds their biocapacity, giving rise to an ecological deficit.

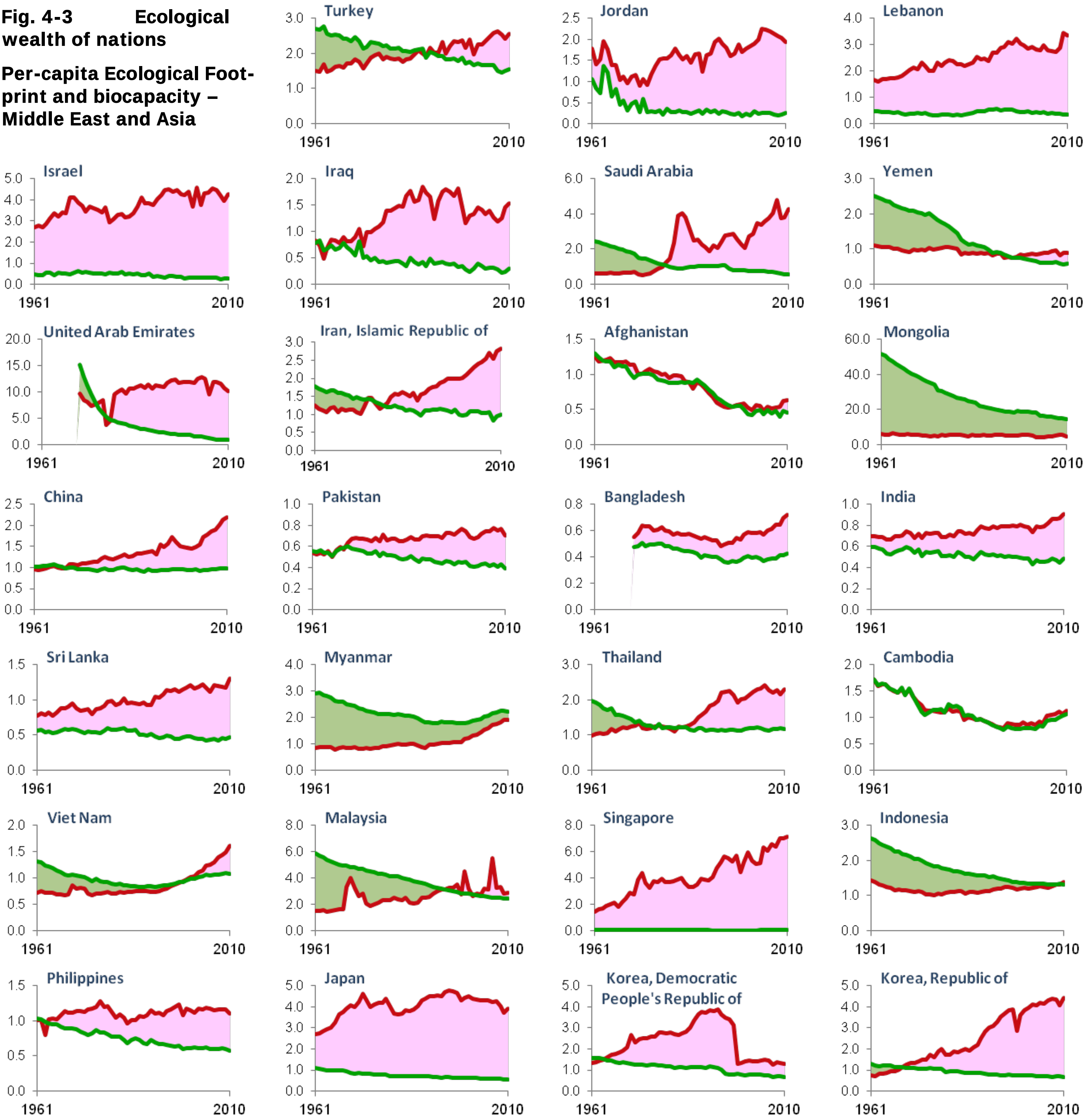
Countries running ecological deficits offset them by means of three mechanisms: they rely on net imports to meet their consumption demand, use global commons as a repository for their carbon emissions or for fishing, and/or overharvest their own ecosystems. All of these strategies carry risks. Overharvested ecosystems may lose productivity and collapse. Trade partners may increase prices and interrupt supplies. Carbon emissions will cost more as a result of climate change management at the global and local levels.

In contrast, those countries whose consumption remains within the capacity of their national ecological assets have more room to manoeuvre. In net terms, their ecosystems can provide the food, fibre and timber demanded by their populations, and absorb the emissions from the energy used to fuel their consumption. The net biocapacity surplus can be used to produce goods for export, absorb carbon dioxide from other countries, or be set aside to protect biodiversity. All of these options generate financial benefits. In addition, ecological creditor countries have more options for producing energy from biomass, such as second-generation biofuels.

Biocapacity per capita declined in most countries from 1961 to 2010, often precipitously. Overshadowing productivity gains, the dominant factor has been population growth, with more and more people sharing ecological assets that are only slightly more available than previously.

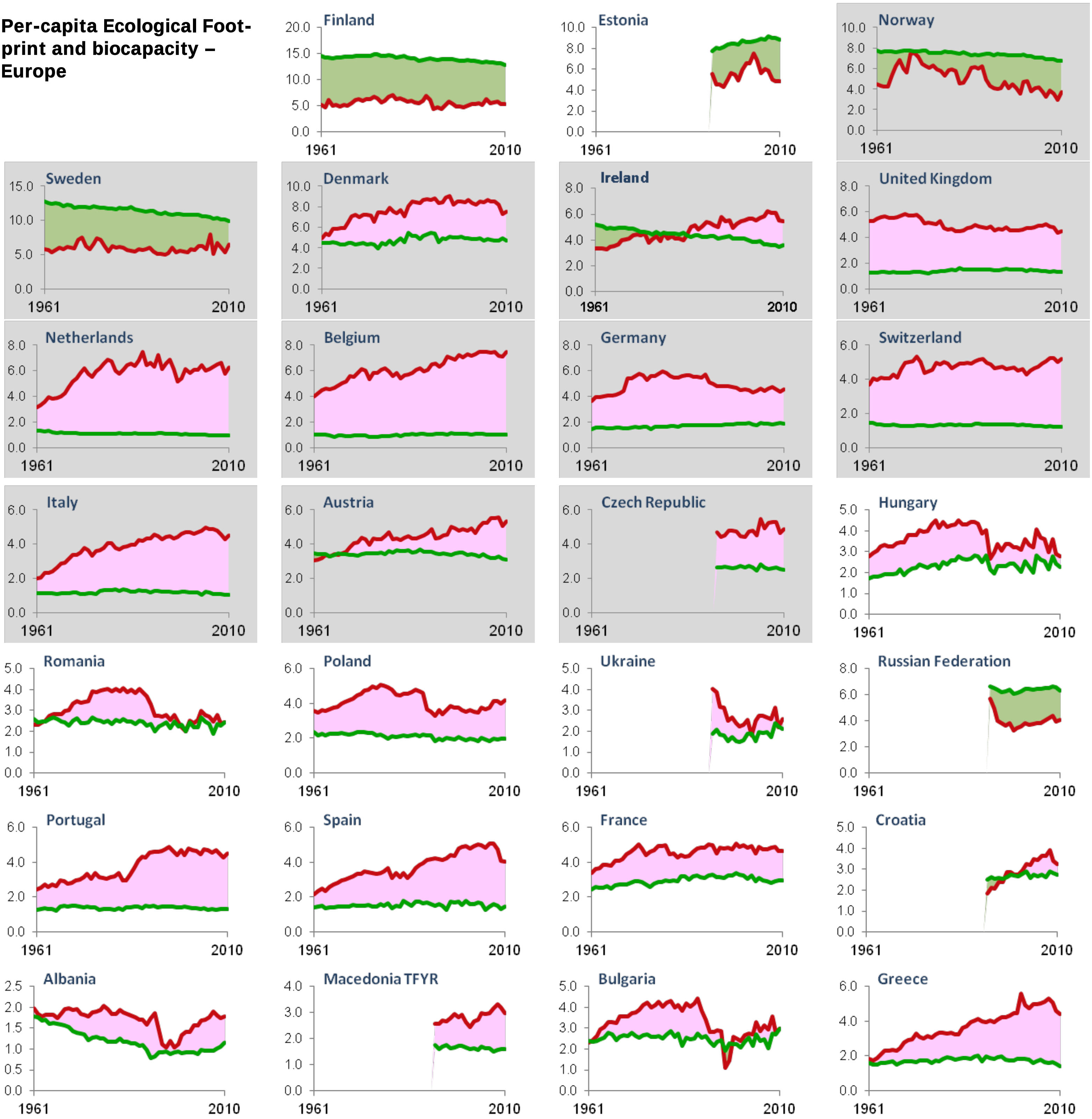
Fig. 4-3 Ecological wealth of nations

Per-capita Ecological Footprint and biocapacity – Middle East and Asia



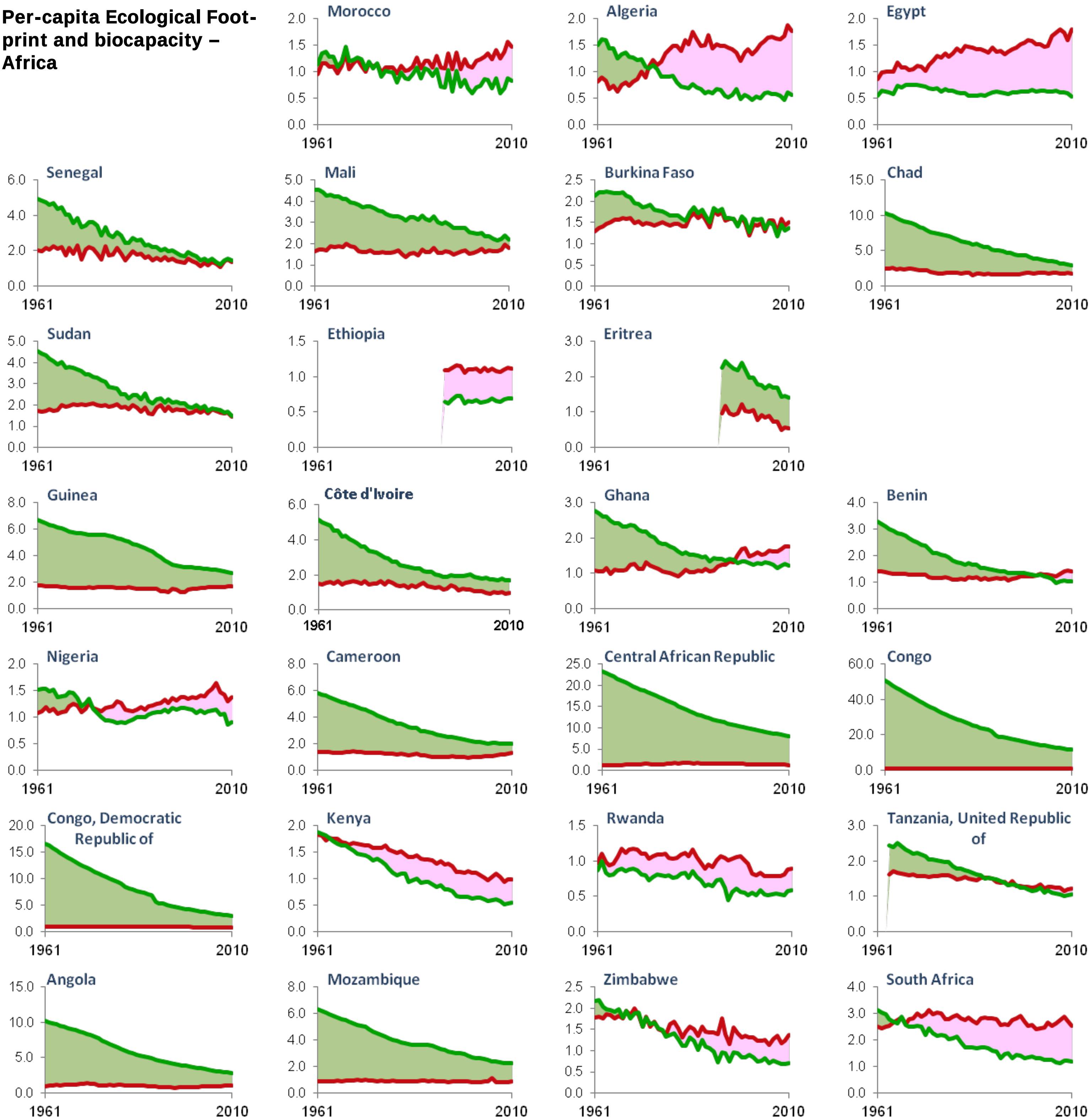
Source: Global Footprint Network (2014).

Per-capita Ecological Footprint and biocapacity – Europe



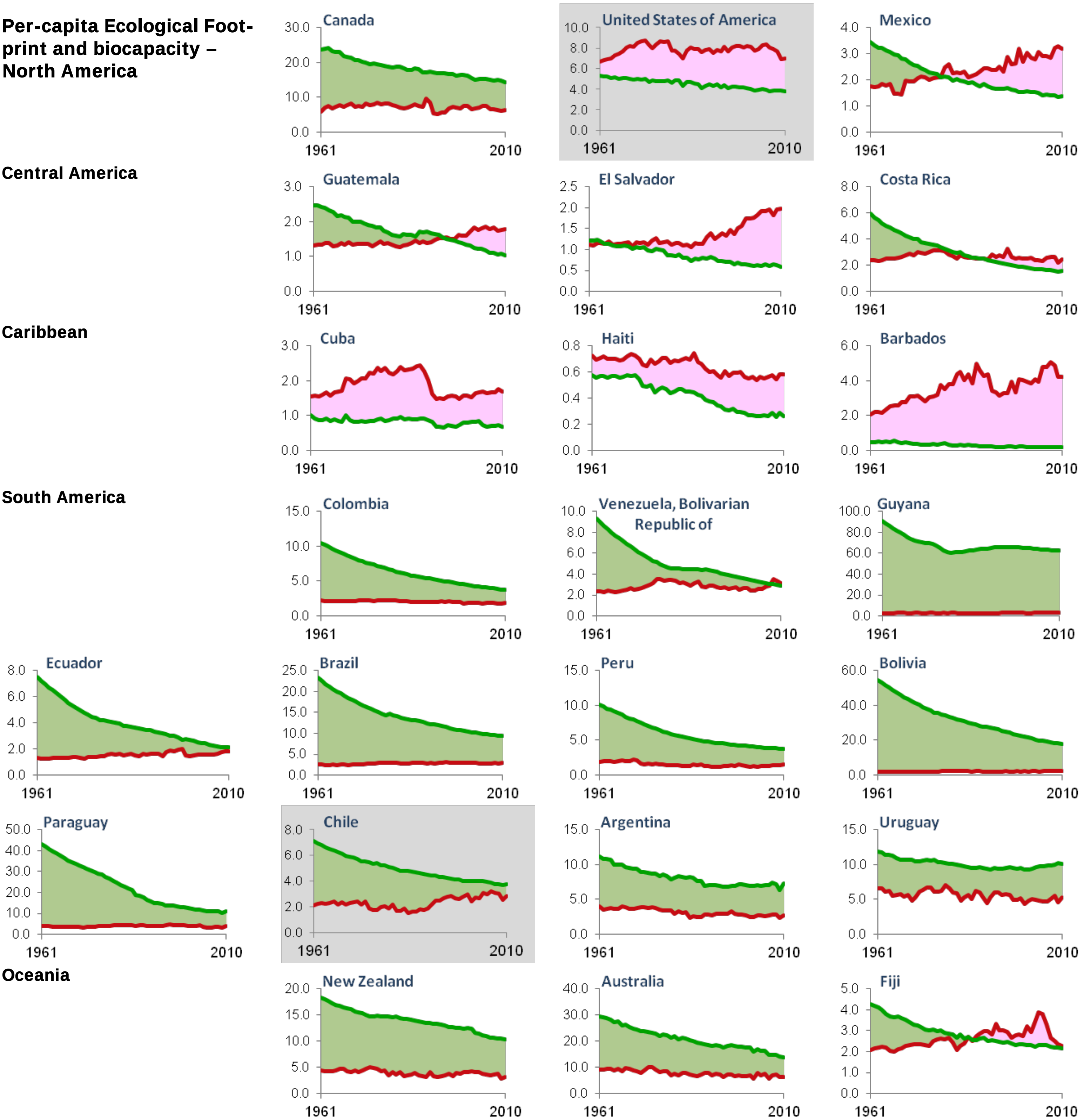
Source: Global Footprint Network (2014).

Per-capita Ecological Footprint and biocapacity – Africa



Source: Global Footprint Network (2014).

Per-capita Ecological Footprint and biocapacity – North America



Source: Global Footprint Network (2014).

Eurasia, the birthplace of two industrial revolutions that precipitated the great historical divergence between Asia and Europe, is running a biocapacity deficit almost across the board, with the exception of Scandinavia, Mongolia, and Myanmar, although the latter two seem to be on the verge of changing status, from ecological creditor to debtor.

Sub-Saharan **Africa** as a whole still has some biocapacity reserve, but it is quickly moving towards ecological deficit owing to its more densely populated regions. If the trend continues towards Africa being the next frontier for foreign resource-seeking investment and cheap labour manufacturing, as some believe, then this move towards biocapacity deficit will accelerate further. Northern Africa and Ethiopia have been ecologically stressed for quite some time: Algeria since the mid-1970s, and Egypt and Ethiopia well before that.

Owing to its agro-ecological situation and its lower population density, **South America** is the most homogeneously biocapacity-rich part of the world, whereas **Central America and the Caribbean** are feeling the pressure of their denser populations settled on tiny territories.

In **North America**, the region as a whole is – as might be expected – running a biocapacity deficit: in Mexico with a medium-sized Footprint but low biocapacity, and in the USA with considerable biocapacity but an even larger Footprint. Canada may have sizeable biocapacity reserves, but still has one of the highest per-capita Footprints in the world.

Switzerland and the majority of countries from the country panel chosen to benchmark national competitiveness (grey-shaded backdrop in Fig. 4-3) are all running ecological deficits alongside the USA. Of the panel, only Norway, Sweden, and Chile are able to retain biocapacity reserves. They are richer in resources than Switzerland, and their highly developed institutional frameworks somehow preserve them from national resource mismanagement.

Canada and other large biocapacity creditor countries may be regarded enviously by smaller and more densely populated countries. However, it can come at the price of making good governance more difficult, if the resource curse theory is any indicator.

On the same note, it is worth observing that, while many contiguous territories share similar agro-ecological contexts, the different resource management strategies that have developed over time from different institutional and national political backgrounds do not seem to produce drastically different impacts across national borders in terms of net biocapacity gaps. However, the drop in biocapacity and Ecological Footprint in the early 1990s does show in ecological accounts from countries from the former Soviet bloc. This illustrates how Ecological Footprint results are sensitive to radical changes in economic regime.

In summary, not all countries are in the same boat, but all are navigating the same stormy sea and suffering similar problems. What remains beyond question is the glaring evidence that:

$$\sum_{i=1}^{<196} Nation_i's\ Biocapacity\ Deficit_{2010} \gg \sum_{j=1}^{<196} Nation_j's\ Biocapacity\ Reserve_{2010}$$

4.2 Are ecological constraints shifting market dynamics?

Demand for bioproductive resources has been rising and is estimated to increase further in the decades to come. What do increased demand and rising biocapacity deficits mean for resource trade and resource access? Is there such a thing as a risk stemming from natural resource overuse? Is there a risk of a resource scramble? And is this risk a significant risk – on a par with public health epidemics – or a minor one that can be ignored?

Resource market dynamics have changed over recent decades. This also emerges from an examination of the renewable resources harvested from the four bioproductive land use types (forests, crops, grazing, and fishing grounds) that comprise the Ecological Footprint.

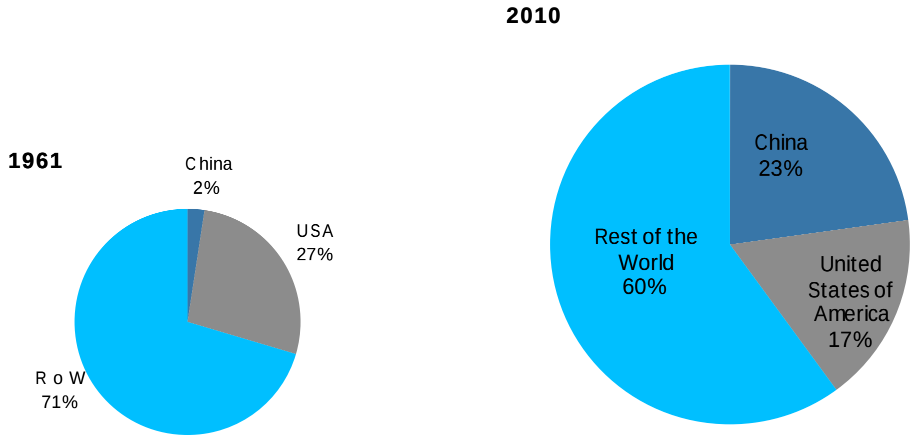
4.2.1 Changing trade patterns

A review of trade data over time indicates that trade flows in natural resources have been redirected in recent years. A continuous increase in natural resource demand is predicted, primarily as a result of uninterrupted world population growth, and rising affluence in China, India, and other emerging economies. Across a range of key strategic resources, large-scale extraction is concentrated in a small number of countries such as the United States, China and Australia. Despite the much-hyped new scramble for Africa, the continent does not yet play a major role in global resource flows. The overall shift to more marginal and unconventional natural resource commodity production will bring with it more energy-intensive extraction, further encouraging resource consumption, and increasing pressure on critical ecosystems.

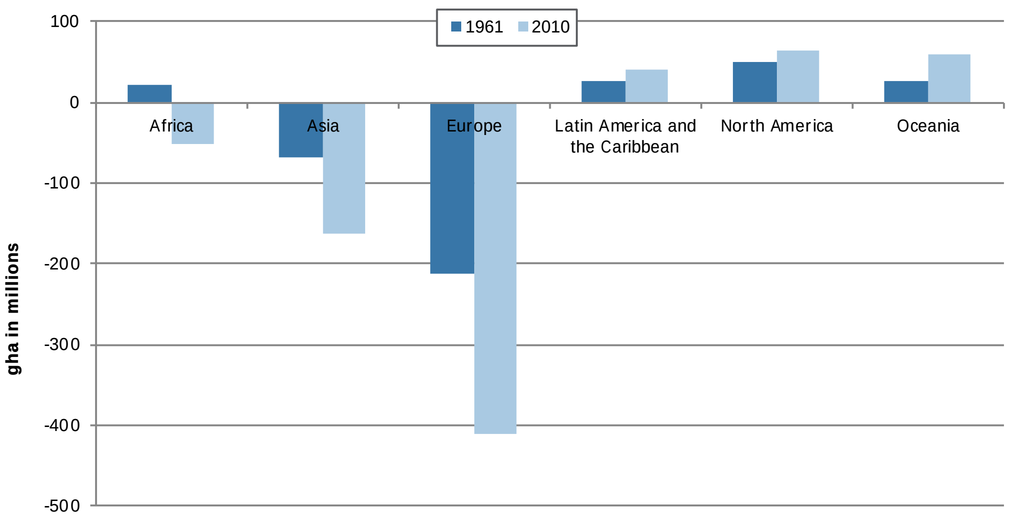
Fig. 4-4A shows with proportional pie chart sizes the overall expansion in traded biocapacity since 1961, including carbon uptake land embodied in trade, as well as the Chinese and US shares of the total. Traded biocapacity in 2010 was almost 7 times that in 1961. This rise in international resource trading is due primarily to rising incomes in many countries, especially China. According to Fig. 4-4B, Asia's net biocapacity imports rose by about 300% between 1961 and 2010, and Africa turned from a net exporter into a net importer. Australia remained a net exporter of biocapacity.

Fig. 4-4 Changing patterns of global resource trade since 1961

A: Ecological Footprint of global trade, showing the Chinese and US shares of the total



B: Evolution of gha balance of traded biocapacity by continent



Source: Global Footprint Network (2014)

Eurasia stands out in 2010 as the most resource import-dependent part of the world. This largely confirms the region's status as biocapacity debtor, previously shown in Fig. 4-3.

Bagliani, Bravo, and Dalmazzone (2008) analysed the relationship between GDP per capita and the Ecological Footprint. They found that there is no Kuznets-type relationship meaning that the Ecological Footprint still increases even as higher-income countries increase their income. Nevertheless, once an Ecological Footprint of four gha per person is reached, then the relationship between GDP per capita and the Ecological Footprint becomes weaker, and the latter increases at a slower rate with rising incomes. This indicates that shifting consumption patterns, an increase in efficiency and improvements in technology may slow down some of the spread in the Ecological Footprint, but it may not be capable of offsetting the effect of income growth.

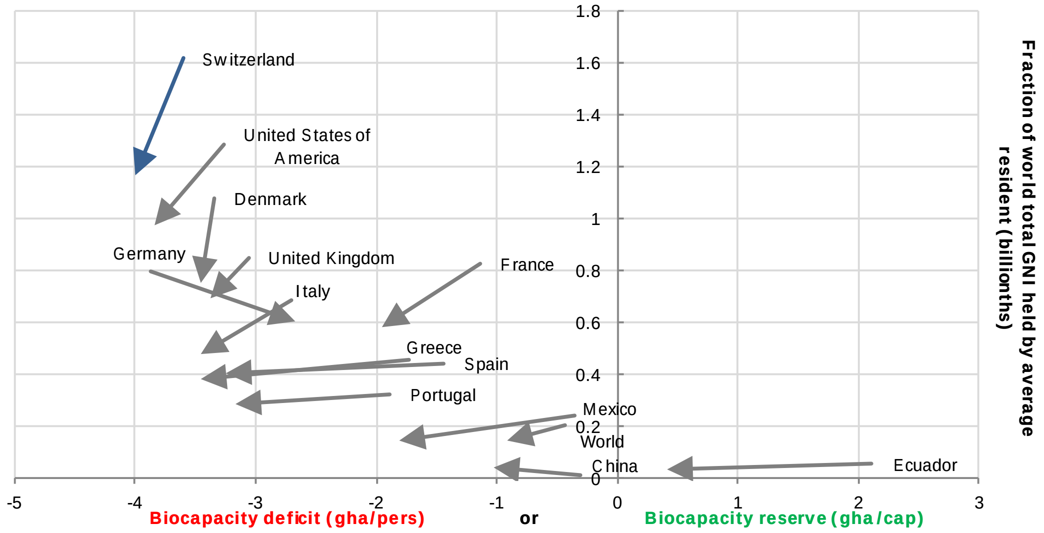
In addition to today's emerging economies, more and more countries will be competing on the international market for natural resources. Rising price trends and sharp rises in prices will not be the only limiting factor to resource access. Unilateral export restrictions and market intervention by governments will also create disruptions, such as that for wheat enacted by Russia in 2008. Looking at the bilateral agreements encompassing resource supply, as well as the widespread use of trade remedies, it is already evident today that nations are increasingly resorting to diplomacy, trade measures and geopolitical power to gain access to resources. Trade is becoming the "front line" for conflicts over resources, and resource politics are set to dominate the global agenda (Lee et al. 2012). Therefore, individual nations' future access to resource stocks will be determined by many factors that can hardly be estimated today. However, for most countries, access to functioning global markets remains the best provider of resource security, to such an extent that rising income trends are considered a predictor of shifts in resource trade patterns (Moyo 2012).

4.2.2 Future access to resources

Changes in overall resource trade flows and prices since 2000 show that a country's access to resources hinges on income dynamics. Fuelled by revenue increases, China's biocapacity imports soared dramatically at the turn of the 1980s, pressing increasingly on the international resource markets (see Fig. 4-4). Average income may therefore be considered an important predictor of the bioproductive resources demanded on international markets by the economic agents of a given country. Of course, geopolitics, military and bargaining power to strike and enforce good international resource deals also matter, but let us set these aside in this study in order to focus on the basic driver (hence we call this the "benevolent scenario"). High-income countries tend to grow at rates of less than two percent a year, while the majority of emerging countries are growing much faster. Their demand for resources is expanding accordingly. As these countries' incomes catch up, the relative incomes of high-income countries decline (see Fig. 4-9). As a result, like a global auction with more financially strong bidders and limited quantities for sale, average economic agents in high-income countries will face declining access to resources (Moyo 2012). This is the rebalancing of global income and power.

The global auction for the world's limited natural resources seems poised to become tougher and tougher, as shown in Fig. 4-5. An arrow represents a country with two data points: relative income and the biocapacity gap. The arrow for any given country originates in 1985 and ends in 2008. The figure illustrates that many countries are losing biocapacity reserves, or increasing their biocapacity deficit, while also facing declining relative income. This makes them more exposed to resource constraints on both accounts – higher dependence and less relative income to compete in the marketplace.

Fig. 4-5 Global auction – the benevolent scenario for access to resources



GNI = Gross National Income
Source: Global Footprint Network (2014)

This figure helps us to understand the future resource access situation of national economic agents in the world economy if income and the biocapacity gap were the only significant factors. For instance, the relative income of one generic citizen of the world has come down because of population growth over the period. The relative income of the average German has also slipped from its position in 1985. However, their biocapacity deficit has contracted thanks to the closing down of inefficient manufacturing and power plants following reunification. Chinese economic agents are among the few worldwide that are experiencing an increase in relative income. However, the corresponding arrow is expanding in the "wrong" direction since, unlike Germany, the biocapacity deficit is increasing. Switzerland, whose receding relative income over time appears in Fig. 4-9 below, is also caught in the vice: less relative income for Swiss economic agents as they compete to purchase ever-scarcer resources.

4.2.3 What makes resource overuse a deceptively rational choice?

Resources included in the National Footprint Accounts – e.g. agricultural commodities, timber, fish, meat, timber products – are considered "renewable" as long as the underlying stocks are not depleted and one harvest does not reduce the resource's ability to produce the next. This regenerative capacity of productive land is called biocapacity. The sustainable use of biocapacity implies, on the one hand, that the underlying stocks, soil fertility, aquifers, fish, biodiversity, etc. are not being depleted and, on the other, that the ecosystems supporting these stocks are delivering the required level of services. A period of overharvesting a biocapacity-related resource may be in order as long as it is followed by a subsequent period of underuse, allowing stocks to replenish. However, most bioproductive resources have a critical threshold for regeneration, beyond which stocks adjust to a lower level, eventually leading to less biocapacity for the next harvests. After depleting the underlying stocks, it is possible to some extent to replenish them. However, it may not be possible to restore them to their initial level, and replenishing them is associated with significant sacrifices in future biocapacity consumption. The human population would have to adjust to a lower level of availability, as shown by predator/prey modelling in ecosystem science. The relationship between repeated overharvesting and the depletion of underlying stocks is complex, and falls beyond the scope of the Ecological Footprint. Ecological Footprint accounts just document the situation. However, the global overshoot of available biocapacity over the last 40 years, as evidenced by the National Footprint Accounts, consistently hints at an accumulating handicap for future regenerative capacity of productive biomass. We might then ask: "why do countries which are reasonably well aware of this danger tend to keep overusing bioproductive resources, either their own or those of their trading partners?"

Let us portray the expanding global economy in relation to the earth's limited biocapacity as a simple game between 193 players (the UN member states). The goal is to extract as much as possible from natural resources through market economics, to maintain an attractive return for the labour force and for capital. Each player suspects that the game will have a negative sum towards the end, because the desired continued expansion increases natural resource throughput, including ecosystemic services, and sooner or later this will clash with a less favourable situation than before where resource access is concerned. This despite human ingenuity which may blur biophysical constraints, but not eliminate them altogether. The negative sum for all players, which are affected differently over time, becomes palpable only after a number of "rounds". It is felt only once underlying ecological stock depletion slows down harvests, or once other ecosystemic or sociopolitical feedback begins to impact on the resource-user.

As in the prisoner's dilemma, this game raises the question of cooperation between players so as to prevent negative impacts for all in the future. It is partly driven by a "tragedy of the commons" (Hardin 1968). Examples include emitting CO_2 from fossil fuels into the atmosphere, or fishing international oceans. But there are also significant motivations to keep playing that are not driven by such a tragedy of the commons. Examples include overusing ecological assets within one's own country or building resource-intensive infrastructures – future stranded assets – in the belief that resources will be available cheaply for a long time. Mathematics suggests that the optimum end to such a game for each individual player comes either by collapse or from mutual coercion (Hardin, 1968), for example in the form of enforcing management agreements on global and regional commons to facilitate the best possible management of national ecological assets. In the meantime, while international cooperation remains elusive, and before the game nears collapse, it is still worth playing. Some players may be tempted to exit the game with a view to immunising themselves against forthcoming negative impacts, or in the hope of leading by example to encourage cooperation on self-restraint between players. However, since unilaterally exiting the game is now costly, and the damage from driving it collectively to the negative sum zone are felt only later, it is definitely a suboptimum exit strategy. It would trigger free-riding behaviours by competitors, and would not bring the other players any closer to regulating the game strictly so that it need not stop.

Resource overuse, either in-country or through trading with other countries, as well as overburdening global commons, therefore seems a rational choice, whether one likes it or not, for as long as the rules of the game are not amended by international cooperation to ensure a positive-sum outcome. Another way out may be to recognise that the "resource game" is not, in the main, a "tragedy of the commons", and that countries therefore benefit from early action.

4.2.4 Risk of a scramble for resources

The Global Risks report by the World Economic Forum (2014) identifies food crises as number eight of the ten global risks of highest concern.[6] Food shortages are mostly driven by price spikes in agricultural commodities on international markets. Furthermore, declining global biocapacity is a plausible outcome for the future if the global overshoot continues unabated. This would result in a dwindling supply of agricultural commodities, thus sparking more and more hunger riots in vulnerable parts of the world. Since countries tend to satisfy national interests first, when access to resources becomes problematic, unilateral trade restrictions, such as exports controls, would be enacted, irrespective of the international regime. This would further fan the fires of geopolitical destabilisation.

Low-income countries with low resilience against resource price shocks are likely to suffer more quickly from a deteriorating trading system with less international rule of law.

[6] The survey consists of participants from businesses (41%) and academia (18%), 72% are males and 78% are aged 30 and older

4.2.5 How does resource-related risk compare with other systemic risks?

The global auction scenario, i.e. assuming a benevolent world with fair access to markets, still exhibits a cumulative, growing risk. Less benevolent scenarios would be even more risky. The benevolent risks arise from growing dependence on biocapacity that is not available domestically, at the same time as a loss in relative income which may signal a systemic weakening in a country's economic position. Whether this is a serious economic risk or not must also be examined.

There are a number of steadily growing risks and costs to economies. For instance, HIV infections continue to increase, and there are other health epidemics which seem to be on the rise: diabetes, obesity, autism, dementia, and so forth. These too represent steadily growing costs to an economy. It is therefore reasonable to question whether these growing health costs, or any other growing costs, are more significant than the resource domain. After all, for Switzerland, the oil import bill, to take one, key resource, accounts for only around two percent of GDP in 2011[7]. In contrast, health costs made up 11 percent of its GDP in the same year (Swiss Federal Statistical Office data on healthcare expenditure as percentage of GDP).

So, could one assume that the growing resource cost spiral, as framed in the global auction scenario, is fundamentally smaller than other risks and therefore not as potentially fatal?

This is a core question Switzerland has to wrestle with. It may well be that, for Switzerland, where GDP per global hectare of biocapacity deficit (a measure of purchasing power for biocapacity that is not found domestically) is comparatively high, fiscal pressures are typically less marked than among its peers with less favourable ratios. However, this means that Switzerland might just be burdened later and perhaps to a lesser relative extent, but still with an absolute impact on welfare.

However, there may also be a hierarchy and sequencing in the individual elements of risk. While the WEF identifies 31 risk categories, they have different time dimensions, and some are more influential than others. For instance, resource-starved economies will exhibit a number of other, additional risks – distributional, financial, and even technological – while financial risks are unlikely to cause or to accelerate environment-related risks.

Is the resource risk "systemic", as in "systemic financial risk" which refers to the possibility of its spreading through and potentially devastating an entire market? If we consider economies with low per-capita incomes which are constrained by their own biocapacity, such as Haiti, Sierra Leone, or Burundi, the answer tends to be positive for low-income, densely populated countries.

4.3 Is this dangerous for Switzerland?

Switzerland may be less vulnerable than some of its peers. But what does that really mean? That Switzerland is well placed overall? If everyone else is relatively poor, on track towards ecological liquidation, is being the best of a bad lot really a good thing? There are a number of mechanisms that protect Switzerland from the risks of such ecological liquidation. But do they provide sufficient protection in the long term?

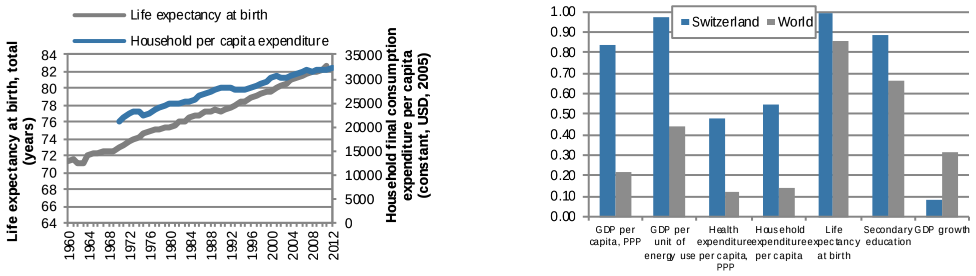
It is appropriate at this juncture to summarise the main economic arguments suggesting that Switzerland is almost out untouchable, despite the many indicators of difficult future access to international resources. Fig. 4-6 A and B suggest that Switzerland might be well hedged against troubles ahead where access to resources is concerned.

[7] Calculated from data presented in CIA Factbook: https://www.cia.gov/library/publications/the-world-factbook/geos/sz.html

Fig. 4-6 Just two of Switzerland's many healthy fundamentals

A: Life expectancy and household consumption

B: Switzerland’s high standard of living (indexed socio-economic indicators, 2011)

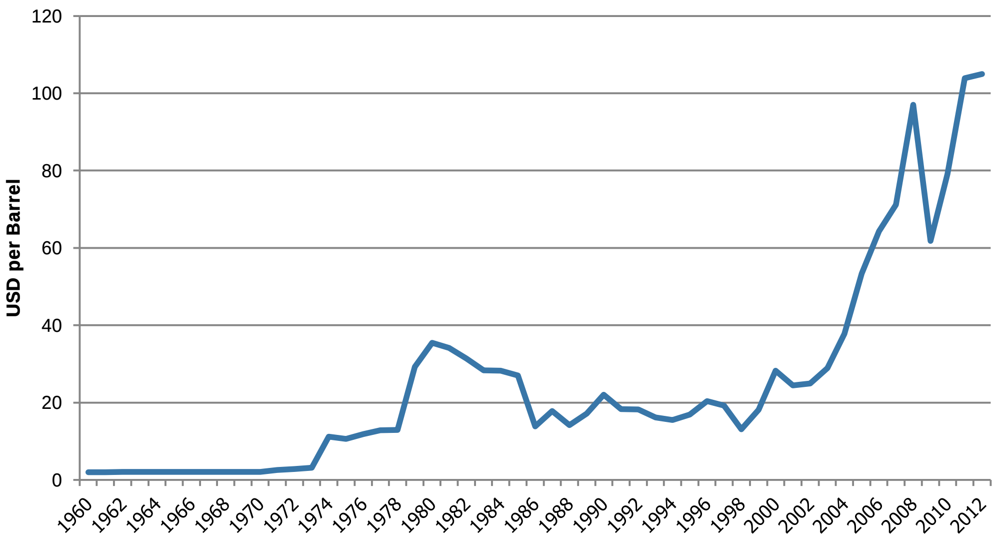


Source: The World Bank (2014)

4.3.1 Prices will react

Prices will react, so that scarcity is acknowledged and acted on in time. That is the theory, but is it really so? Apart from in economics textbooks, prices do not necessarily reflect the real scarcity of the underlying asset (Norgaard 1990). Sometimes, they do not act at all, as in the case of the passenger pigeon (see Box 3).

Fig. 4-7 Crude petroleum price



Source: UNCTAD (2014)

In the resource realm, spot and future prices tend to reflect rational anticipations about short-term access rather than long-term availability, combining information on man-made stocks and current flows, rather than physical reserves, factors limiting biocapacity, and geopolitical trends. Oil is a case in point. Relative to the impending depletion of large and easily accessible reserves, its long-term price lags behind its theoretical value. This "missing value" is compounded by failed attempts so far to internalise negative externalities, such as CO_2 emissions through the carbon market. If oil prices do not surge to a level that would ultimately deter the main drivers of its consumption, such as transport, one might ask if this price surge is not happening because economic agents are so deeply convinced that oil will never be completely substitutable that they prefer to turn a blind eye to the ultimate outcome.

Box 3: The passenger pigeon

The passenger pigeon, *Ectopistes migratorius*, is the most famous extinct species since the dodo. It was also the most numerous bird species in North America before it was hunted to extinction by humans in the 1870s. A typical migrating flock would have contained several billion individuals. In 1813, John James Audubon saw a flock moving at sixty miles an hour and obliterating the noon sun. It was merely the advance guard of a multitude that took three days to pass. The bird was little studied while alive, other than how to catch, kill, and cook it. The central question is how a bird could go from a population of billions to zero in less than fifty years. The short answer is that it tasted good, and its valuation on urban markets never came anywhere close to reflecting its actual, growing, scarcity.

For as long as America was rural and untraversed by railroads, the killing did not seem to do much more than dent the vast pigeon population. After the Civil War, however, things began to change rapidly. It was possible to find out by telegraph where pigeons were nesting, get there quickly by train, and sell what you killed to a city hundreds of miles away. Soon, market hunters began operating on an enormous scale, cramming tens of thousands of birds into refrigerator cars. This meant that rural migrants to growing cities could still get wild game. All this coincided with an explosion in logging, which began destroying the pigeon's habitats. A pair patriotically named George and Martha remained at Cincinnati Zoo until Martha died on September 1, 1914. The fate of the passenger pigeon inspired what became the first federal bird protection law, the Lacey Act, of 1900.

(After Jonathan Rosen, The New Yorker, 28.02.2014)

The most likely scenario would thus feature an upward trend in oil prices and volatility alike. In view of the way in which oil is intertwined with economic activity overall, this would also be felt in the prices of other resources. The days of easy access and low prices would be consigned firmly to the past. However, this would not happen at a sufficient pace and on a sufficient scale to enable the next energy transition out of the petroleum age.

Let us imagine that this mid-range scenario is flanked by two opposing, more extreme scenarios. Suppose that Swiss economic agents are like high-income bidders at the global resource auction, with prices fully reflecting underlying scarcities, as they would in an ecological economist's dream world. Factors would tend to be allocated optimally, structural shortages would be avoided, and international trade would be able to specialise to its full extent. Would such a textbook, tougher universe really deliver safer resource supplies and trade routes than the imperfect (from the theoretical perspective) world we live in? This is uncertain, because only land and brand-owners, as well as rentiers, could possibly thrive in such a high-priced, ecologically and economically correct world. Without enforced wealth distribution mechanisms, the minority winners would take all and the majority losers would be left no other option than to rise up and cut off the supply routes, back to Robin Hood times.

At the other extreme, if resource prices consistently fail to reflect underlying scarcities and ecological limits, then in the absence of technological substitution at the pace and on the scale required, supply disruptions would be structurally in-built. This would result in a similar outcome as above: social unrest worldwide would make global supply chains much more shaky.

In conclusion, if prices alone were to be expected to fix scarcity and avoid repeated shortages, then whether they were high enough or much too low, the outcome would still be worrisome. The devil is in the mismatch between economics and thermodynamics once the full chain of systemic spillover, including social and environmental feedback, is considered.

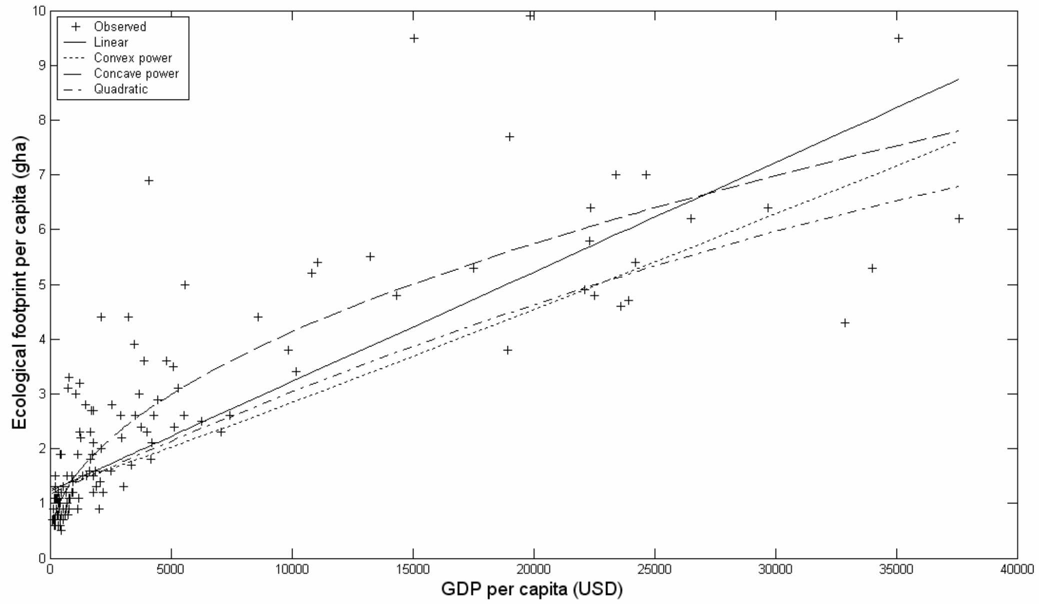
4.3.2 Technology will save us

Let's ask: which technology? Some technologies do indeed make us less dependent on resources (bicycles, insulation, clean technologies) while others just increase resource use, and would be far less accessible if no cheap resources and energy were available (plastics, smart phones, SUVs, leaf blowers instead of brooms). For instance, the labour productivity gains owing to the ICT revolution have been obtained to some extent by substituting more resources and energy for labour. In addition, it has been observed that the more frontier extraction or extreme engineering needed to replace dwindling easily-accessible, high-grade reserves, the costlier the extraction becomes. In the oil industry, the energy return on investment is falling rapidly (Hall et al. 2013).

The energy intensity of each unit of GDP may be declining over time in most high-income economies. However, the technological revolution which is so desperately required is one which delivers enough resource decoupling to take the global civilisation back to safe, one-planet resource use.

In Fig. 4-8, Bagliani, Bravo and Dalmazzone (2008) find that there is no turning point for GDP in relation to the Ecological Footprint. The latter is increasing steadily with GDP per capita, although at a declining rate. Some technological improvements are taking place, leading to a lower Ecological Footprint intensity at higher levels of GDP per capita, but technology is still unable to level off the effect of rising GDP per capita on the Ecological Footprint for consumption. Higher incomes consistently result in higher levels of resource consumption.

Fig. 4-8 Ecological Footprint per capita vs. GDP per capita, 2001



Cross-country data. The chart shows linear, convex power, concave power and quadratic WLS regression curves.
Source: Bagliani, Bravo and Dalmazzone (2008)

Can we possibly measure how much efficiency gain it would take to decouple resources and energy in absolute terms from GDP that is still growing? Without answering this question, the 2006 Stern report on the cost of climate change envisaged that the costs of early action are much lower than the costs of protracted action. This involves making more informed use of bioproductive resources and fossil fuels by heeding the planet's boundaries – and the sooner this is done, the less expensive it will be.

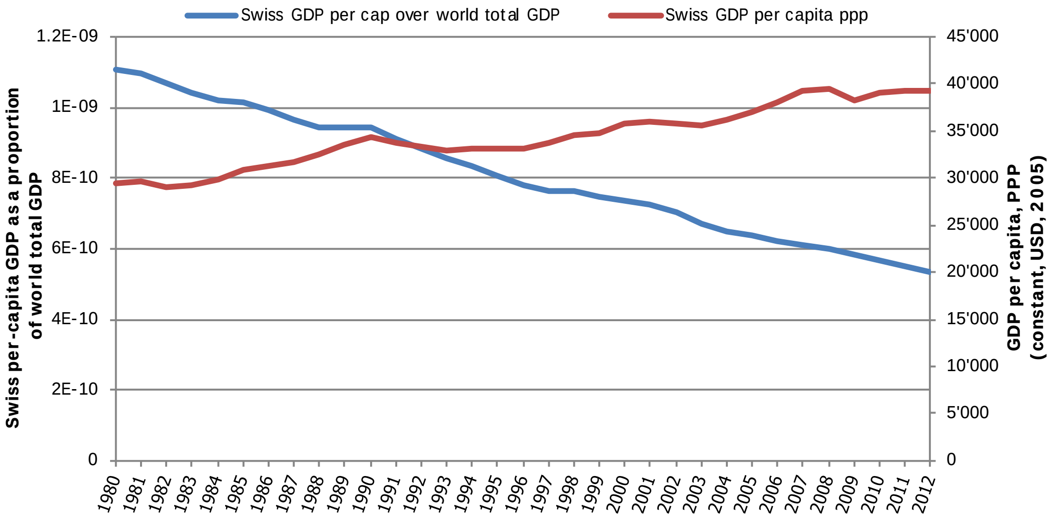
In spite of considerable efforts in Switzerland, i.e. deliberately using fewer resources and less energy today than a year ago, there has so far been no absolute resource decoupling. Less (heating) oil has been burned as a result of more efficient housing stock, but this has been offset by more (fuel) oil burned owing to higher traffic levels, despite more efficient vehicle fleets. It is tempting to assume that accelerating relative decoupling – i.e. using fewer resources and less energy per unit produced today than yesterday – can take us ever closer to the absolute decoupling that is needed. Yet, a word of caution is in order here. The marginal cost of relative decoupling increases steeply once all of the easy and politically feasible technology management options have been taken. Furthermore, the Stanley Jevons Paradox – that increased resource efficiency does not, *ceteris paribus,* result in less economy-wide demand for resources – has yet to be disproved by empirical observations.

4.3.3 Swiss high incomes will save us

In many countries, the rise in resource costs could shave growth. It could even cost several GDP percentage points. In the context of sluggish economic growth in high-income economies, of less than two percent per annum over the past decade (Fatas, INSEAD 2014), and even poor growth potential if the secular stagnation hypothesis proves correct (Canuto et al. 2014), such an additional resource cost could be felt as a drain. However, in view of Switzerland's great financial resilience, and its consistently increasing average per-capita income, one might argue that Swiss economic agents will in any case remain one of the preferred purchasers in international resource markets, and thus remain unchallenged in their capacity to weather any severe resource storm better than most. This line is called in question by two observations that have already been made in this chapter:

- A scramble for resources, as described above, is likely to alter trade patterns, international markets, and geopolitics to such an extent that means of gaining access to international resources tomorrow might only bear a distant resemblance to the benevolent "global auction" market of today, where purchasing power is still the driving factor of success.
- However, even if we dismiss frightening international scenarios, Swiss average per-capita income has, in fact, been declining in relative terms, because the share of world income generated by a typical Swiss economic agent is contracting. This means that purchasers in Switzerland will increasingly be competing in international resource markets with others who have managed to raise their purchasing power in relative terms, such as the Chinese today.

Fig. 4-9 Average income of Swiss residents: absolute and relative to total global income



Source: Feenstra (2013)

One counter-argument to Switzerland's vulnerability to resource price increases could be that it is specialised at the very highest end of its value-added chains, so that it is almost insensitive to resource input prices. In any case, Swiss companies have an outstanding capacity to pass such prices on to the global consumer. Indeed, it might be argued that, for Swiss intermediate and final consumers, many resource inputs are treated as quasi-inferior goods, for which the price elasticity of demand is by definition almost zero. Think of raw coffee, cocoa, cereals, rubber, metals or rare earths for branded, high-value export goods, including capital goods.

Without considering other externalities such as trade tensions, the potential for squeezed margins is actually how Swiss economic agents' performance is most likely to be affected by constant resource price rises. This is because a rise in resource prices might change the overall purchasing power of Swiss export destinations, or because it might deflect Swiss income-generating foreign direct investment, which has benefited Switzerland in the past as an investment haven.

4.3.4 Trade and resource security policies will save us

In a world of plenty with ecological limits still far away, trade would be the endless buffer adjusting for a lack of national biocapacity in the face of rising consumption. Many still believe in such an easy world, as few can resist a convenient idea! These include supporters of the biophysical view. They simply observe that, instead of clearing to zero, the overall balance between biocapacity creditor and debtor countries has been negative since the 1970s, so that the total biocapacity required at present to meet the world's consumption is the equivalent of one and a half planets per year.

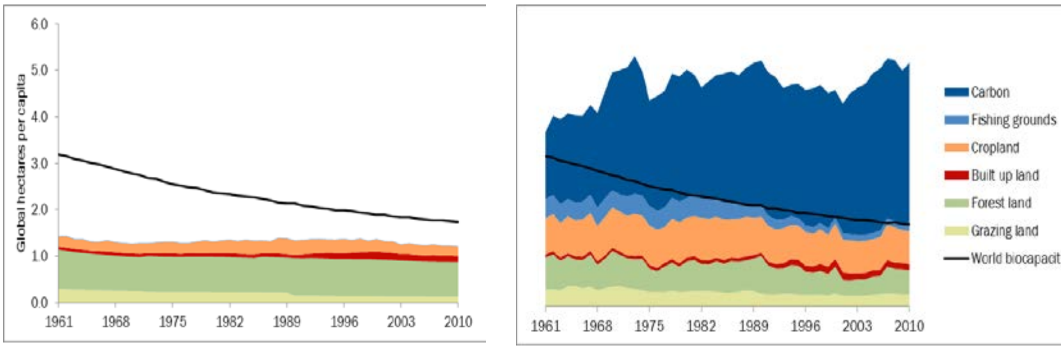
But again, isn't Switzerland a special case? Too small to fail, yet too proactive and helpful in international affairs to be bypassed, it appears well prepared always to find the best path. The country seems able to do so whatever the constraints, be it the global auction of a dwindling resource base or, worse, the global scramble for resources as resource nationalism begins to grow. This may seem a rather blue-eyed view, and some may argue that today's resource challenges have been known about for some time, and Switzerland is in fact well prepared. After all, it has a long tradition of policies to keep the country secure: compulsory stockpiling, food, energy, environment, thrift, employment, fiscal prudence, trade, defence and foreign policies all emphasise security and risk reduction. For instance, agricultural policy aims to ensure around 60 percent food self-sufficiency, while foreign economic policy endeavours to secure strategic supplies. It recognised gridlock at the WTO at an early stage, and deployed bilateral strategies instead – although such deals have tended to be easier with other resource-stressed countries than they have with Brazil or Russia. Still, in spite of all these proper institutional arrangements in Switzerland, the biocapacity embodied in trade has to come from somewhere, and there is no getting around the fact that all trading partners are depending to a growing degree on scarcer bioproductive resources.

4.3.5 And even if ...

Prices, technology, high incomes, and trade may indeed shield Switzerland from the worst, but the country still faces a serious biocapacity deficit, which cannot be helped simply by removing the carbon component from the overall Ecological Footprint, as shown in Fig. 4-10, below, which also shows the global per-capita biocapacity line.

Is this worthy of attention in domestic policy-making? Is it politically possible to make a unilateral effort to reduce the risks relating to Switzerland's dependence on other jurisdictions' biocapacity, should access to resources become more difficult in the future? Can such unilateral policy efforts be pursued without damaging current competitiveness, by inadvertently giving an advantage to competitors encouraged to freeride on these efforts? These questions are not easy to answer, as the main gains from today's policy action will accrue only in the future, while the costs will be felt now. If unilateral action is not rewarded by short-term co-benefits, we might seriously wonder if it is not unnecessarily reckless to trade off today's competitiveness for the sake of tomorrow's prosperity. Indeed, many governments ask themselves that very question when shown the evidence provided by National Footprint Accounts.

Fig. 4-10 Swiss per-capita biocapacity and Ecological Footprint on the same scale



Source: (Global Footprint Network 2014)

The global per-capita biocapacity line, as drawn in Fig. 4-10, seems to be a convenient benchmark against which to assess per-capita Ecological Footprint. This is particularly relevant in benchmarking the carbon component – the dominant one in high-income economies – of the national Footprints, since carbon emissions from national consumption are externalised against global rather than national ecological assets. This benchmark may also be interpreted as the fair and equal allocation of biocapacity to one individual, wherever he/she was born, in year X (the biocapacity available per capita may change from one year to another, as a result of many positive and negative developments, including population change and better yields owing to improved technology or higher inputs). However, it should be noted that this benchmark implies an idealistic assumption that every individual has access to the same share of global biocapacity wherever he/she was born, in a world in which international trade and transport infrastructure would act as trusted resource providers. But does such a world, without geographical differences or geopolitics, as well as perfect trade and infrastructure, really exist?

This is why the domestic resource endowment, as approximated by national per-capita biocapacity, still matters as a driver of sustainable national policies. Global per-capita biocapacity is currently 1.7 gha, compared to 1.2 gha per capita in Switzerland. As a biophysically resource-poor country, Switzerland would therefore be better off in terms of biocapacity deficit if the global benchmark were adopted. Resource-richer countries, like Canada, would be worse off. Switzerland will have to access extra capacity from elsewhere if it wants to consume beyond this 1.2 gha per person without overusing its own ecosystems. Similarly, it is more useful for farmers to compare their cow herd to their farm size, rather than to the average farm size.

To understand the economic ramifications of ecological constraints, it makes sense to look at the ratio of a country's Footprint to its own biocapacity. Note that this is not a call for countries to live within their own biocapacity. Certainly it is not a call for self-sufficiency, since there is considerable benefit from specialisation through trade. It is only to point out the implications of extending demand beyond what is available within that country's borders and that not every country can be a net-importer.

Consequently, although the global per-capita biocapacity benchmark seems to be a fairer means of apportioning national consumption Footprints, Global Footprint Network also advises using national biocapacity as a benchmark.

4.4 How does this risk play out, specifically?

If we accept the premise that ecological constraints do shape future economic performance, and that those risks, unmitigated, are becoming a significant threat then how, specifically, will these trends play out for countries like Switzerland?

The following section analyses how the risk of being dependent on imports of natural resources affects national competitiveness, especially in the case of Switzerland. There is a large volume of literature on the effect of natural resource exports on economic growth. Generally, the natural resources under review are non-renewables such as oil and minerals. The overall conclusion is that countries with appropriate institutions and a high level of human capital do benefit from exporting natural resources. This is true of countries such as Norway and Chile. They are included in the panel for benchmarking. For many countries, however, resource exports have a negative effect on economic growth owing to rent-seeking by corrupt regimes (Deaton 1999; Sachs and Warner 1999). Renewable natural resources have been given much less attention so far. They have, however, received some recognition as an important factor in economic growth. Collier and Goderis (2009) found that commodity price booms have positive short-term growth effects for exporting countries, and negative long-term effects overall owing to non-agricultural commodities such as fossil fuels. Price spikes in agricultural commodities mostly hit low-income countries, whereas price spikes in fossil fuels hit all economies, and especially high-income ones owing to their higher demand for fossil fuels.

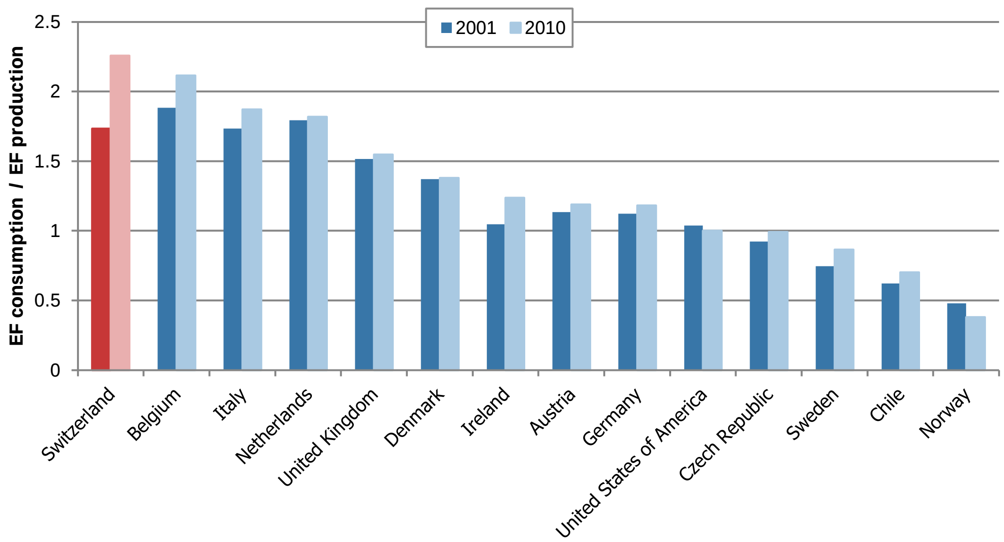
Currently, attention is shifting towards natural resource import dependency and how it might affect economic growth. Carmody (2011) refers to rising demand for resources and imports as a "scramble for Africa", in which countries are trying to secure their long-term resource imports from the continent. Resource import dependency has become an important factor in the wake of the sharp increase in resource price volatility in this new millennium. Baffes and Haniotis (2010) show that commodity prices have also been increasing over time. They find that low-income countries are more prone on average to negative effects. Therefore, the following section is dedicated to analysing the reasons that resource import dependency might affect economic performance, and the specific risks related to this. The analysis is based on the E-RISC by Hill Clarvis et al. (2013), applied to the 13 panel countries and Switzerland.

4.4.1 What are natural resource-related risks?

It was suggested in Section 3 that the availability of bioproductive resources ultimately determines the availability of other natural resources, since it is a limiting factor for the extraction of commodities, including oil and ores. Therefore, from now on the more conventional phrase "natural resources" will be used as a synonym for bioproductive resources. The countries in the panel that are net importers of natural resources are generally more vulnerable to trade-related shocks. These shocks may occur in the form of price shocks on the international markets for agricultural and mineral resource commodities, or they may materialise as unilateral trade measures, as happened in 2008 with the export ban on wheat enforced by Russia.

Fig. 4-11 shows the change in individual countries' resource import dependency between 2001 and 2010. Resource import dependency is defined as the ratio between the Ecological Footprint (EF) of consumption and the EF of production, i.e. 1 + the ratio of the EF of net resource trade over the EF of production. Net resource imports increased in all countries except Norway between 2001 and 2010. Interestingly Switzerland stands out, showing the highest (+ 23%) dependence on resource imports, and the fastest growth rate . A ratio higher than one indicates that a country has to import resources from abroad that are higher than its resource exports in order to satisfy domestic consumption needs. The USA, Sweden, Chile and especially Norway have a ratio below one, and therefore generally depend less on resource imports, whereas the Swiss economy depends rather heavily on resource imports. Being a small domestic market and critically dependent on resource imports makes Switzerland a price-taker on international resource markets. If prices spike, then Switzerland's import costs will necessarily soar.

Fig. 4-11 Dependence on resource imports

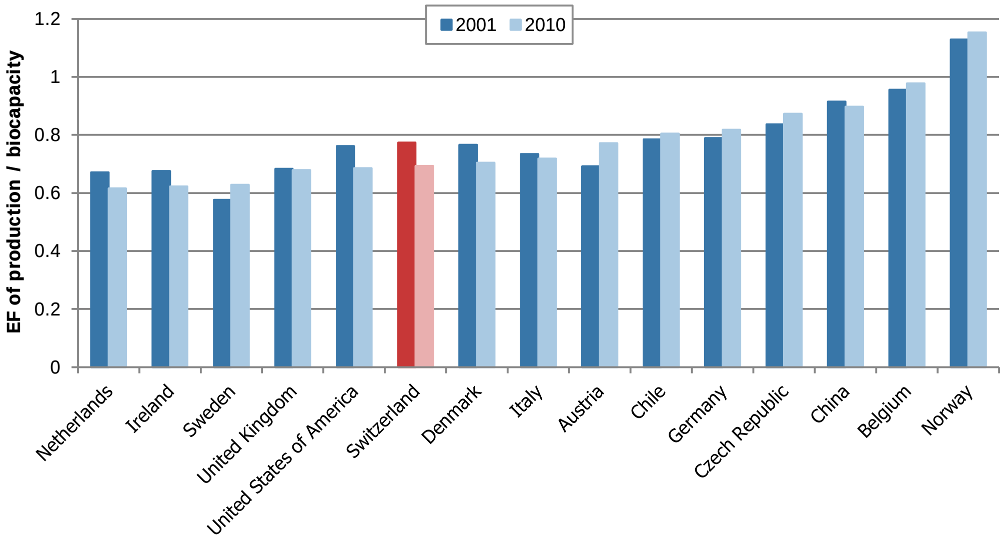


Source: Global Footprint Network (2014)

Overusing underlying ecological assets, such as soil fertility, groundwater, fish stocks, forest stocks for carbon uptake, fuel wood, timber, and biodiversity, inevitably leads to a future decline in a country's biocapacity. Overuse is therefore another important factor in natural resource import dependency. At a constant level of consumption, by eventually lowering the productivity of domestic ecological assets over time, it will increase imports of natural resources. Overharvesting can lead to irreversible domestic biocapacity depletion, in other words, a lower capacity to regenerate bioproductive resources within a country's national borders.

Fig. 4-12 shows resource overuse defined as the ratio of the EF of production over biocapacity. It includes all land types except carbon uptake land in the numerator. A ratio above one is a clue that a country may be putting its biocapacity at risk owing to the potential overuse of domestic natural resources. A ratio below one indicates that a country's biocapacity is not totally used for production, which allows more room for manoeuvre in terms of managing the future consumption of natural resources. Such a country may, however, be consuming resources in unsustainable ways that are not accounted for by the Ecological Footprint. The majority of countries in the panel, including Switzerland, have a ratio below one, which is rather a good result for the land types concerned. (Owing to methodological and data limitations, National Footprint Accounts are not yet able to show overgrazing or overharvesting of cropland.) This is typical of high-income economies which can afford a higher natural resources import bill, and have thereby managed to shift the ecological pressure away from their domestic natural resources base. Worth noting is that Switzerland, along with the USA and Denmark, is one of the few countries in the panel significantly reducing its overuse.

Fig. 4-12 Resource overuse ratio (excluding carbon footprint in the EF of production):

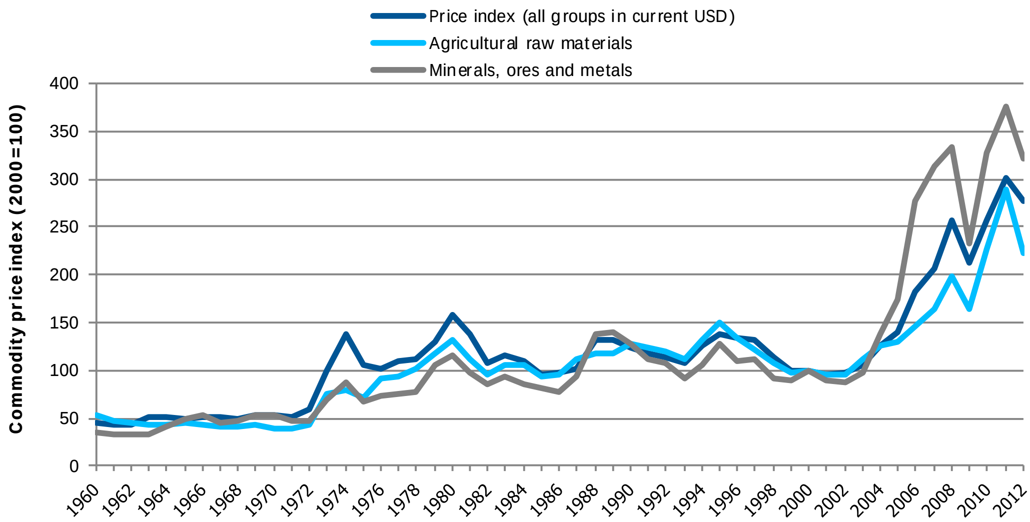


Source: Global Footprint Network (2014)

4.4.2 Economic significance of resource risks

The price volatility of imports is analysed in this section to identify the significance of the risk from resource import dependency to a country's competitiveness.

Fig. 4-13 Commodity price index for agricultural raw materials



Source: UNCTAD (2014)

Fig. 4-13 shows an upward price trend for commodities. The picture is much more volatile when looking at real prices. It shows that prices for agricultural raw materials have soared by about 250 percent since 2000. This steady rise and high volatility in the resource market create a risk when combined with high resource import dependency. If countries do not have the financial resilience to compensate for this rise in import prices, the result will be a negative impact on their balance of trade.

Exposure to resource price volatility rises as dependency on resource imports grows. As shown in Fig. 4-11, Switzerland and Belgium are more exposed to resource price shocks than the other countries in the sample. A large proportion of resource imports is processed and then exported again. Processing industries depend on stable resource markets and stable prices.

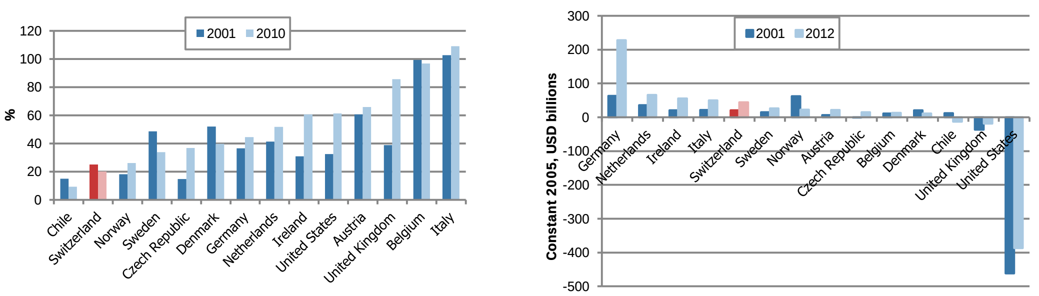
4.4.3 Financial resilience

Depending on natural resource imports might represent a general risk, but the actual impact of this risk still depends on a country's capacity to compensate for its exposure to resource price volatility or supply disruption. Several macroeconomic indicators are presented below in order to show how resilient the economy of a country may be in the face of resource shocks and growing resource scarcity.

Fig. 4-14A shows the panel countries' central government debt as a share of GDP. Switzerland appears as the second-least indebted country in this peer group behind Chile, despite its low resource endowment. It performs well, for instance, if compared with Italy, which has a debt ratio which exceeds 100%. The United States of America showed a ratio of 61% in 2010. There is a heated debate on the effect of debt on economic growth. Thresholds have recently been revised after trusted experts have been proven wrong (Reinhart and Rogoff 2010). Nevertheless, there is a common sense consensus that high debt rates tend to destabilise an economy.

Fig. 4-14 Financial resilience

A: Central government debt as a percentage of GDP **B: Net trade balance in goods and services**



Source: The World Bank (2014)

Fig. 4-14B shows the net trade balance of the panel countries. This is expressed as a monetary value for all goods and services, and no longer limited to biocapacity trade in gha. It hints at some potential for countries to compensate for price hikes in imports such as natural resources commodities. At opposite ends, Germany and the USA stretch the scale. Switzerland ranks only fifth among the eleven net exporters from the panel. Germany boasts a strong export surplus, which is positive in general in compensating for import dependence, but also points to export market dependence. Switzerland faces the same situation, but to a lesser extent. The USA must cope with a large but declining trade deficit, largely as a result of manufactured goods trade with China.

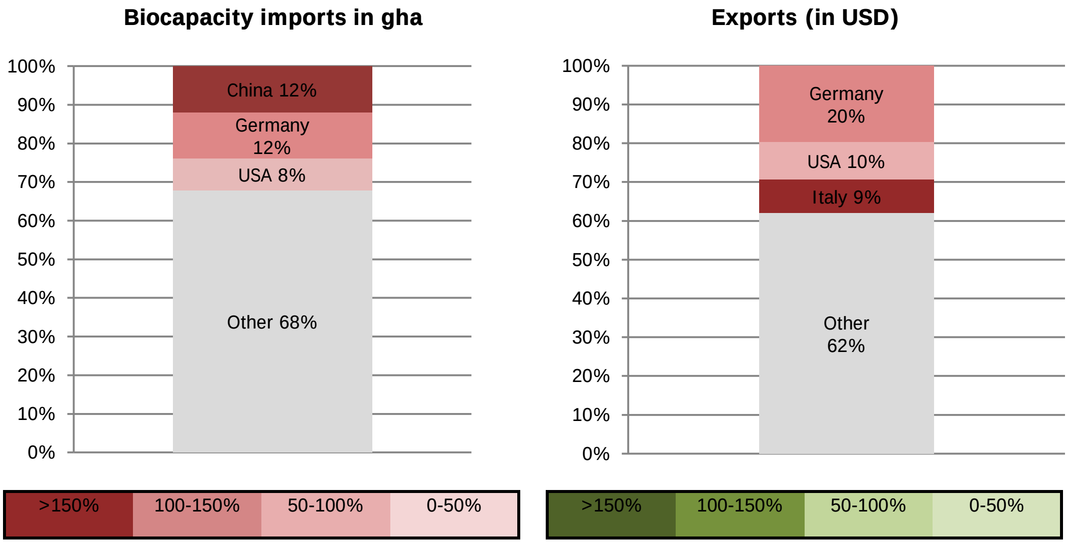
4.4.4 How does this affect Switzerland? Trade quality

The positive conclusion at this juncture is that Switzerland might still be able to pay a larger bill for its resource imports in the future, and could do so even if the domestic supply of natural resources were to decline and demand were to keep increasing in the wake of growing consumption and a rising population. In other words, barring negative developments affecting the patterns of international trade, Switzerland does not currently face a high purchasing power risk arising from its consumption of natural resources. However, the country may depend more on the economic stability of its export markets to finance its resource imports bill. This will be investigated below.

But let us add one final consideration on resource import dependency before moving on to export analysis: Fig. 4-15 shows that Switzerland's natural resource imports are from countries which themselves are running a biocapacity deficit. This hints that these countries may possibly be weakening their access to biocapacity. In the long run, they may not be able to maintain the current level of resource supplies to Switzerland. The biocapacity deficit of the three countries shipping the highest share of embedded bioproductive and carbon uptake land to Switzerland is severe, especially that of China, from which Switzerland imports 12 percent of its domestic biocapacity gap. Worth noting is that China's per-capita Footprint is still less than half that of Switzerland. This places the former positive conclusion in the more accurate context that, if Switzerland ever faces a risk in relation to import dependency, it will be because of potential supply disruption rather than price volatility.

The second chart in Fig. 4-15 looks at the main export destinations for goods and services. Ideally, export markets should be more diversified. As noted above, Switzerland has already secured the purchasing power to afford an even higher resource bill than today. However, this purchasing power also comes from the income generated by exports. What if those export markets were affected by economic recession? To a large extent, Switzerland exports high-quality goods, almost 40 percent of which go to only three countries: Germany, the USA and Italy. Therefore, the economic stability of these destination markets matters greatly. Fiscal stability and net trade balance are favourable in Germany, but less so in Italy and the USA. The very day Europe and/or the USA are hit by the next economic depression, Switzerland may have a problem finding continued demand for its exports. This might imply a follow-on effect on its own purchasing power for natural resource imports. Switzerland's comparative advantages might still remain unscathed, but the its competitiveness would certainly change, as it would not have the means to sustain the necessary level of investment. In other words, Fig. 4-15 shows that Switzerland may be caught in a vice: the worsening biocapacity situation of its main natural resource suppliers is compounded by the continuing concentration of its export markets of goods and services in 2008.

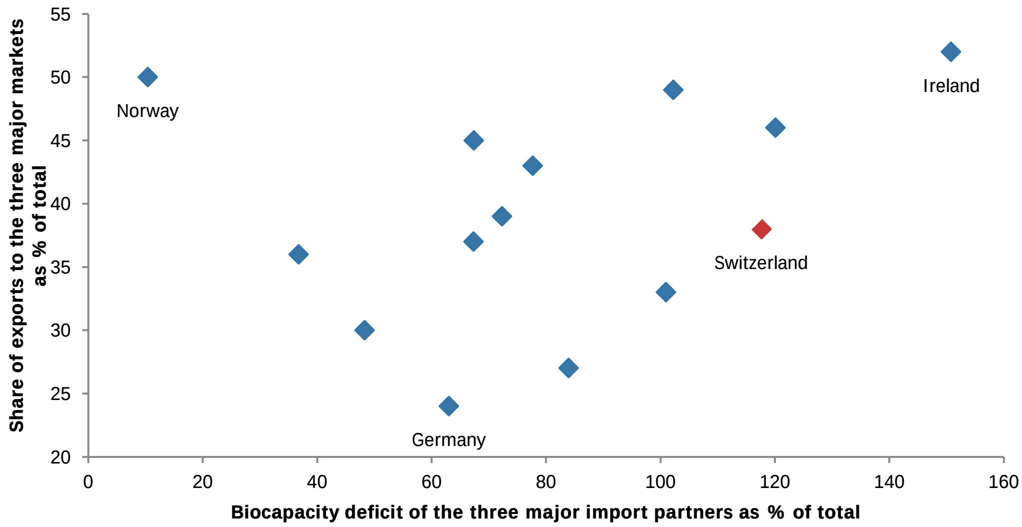
Fig. 4-15 **Switzerland's trade quality (2008)**



Source: Global Footprint Network 2014

Fig. 4-16 plots the export market diversification of goods and services for each panel country (the Y axis) against its vulnerability to a biocapacity deficit run by its main suppliers (the X axis). Ideally, a country would receive its natural resource imports from countries with as small as possible a biocapacity deficit, or even a biocapacity reserve, while it would export goods and services to the broadest possible group of countries. Therefore, for each country in the panel, the closer to the origin, the less the vulnerability to the quality of trade. Switzerland is vulnerable on both scores: it shows a rather concentrated export market for goods and services. On top of that, the three countries supplying the major share of its biocapacity resources are all running sizeable biocapacity deficits. This places Switzerland in the third-worst position in the panel, ahead of the Czech Republic and Ireland.

Fig. 4-16 **Trade diversification and dependence on suppliers' biocapacity deficits**



Source: Global Footprint Network (2014)

5 The significance of natural resources to Swiss competitiveness – the economic perspective

Section 4 demonstrated that the scarcity of natural resources is a problem of global dimensions. In the following analysis of Swiss competitiveness, the assumption is therefore made that all countries are affected by bottlenecks to a similar degree.

Availability problems with energy, critical materials and environmental quality are of particular importance to Switzerland's competitiveness. For data-related reasons, the investigation into environmental quality as it relates to Switzerland's particular pattern of specialisation is limited to emissions of CO_2. This is particularly important because of the carbon sink problem (for energy).

As a general rule, the analysis is based on the direct, domestic use and consumption of natural resources. Data availability issues mean that indirect flows of exports cannot generally be factored in.

5.1 Competitiveness through specialisation

This section looks into whether the Swiss economy's pattern of specialisation is more of a help or a hindrance to Switzerland's competitiveness when natural resources are taken into account. In addition to structural effects, it will show whether or not Swiss economic sectors manage natural resources more efficiently than other countries. Resource efficiency can mitigate the negative effects of the growing scarcity of natural resources, because more efficient management can reduce the negative impact of higher material and access costs. That said, even a high degree of resource efficiency would be of no benefit if there were major supply problems or even a complete breakdown in the supply chains for certain resources. The following analysis concentrates on energy consumption, environmental pollution (measured as the level of the air pollutant CO_2), and the use of critical minerals. It is based on the assumption that resource availability is determined exogenously, and that neither geopolitical power nor extensive reserves of resources are at all relevant. For example, the new wave of industrialisation in energy-intensive sectors in the USA, thanks to low-cost shale gas, does not affect the competitiveness being studied here. For reasons of comparability, the key point in this analysis is only efficiency in the way in which resources are used and managed, not the origin of those resources.

5.1.1 Energy

Energy is one of the most important limitations on any national economy. No economic system exists that could function without energy. The availability of energy thus occupies a correspondingly important place in the public discussion. The emphasis here is less on the availability of the raw materials to generate energy, and more on the security of supplies of electrical and fossil fuel-based energy at acceptable prices. Significant energy price differences exist at the international level. To a certain extent, these are politically induced. Differing production costs at country level also have a bearing on national competitiveness. In terms of electricity prices, Switzerland is currently one of the lowest-cost countries in Europe. Energy prices here are likely to rise sharply with the implementation of the Energy Strategy 2050, however. Nuclear power stations, whose energy is currently sold at low cost, will be shut down, and measures to promote new renewable energies and reduce emissions will result in an increase in the duties payable on power. The competitive situation of the Swiss economy in comparison with countries which are also shutting down their nuclear generation facilities, such as Germany, is unlikely to change significantly. In contrast, the United Kingdom and France continue to emphasise low electricity prices and broad availability by remaining committed to nuclear power.

Productivity and intensity – indicators of efficiency

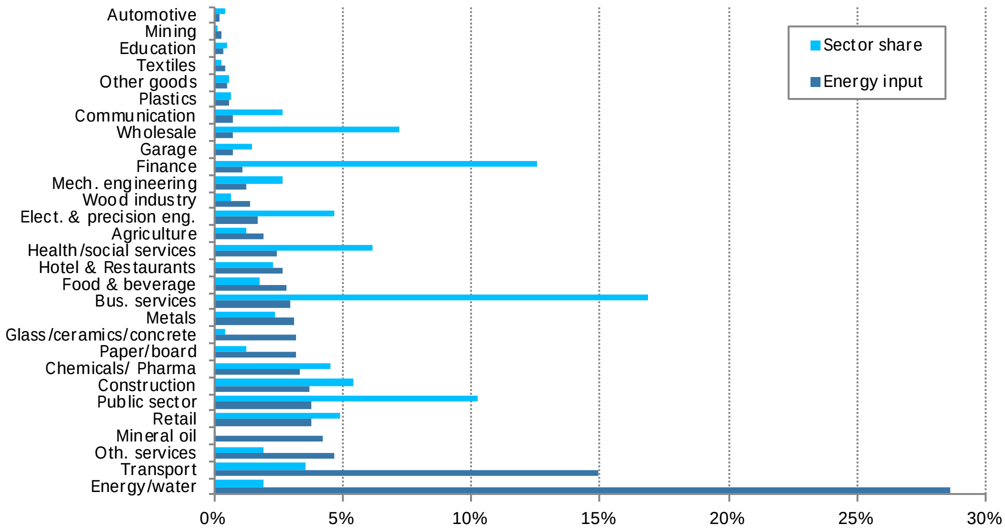
The productivity of a factor of production such as energy or materials indicates how much economic output can be produced with one unit of this factor.

$$Productivity = \frac{Gross\ domestic\ product}{Input\ factor}$$

Productivity is thus an expression of how efficiently an economy manages and uses the factor in question. Productivity increases when GDP increases at a constant level of resource or energy input, or when the same level of GDP can be generated with lower factor inputs. Intensity is the inverse of productivity. Rising productivity means declining intensity, and the production process becomes more efficient. Intensity is also useful as an indicator of efficiency in the unwanted by-products of the production process. For example, CO_2 intensity indicates how much CO_2 the production process emits per unit of value added. The lower the intensity, the more efficient the production process.

In 2008, the Swiss economy used around 763,000 terajoules (TJ) of primary energy. This corresponds to 65 percent of aggregate national primary energy consumption. A little less than half of the energy used by the economy (44%) originates from fossil fuel sources, while a quarter is accounted for by nuclear fuels, and around a fifth (22%) is electricity.

Fig. 5-1 Energy usage of economic sectors in Switzerland, 2008



Sector shares of direct domestic energy usage and nominal gross value added for the economy as a whole, 2008, in %
Source: SFSO

The two sectors which display by far the highest energy usage in Switzerland are energy and water supplies, and transport (cf. Fig. 5-1). The share accounted for by the transport sector is probably underestimated, as the data cover transport-only companies exclusively. Distances travelled by companies in other sectors, such as wholesalers, etc. are not attributed to the transport sector. With the exception of the Netherlands, energy and water supplies are among the extreme consumers of energy in all peer countries. The mineral oil processing sector is also at the top of the list in most countries. In Switzerland, this sector is negligible in size, and thus accounts for a much lower proportion of the economy's energy consumption.

In its peer countries, the two sectors which, on an aggregated basis, use the most energy, make up half of all energy usage. In Switzerland, energy and water supplies and transport together account for "only" 44 percent of the economy's consumption of energy. These two sectors account for five percent of nominal gross value added in Switzerland. Thus, 95 percent of Swiss economic output is achieved with 66 percent of total energy consumption in the economy as a whole. This is one of the lower figures internationally. The picture in Denmark is much more positive, with 92 percent of output achieved with 36 percent of total power consumption.

Absolute energy consumption tells us nothing about a country's competitiveness, however. The following analysis therefore examines energy intensity and energy efficiency.

The energy supply and mineral oil processing sectors are excluded from the country comparison. By their nature, both display extremely high levels of energy usage. Efficiency in these sectors is therefore the key determinant of the economy's overall energy profile, and overshadow differences between other sectors. In Switzerland, these two sectors are given just a two percent weighting in gross value added for the national economy as a whole. They are attributed similarly small shares within Switzerland's peer group, ranging from 1.9% in the United Kingdom to 5.0% in the Czech Republic. Furthermore, it is almost impossible to make a meaningful country comparison of energy efficiency in the energy supply sector. The picture is distorted by pumped-storage power plants, which are numerous in countries such as Switzerland and Austria. These power plants are used as temporary storage for surplus electrical power, before releasing it again on demand with relatively little loss of energy. Energy usage in the energy supply sector is thus distorted upward in countries in which there are many pumped-storage facilities.

While energy supply is analysed separately in a brief digression from this main report, the mineral oil processing sector will not be discussed. This sector is unimportant to Switzerland, as it accounts for a negligible 0.02% of the aggregate economy, and products from this sector are largely imported. Domestic output from mineral oil processing is not the important factor in the competitiveness of the Swiss economy. Rather, it is the degree to which other sectors are dependent on the import of goods made from that oil.

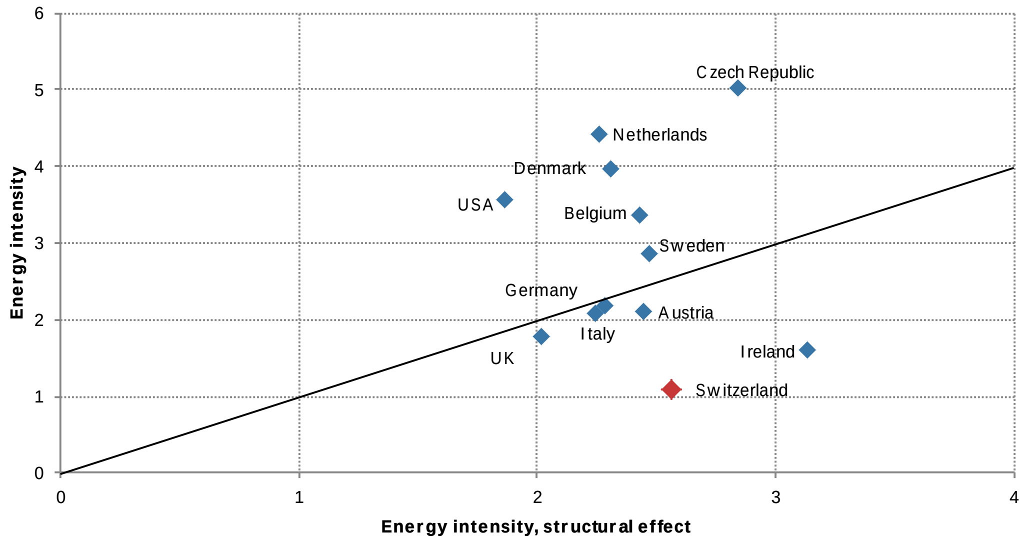
A digression – energy supply

The energy supply sector accounts for by far the greater share of energy usage in the aggregated energy and water supply sector. The energy supply sector essentially comprises electricity, gas and heat supplies, with electricity supply the largest of these subsectors.

In Switzerland, around 60 percent of electricity is generated using hydropower. A further 35 percent comes from nuclear facilities, and just six percent is generated using other sources of energy (fossil and new renewables). Water will not become a scarcity factor in Switzerland (Federal Council 2009). A lower risk is attributed to nuclear fuel-based power supplies than to those based on natural gas and oil, both in geopolitical terms and with regard to static lifetime (cf. SCNAT 2007). The decision to abandon nuclear power in connection with the Energy Strategy 2050 should eliminate Switzerland's dependence on nuclear fuels entirely by 2034. Thus, at first glance the country's energy supplies are less affected by resource supply bottlenecks than the average Western European country, where a larger proportion of energy usage is covered by fossil sources. That said, the implementation of the Energy Strategy 2050 is likely, at least for a time, to involve gas-fired thermal power stations. This will increase both dependence on raw materials and Switzerland's overall CO_2 emissions. A further potential danger of the Energy Strategy 2050 is associated with plans to promote energy-efficient appliances, solar power, and electricity storage. The technologies used to manufacture such appliances and storage make greater use of materials whose availability should be classified as critical, such as rare earths. The risk here is that resource availability problems will merely be shifted into a different domain (cf. also EU 2010).

Fig. 5-2 shows a comparison of energy intensity in other sectors in different countries. In addition to energy intensity in itself (the Y axis), it illustrates what is referred to as the structural effect of energy intensity (the X axis). This structural effect corrects energy intensity to account for the structure of the national economy concerned. It provides a measure of target mean energy intensity for the given economic structure. Mean energy intensity is calibrated using figures for the aggregate Western European economy. Countries which are shown above the diagonal bisecting line on the chart use more energy than might be expected in view of their economic structure. Countries which appear below the bisecting line are thus more efficient users of energy than their economic structures would suggest.

Fig. 5-2 Energy intensity, 2008



Energy intensity in TJ/ USD m (PPP); the structural effect of energy intensity is the energy intensity to be expected on the basis of economic structure (Ø energy intensity in Western Europe * regional economic structure); this chart excludes the energy and water supply and mineral oil processing sectors.
Source: BAKBASEL, BFS, WIOD

The Swiss economy displays the lowest energy intensity of the entire peer group sample. In other words, aggregate gross value added is achieved at a relatively low level of energy usage.

Although the Swiss economy is heavily weighted towards energy-extensive sectors such as the financial industry, with the rather more energy-intensive secondary sector accounting for 28 percent of output, Switzerland is still average within the peer group selected for this study. Overall, Switzerland's economic structure indicates that it should actually be one of the three most energy-intensive countries in its peer group.

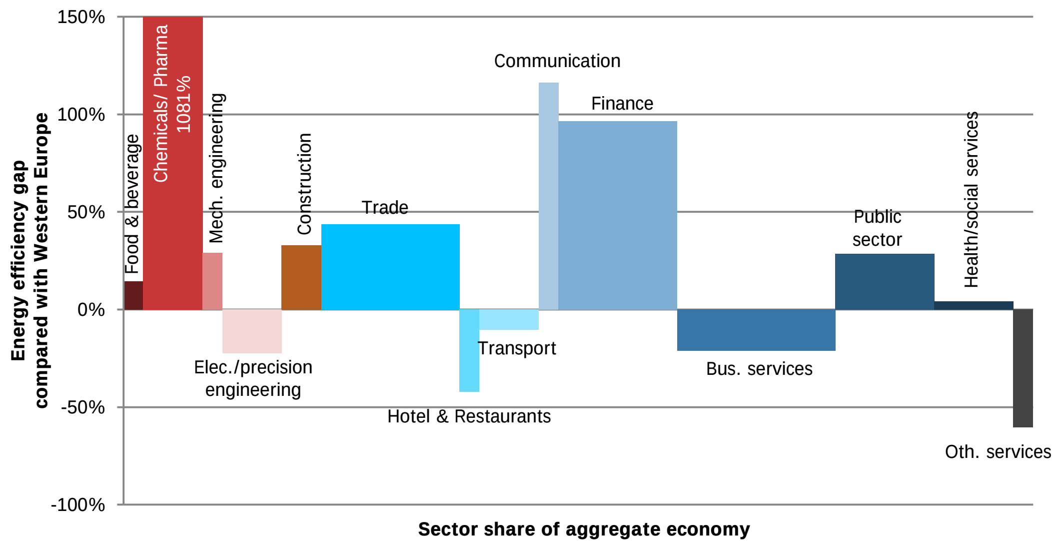
In fact, for each unit of value added, the Swiss economy uses less than half of the energy that might be expected given its sector mix. The main reason for this is the high weighting of the energy-intensive chemical and pharmaceutical industry. In Switzerland, this sector is biased towards the pharmaceutical industry, which is typically much less energy-intensive than the chemicals sector. The scope and availability of data makes it impossible to analyse these two sectors separately, and taking their average unfortunately distorts the results slightly in Switzerland's favour. A similar effect can be observed in trade.

The Swiss economy is still very energy efficient without these distortion effects, however. Energy-related price increases and availability problems are likely to result in less of a competitive disadvantage than in other countries.

The Czech Republic not only displays an energy-intensive economic structure, but the energy efficiency of the individual sectors of that economy is also generally below average. The Czech metals industry, in particular, is much more energy-intensive than the Western Europe average. At four percent, its weighting as part of aggregate gross value added is double the average. The Czech Republic thus fares worst in its peer group. Although the Netherlands – theoretically – has an economic structure that is less energy-intensive, it still displays a number of efficiency deficits compared with the Western European average, especially in the secondary sector and in transport. In Denmark, the shipping sector accounts for 39 percent of aggregate energy usage. Add in the other transport sectors, and the share of energy usage rises to 43 percent. Since this sector overall does not generate a great deal of value added, the result is a high – i.e. poor – level of energy intensity. In the Western European average, traffic and transport account for "only" seven percent of all energy used by the economy.

The analysis of the energy efficiency of individual sectors in Fig. 5-3 illustrates why the Swiss economy comes out on top for energy intensity within its peer group. The X axis displays the share of gross value added in the Swiss economy that is accounted for by the sector in question. The Y axis shows the difference in energy efficiency between Switzerland and the Western European average. Positive figures mean that the relevant sectors in Switzerland are more energy efficient than Western Europe overall. In other words, they add more value per unit of energy used.

Fig. 5-3 Energy efficiency, 2008



Difference in energy efficiency in % to the Western European average (energy efficiency = USD (PPP)/TJ of direct domestic energy consumption); includes only those sectors which account for 2% or more of aggregate gross value added; 2008
Source: BAKBASEL, BFS, WIOD

Most economic sectors in Switzerland are more energy-efficient than the Western European average. In particular, the chemical/pharmaceutical industry, as well as the financial sector, use energy much more efficiently. Although Switzerland's chemical/pharmaceutical industry also has local production facilities, it is closely focused on research and development. This creates considerable value at a low level of energy-intensity. However, this substantial lead is also a product of the above-average weighting of the pharmaceutical industry within the chemical/pharmaceutical aggregate in Switzerland. The financial sector in Switzerland is larger than in most other countries within the peer group. It accounts for 13 percent of aggregate gross value added, so its weighting is around twice that of the Western European average (6%). Since Switzerland's financial sector is also around twice as energy-efficient as the average for Western Europe, it is a key factor in the low energy-intensity of the Swiss economy as a whole.

Like the aggregate chemical/pharmaceutical sector, the Swiss trade sector's efficiency advantage is rooted to some extent in its structure. In Switzerland, commodity (raw materials) trading is a more important part of trading overall than is the case with the peer group overall. This area of trade requires much less energy than retailing, for example, and also adds more value.

The Swiss economy loses out most when it comes to business-related services. Within this sector aggregate, real estate is more energy-efficient than average, but the IT services and research and development subsectors in Switzerland prove to be relatively energy-intensive. A lack of raw data unfortunately makes it impossible to make an international comparison of the individual subsectors within the electrical and precision engineering sector aggregate. Data for Switzerland nonetheless implies that the combined precision engineering, optics and watchmaking sector is around twice as energy-efficient as the manufacturing sector for electricity generating equipment and communications technology. It can therefore be concluded that the deficit in energy efficiency compared with Western Europe as a whole is caused primarily by this latter sector. Below-average energy efficiency in the transport sector is explained to some extent by Switzerland's particular topographical conditions.

Very generally, with the exception of the electrical and precision engineering sector aggregate, those sectors with below-average levels of energy efficiency are also less productive than the Western European average in terms of the hourly productivity of labour. Meanwhile, those sectors which are more productive and thus more competitive are also more energy efficient than the average. Switzerland is often found to be highly competitive, by indicators such as the Global Competitiveness Index, for example. This is also reflected in the energy efficiency of the Swiss economy.

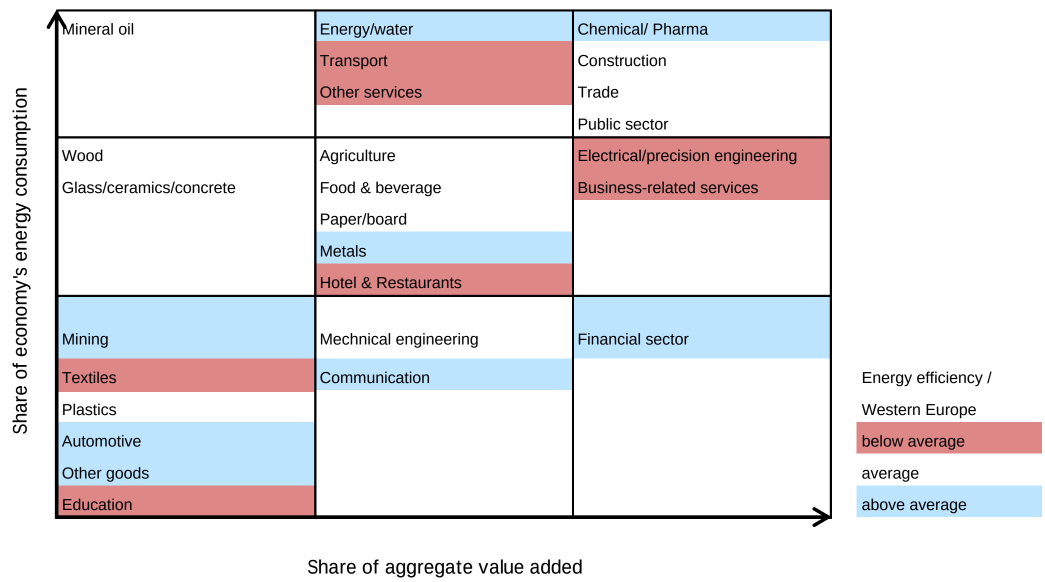
The data show that his efficiency has continued to improve over time. Between 2001 and 2008, the energy efficiency of the economy as a whole in Switzerland improved by an average of 1.6 percent per year. This is right on the average for Western Europe. The communications industry reported the greatest increase (Ø +13.1% p.a.), while the chemical industry (Ø +5.6% p.a.), the financial sector (Ø +3.3% p.a.) and the wholesale trade (Ø +2.8% p.a.) all made further significant contributions to increasing energy efficiency overall. The transport sector, which is one of Switzerland's top-two energy consumers, improved its energy efficiency by an average of 2.3 percent per year, although this result was achieved with more rapid expansion in value added, and not with an absolute reduction in energy usage.

The decline in energy efficiency in the energy and water supply sector is disappointing (Ø -0.8% p.a.). It uses by far the largest amount of energy in Switzerland, and consumption continued to rise between 2001 and 2008 (Ø +0.6% p.a.). Energy efficiency in this sector in Western Europe overall rose by an average of 1.1 percent annually during this period.

Fig. 5-3 illustrates which sectors are important both economically (the X axis) and in terms of energy usage (the Y axis). Colour is used to indicate whether the energy efficiency of individual sectors is higher or lower than the Western European average.

The energy efficiency of the Swiss economy could be improved further by means of a structural shift towards less energy-intensive sectors, or by improving energy efficiency in the most energy-intensive industries. Simply transforming its sector structure, away from industry towards the service sector, does not itself appear feasible, however. The service sector, in particular, has a number of subsectors which are much less energy efficient than the Western European average. These are precisely the service subsectors which offer potential for significant energy efficiency gains, i.e. transport, business-related services, hotels and restaurants, and other services. The sectors mentioned here are important not only because of the share of national value added for which they account, but also because of the large amounts of energy they consume, and the below-average energy efficiency that they display.

Fig. 5-4 Need for action by sector, 2008



Source: BAKBASEL

5.1.2 Environmental pollution

Environmental pollution is relevant to the competitiveness of Switzerland's economic sectors in two respects. The quality of the environment has a bearing on sectors which build upon it directly. Tourism is a prime example here. However, since it absorbs emissions and waste products, the environment is used by all sectors to some extent. Environmental quality will therefore be regarded as a good which has limited availability. Statutory limits or guidelines exist for a number of pollutants which damage the environment if emitted to excessive levels. Once these limits have been reached the environment, as a resource, may be deemed exhausted.

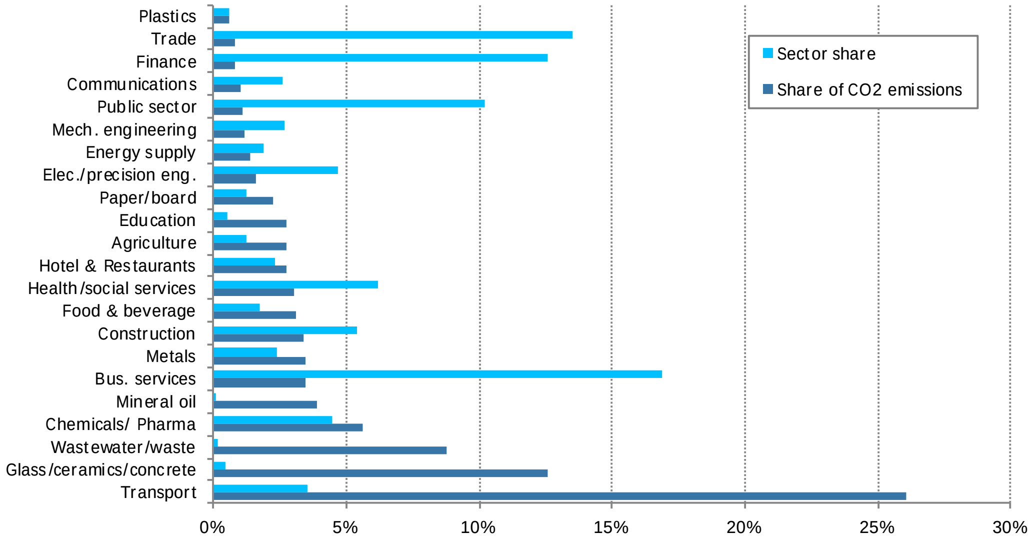
Climate change is an expression of one of the most significant forms of environmental pollution. It affects the various sectors of the economy, and the population, in two ways. The first is the direct effect of the natural, physical impact on the climate. This includes phenomena such as changing climatic conditions and extreme weather. The second is the indirect effect of climate change as it shapes markets and regulation. The Swiss economy is probably being affected primarily by the indirect impacts of climate change. In a study based on a survey of companies, Mahammadzadeh (2013) investigated the vulnerability of German companies and economic sectors to climate change. Vulnerability in this sense is a product of the perceived impact of climate change and available adaptation capacity. The findings show that only a very small number of sectors consider themselves invulnerable to climate change. According to Mahammadzadeh, the logistics sector, the metals industry and construction, as well as chemicals to some extent, may be considered "safe" at the present time. This may change in the future, however.

By way of example, the following section examines the competitiveness of different economic sectors in terms of their CO_2 emissions. This is the most important indicator of how pollutants that are damaging to the environment are being managed.

Business was responsible for less than half of Switzerland's **CO_2 emissions** in 2008 (42%). Of this figure, more than a fifth originated from the transport sector (cf. Fig. 5-5). Waste disposal and wastewater treatment, as well as the manufacture of glass, ceramics and concrete, all account for high percentages of total CO_2 emissions. However, these sectors account for insignificant proportions of aggregate gross value added. The three largest emitters of CO_2 are together responsible for 47 percent of CO_2 emissions from the Swiss economy. Their combined share of value added is just four percent, but they are still important links in the country's value chains. The greater part of the Swiss economy would thus seem to emit rather low levels of CO_2. The chemical/pharmaceutical industry, one of the greatest drivers of the Swiss economy, nonetheless takes fourth place in the list of major emitters.

In an international comparison, alongside transport, energy supplies cause the highest levels of CO_2 emissions. Electricity generation in Switzerland, which is based principally on hydropower and nuclear power, may be described as CO_2 free. In the peer sample analysed here, the shares of aggregate CO_2 emissions accounted for by the energy supply sector range from 1.3 percent in Switzerland to 56.0 percent in the Czech Republic.

Fig. 5-5 Territorial CO_2 emissions by sector, 2008



Sector shares of domestic CO_2 emissions and nominal gross value added for the economy as a whole, 2008, in %
Source: SFSO

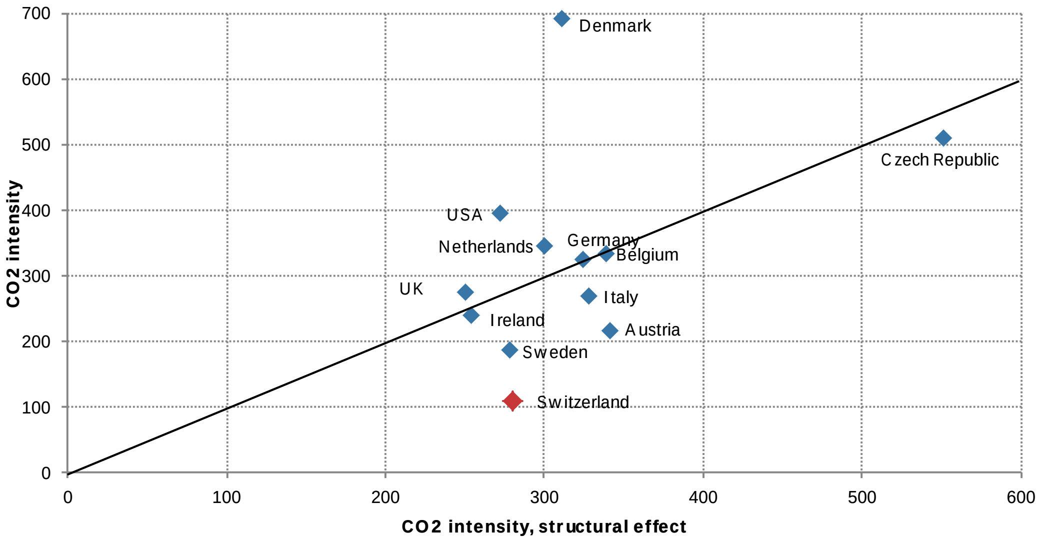
Similar to the analysis of energy intensity, Fig. 5-6 displays the CO_2 intensity of the national economies covered by this study. Switzerland once again leads the field. The Swiss economy is much less CO_2 intensive than is to be expected in view of its sector structure. The significant distance between Switzerland and the Western European average is explained mainly by the extremely low CO_2 intensity of the Swiss energy supply sector (Switzerland: 13 t/USD m, Western Europe: 7,000 t/USD m).

Denmark was one of the back-markers with regard to energy intensity, and now falls to the very bottom of the rankings for its CO_2 intensity in isolation. Once again, the reason for this can be found in its shipping industry, which is responsible for 47 percent of all CO_2 emissions in the Danish economy, and is much less CO_2 efficient than the Western European average.

Although the sector structure of the Czech Republic would imply a high level of CO_2 intensity, a number of major sectors – like transport and vehicle construction – do succeed in achieving above-average CO_2 efficiency. The Czech economy thus reports low CO_2 intensity relative to its sector structure.

The other countries in the sample are all clustered closely together around the levels that might be expected given their individual economic structures.

Fig. 5-6 CO_2 intensity, 2008



CO_2 intensity in t/USD m (PPP); structural effect of CO_2 intensity = CO_2 intensity in Western Europe * regional economic structure. The calculation factors in territorial CO2 emissions only.
Source: BAKBASEL, SFSO, WIOD, Eurostat

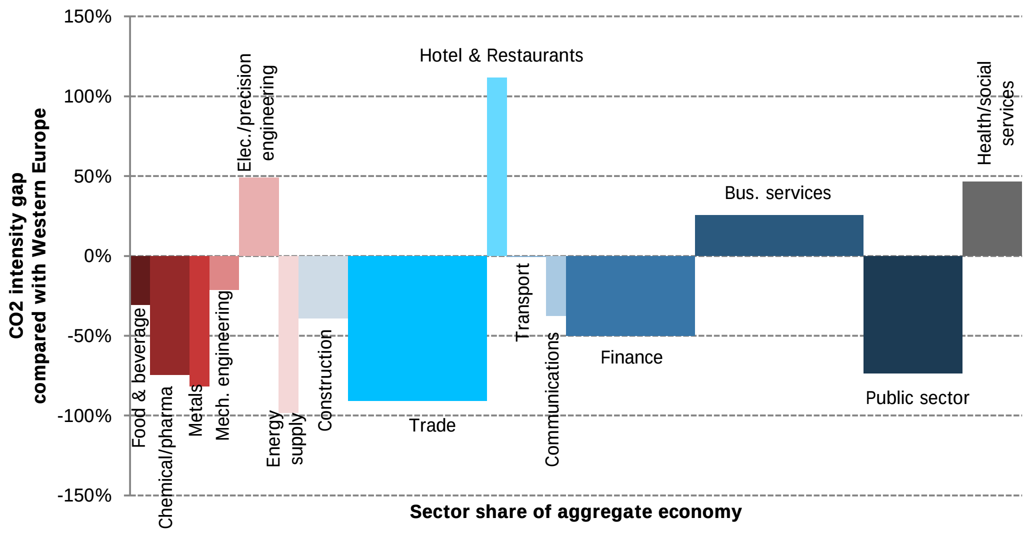
With the exception of the energy and water Supply sector, the Swiss economy's outstanding CO_2 intensity is attributable less to an individual sector, and more to generally below-average levels of CO_2. In addition to sector shares of aggregate value added (on the X axis) Fig. 5-7 shows how the CO_2 intensity of those sectors differs from the Western European average (on the Y axis). A negative figure means that the sector in question produces less CO_2 per unit of value added, i.e. it is operating less CO_2 intensively than the Western European average.

Trade is one of the greatest contributors to Switzerland's lead over Western Europe on CO_2 intensity. This sector aggregate (garage trade, wholesale and retail) accounts for 14 percent of the economy as a whole, and is 91 percent less CO_2 intensive than its Western European peers. Once again, the high weighting of commodity trading in Switzerland is a key factor in this positive result. With a CO_2 intensity of close to zero, the energy supply sector shows the greatest difference compared with Western Europe. Even taking ever-scarcer carbon sinks into account, the Swiss energy supply sector is extremely competitive at present, as it still uses hardly any CO_2-producing technologies and resources. This may change when greater use is made of fossil fuel-fired thermal and biogas power plants in the wake of the Energy Strategy 2050. Switzerland is nonetheless likely to maintain its CO_2 intensity lead over Western Europe in the energy supply sector in the future.

In view of the high proportion of the economy's CO_2 emissions for which it is responsible, the precisely average CO_2 intensity of the transport sector gives less cause for celebration. There is considerable potential here to improve the CO_2 intensity of the Swiss economy overall.

The business-related services, health and social services, aggregate electrical and precision engineering sector and the hotel and restaurants sector emit far more CO_2 per unit of value added than the Western European average.

Fig. 5-7 **CO_2 intensity by sector, 2008**



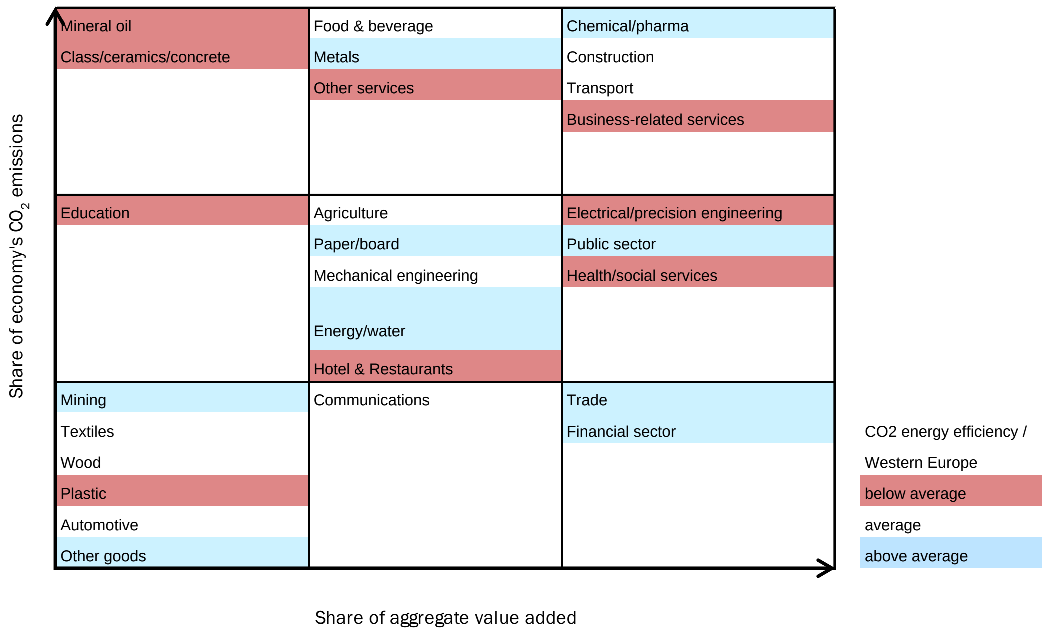
Difference in CO_2 intensity compared with Western Europe in %; includes only those sectors which account for 2% or more of aggregate gross value added; 2008
Source: BAKBASEL, SFSO, WIOD, Eurostat

The competitiveness of the Swiss economy is unlikely to be jeopardised significantly by international restrictions on CO_2 emissions. Many of Switzerland's important sectors already display a relatively low CO_2 intensity, and the country currently has a competitive advantage in this regard. This advantage should even be sufficient to maintain competitiveness if Switzerland were to introduce more stringent limits on CO_2 emissions, whether unilaterally or together with a small group of other countries. Private households and private transport nonetheless offer much greater potential than business for reducing CO_2 levels (cf. also Section 5.2.2). In view of the Swiss economy's major export focus, it should also be well placed to withstand a weakening of the domestic market brought on by a fall in household incomes owing to higher CO_2 levies.

One of the likely reasons for the Swiss economy's outstandingly low level of CO_2 intensity is the fact that many CO_2-intensive intermediate inputs goods are imported, and only reprocessed in Switzerland. Grey CO_2 emissions would have to be analysed to draw a conclusive picture of Switzerland's CO_2 intensity. This is not possible with the sector data that is currently available. However, it may reasonably be assumed that the Swiss economy, centred as it is on high-quality, innovative products, would be able to pass higher prices on to customers without seeing a dramatic drop in sales. Switzerland's competitiveness would not suffer significantly, although this has less to do with the environmentally friendly nature of the Swiss economy, and more with its innovative capacity and high quality standards. That said, respect for the environment and sustainability are an excellent fit with the traditional values and success factors of the Swiss economy, and may well present opportunities to maintain and improve the country's competitiveness.

The CO_2 intensity of the Swiss economy fell by 11.0 percent overall between 2001 and 2008. This trend is marginally below average for Western Europe (-11.4%). Reductions in CO_2 emissions per unit of value added were achieved first and foremost by fields within the service sector. In absolute terms, lower CO_2 intensity in Switzerland as a whole was achieved by a rise in value added at a constant level of CO_2 emissions. In other words, economic activity has decoupled from the use of fossil fuels only in relative terms. Switzerland is also positioned in the middle of its peer group in the trend in absolute CO_2 emissions between 2001 and 2008. In the same period, Ireland achieved the greatest reduction in its economy's CO_2 levels, while simultaneously growing gross value added. The CO_2 intensity of the Irish economy contracted by around 28 percent, followed closely by the Czech Republic, which reported a 27 percent reduction.

Fig. 5-8 Impact on individual sectors, 2008



Source: BAKBASEL

Fig. 5-8 illustrates which sectors are important both economically (the X axis) and as emitters of CO_2 (the Y axis). Colour is used to indicate whether the CO_2 efficiency of individual sectors is higher or lower than the Western European average. Once again, it is striking to see that more subsectors within the service sector show room for improvement than is the case in the secondary sector. For example, although the chemicals and metals industries account for relatively high shares of aggregate value added and CO_2 emissions, they are already operating at a very high level of CO_2 efficiency. The law of diminishing marginal returns will make it more difficult to achieve improvements in these sectors. It would be simpler, and cost the economy as a whole less, if efficiency gains were to be made in the electrical and precision engineering sector, in business-related services, or in healthcare and social services.

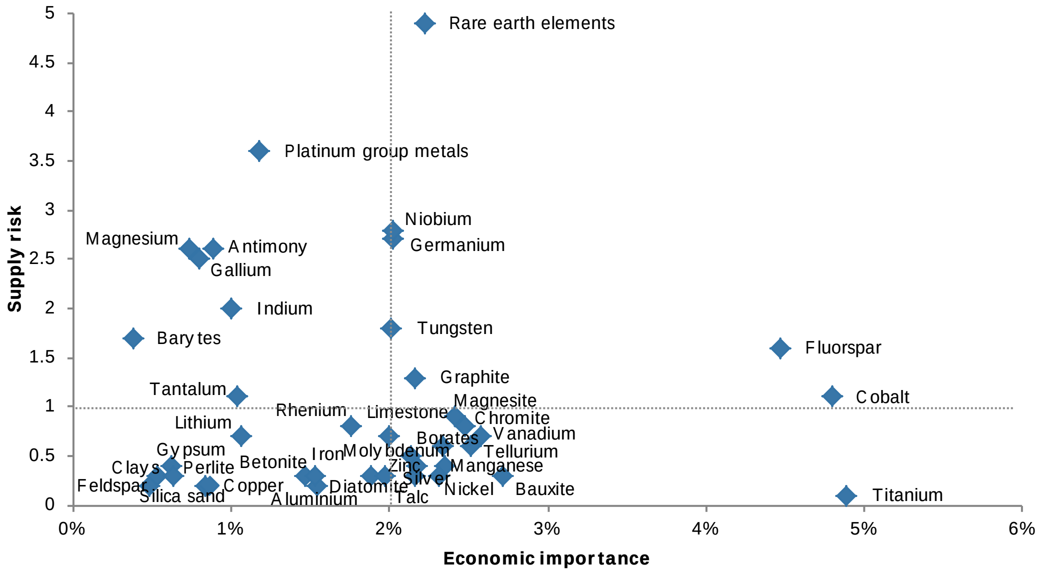
5.1.3 Critical materials

Raw materials are essential to the proper functioning of the Swiss economy. The importance of these industrial materials to downstream industries is often underestimated, however. Hi-tech metals, for example, are crucial components in the development of sophisticated products. The manufacture of solar cells requires rare earths, indium, gallium, selenium and tellurium. Platinum is an essential component of modern catalytic converters. Securing reliable access to raw materials is a major challenge for the resource-dependent countries of the world.

Switzerland is in a particularly difficult position. It is extremely dependent on imports of a large number of raw materials (cf. Section 5.2.1) that are exposed to growing demand-side pressure, from emerging economies as well as action at the national political level. At the same time, the production of many of these materials is concentrated in a small number of countries. More than 90 percent of rare earths are produced in China, for example. Furthermore, high-tech metals are often a by-product of the extraction and processing of major industrial metals such as copper, zinc and aluminium. This means that their availability is almost entirely dependent on the availability of these primary products.

Fig. 5-9 synthesises economic significance and supply risk for 41 materials. The scatter graph is based on the calculations of the EU's Ad-hoc Working Group on Defining Critical Raw Materials (EU 2010), supplemented with current data on value added. The X axis shows the economic significance of the material to Switzerland. The percentage figures indicate the proportion of the Swiss economy which uses that material. The further to the right a material is located, the larger the section of the value chain that would be affected by potential restrictions on access to it. However, supply problems with raw materials of low economic significance can also trigger major problems, as these materials are used in production for very specific applications. The Y axis shows how the materials are positioned in terms of their supply risk. Where production of a material is concentrated in a few countries which are characterised by political and economic instability, and if both their recycling rate and substitutability are low, the result will be a high supply risk.

Fig. 5-9 Economic importance and supply risk, 2010



Notes: Rare earths and platinum-group materials comprise 6 and 17 different raw materials respectively
Source: BAKBASEL, EU

The materials in the upper right corner of the graph may be regarded as critical, because they are very important to the Swiss economy, while also being exposed to an elevated supply risk. This high level of risk is based on the fact that the majority of global production comes from China (fluorspar, germanium, graphite, rare earths, tungsten) and the Democratic Republic of the Congo (cobalt). In many cases, the supply risk is exacerbated by low substitutability and a low recycling rate.

The materials in the lower right area of the graph are also very important economically, but this is paired with a low supply risk. A change in one of the parameters for the supply risk calculation (production concentration or political stability of extractive countries) may suddenly shift these materials higher up the Y axis. Titanium is much more important to Switzerland than it is to Western Europe overall. This might be explained by its use for medical applications, watches and jewellery. By contrast manganese, vanadium and chrome are all much less economically significant in Switzerland than the regional average. This is because of these materials' use in steel production.

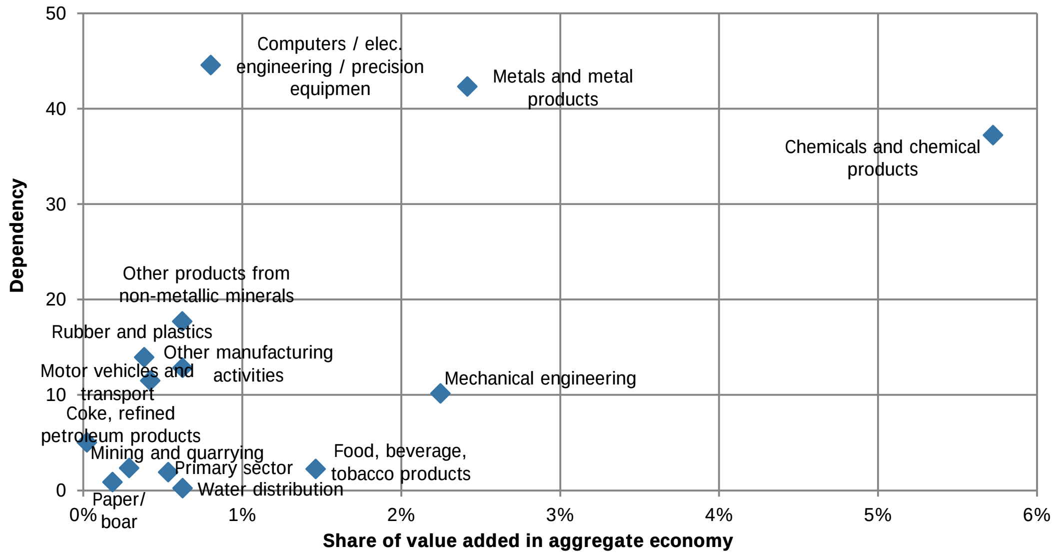
The upper left corner of the chart contains materials for which the supply risk is high, but which are of low economic significance. This is where we find magnesium, antimony, gallium and indium, all of which are deemed less important in Switzerland than is average for Western Europe, where they are classified as critical materials. The reason for this may be their primary usage in the production process for vehicles, and the electronics sector. Platinum-group materials also fall into this segment. They play an important part in converging technologies, such as nanotechnology, biotechnology and information technology. Since the life sciences industry – which offers enormous growth potential – is an important part of the Swiss economy, it may be assumed that the economic significance of these materials will increase in Switzerland in the future. They may be classified as critical for this reason.

The materials which feature in the bottom left corner are those of minor economic significance and low supply risk. According to the EU's Ad-Hoc Working Group on Defining Critical Raw Materials (EU 2010), supply bottlenecks may arise in the future for industrial materials such as lime, clay, sand and talcum when output from quarries and mines in the EU declines.

Combining a given sector's share of aggregate value added with its material dependency, as shown in Fig. 5-10 permits three main highly dependent sectors of the Swiss economy to be identified: the metals industry, chemicals/pharmaceuticals, and the electrical and precision engineering sector.

Accounting for over five percent of aggregate value added, the chemical industry in particular should be regarded as critical, because it employs a large number of materials that are exposed to a high supply risk, such as rare earths, platinum-group materials, germanium, antimony, fluorspar, graphite and cobalt. The metals & metal products industry also displays an elevated level of dependency, which is due mainly to its use of niobium in alloys. Mechanical engineering is less at risk because it uses fewer materials. Tungsten might be a limiting factor here in the future, however, as its substitution would result in higher costs and lower quality. The Swiss electrical and precision engineering sector displays the highest dependency on critical materials, because it uses a particularly broad range of them, including gallium, germanium, platinum and rare earths. These materials are essential components in modern technologies, and are being used increasingly in the cleantech field, especially. Under the Cleantech Masterplan (FDEA and DETEC 2011), Switzerland is to become the leading business location for resource-efficient products, services and renewable energies by 2020. With this in mind, these industries' share of aggregate value added is set to rise. This will also increase dependency and risk for the Swiss economy. With the free trade agreement between Switzerland and China that was signed in July 2013, Switzerland has already been able to secure very good access to one of the largest exporters of critical materials. This agreement may become very important in the future.

Fig. 5-10 Material dependency and economic significance of selected sectors, 2010



Notes: The chemicals sector comprises the two subsectors of chemicals and pharmaceuticals. If these two sectors are analysed independently, the chemical sector's dependency declines only marginally compared with the aggregate, while that of the pharmaceutical industry in Switzerland falls markedly.
Source: BAKBASEL, EU

5.2 Competitiveness through locational quality

Locational factors are one of the key influences on a country's pattern of specialisation and how it develops over time. As the real determinants of competitiveness, they set the framework in which companies and sectors can grow and thrive, and thus lay the foundations of a nation's welfare and competitiveness.

A number of different and frequently overlapping factors may be derived from the various approaches to regional competitiveness. No overall consensus exists on a certain set of locational factors, however. Each approach emphasises different elements. Through its research activities and its contact with representatives from a wide range of sectors, in international benchmarking in particular, BAKBASEL has found that the following locational factors are especially important to the competitiveness of a given business location: regulation, accessibility, innovation, and the availability of skilled employees. The latter point is closely associated with quality of life. These findings, combined with desk research[8], were key to the selection of the determinants (locational factors) of Swiss competitiveness examined here – bearing in mind that natural resources will become less available in the future. A number of indicators are used to illustrate the quality and characteristics of the locational factors covered by this study. Viewed together, they provide information on the locational quality of Switzerland and its international peers. To produce a more rounded overall picture, the focus here is on indicators which are not already covered by the Ecological Footprint concept. These indicators should be linked directly to locational factors. International comparability and data quality were also decisive criteria in the selection process. The analysis looks not only at locational quality as it is today, but also how it has changed over the past ten years.

From the information collected in this way, five issues were identified which, taking particular account of the availability of natural resources, are very important to competitiveness in Switzerland. These five main issues can be used to structure the relevant locational factors and their indicators. They are: the availability of natural resources, innovation and resource efficiency, accessibility, availability of skilled employees (quality of life and environmental quality), and regulation.

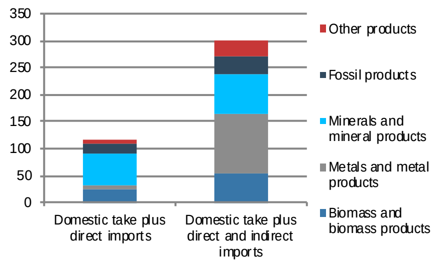
5.2.1 The availability of natural resources as a production input

When extracting raw materials, countries are subject to their own boundaries, and thus on the geography and climate within their own physical borders. Global trade in raw materials and semi-finished and finished goods is therefore immensely important to resource-poor nations such as Switzerland. Certain natural resources are important inputs in economic processes, and thus key to a country's competitiveness. This necessitates a greater focus on resource consumption, import dependency, and recycling rates.

Any analysis of **a country's consumption of materials** should include not only direct material input (DMI), but also the consumption of raw materials that are required to manufacture imported products. Fig. 5-12 shows the domestic extraction and import of raw materials. The right-hand chart presents DMI along with "hidden" imports in the form of imports to countries abroad which manufacture goods which are then imported to Switzerland. According to Swiss Federal Statistical Office findings, imports more than double when foreign raw material consumption is factored in. This also affects material efficiency. If we look at total material consumption (TMC) instead of simply domestic material consumption (DMC) (cf. Section 5.2.3) the 40 percent increase in material productivity between 1990 and 2011 falls to just 18 percent. In 2011, this corresponded to a productivity of USD 0.93/kg instead of USD 3.20/kg.

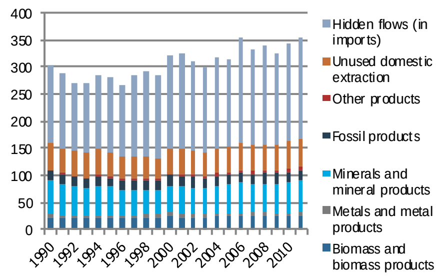
[8] UN: Indicators of Sustainable Development, OECD: Green Growth Indicator, EUROSTAT: Sustainable development in the European Union, EEA: core set of indicators, WEF: Global Competitiveness Report, SFSO: Monitoring Sustainable Development, German Federal Statistical Office: 2012 Indicator Report on Sustainable Development in Germany, and Environment Agency Austria: sustainability indicators

Fig. 5-11 Use of raw materials by main categories 2011



Swiss data in millions of tonnes
Source: SFSO

Fig. 5-12 Development of DMI and TMR



Swiss data in millions of tonnes
Source: SFSO

Between 1990 and 2011 (cf. Fig. 5-12) per-capita DMI fell from 16.4 t/cap to 14.6 t/cap – a decline of 10.8 percent. Over the same period, the total material requirement (TMR) per capita was reduced by just 1.1 percent to 44.7 t/cap. In absolute terms, DMI in Switzerland rose by 5.1 percent, and TMR was up by 16.6 percent. One of the principal factors in this increase is the 28 percent growth in hidden imports in imports to Switzerland. This may be evidence that Switzerland has relocated particularly raw material-intensive production stages abroad. This does not, ultimately, improve raw material productivity if global supply chains are taken into account. This also means that more than half of the environmental impact of Swiss consumption is felt abroad (cf. Jungbluth et al. 2011).

As an export-oriented industrialised country, Switzerland relies to a high degree on supplies of primary raw materials. The lack of raw materials domestically, and declining extraction volumes, result in dependence upon countries which are rich in raw materials. Importing resources is not a problem in itself, providing international trade functions properly. This is not always the case (e.g. supply monopolies), however, and whether or not these markets would withstand a sharp fall in the availability of resources in general, or individual raw materials in particular, is open to question. This report will therefore now look at **import dependency**, which compares net imports with domestic material consumption. Import dependency can be used as a measure of the economy's reliance on the raw materials in question. A value of 1.00 in Tab. 5-1 means that the country is entirely dependent on imports from abroad, while negative values classify the country as a net exporter.

Switzerland's dependence on imports of biomass and non-metallic materials increased slightly between 2000 and 2011. The country was already entirely dependent on other countries for imports of ores and fossil energy materials in 2000. Many countries rely on the global market in precisely these two areas. Along with Italy and Belgium, Switzerland is one of the most raw material dependent countries in its peer group. There are only a very small number of segments in which countries are net exporters, as is the case for biomass in Sweden, the Czech Republic and the USA, for example. Yet this, too, has changed over time. While some countries were still exporters in 2000, by 2011 they had become importers alone. This is also confirmed by global comparisons (German Federal Environment Agency 2013). It means that a growing number of countries are competing for materials from a declining number of exporting countries.

Tab. 5-1 Import dependency, 2011

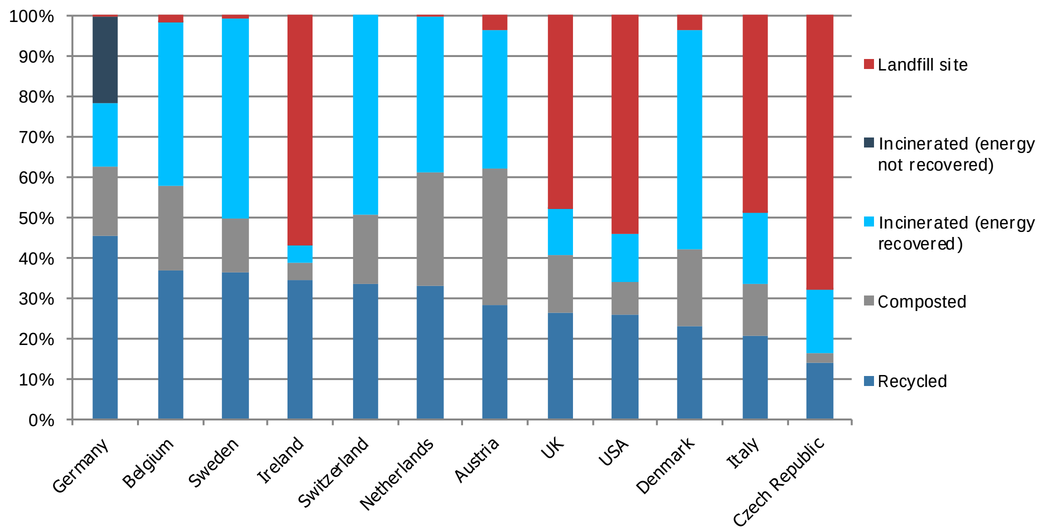
	Biomass		Ore		Non-metallic materials		Fossil energy materials	
	2000	2011	2000	2011	2000	2011	2000	2011
Belgium	0.27	0.27	1.00	1.00	-0.07	0.11	1.00	1.00
Denmark	0.09	0.08	1.00	1.00	0.00	0.07	0.09	0.48
Germany	-0.01	0.04	0.99	0.99	0.00	-0.05	0.48	0.52
United Kingdom	0.14	0.15	1.00	1.00	-0.03	-0.01	-0.14	0.38
Ireland	0.05	0.05	0.62	0.31	0.04	0.06	0.64	0.76
Italy	0.15	0.18	0.99	0.97	0.01	0.00	0.90	0.91
Netherlands	0.20	0.17	1.00	1.00	0.28	0.41	0.26	0.12
Austria	0.05	0.06	0.64	0.74	0.02	0.02	0.84	0.92
Sweden	-0.08	-0.13	-0.56	-0.53	-0.01	0.01	0.98	0.96
Switzerland	0.07	0.12	1.00	1.00	0.19	0.20	1.00	1.00
Czech Republic	-0.13	-0.50	0.97	0.97	-0.03	-0.01	0.11	0.17
USA	-0.06	-0.05	0.13	0.12	0.02	0.03	0.25	0.29

Import dependency in terms of net imports/net exports, based on domestic material consumption (DMC) for 2011, US data from 2005 (Krausmann et al. 2009).
Source: Eurostat, Krausmann et al

In a global market in which competition for raw materials is playing an increasingly important role, recycling becomes more and more important not just from the environmental, but also from the economic perspective. Recycling has the potential to reduce import dependency and thus improve raw material security and help to improve national competitiveness. As an indicator, **treatment of municipal waste** shows in percent how waste is handled by landfill sites, incineration plants both with and without energy recovery systems, composting, and recycling. Municipal waste is household waste and other waste of a similar composition which originates from industry and businesses. The indicator provides a rough estimate of how an economy recovers secondary raw materials.

In 2010, half of all municipal waste in Switzerland was incinerated in plants with energy recovery systems, while 34 percent was recycled, and 16 percent composted. This means that all municipal waste returns to the economic cycle, either as secondary raw materials, or as energy. A look at secondary raw material recovery between 2000 and 2010 reveals a six percent increase in the recycling rate, taking Switzerland to fifth place at the end of that period. At just under 46 percent, Germany has the highest recycling rate of the peer group, but of all countries it also incinerated the highest proportion of waste without recovering the resulting energy. The data show that the recycling rate in other peer group countries has risen much faster than it has in Switzerland. The 2012 waste survey found that rubbish still contains significant quantities of essentially recyclable materials (FOEN 2012).

Fig. 5-13 Treatment of municipal waste 2010



Treatment of municipal waste in 2010; 2009 figures used for the United Kingdom, as 2010 data were unavailable.
Source: OECD

In terms of the aggregate volumes of biomass, fossil energy materials, non-metallic materials and ores, Switzerland has the fewest natural resources of all the countries in the peer group. Switzerland also takes one of the bottom spots in a per-capita comparison. This results in considerable import dependency, especially where fossil energy materials and ores are concerned. Recovering secondary raw materials and generating energy from waste are seen as a possible response to this dependency on other countries. In this regard, Switzerland feeds all of its waste back into the economic cycle, with a focus on energy recovery.

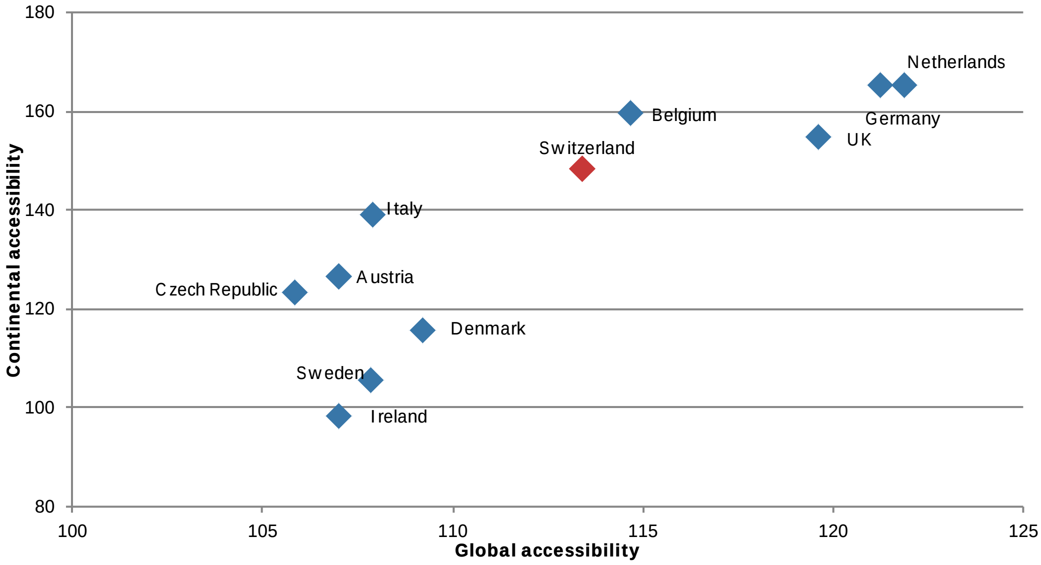
5.2.2 Transport

A high-quality infrastructure is one of the essential factors in the smooth functioning of a highly developed economy, and is thus crucial to a country's competitiveness.

A subindex of the Global Competitiveness Index mentioned above evaluates the quality of **basic infrastructure**. According to this index, Switzerland is in sixth place, with the quality of its overall infrastructure judged very good. The subindex also rates the quality of the country's road and rail infrastructure, as well as electricity supplies, as excellent.

A well-developed basic infrastructure permits the transport of goods and services, on the one hand, while also making it easier for the working population to reach the businesses in which they work. In an increasingly globalised world, the **accessibility** of a location by various forms of transport is key to the extent to which the regional in question is able to share in the economic growth process. However, since the transport of goods and passengers is also associated with external effects and resource consumption, the analysis looks not only at accessibility, but also at **CO_2 efficiency** and **modal split** as a possible response to inefficiency.

Fig. 5-14 Continental and global accessibility, 2012



Index (average accessibility of regions 2010=100), 2012
Source: BAKBASEL, IVT

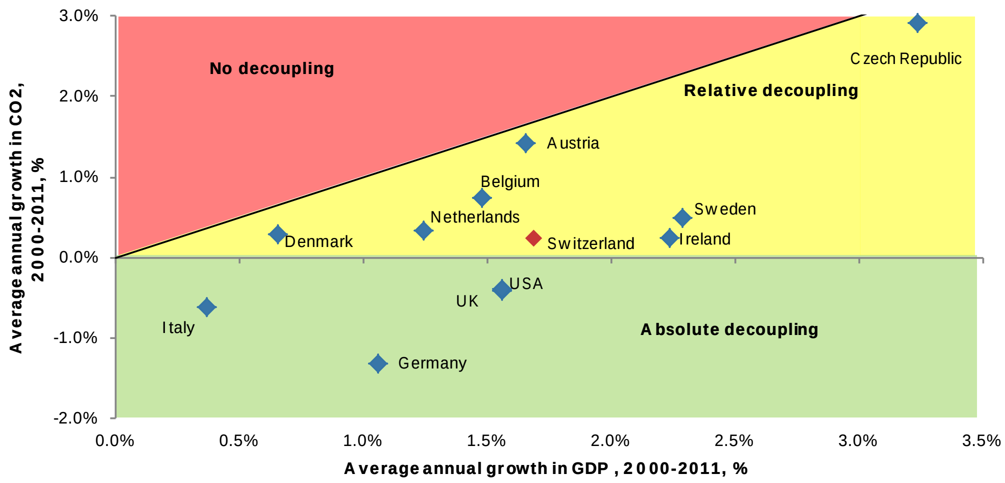
An excellent infrastructure is a major factor in Switzerland's accessibility[9]. It represents an important locational advantage, and is illustrated in Fig. 5-14. In the global context, Switzerland has its airports, and Zurich airport in particular, to thank for making its so accessible. Good connections to the high-speed rail network, and its central location within Europe, also make it very easy to reach Switzerland from all regions of the continent. Furthermore, the country is continuously improving its accessibility by investing large sums in its infrastructure, such as completing individual stretches of the A4 motorway, the Lötschberg Base Tunnel (as part of the rail network), and increasing the frequency of public transport services. In the peer group, only Belgium, the United Kingdom, the Netherlands and Germany proved more accessible, owing to their major airports.

The transport infrastructure should do more than ensure good accessibility, however. It should also be as light as possible on resources, displaying low resource use and no significant external effects. Private motorised traffic, for both goods and passengers, is particularly damaging to the environment because of its high consumption of mineral oil, and its high CO_2 emissions. A high level of **CO_2 efficiency in the transport sector** is thus important to long-term competitiveness (cf. relationship between CO_2 emissions and competitiveness in Section 5.1.2). More efficient vehicle technology or a shift in the modal split may help to reduce CO_2 emissions. CO_2 emissions refer to the emissions from fuel combustion for all types of transport[10].

[9] Accessibility relates to a specific geographical point, so data for the best-rated city is used when establishing the accessibility of a given country.

[10] Domestic air travel, domestic waterborne transport, road, rail, and pipeline transport (IEA)

Fig. 5-15 Growth in GDP and territorial CO_2 emissions from transport, 2000 – 2011



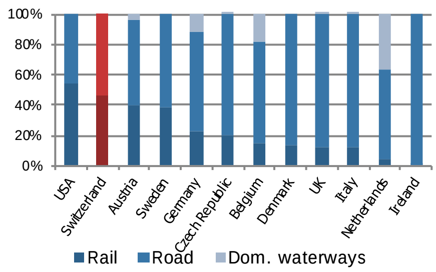
No decoupling = CO_2 emissions are rising faster than economic growth; relative decoupling = CO_2 emissions are rising more slowly than economic growth; absolute decoupling = CO_2 emissions are falling as the economy grows
Source: BAKBASEL, IEA

CO_2 emissions from the transport sector in Switzerland rose by 0.2 percent annually between 2000 and 2011, from 16.42 million tonnes to 16.86 million tonnes. In absolute terms, this level means that its emissions were low in an international comparison. At the same time, freight transport grew by 1.5 percent a year, and passenger transport by 1.6 percent a year. Both segments thus recorded above-average growth compared with other countries. When CO_2 emissions are placed in the context of traffic volumes (person kilometres + tonne kilometres), Switzerland is found to have high emissions relative to its peer group.

The data for the observation period show that the great majority of the countries studied, including Switzerland, managed in relative terms to decouple economic growth from CO_2 emissions in the transport sector (cf. Fig. 5-15). Relative decoupling indicates that CO_2 emissions rose more slowly than gross domestic product. Absolute decoupling would be achieved if CO_2 emissions were to fall as the economy expanded. Germany, Italy, the United Kingdom and the USA are the only countries which have so far achieved this absolute decoupling. According to the OECD study entitled "ITF Transport Outlook 2013" (OECD 2013A), decoupling economic growth from freight transport would enable CO_2 emissions to be cut by up to four percent. The IEA and other organisations are calling for a reduction in average fuel consumption to achieve this target. This is where the "Improving the Fuel Economy of Road Vehicles - A policy package" (IEA 2012) report identifies the greatest room for improvement, as the necessary technologies already exist, but are not yet broadly used. Switzerland could exploit development potential in this area.

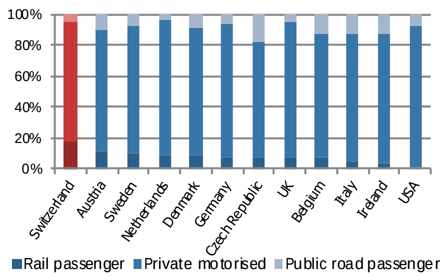
The way in which transport volumes are distributed across the various modes (e.g. rail or road) is important because CO_2 emissions are to be cut and, along with fossil fuels, they are one of the natural resources which will tend to be less available in the future. Once decided-upon, infrastructure projects are particularly path-dependent, and can be amended only slowly. With this in mind, a transport infrastructure that favours rail should be given preference in the long term. One indicator of this distribution is the **modal split.** It is calculated from the percentage shares of total traffic volumes accounted for by the individual modes of transport, and thus provides information on the usage of different carriers. The indicator depicted in Fig. 5-16 shows the distribution of freight traffic across rail, waterborne and road transport in 2011. The indicator shown in Fig. 5-17 illustrates the distribution of passenger traffic in 2011.

Fig. 5-16 Modal split – freight traffic, 2011



Shares of total traffic volume taken by different modes of transport, in %; USA figures from 2002
Source: EUROSTAT, UNECE

Fig. 5-17 Modal split – passenger traffic 2011



Shares of total traffic volume taken by different modes of transport, in %; USA figures from 2010
Source: EUROSTAT, UNECE

Fig. 5-16 reveals that, in 2011, the modal split for freight traffic in Switzerland was 46 percent rail and 54 percent road. At 41 percent, only the USA carried less freight by road, and with just under 50 percent of freight traffic travelling by rail, took first place ahead of Switzerland. It should be noted here that rail freight traffic in the USA is powered by diesel locomotives, which results in higher CO_2 emissions than comparable electrically-powered trains. Furthermore, the US data originates from 2002. In Ireland, 99 percent of freight traffic was carried by road that year – the highest percentage in the sample.

With road freight traffic accounting for only a small proportion of the freight total, the USA fared very well on this score. It fell back to last place on passenger traffic, however, as 92 percent of all passenger journeys in 2011 were made by private car. Passenger traffic is another area in which Switzerland remains convincing, with 77 percent of passenger journeys taken by private car. Only the Czech Republic displayed a lower figure. Some 18 percent of passenger traffic is carried by rail in Switzerland, which is almost twice as high as in the second-placed Netherlands.

The modal splits in both freight and passenger traffic indicate that Switzerland has an advanced infrastructure. A shift in modal split towards more public transport is desirable for long-term competitiveness, as this uses less energy and results in lower emissions. Switzerland is leading by example here.

5.2.3 Innovation and resource efficiency

Technological progress and innovation determine both the growth and the productivity of an economy, and thus its competitiveness. Innovations represent the successful implementation of ideas and new technical solutions, new processes, new products and services, and new forms of organisation. Innovations arise from the interplay of a number of factors in a multi-faceted and multi-step process.

An analysis of how innovation is structured breaks it down into input, throughput and output factors. The general framework for innovation, such as the quality of universities and research institutes, as well as skills and educational structures, are often seen as input indicators. The number of patents awarded, and the size of knowledge-based economic segments, may be used as a measure of throughput factors. Output factors in this sense describes the results of innovation. Some indicators cannot be allocated neatly to one of the three categories of inputs, throughputs and outputs. They may therefore appear in several different areas.

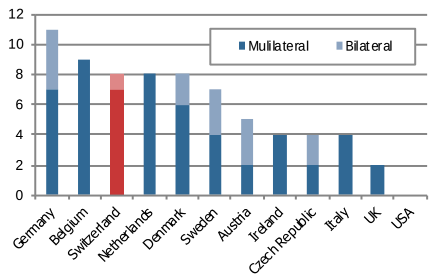
On the environmental front, international environmental agreements and the number of environmental patents may be regarded as input and throughput factors respectively. The output factors of innovation may be described in terms of efficiency data for resource use (energy, CO_2, materials, etc.), and renewable energies as a proportion of total primary energy supplies. Unlike the section on patterns of specialisation, which also takes a close look at efficiency (cf. Section 5.1.1), this section analyses not only the efficiency of the economy (the supply side), but also that of the country as a whole (economy and households, or both supply and demand). As an output of innovation, efficiency is expressed not only as economic activity, but also as consumption. Since both sides are competing for ever-scarcer resources (e.g. energy), private households must also be included in any examination of a country's efficiency[11].

Research and development by both the public and private sectors in Switzerland create a fertile environment for innovation.[12] Switzerland generally also takes one of the top spots in international comparisons of innovative capacity. For example, the World Economic Forum's Global Competitiveness Index 2013/14 awards Switzerland an outstanding second place in a peer group of 148 countries.

International environmental agreements may be regarded as a possible driver of technology transfer in the environmental domain. They offer a weaker indicator than international trade in technologies and foreign direct investment, but have been chosen deliberately because today's environmental problems, such as climate change, must be resolved at the global level through international cooperation. Participation in such agreements may promote the exchange of environment-related technologies, and thereby reduce the negative externalities of more anthropological activities. The OECD study entitled "Invention and Transfer of Environmental Technologies" (OECD 2011A) reports a positive effect in countries which participate in an international environmental agreement. The following chart shows the number of multilateral and bilateral environmental agreements concluded by different countries since 2000. A high number signals close international cooperation, and thus a potentially higher chance of international technology transfer.

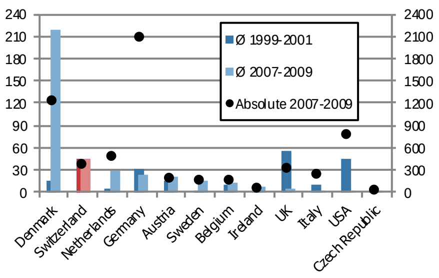
Agreements such as that concluded between Switzerland and China at the end of 2012 to engage in closer dialogue on environment policy, and to facilitate the exchange of knowledge and information on air and water pollution controls, waste management and nature conservation, may further strengthen technology transfer, and are regarded as worthwhile.

Fig. 5-18 International environmental agreements, 2013



Ratifications of international environmental agreements since 2000
Source: Ronald B. Mitchell: International Environmental Agreements Database Project

Fig. 5-19 Environmental patents, 2000-2009



Patents per million inhabitants, 99-01 and 07-09 (left axis), and absolute patents 07-09 (right axis).
Source: OECD

With one bilateral and seven multilateral environmental agreements, Switzerland is positioned in the upper middle of its peer group. Germany leads, with a total of eleven agreements. The USA brings up the rear, because it has not concluded a single bilateral agreement. Most agreements are multilateral in nature.

The **environmental patents** indicator shows the extent of technical invention, and thus innovative capacity, in this area[13]. Even if not all patent applications are successful, each one is evidence of technical endeavour, and they thus offer a suitable estimate of inventive potential. A high number thus reflects high innovative capacity.

[11] In contrast, the analysis of patterns of specialisation focuses on output from the different economic sectors, which by definition excludes private household consumption.

[12] Switzerland is very well positioned in an international comparison, with R&D spending in excess of 3% of GDP. When absolute spending is compared, Switzerland is beaten only by major economies such as the USA and Germany.

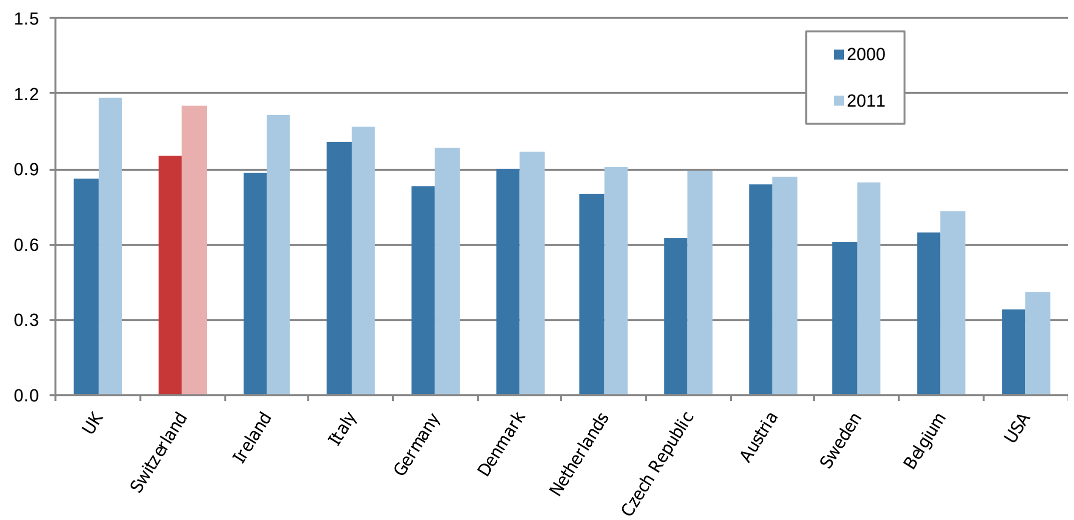
[13] This indicator aggregates patents from the following areas: general environmental management, emissions abatement and fuel efficiency in transportation, energy efficiency in buildings and lighting, and energy generation from renewable and non-fossil sources. This breakdown is used by the OECD (http://www.oecd.org/env/consumption-innovation/indicator.htm)

A high number of patents in the solar energy segment between 2007 and 2009, as well as 219 environment-related patents per million inhabitants and an absolute figure of 1201 meant that Denmark emerges top in this comparison. Led by Switzerland (46 per million inhabitants, 350 in absolute terms), the other countries followed at a significant distance. With two patents per million inhabitants and 22 overall during the 2007–2009 period, the Czech Republic occupied last place. In an analysis of the absolute figures, with 2067 patents Germany underscores its status as one of the leading countries for environment-related innovations and technologies. This comparison also placed Switzerland among the upper ranks, despite its small population. Switzerland's innovative potential in the environmental domain can thus be classified as high.

Innovation often manifests itself in the form of efficiency gains. An increase in **energy efficiency** is an important means of reducing energy consumption without forfeiting utility. Greater energy efficiency allows the desired level of utility to be achieved at lower energy costs. Innovations in energy efficiency are not limited to the production side, however. They also have a bearing on the finished products. Greater energy efficiency in consumer products reduces the rivalry for resources between consumption and production, and reduces the supply risk to the economy as a whole. This latter point is key from the competitive perspective. That is why, unlike the sector analysis (cf. Section 5.1.1), this examination also factors in private households.

A more efficient use of energy may result in lower consumption of energy feedstocks, and help to lower CO_2 emissions. In contrast to the section on sector mix, energy productivity here relates to final energy consumption. This indicator is adjusted for the energy mix that has been used, with its different types of power plant and efficiency factors.

Fig. 5-20 Final energy productivity, 2000 und 2011



GDP in USD/ domestic final energy consumption in kWh
Source: BAKBASEL, SFSO, EUROSTAT, eia

Like its economy, Switzerland as a whole displays outstanding energy productivity. Furthermore, it actually improved by an average of 1.8 percent annually between 2000 and 2011. Although this indicates that energy is being used efficiently, it is actually due primarily to an annual 1.7 percent rise in gross domestic product, although final energy consumption has actually fallen slightly in absolute terms since 2000. Placed in an international context, the increase in Switzerland's energy productivity is more or less average.

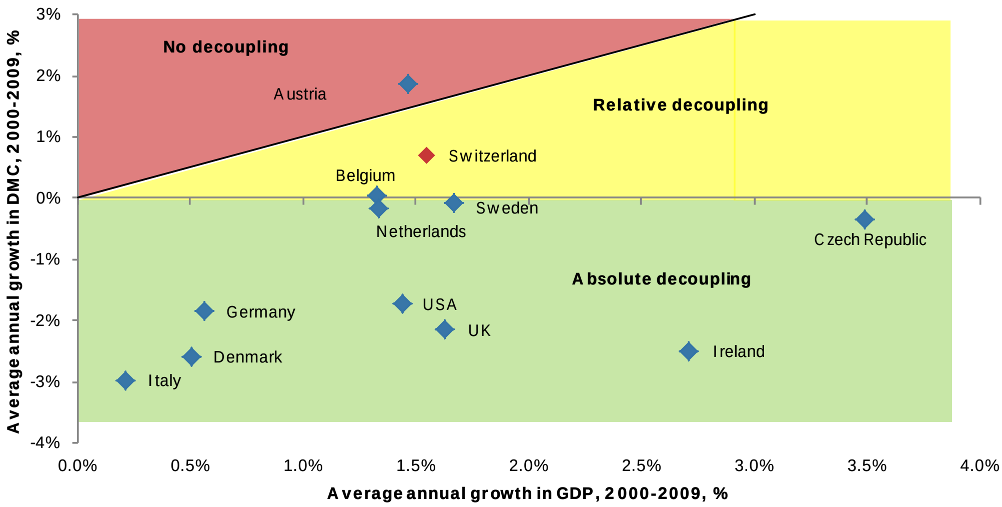
Switzerland must therefore continue to push ahead with reducing energy consumption overall through greater energy efficiency. The first steps have already been taken, such as the introduction on 1 January 2014 of new limits for energy usage when electronic devices are in standby and off mode. Further research into new and more efficient electricity technologies and applications is still require from Switzerland's innovators, however.

A massive improvement in energy efficiency is one of the objectives of the Energy Strategy 2050. While buildings are the main target, action is also to be taken with regard to electrical appliances. Electricity storage is also becoming more important in view of the decision to shut down nuclear power plants, and the increasing use of new renewable energies. Although energy-efficient appliances and electricity storage devices (batteries) alleviate the problem of resource availability as it applies to energy, the manufacture of these products requires rare earths, for example, which are themselves in short supply, and are likely to be the subject of even greater competition in the future (cf. Section 5.1.3).

In summary, Switzerland can be said to be very efficient in the way in which it handles energy, but it has not achieved any substantial reduction in absolute consumption to date. Most other countries in the sample have succeeded in this. Switzerland's future competitiveness will not rest on more efficient energy usage alone, but also on an absolute decline in overall consumption. This is the only way to reduce the country's dependence on the international market, and make it less vulnerable to fluctuations in price. Further efforts in this area are thus required to maintain Switzerland's competitiveness in the future.

Ever-scarcer resources and the resulting deterioration in security of supply, as well as highly volatile raw materials prices, may result in considerable economic distortion. Countries which are poor in raw materials, such as Switzerland, are under particular pressure to counter the related competitive disadvantages by making more efficient use of resources. **Material efficiency** is an important means of achieving this objective.

Fig. 5-21 Growth in GDP and DMC, 2000 – 2009



No decoupling = material consumption is rising faster than economic growth; relative decoupling = material consumption is rising more slowly than economic growth; absolute decoupling = material consumption is falling as the economy grows
Source: BAKBASEL, SERI

Domestic material consumption[14] (DMC) describes the aggregate take-up of materials utilised directly within a national economy. DMC in Switzerland rose by approximately 6 million tonnes to 100 million tonnes between 2000 and 2009. This corresponds to an increase of six percent. Per-capital DMC remained roughly steady at 13 tonnes during the same period, however. In 2009, materials belonging to the minerals group accounted for the largest share of DMC (59%), followed by biomass (19%). Energy sources made up 18 percent of DMC in the same year. Switzerland has the lowest absolute direct domestic materi-

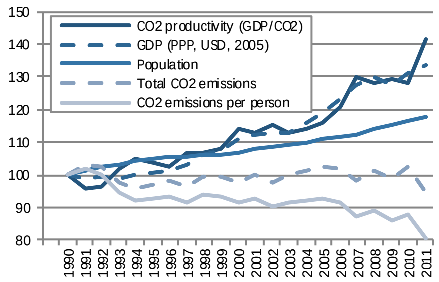
[14] Annual volume of raw materials (biomass, energy sources, (non-metallic) minerals and metals) extracted from domestic sovereign territory, plus all physical imports, and less all physical exports

al consumption of all the countries in its peer group. Its material consumption per inhabitant was much lower than the average for the sample.

All countries except Austria succeeded in growing their income faster than their material consumption during the 2000–2009 period studied here, and thus achieved the targeted decoupling (cf. Fig. 5-21). While Switzerland demonstrated this absolute decoupling between 1990 and 2000, only a relative decoupling could be observed between 2000 and 2009. Material productivity in DMC terms (GDP per unit of DMC) rose by an average of 0.8 percent annually. This puts Switzerland well below the average increase of 2.5 percent per year within its peer group. Although Switzerland consumes the least in terms of absolute requirements, it still posted a rise in absolute consumption. Since many countries around the world have already succeeded in decoupling economic growth and material consumption in absolute terms, Switzerland has some catching up to do if it is to maintain its previously good position. It is also worth noting that much of the improvement in DMC is attributable to higher imports of finished goods, and lower imports of raw materials and semi-finished goods. This shift makes it a zero-sum game for the environment (compare with Section 5.2.1). DMC per inhabitant confirms this.

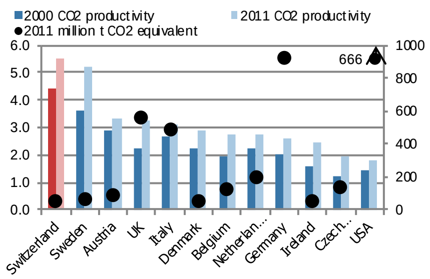
CO_2 emissions are closely linked to the provision of energy. A continuous rise in the consumption of fossil fuels means not only that their availability is becoming limited but also, increasingly, that a lack of take-up capacity in the world's environmental sinks (the atmosphere, ecosystems and oceans) for CO_2 and other greenhouse gases is becoming the most important limiting factor. For example, even if coal reserves were to last for centuries more, the CO_2 contained in that coal cannot be released into the atmosphere when it is burned without taking the environment to a tipping point by dramatically and irreversibly speeding up the process of climate change. The **CO_2 efficiency** of a country is therefore important in reducing its carbon emissions.

Fig. 5-22 CO_2 productivity in Switzerland, 1990 – 2011



Indexed, 1990 = 100;
Source: SFSO

Fig. 5-23 Territorial CO_2 productivity, 2000 – 2011



GDP in USD / kg CO_2 equivalents (left axis); CO_2 emissions in millions of tonnes
Source: OECD

Total CO_2 emissions refer to greenhouse gases overall[15]. These various gases are then converted into CO_2 equivalents. Between 1990 and 2011, greenhouse gas emissions in Switzerland fell by five percent to 50 million tonnes of CO_2 equivalents. Per-capita emissions were down one fifth from 7.9 tonnes of CO_2 equivalents to 6.3 tonnes, with PFCs (-61%) and methane (-20%) recording the sharpest drops. Switzerland thus has the lowest greenhouse gas emissions of any country in the study in both absolute and relative terms.

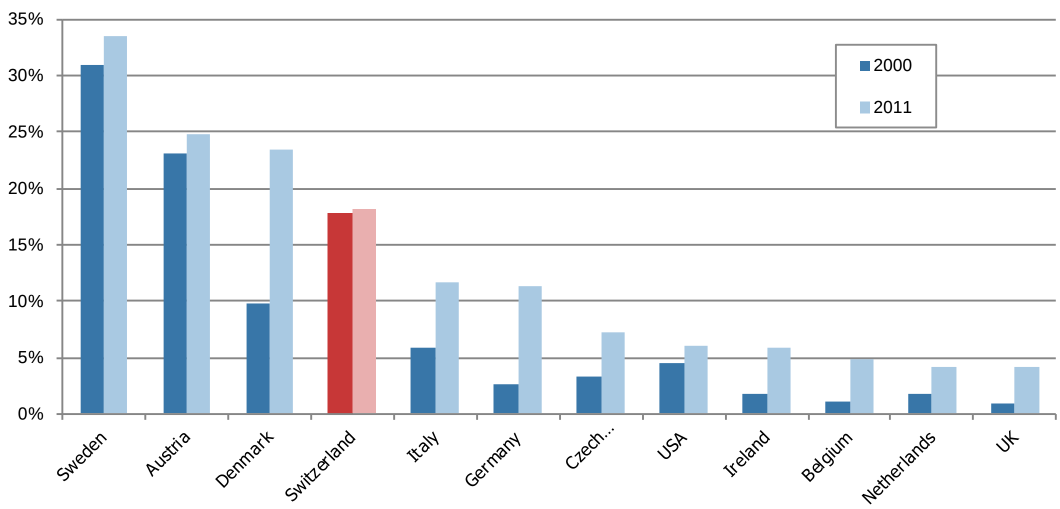
A decoupling of economic growth and greenhouse gas emissions can be seen in Switzerland during the observation period (cf. Fig. 5-22). CO_2 productivity, measured in USD per 1 kg emitted unit of CO_2 equivalent, rose by 42 percent. Switzerland thus has the second-lowest growth rate in its peer group after Italy. The average is 80 percent. However, since productivity in Switzerland was already at a very high level in 1990, in 2011 it still had the highest CO_2 productivity of any country in the sample (cf. Fig. 5-23). With this high figure of USD 5.5 per kg, Switzerland can be classified as very competitive in this area. Alongside

[15] CO_2 emissions (emissions from energy consumption and industrial processes), CH_4 emissions (methane emissions from waste and livestock breeding, mining of hard coal and lignite, agriculture and leaks from natural gas pipelines), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6)

Sweden, which generates USD 5.2 per kg, it leads the other countries in the group – which produce USD 2.7 per kg on average – by a wide margin. The Swiss economy will be hit less hard than others by a further reduction in carbon sink capacity, although there is a danger that CO_2 productivity might decline if more combined-cycle gas-fired power stations are brought on line to generate electricity in the wake of the Energy Strategy 2050. There have also been other steps to reduce emissions, such as the CO_2 emission regulations for new passenger vehicles that became effective in July 2012, and the Ordinance on the Reduction of CO_2 Emissions that came into force on 1 January 2013.

For the use of energy to remain in line with sustainable development targets, the consumption of non-renewable resources must be kept below the growth potential of renewables. In a future of scarce natural resources, this will increase a country's competitiveness because generating energy from non-renewable resources is very resource-intensive with regard to both input and extraction. This form of energy generation is also linked to emissions of CO_2. Replacing it with renewable energies is thus a matter of vital importance, which is why the next indicator examined here is **renewable energies as a proportion of total primary energy supplies**. The higher this proportion, as shown in Fig. 5-24, the more independent the country in question should energy feedstocks become scarce, and the lower the CO_2 emissions released by energy generation.

Fig. 5-24 Renewable energies as a proportion of total primary energy supplies, 2000 – 2011



"Renewable energies" refers to geothermal, solar, wind, hydro and tidal power, as well as energy gained from combustible waste.
Source: OECD

Switzerland managed to raise the share of primary energy supplies accounted for by renewable energies from 17.7 to 18.2 percent between 2000 and 2011. This corresponds to an annualised increase of 0.2 percent, which is lower than the peer group average of 7.4 percent per year. Renewables grew extremely quickly in Germany (Ø +14% p.a.) and the Belgium (Ø +15% p.a.), in particular. Posting the lowest growth rate, Switzerland also performs below average in a comparison of countries which already had a high percentage of renewables in 2000: Sweden, Austria and Switzerland. Renewable energies must increase as a proportion of total primary energy supplies if a country is to remain competitive in the long term. Switzerland could thus do better on this point. Although its renewables share is still high compared with other countries, it has also grown the slowest.

Conclusions: For a country to remain competitive in the medium and long term, it must be able to maintain and extend its productivity lead over its competitors. This requires continuous improvement, which in turn demands a high level of innovation. In this respect, Switzerland is in an excellent position to rise to the challenge. Some three percent of GDP is fed into research and development, placing the country well up the league tables. Switzerland has also demonstrated its willingness to cooperate in international environmental agreements, and the picture with regard to environmental patents is just as positive. Although the country's size means that it lags behind others in absolute terms, it is one of the world leaders according to the relative measure of patents per capita of population. Switzerland also performs very well on efficiency. The figures for energy, materials and CO_2 reflect the country's outstanding climate for innovation, but an international comparison shows that growth rates have been too low in recent years. So far, Switzerland has been able to draw on its high productivity to maintain its position, but it must be careful that it is not overtaken by its competitors in the future. The trend in the use of renewable energies also clearly shows substantial catch-up potential. Where energy is concerned, Switzerland appears to have been resting on its laurels – the high proportion of renewables that it had already achieved by 2000.

5.2.4 Regulation / environmental regulation

Regulation sets the framework for economic activity and marks out the opportunities for and restrictions on commercial undertakings. Regulation corrects market failures, imbalances in information, and negative externalities. Regulation also has its costs, however: directly, in the form of administration and monitoring, and indirectly, in the form of incompatible incentives, or government failures. There is no theoretical means of deriving the optimum degree of regulation.

The World Economic Forum Global Competitiveness Index 2013/2014 (WEF 2013B)[16] attests that Swiss institutions take seventh place in a peer group of 148 countries. Property rights, the reliable exercise of state authority, the efficient legal system and a very liberal labour market are particularly worth emphasising here. As natural resources become scarcer, attention turns to environmental regulation to reduce negative externalities caused by economic activity. Yet environmental regulation can also be used to promote a country's competitiveness, by encouraging companies to make their production more efficient. The counter-argument to this is that more stringent regulation than in other countries increases production costs for domestic companies, which may impair the competitiveness of the country's export industries (Jenkins 1998).

Many studies have provided evidence of a positive correlation between more stringent environmental requirements and long-term competitiveness. For example, Testa et al. (2011) discovered that more stringent environmental regulation has a positive effect on both investment in high-tech and innovative products, and on business performance overall. Launching products on the market at an early stage earns companies certain supply and demand-side competitive benefits (first mover advantages). Porter (1991) and Porter and van der Linde (1995) ascertained that, even where regulation results in additional costs for the companies concerned, these costs are more than offset by income from the innovations induced by the new rules. This proposed correlation is known as the Porter hypothesis, and it assumes that environmental regulation creates a win-win situation. Investments that improve companies' resource and material efficiency also reduce manufacturing costs, because processes require fewer resources and materials, and less energy.

The number of **environmental laws and regulations** offers an initial overview of the degree of regulation in a given country and also gives an indication of their enforcement. Laws represent rules passed by the legislature, and regulations the process of monitoring and enforcing these requirements. This analysis compares regulations and laws in environment-related areas[17], as recorded in the ECOLEX database. Separate surveys provide further information on the stringency and enforcement of environmental laws. In this respect, the Executive Opinion Survey[18] published by the World Economic Forum provides valuable qualita-

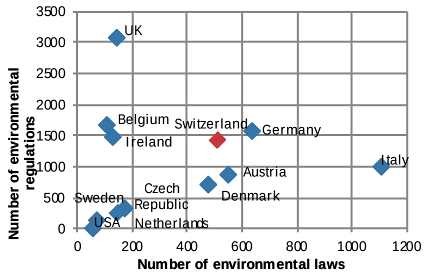
[16] Published by the WEF, the Global Competitiveness Index provides a comparison of 148 countries. Switzerland took first place in the aggregated index in the 2013/2014 edition, and is also among the leaders in the various subindices.

[17] Agriculture, air & atmosphere, cultivated plants, energy, environment gen., fisheries, food, forestry, land & soil, livestock, mineral resources, sea, waste & hazardous substances, water and wild species & ecosystems.

[18] The survey asks executives to state their position on various aspects of their business environment. The data it collects offer useful insights and permit a qualitative analysis of a country's economic and business climate from the businessperson's perspective, in an international context.

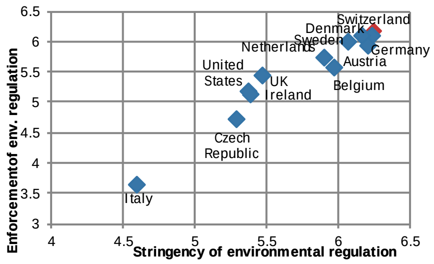
tive data and may be consulted for a more rounded picture. Two indicators in particular – **stringency of environmental requirements** and **enforcement of environmental legislation** – supply additional information that is comparable internationally. Incentives within a given country to innovate and to invest tend to rise in tandem with the number of environmental laws and regulations, and as requirements and enforcement become tougher.

Fig. 5-25 Environmental laws and regulations, 2013



Applicable laws and regulations
Source: www.ecolex.org

Fig. 5-26 Stringency of environmental requirements and enforcement of environmental legislation, 2013



Subjective evaluation by managers (1 = very relaxed; 7 = among the most stringent world-wide)
Source: WEF

Environmental legislation is used as a means of conserving the natural environment in German-speaking countries, in particular. This approach is increasingly being taken in Italy, and to a lesser degree in Denmark (cf. Fig. 5-25). Environment law is not particularly well developed in the other countries studied here. An examination of the monitoring and enforcement of these requirements, as illustrated by the left-hand chart, reveals an above-average level of regulation in the United Kingdom. Switzerland, meanwhile, occupies the upper middle ground. The figures for Italy are striking, in that the country has the highest number of laws, but is ranked only in the middle of the field where the attendant regulations are concerned. This imbalance also emerges in the stringency of Italy's environmental requirements, on the one hand, and their enforcement, on the other (cf. Fig. 5-26). The WEF survey participants thought that Italy was weakest in this regard. They also said that Switzerland had the strictest environmental requirements of the peer group. In their opinion, these requirements became an average of 2.4 percent weaker between 2004 and 2012. They are believed to have become more stringent only in Ireland and the Czech Republic. In contrast, the enforcement of environmental requirements has tended to improve, by an average of 5.2 percent, with Belgium recording a particularly steep increase (+25.9%). For Switzerland, the change in both indicators was in the average range compared with the other countries in the sample.

Clear and reliable rules are an important element of a company's decision on where to locate its business. The regulatory framework in Switzerland appears to be a favourable one in an international comparison. The country's environment-specific rules – environmental laws and regulations – are relatively stringent, which might impair competitiveness in the short term. That said, they also encourage resource-friendly economic activity, which is likely to have a positive effect on competitiveness in the long term.

5.2.5 Quality of life

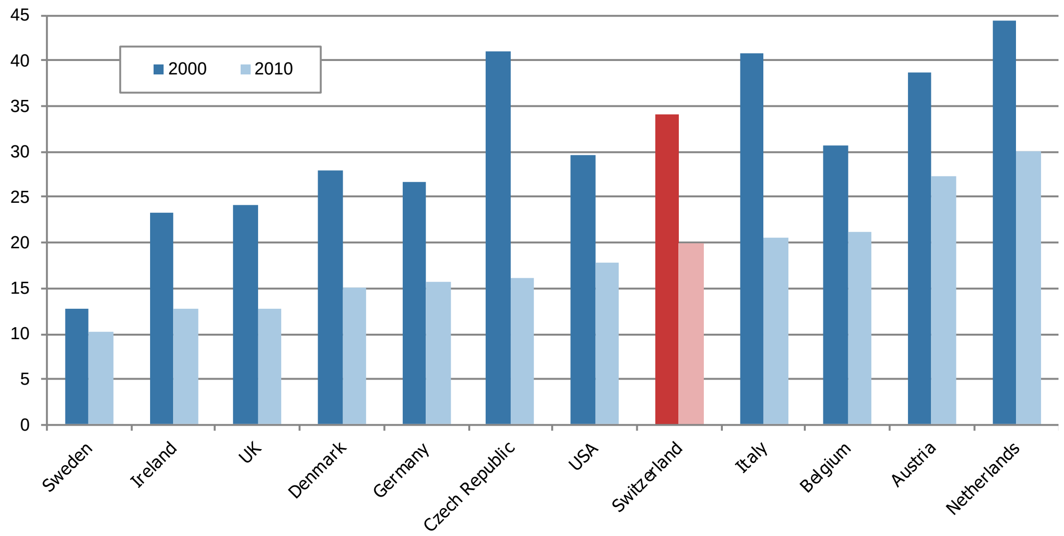
One of the factors in any country's economic success is the availability of skilled and highly qualified workers. These workers are becoming increasingly mobile, and are choosing where to live and work according to the quality of life on offer. Quality of life is thus growing in importance as a locational factor. For humans, quality of life represents the synthesis of a variety of both objective and subjective aspects (Stiglitz et al. 2012). Measures of quality of life thus generally cover a range of different dimensions, from the material standard of living, to health and education, and current and future environmental conditions, to name just a few.

The OECD Your Better Life Index measures quality of life in terms of 11 aspects in 34 OECD countries, as well as Brazil and Russia.[19] In addition to ranking fifth out of 36 overall, Switzerland occupies a leading position in many of the areas covered by the OECD index, and thus offers a very high quality of life.

Environmental conditions which are damaging to health reduce quality of life. Many studies in recent years have shown that **particulate matter (PM_{10})** in the air poses a significant risk to health. The following indicators shows mean annual figures for concentrations of respirable particulate matter (PM_{10}). The higher the level, the worse the conditions for human health. A reduction in particulate matter concentrations can be observed across the entire country sample depicted in Fig. 5-27, with the 60 percent fall in the Czech Republic particularly impressive. At a level of 19.84 $\mu g/m^3$, Switzerland came in just below the set threshold, and thus comes off badly in the sample as a whole. The rate at which it is reducing concentrations of particulate matter is average for its peer group in this study.

According to the FOEN (FOEN 2013), although particulate matter concentrations in Switzerland have been falling, limits are still exceeded regularly, especially in cities and conurbations, as well as along busy roads. The FOEN believes that the action that has been adopted and instituted to reduce these levels will cut PM_{10} emissions in Switzerland by 15 percent between 2005 and 2020.

Fig. 5-27 Territorial PM_{10} concentrations in 1990 and 2010

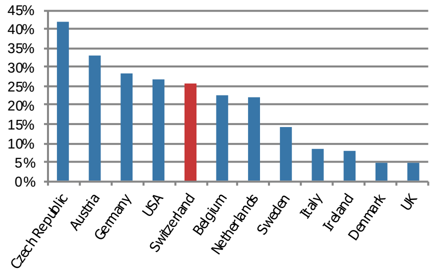


PM_{10} in microgrammes per cubic metre
Source: World Bank

Living in an intact environment is a further aspect of quality of life, however. Those living in such surroundings are happier, more able to recover from everyday stress, and more physically active. Recreational space and green areas play a particularly important part here.

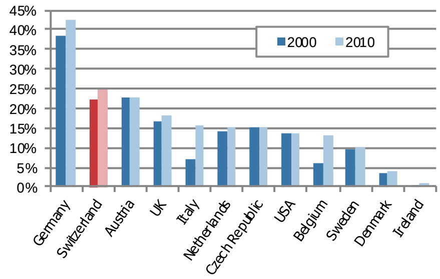
[19] The OECD Better Life Index enables quality of life in different countries to be compared, and indicates the importance of each of the eleven individual aspects that contribute to quality of life and wellbeing – community, education, environment, civic engagement, health, housing, income, jobs, life satisfaction, safety, and work-life balance. In each country, it measures quality of life using a total of 24 separate indicators which together comprise the aspects of quality of life (http://www.oecdbetterlifeindex.org).

Fig. 5-28 Protected marine and land area



Source: World Bank

Fig. 5-29 Endangered species



The data presented here are the latest available for each of the countries shown.
Source: OECD

In 2010, Switzerland (25%), Germany (42%) and Austria (23%) had the highest percentages of protected marine (water) and land area (cf. Fig. 5-28). The low figure shown for Ireland (1.2%) is connected to land usage, as two thirds of land area is devoted to agriculture (epa 2012), while the corresponding figure for Switzerland, for example, is "just" 35.9 percent (SFSO 2013). With over 40 percent of species endangered, the situation is worst in the Czech Republic. Even in most other countries in the sample, including Switzerland, some 25 percent of all species are considered at risk. Italy, Denmark and the United Kingdom show a more positive picture, however. In these countries, less than 10 percent of species are endangered.

Switzerland displays a high quality of life overall, as confirmed by many rankings such as that of the OECD. Switzerland's strengths on the environmental front, as an aspect of quality of life, lie in its protected water and land areas. It is worth mentioning the very high growth in the former, in particular, in recent years. Switzerland makes only a mediocre showing with regard to endangered species, and particulate matter levels may have a negative effect on quality of life. Considerable room for improvement still exists in these two areas.

5.3 Summary

5.3.1 Pattern of specialisation

The Swiss economy is well positioned in the international comparison of energy efficiency and emissions avoidance (CO_2). On each of these points, Switzerland displays the lowest intensity or – in other words – the highest efficiency. The country's pattern of specialisation is only one of the reasons for this outstanding result. Indeed, Switzerland's sector mix would suggest higher energy inputs and higher CO_2 emissions than are actually the case. This means that at least some of the sectors in the Swiss economy are more efficient than the average of their peer group when it comes to energy usage and CO_2 emissions from production processes. The detailed analysis of efficiency in the individual sectors confirms that secondary sectors, in particular, are frequently more efficient than segments of the tertiary sector.

Thus, the primary reason for this excellent result is not the pattern of specialisation alone, but rather the highly efficient way in which the sectors of the Swiss economy handle the resources they use. Switzerland therefore emerges as a particularly competitive economy within its peer group. As a result of this, availability problems with natural resources are likely to have less of an impact on the Swiss economy than they do on the other countries of the sample. In contrast, the availability of critical materials, such as rare earths, has the potential to threaten Swiss competitiveness. Critical materials are essential components of modern technologies in sectors which are expected to become increasingly important within the Swiss economy as a whole.

When natural resources are factored in, an economic shift towards the tertiary sector would not be an effective means of improving Swiss competitiveness. Although this sector by definition uses fewer resources and generates lower emissions, the efficiency of its resource management is often below average. This is particularly true of those sectors which are exposed to little, if any, international competition, such as business-related and other services. Meanwhile, Switzerland's export-oriented sectors are also those which display the greatest lead on efficiency. Examples include the chemical/pharmaceutical industry, the metals industry, trade and the financial sector. This allows parallels to be drawn with labour productivity, which generally gives Switzerland a competitive boost in the international arena. The high level of international competitiveness that is attributed to the Swiss economy as a whole and its individual sectors is also reflected in its handling of natural resources.

In addition to sectors focused on the domestic market, the hotel and catering sector, and the electrical/precision engineering sector aggregate, are less resource-efficient. Furthermore, the greatest room for improvement is to be found in the transport sector – one of the most important in terms of energy consumption and CO_2 emissions.

5.3.2 Locational quality

A variety of selected indicators from the five domains listed below are used to analyse the quality of Switzerland as a business location, from the perspective of resource availability:

- Availability of natural resources
- Transport infrastructure
- Innovation and efficiency
- Regulation
- Quality of life and environment

This analysis determines Switzerland's locational quality both in an international context and over time. In isolation, the indicators chosen for these domains can never replicate all aspects of locational quality for that domain. When aggregated, they nonetheless allow for a good assessment of Switzerland's locational quality in the area in question, and also overall.

The last stage in the analysis is a synoptic assessment, in which the findings for the indicators selected for each domain are summarised in a table (Tab. 5-2). Switzerland's score is a product of its positioning within the peer group, and the peer group average.

Tab. 5-2 Summary – overview of Swiss locational factors in an international comparison

Indicator	Current status	Over time
Availability of natural resources		
DMI with hidden imports	Not possible	Not possible
Dependency on raw material imports	− −	−
Treatment of municipal waste	+	− −
Transport		
Continental and global accessibility	+	− −
CO_2 efficiency of transport sector	+ +	+
Modal split – freight traffic	+ +	+
Modal split – passenger transport	+ +	+ +
Innovation and resource efficiency		
International environmental agreements	+	Not possible
Environmental patents	+ +	−
Energy efficiency	+ +	+
Material efficiency	+ +	− −
CO_2 efficiency	+ +	− −
Renewable energies as a proportion of total primary energy supplies	+	− −
Regulation / environmental regulation		
Environmental laws	+	Not possible
Environmental regulations	+	Not possible
Stringency of environmental requirements	+ +	+
Enforcement of environmental legislation	− −	−
Quality of life		
OECD Better Life Index	+ +	Not possible
Particulate matter	−	+
Protected marine and land area	+ +	−
Endangered species	−	Not possible

Notes: + += among the best three countries in the sample, += above average for the sample, −= below average, − −= among the worst three countries in the sample.
Source: BAKBASEL

Looking at the current figures for the selected locational quality indicators, it can be said that Switzerland enjoys an excellent level of competitiveness. Outstanding results in the innovation and efficiency domains place Switzerland in a very strong position. Where infrastructure is concerned, the country also does very well on transport. The positive result is rounded out by above-average showings for environmental regulation and quality of life. Resource availability is poor compared with the countries covered by the study, however.

If the changes in these individual indicators are tracked over time, and compared with the other countries, then Switzerland is found to be below par. There has not been as much change in innovation and efficiency – the very areas in which the country is placed best – as there has been in other peer group countries. This is due to a range of factors. For most of the indicators, Switzerland's initial level was already very high. Diminishing marginal returns make it difficult to increase a score that is already very good. It is also possible, however, that Switzerland has been resting on the laurels of its excellent results of the past, and has thus been less motivated than other countries to keep driving improvements forward. The trend in renewable energies supports the second hypothesis, as Sweden and Austria, for example, had even higher initial levels than Switzerland in 2000, yet have still shown somewhat stronger growth. The Swedish example, in particular, shows that despite a high initial level (2000: 31%; CH 2000: 18%), higher annual growth can still be achieved (0.7% p.a., CH 0.2% p.a.). The two efficiency indicators – CO_2 efficiency and material efficiency – also corroborate the supposition that Switzerland has not been doing as much as it might. While material productivity in the Netherlands was higher than that in Switzerland in 2000, the former has still managed to raise it by 1.5 percent annually, compared with a Swiss increase of 0.8 percent per year.

New renewable energies show a similar picture. Electricity generation from new renewable energies expanded by 7.1 percent annually between 2000 and 2012. However, the annual increase would have to be 10.8 percent per year from 2012 onwards to meet the target for 2020 of 4,400 GWh[20]. A look at CO_2 emissions and the targets agreed in the Kyoto Protocol confirms this. In the first commitment period, Switzerland was required to reduce greenhouse gas emissions by an average of eight percent per year between 2008 and 2012, bringing them down to 92 percent of their 1990 level. This objective is likely to have been achieved, because the country was able to count the Certified Emission Reduction (CER) credits purchased abroad for approximately three million tonnes of CO_2 equivalents (representing expenditure of CHF 720 million[21]) towards its target, and also because of the carbon sink function of the nation's forests. Emissions are now to be reduced by 20 percent in the second commitment round up to 2020. Switzerland's sixth report to the UN Framework Convention on Climate Change gives an overview of all of the action that has been taken or are planned in all relevant sectors to ensure that these targets will be achieved by 2020.[22] As things stand, however, if the rate of reduction remains the same, by 2020 Switzerland would have to purchase CER credits for over 8 million tonnes of CO_2 equivalents, costing some CHF 2 billion. If it wants to avoid this, it will have to make a massive additional effort to speed up the reduction in its CO_2 emissions. Thus, in the future, it will no longer be enough to charge the CO_2 levy (the "climate cent") on fossil energies used for stationary purposes only. For example, the levy might be extended to cover fossil fuels in the transport sector, as traffic is responsible for a significant proportion of CO_2 emissions. Expanding the climate cent to cover fossil energies used for mobile purposes would increase the revenue base, thus reducing the negative effects of the levy and making it more efficient. This would mean that CO_2 targets could be achieved more economically.

Switzerland's competitiveness can thus be judged to be middle-of-the-road overall. Although it occupies a leading position at present, rapid improvements in efficiency and in renewable energies are immensely important to secure this competitiveness in the long term. A great deal must be done here to avoid missing the boat.

The above discussion permits the following strengths, weaknesses, opportunities and threats to be identified for the Swiss economy in connection with resource availability.

[20] 4,400 GWh represent an energy equivalent of around 40,000 tonnes of crude oil.

[21] http://klimarappen.ch/fileadmin/Downloads/Medienmitteilungen/Kennzahlen_SKR_DE.pdf

[22] http://www.news.admin.ch/message/index.html?lang=de&msg-id=51885

5.3.3 SWOT analysis of Swiss competitiveness

Strengths

- Primary energy efficiency in the Swiss economy is relatively high.
- Switzerland occupies the upper middle ground with regard to renewable energies as a proportion of total primary energy supply.
- The Swiss economy is the least energy intensive in its peer group. For each USD of gross value added, the energy it uses is less than half of the Western European average for the same output. The chemical/pharmaceutical industry, as well as the financial sector, use energy much more efficiently.
- The Swiss economy was responsible for less than half of the country's total CO_2 emissions in 2008 (42%).
- Switzerland's economy emits the lowest level of CO_2 per USD of value added of any country in its peer group. Compared with the Western Europe average, Switzerland is around three times more CO_2 efficient.
- Switzerland's quality as a business location is currently good to very good.
- Switzerland displays a high degree of innovative capacity and efficiency.
- It offers a good regulatory environment and its environmental regulations are relatively stringent in an international context, thereby incentivising the careful use of resources.
- Switzerland offers a high quality of life, although there is still plenty of room for improvement where the environment is concerned, for example on particulate matter and recreation areas.
- The modal split for both freight and passenger traffic indicates that Switzerland has an advanced infrastructure.

Weaknesses

- Swiss households are responsible for 35 percent of primary energy consumption.
- In an international comparison, growth in renewable energies has been below average for the past 11 years.
- Switzerland has succeeded in decoupling domestic CO_2 emissions from primary energy consumption from economic growth, although the actual reduction in CO_2 emissions has been only minimal compared with the international peer group.
- Where domestic CO_2 emissions are concerned, a much greater improvement must come from private households and the private transport segment than from business. However, even in the business sector, decoupling has been relative rather than absolute.
- Some segments of the service sector are less efficient than average.
- Efforts to date to improve efficiency and to reduce the burden on the environment are not enough to achieve the political goals that Switzerland has set for itself in this area.
- Switzerland's progress on improving its locational factors has tended to be slower than the international average.
- The Swiss economy and Swiss society are highly import-dependent, which may prove a risk under certain circumstances such as supply monopolies, and as natural resources become depleted.

Opportunities

- The decision to shut down nuclear power plants as part of the Energy Strategy 2050 will reduce dependency on imports of nuclear fuels.
- The international comparison shows that greater efficiency gains are possible, despite levels already being high.
- Efficiency gains and a greater use of new renewable energies as the Energy Strategy 2050 is implemented may reduce dependency on fossil fuels. This might also help to reduce CO_2 emissions.
- The transition towards more renewable energies demands innovation at many social and economic levels, which may present opportunities for Switzerland as a business location.

Threats

- The Energy Strategy 2050 will, at least in the short term, increase Switzerland's dependency on fossil fuels, and on foreign imports, to meet its energy needs. Energy efficiency in this sector may decline as a result.
- The Energy Strategy 2050 may simply relocate the resource availability problem for the economy as a whole. Modern technologies for energy generation and storage, as well as those which increase efficiency, often require scarce raw materials such as rare earths or lithium.
- The global overshoot on natural resources may take the climate to an irreversible tipping point (negative feedback effect). This describes changes in connection with the climate system which have the potential to change the global climate at the fundamental level, such as the acidification of the oceans and the resulting decline in their capacity to absorb carbon dioxide. These shifts would also affect the Swiss economy and have a massive impact on Swiss competitiveness and welfare.

6 Conclusion

The present study examines the importance of current trends in resource consumption and reserves to the competitiveness of the Swiss economy. The relevance of the declining availability of natural resources to Switzerland, as a business location, is examined from both a biophysical and an economic perspective. This approach was chosen because, from the conventional economic theory perspective, a decline in the availability of resources presents only a qualified risk to competitiveness. A reduction in the supply of resources results in a shift in relative prices, which triggers changes in the production and consumption patterns of economic agents and ultimately results in the optimum allocation of natural resources. This nonetheless requires a functioning price system and sufficiently rapid substitutability between resources. In reality, externalities and other market failures result in less-than-optimum allocations of certain natural resources, and/or their gradual depletion. Full substitutability cannot be guaranteed, either. It is thus important to set this economic view alongside one which measures resource usage and availability from a non-market economy perspective.

In biophysical terms, the availability of resources is measured through the biocapacity lens – an approach which syntheses the supply and consumption of resources for a given country. The analysis of global resource trends shows that, since the 1970s, human demand for resources has exceeded the supply which the earth's ecosystems are able to replenish, resulting in a biocapacity deficit at the global level.

Considering the analytical findings provided by the biophysical view, many countries are likely to experience natural resource-related problems in the not-too-distant future. This is especially true of low-income countries whose global economic integration may not deliver on its welfare promises in a resource-constrained world. Compared to 13 other countries, Switzerland itself is not as best-in-class as is often assumed. The country is one of the most closely integrated countries in the global economy, so does not seem to exhibit any immediate vulnerability to resource supply. However, this may change owing to 1) its receding relative income, which may signal less purchasing power for global resources in the future, and 2) the risks stemming from dysfunctional global resource markets. In this respect Switzerland, as a small power refraining from political alliances, may face particular challenges in a more conflict-stricken world. And such a world may come earlier than expected because of the increasing biocapacity bottleneck.

It may be assumed that, as gross domestic product rises in the high-population emerging economies of Asia, so too will their consumption of resources. In the past, resource consumption has always continued to increase as per-capita incomes have advanced, and no turnaround in this trend has (yet) been observed. Unless resource consumption can be decoupled from economic growth, a surge in resource demand from these countries will be the result. The rise in these countries' relative purchasing power – meaning the share of global income represented by the income of each citizen of a given country – will make it easier for them to compete on the international resource market.

What impact will this development have on Switzerland as a business location, and on its competitiveness? In view of its very robust economic position, its resource-efficient technologies and its trading options, Switzerland can be seen as less vulnerable than other countries to resource shortages. The country is nonetheless dependent on imports of biocapacity. The Swiss economy relies heavily on resource imports to manufacture its goods and offer its services, as well as to meet consumer demand. As a small economy, it must also pay global market prices. Switzerland has been found to obtain many of the resources it needs from countries which themselves are running a growing biocapacity deficit. This could cause problems, because the availability of resources in these countries will decline, making it more difficult for Switzerland to meet its resource needs. The Swiss economy's dependence on exports is illustrated by the fact that around a quarter of Swiss GDP is generated by exported goods and services. Furthermore, these exports are concentrated on three markets, of which Germany takes the lion's share. If resources become less available on global markets, the Swiss economy might face growing risks in both its supplier and its export markets. A growing global biocapacity deficit also increases the danger that the world will reach tipping points, i.e. change will happen which may have a fundamental effect on the earth's climate.

From the economic perspective, the study examines resource use and efficiency at sector level, as well as the quality of Switzerland's locational factors in an international comparison. The sector-level analysis focuses on energy consumption, CO_2 emissions and the use of critical minerals. CO_2 is regarded as a good with limited availability, because statutory thresholds or guidelines effectively limit the environment's capacity to absorb emissions and waste products. As it relates to resource availability, Switzerland's appeal as a business location is examined using selected indicators for the availability of natural resources, infrastructure, innovation and efficiency, regulation, and quality of life and the environment. This analysis thus looks at Switzerland's locational quality both in an international comparison and over time.

The sector analysis shows that the economy's pattern of specialisation is not the only factor in the country's outstanding current competitiveness with regard to environmental pollution, measured as territorial CO_2 emissions. Rather, the key to this position is the highly efficient way in which the Swiss economy manages resources. The chemical/pharmaceutical industry, as well as the financial sector, use energy much more efficiently than the same sectors in the peer group. Overall, the detailed sector analysis scores segments of the secondary sector more highly on efficiency than those of the tertiary sector. The Swiss economy is the best performer in its peer group on energy intensity, as most of Switzerland's economic sectors operate more energy-efficiently than the Western European average.

In an international comparison, the various sectors of the Swiss economy are thus likely to be more resistant to problems with the availability of natural resources than economic sectors in other countries. However, the availability of critical materials, such as rare earths, has the potential to threaten Swiss competitiveness. Critical materials are essential components of modern technologies in sectors which are expected to become increasingly important within the Swiss economy as a whole, such as the metals industry, and electrical and precision engineering.

The analysis of locational quality also indicates that Switzerland is highly competitive as a place to do business. Switzerland is in a very strong position in the innovation and efficiency domain. Where infrastructure is concerned, the country also does very well on transport. The positive result here is rounded out by above-average showings for environmental regulation and quality of life. However, if the changes in these individual indicators are tracked over time, and compared with the other countries, then Switzerland is found to be below par. The very areas in which Switzerland has shone in the past, specifically innovation and efficiency, have not developed as quickly compared with the other countries in the study. Although these have not yet been able to match Switzerland's excellent current position, if their growth rates can be maintained they will overtake the Swiss level in the medium to long term. A look at material consumption also shows that hidden imports have risen by almost a third in recent years. This might be an indication that particularly raw material-intensive production stages have been outsourced abroad, which would ultimately distort measures of domestic material productivity.

In conclusion, it can be said the importance to Swiss competitiveness of current trends in resource consumption and reserves requires a nuanced approach. Switzerland currently enjoys an excellent competitive situation, which is reflected in its very robust economic position, its resource-efficient technologies, its trading opportunities, its efficient sector mix, and its outstanding locational factors. The country will therefore continue to succeed for longer than other countries as resources become scarcer. On the other hand, as a small and open economy, Switzerland depends heavily on imports and exports. It will be able to maintain its high level of competitiveness in the long term only if it works alongside importing nations and export markets, along the entire length of the value chains concerned, and in doing so factors in grey energies and emissions. This would require reengineering on a broader scale to create a green economy for Switzerland. The following section discusses possible ways in which Switzerland might respond to a future decline in resource availability.

7 What are Switzerland’s choices?

It must be acknowledged that, enabled by smart public policies, Swiss economic agents are successfully playing the global integration game within a tangle of known, familiar constraints. However, by pointing out potential vulnerabilities “outside the box” if current trends on resources continue, this joint report cannot help but answer the question about competitiveness and resources with another moot question: what if global integration game is halted by a surge of unknown, yet predictable, resource constraints? In other words, what if natural capital ceases to be a benign factor of production and becomes a more critical one, not because of local shortages, as prior to the Industrial Revolution, but because of a general biocapacity deficit? Again, Switzerland is blessed to belong to a less vulnerable geopolitical zone in this respect. But still, there is an incipient movement across political lines in Switzerland to include the global resource threat in policies and planning. What are Switzerland’s options and levers to address these emerging risks as a national jurisdiction, and as an economic community?

Geography and history have come together to give a name to the fine art of managing interdependency: Switzerland! As power politics has never been an option to help Switzerland eliminate international threats, management under constraints has been the default position ever since Switzerland decided not to engage in extra-territorial wars in 1515. Indeed, since its inception as an integrated country in the mid nineteenth century, Switzerland has often succeeded securing its needs in very tight situations, be it under political pressure from its more powerful neighbours or because of its limited resource base in the face of industrial revolution. Over time, Switzerland's persistence in overcoming the many obstacles it has faced has given it a peculiar ability to turn its small scale (in many respects, including territory) into a competitive advantage in world politics and business, not least in the form of a vital incentive to innovate.

Consequently, if Switzerland wants to remain true to its customary ingenuity, it must anticipate the 21st century's global resource challenge early enough, and adjust its institutional development and governance accordingly. This proactive adaptation might be the best way to uphold Switzerland’s reputed competitiveness in the future.

Should the Swiss biocapacity deficit be recognised as a growing risk, five thought-provoking options for action stand out beyond business as usual, reflecting the – at times contradictory – aspirations of the Swiss people. More than competing blueprints, these options are largely determined by the domestic political and international contexts. However, before moving on to real choices, it is appropriate to set out the zero option: “let-us-choose-not-to choose”.

1. "Business as usual". This is the standard baseline. Public policies and economic agents would remain only marginally concerned by the global resource threat or would dismiss its actual materiality or economic relevance. The national interest would dictate doing nothing prematurely or unilaterally to avoid harming national competitiveness. In this scenario, no major effort is made to squeeze extra efficiency out of factors of production, the relative decline of average per-capita Swiss income compared with that of emerging economies is not addressed, neither are the generic risks stemming from dysfunctional global resource markets. In this instance, there would be a shared sense of denial of the impending trends - shifting wealth, the growing economic scarcity of natural resources, resurgent arcs of tension along trade routes, and population growth. Their relevance in a world of finite resources would not be noticed.

Discussion: Risk denial does not fit with the risk-averse national ethos. Switzerland’s “customary ingenuity”, as mentioned above makes this scenario rather unlikely. There are two main chains of factors opposing transformative economic change to a more sustainable world: a) powerful status-quo forces bearing on the global and domestic economy, such as those linked to fossil fuel extraction and use, and b) inertia in the consumption behaviours of economic agents[23] . These opposing factors notwithstanding, Switzer-

[23] For instance, unconscious behaviours such as “keeping up with the Joneses”, which indicates a household’s compulsion to emulate the neighbours' consumption owing to their own social status anxiety.

land is moving forward. The commitment to a transition to renewable energies bodes well for Swiss capacity to alter course under the pressure of changed circumstances.

A number of choices are possible to avoid being caught in the resource crunch:

2. "Retreat from the world". Overwhelmed by the "dark side" of globalisation and convinced that the level of integration that has been achieved has jeopardised the collective values that made Switzerland what it is, the aging majority of citizens brings their preference for staying behind closed doors to bear on foreign policy. Standards of living may also decline, as may the country's international standing. Perhaps these negatives would be tolerated in exchange for less tense interaction with the environment, traditional institutions, and existing infrastructures. The most dynamic elements in Swiss society would leave the country in the wake of many foreign investors. However, a quota of the finest renters in the world would still be granted residence, whatever their origin.

Discussion: Such a stand-off may resonate with the sections of public opinion that are calling for a slowdown in the pace of change and measures to protect national independence. It may be enticing to both ends of the current political spectrum. Some hardliners may be attracted to such supposed self-sufficiency. These individuals view withdrawing from the world as an opportunity to reconsider the level of global integration that has been achieved, and for Switzerland to introduce its own restrictions on domestic consumption and/or production. The intended outcome for some, and unintended consequence for many, would be to narrow the national biocapacity gap by reducing (economic) welfare. This is clearly a non-starter for the political mainstream, including trades unions. From a biophysical standpoint, as well as under international economic rationale, this would not deliver any significant move towards resolving the global resource challenge ahead. Also, it would unnecessarily undermine the country's competitiveness, its voice in international affairs, and its welfare. These isolationist calls should therefore be resisted. Nonetheless, this tension is here to stay, as shown by the latest political developments supported by direct democracy.

3. "Engage in hypergrowth". In contrast to “business as usual”, this option is highly informed by the global resource threat and the relative decline of average Swiss income. It is intended to respond to these changes by betting on “far more of the same” policies, and enhancing the economic growth strategy framework. In the remaining window of opportunity (assuming it is finite), the idea is to outperform everybody for as long as possible. This includes emerging economies. Switzerland's well-established competitiveness would be put to good use in order to remain more than best in class within the OECD, and even grow faster than China. Continued prosperity in a more complicated, non-polar, more ecologically-constrained world would be created by furthering international specialisation, attracting more niche players in the service industry, expanding infrastructures to avoid saturation, and gearing education to provide the expertise needed by a sophisticated labour market. Innovative technical solutions would be devised to mitigate tricky issues of access to resources and environmental degradation. Agile foreign economic policy would continue fine-tuning the optimum level of integration for Switzerland. It would also set out to secure Switzerland's supply by establishing long-term bilateral resource contracts with biocapacity-rich nations.

Discussion: The reasoning behind this maximalist option is to achieve sustainable development by emphasising its market economy dimension.. It is convenient to the political establishment and displeases isolationists as well as neo-Malthusians, but might nonetheless deliver handsomely in the face of global resource challenges. Meanwhile – one never knows – international negotiations might gather momentum and produce a binding agreement on climate change towards a less fossil fuel-addicted world. Switzerland would keep up with emerging economies by trading with them, thereby stabilising – or even increasing – its relative average income. The aim of this option would not be to reduce the national biocapacity gap, but rather to keep the national economy immune to its forthcoming effects. With respect to feasibility, including on the domestic front, negotiating long-term supply contracts with sub-standard democratic regimes may be politically challenging. Firstly, Switzerland's special economic interests may remain uninteresting to resource-rich countries and, secondly, currying favour with them may be seen as a shift away from the principle of neutrality. From a biophysical point of view, the sticking point remains that Switzerland is not secure enough just by outperforming others. Optimum resource consumption must come from two apparently conflicting movements: a) the continued furthering of gains from closer integration, while at the same time, b) preparing for such a time when increased ecological constraints may weaken economic globalisation as we know it, and undermine its reliability as a resource provider. Therefore, it is suggested that domestic and imported resources cannot be economically – let alone ecologically – managed in an optimum, biophysically-informed way simply by being a compliant and passionate player in the global economy. Instead, reinstating domestic resource endowments, as a compass of sustainability, somehow offers a safer potential way out of the likely resource crunch ahead. This observation leads on to all of the following options.

4. "Hedge your bets". Here is a logical attempt to deal with the dilemma exposed above. All uncertainties are amenable to an insurance solution on the grounds that a downpayment today may help mitigate the cost of an undesirable development tomorrow. The global resource challenge ahead typically represents such an uncertainty. Therefore, capitalising on current economic advantages, a sovereign wealth fund would be constituted as an insurance policy so that Switzerland is equipped to react when it is forced to. Adjusting later may cost less owing to improved technology, but it may also be riskier, since reengineering infrastructure takes time and the new technologies may not yet have emerged. The opportunity cost of accruing the fund notwithstanding, this option would typically emulate hypergrowth, and would continue until the proceeds were actually used to adapt Switzerland to today's "unknown unknowns" – possibly triggered by global environmental feedback. From this point onwards, this fourth option would diverge from hypergrowth, taking an adaptation approach by means of a forced march away from the previous wealth-accumulation rationale. Since such a sovereign wealth fund might attract accusations of government intervention in the marketplace and industrial policy – measures not customarily considered by Swiss policymakers – it seems unlikely that one will be put in place any time soon.

Discussion: The point is less the actual foundation of a sovereign wealth fund than the rationale behind it. Switzerland has a name in the insurance industry and in the management of protective investments. Countries which have set up a sovereign wealth fund have all had good reason to do so, mainly to provide financial capital compensation when the main extractive resource on which they are making a living is finally depleted. Switzerland, on the other hand, cherishes a self-image of being deprived of extractive resources, which has provided a powerful incentive to compensate by specialising in high value-added products and services. Therefore, it may appear rather counter-intuitive to float the very concept of a sovereign fund in this context. However, considering the paramount importance of the "Swiss made" trademark for promoting its export industries, one might ask if the "Swiss-made" is not ultimately equivalent to an extractive resource amenable to depletion. Indeed, the worst case scenario of fragmented trade and a general scramble for dwindling resources might well prompt the demise of the global brand of Switzerland to the extent that it becomes heavily reliant on continued globalisation and a sufficiently large and solvent market. From this perspective, as Norway or Chile will enjoy their accumulated capital once oil and copper are eventually depleted, Switzerland would do likewise if it set up a similar fund for the times when bread is more valuable than brand and every nation is forced to reduce its ecological deficit. This option indicates a deferred strategy to come to terms with the national biocapacity deficit, but not before Switzerland is forced to do so by pressing circumstances.

The next option would tip further Switzerland towards activating available policy levers, without waiting for the ultimate signals to come from the international community.

4. "Extreme reengineering right now". Switzerland has a proven ability to adapt in anticipation once risks are eventually acknowledged. Drawing on this, the reengineering option would "hyper-technically" prepare Switzerland for a soft landing out of today's form of globalisation, from "more butter, fewer guns" in Samuelson's terms, towards "less butter, more post-oil infrastructure". This is not only enlightened self-interest, but also future damage control. As in the French philosopher Blaise Pascal's wager – even if God does not exist, it ultimately makes us better off to believe so – there are domestic, unilateral measures to prepare for a paradigm shift that are can actually be financed by co-benefits accruing in the short to medium term. These measures are well identified and spelled out in most green economy policy frameworks supported by different international authorities:

- phase out harmful fossil fuel subsidies (including tax holidays)
- more energy efficiency (especially in buildings and infrastructures)
- more renewable energy
- more smart grids
- more recycling of waste and circular economies
- incentivised production/service capacity-sharing
- more spending on innovation and higher education
- reset the tax system so as to make the acknowledged "public bads" (pollution, energy overconsumption) more expensive and the public goods (labour, profit) less expensive
- increase open trade, thus enabling more international specialisation within a framework of common social and environmental standards
- sustainable agricultural policies that ensure a reasonable market share for domestic food production
- encourage more land-saving regional development and urban planning, and severely limit further encroachment of infrastructures over productive land, as well as urban sprawl.

Assuming it will matter internationally earlier than expected, sustainable consumption is a central issue. Mature economies with high living standards perhaps have an underexploited competitive advantage in this regard. Owing to their high incomes and greater institutional density, the aforementioned green policies give them greater scope to “lock in” the established and more mature consumption patterns of their economic agents away from resource inputs. Switzerland may want to explore this avenue, while successfully avoiding any inadvertent loss of labour productivity.

Discussion: Furthering this bolder option would require two ingrained conventional wisdoms to be overcome: a) unless very hard pressed, Switzerland always gains from keeping its domestic legal system distant from anti-status-quo international pressures, and b) as a small and well-connected country, and a high value-added producer and service provider with high incomes, Switzerland would be spared the harshest consequences of a global resource crunch anyway. These illusory beliefs tend to deflect and postpone public action away from anticipation. To the extent that this option would feature less consumption and more public investment right now, it is true that elected decision-makers may understandably hesitate to show their support. For instance, there is a danger that the necessary post-oil infrastructure investments (or the post-oil-proofing of existing infrastructures) may meet the same fate as military spending, which plummeted in Europe after the fall of the Berlin Wall. Or they may otherwise be turned down by popular initiatives. What would instead make the difference is a better informed general public, provided with channels of open dialogue with public administration and the parliament. This option aims proactively to slow down natural resource throughput at the national level using both sides of resource consumption. This means acting not only on the supply side – by reducing the environmental impacts of a given volume of consumption – but also altering individual or collective consumption behaviours.

The last option below would be a perfect match to “extreme reengineering” on the domestic front. However, it could also be a stand-alone choice for the international aspects of the problem, with a strong commitment to international cooperation, including from the corporate sector.

5. "Sustainable economic practices and global responsibility – the green economy" In view of the global biocapacity deficit and a general trend towards greater resource consumption as other countries catch up economically, Switzerland's use of resources is becoming an ever smaller part of global consumption. From this perspective, it is no longer enough to focus solely on Switzerland when examining output and consumption. Although high resource efficiency on both the supply and demand sides is an important element of Switzerland's ability to meet its own needs in an ever-tougher world, it has little direct influence either on world supply and world resource consumption, or on the global availability of resources. However, as a small and open economy, Switzerland has close ties with the rest of the world via international trade. Any restructuring process in Switzerland, as described in option four, "Extreme reengineering right now", should therefore also be accompanied by international restructuring efforts. Knowledge about efficient and environmentally-friendly technologies should be passed on to the value chains interacting with the Swiss economy. By increasing the efficiency of these value chains and through global standards, resource dependence would be reduced. Resource imports into Switzerland in the form of semi-finished and finished goods (including consumer goods) would then be lower, while knowledge and technology transfer would result in that knowledge being diffused within these countries. This might in turn result in an increase in global resource efficiency, thus countering growing resource consumption in low-income countries and emerging economies. In this way, in addition to its advocacy of international environmental conservation agreements, Switzerland might be able to exercise an indirect influence over resource consumption world-wide. Although this would not resolve the global overuse of resources, Switzerland would be able to demonstrate the advantage of resource-efficient value chains and, within its limitations, contribute to more sustainable economies and lifestyles.

Discussion: As one of the world's most innovative and most efficient countries, Switzerland has an opportunity here to pass on the knowledge that it has gained. Greater international cooperation on conserving resources, particularly in the international value chains associated with the Swiss economy, will reduce Switzerland’s resource dependence while also stimulating an increase in global resource efficiency. Such cooperation would have other benefits, as transport and energy infrastructures, as well as production technologies, would tend to comply more fully with the standards that are to be expected world-wide in the future. It is also important that Switzerland's domestic economic sectors are not the only ones to manage their resources very efficiently. This efficiency must also be applied to their international subsidiaries and suppliers. A whole range of opportunities for the Swiss economy will arise from this process. It may be possible, for example, to enter new areas of business or even whole new sectors. What's more, sustainability is a perfect fit with the image of the Swiss economy as having very high standards of quality. If Switzerland's economic agents were to take greater responsibility in dealings with their suppliers and customers (abroad), it is entirely possible that they might reap first mover benefits which would further strengthen the competitiveness of the Swiss economy as a whole.

Such international cooperation would, however, be needed not only in production, but also in consumption, as this is a major factor in resource use both at home and abroad. A variety of approaches might support moves towards lower consumption, such as environmental assessments, economic instruments, sector agreements, labels, recommendations for product declarations, or standards for sustainable public procurement.

Following this course of action, the national biocapacity deficit would be dealt with by acting internationally on the supply side of global consumption. This involves investing more forcefully in international cooperation, including an increase in public-private partnerships, so that multilateral coercion can eventually get the global economy back on ecological track.

Every option has far-ranging consequences, and none offers a quick win. Some of them can be mixed, others are mutually exclusive. Is there one more option not yet envisaged? How can we reach a broad consensus on the optimum policy mix, including the optimum biocapacity deficit? What are the tools to assess which policy interventions would produce the most effective outcomes?

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9 Glossary

Term	**Definition**
Accessibility	Accessibility reflects the entire potential means of reaching travel destinations in a selected region where no limit is placed on travelling time.
Biocapacity deficit / reserve	The difference between a region or country's biocapacity, and its Ecological Footprint. An ecological deficit arises where a population's Footprint exceeds its available biologically productive land area. The opposite is an ecological reserve, in which biologically productive area is larger than the Footprint for the population of that region.
Biological capacity (biocapacity)	The ability of ecosystems to produce biologically useful material and to absorb the waste products generated by humans under current conditions.
Biologically productive area	Land and water area is described as biologically productive if it is useful to humans owing to considerable photosynthesis activity and the production of biomass.
Carbon Footprint	The forest area required to sequester human-produced CO_2 emissions, primarily from the combustion of fossil fuels (only that portion not absorbed by oceans is considered).
Competitiveness	A country is competitive if it is able to raise or at least maintain a high degree of, and growth in, prosperity, especially when compared to other countries. A country's economic capacity, both alone and in comparison to that of others, rests on the quality of its locational factors, and that country's specific sector mix.
Consumption Footprint	The consumption footprint, stated in global hectares, represents the area that is needed to produce goods that are to be consumed and to absorb the associated waste.
Critical materials	The term "critical materials" describes raw materials, and minerals in particular, which are highly economically significant, yet subject to an elevated supply risk. Their economic significance is calculated from the weighting in the aggregate economy of the sectors which use the material in question. The supply risk is defined by the concentration of the production of a material in a few countries which are characterised by political and economic instability, combined with a low recycling rate and low substitutability.
Decoupling	(De)coupling describes the relationship between economic activity and the use of natural resources or the release of emissions over time. Economic activity has been closely linked to resource consumption and emissions ever since industrialisation began. Decoupling today tends to be relative. In other words, resource consumption or emissions are rising at a slower rate than economic growth. Absolute decoupling would require emissions or resource consumption to fall as the economy grows.
Domestic material consumption	Domestic material consumption (DMC) describes the aggregate take-up of materials utilised directly within an economy. It comprises the annual volume of raw materials (biomass, energy sources, (non-metallic) minerals and metals) extracted from domestic sovereign territory, plus all physical imports, and less all physical exports.
Ecological debt	Humanity has been in a state of overshoot since the mid-1970s. Since then, human demand has exceeded the planet's biological output capacity. With every year's deficit, humanity has thus continued to accumulate an ecological debt.
Ecological Footprint	A measure which shows how much biologically productive land and water area an individual, a population or an activity requires to produce all of the resources consumed, and to absorb the waste that has been created.
Ecosystem productivity	The volume of biological material that is useful to humans that is available from a certain area.

Efficiency, intensity and productivity	The productivity of a factor of production such as energy or materials indicates how much economic output can be produced with one unit of this factor. Productivity is thus an expression of how efficiently an economy manages and uses the factor in question. Productivity increases when GDP rises at a constant level of natural resource input, or when the same level of GDP can be generated with lower factor inputs. Intensity is the inverse of productivity. Intensity is useful as an indicator of efficiency in the unwanted by-products of the production process. For example, CO_2 intensity indicates how much $CO_2$the production process emits per unit of added value. The lower the intensity, the more efficient the production process.
Environmental regulation	Environmental regulation is a collective term for all environmental legislation and regulations, environmental standards, and the enforcement of environmental requirements.
Footprint intensity	The number of global hectares required to produce a certain volume of a resource or to absorb a certain volume of waste.
Global hectare	A global hectare represents a biologically productive hectare of land or water area with world average biological productivity.
Grey emissions / grey energy (typically called embodied emissions or embodied energy)	Emissions released in the value chain of a product. Embodied energy refers to the volume of energy used across the entire life cycle of a product – for its production, transport, use, and disposal.
Gross domestic product (GDP)	Gross domestic product is the total value of all goods, i.e. both physical goods, and services, produced in one year within an economy's national borders, less the cost of all inputs.
Gross value added	Gross value added is the key indicator of actual output, in the economic sense, from a sector or a company. It measures the added value that is generated by the production process. This added value is determined as the difference between the value of the output, and the value of the inputs used to produce that output. As an indicator of overall economic output, gross domestic product is calculated from the sum of all gross value added produced by the different sectors, plus goods taxes and less subsidies.
Income	Gross national product (GNP) is used as a measure of a country's income. GNP covers the value created by the domestic population which is permanently domiciled or resident within a country.
Intensity	See Efficiency, intensity and productivity
Life cycle analysis (LCA)	A life cycle analysis is a quantitative record of a product's impact on the environment. An LCA measures what volumes of energy and materials are consumed to produce and distribute a product, as well as the associated waste, throughout its life cycle, including its use and disposal.
Modal split	The modal split is calculated from the percentage shares of total traffic volumes accounted for by the individual modes of transport (rail, water and road), and thus provides information on the usage of different carriers.
National Footprint Accounts	A set of data which provide environmental accounts for different countries. The accounts cover the Footprints and biocapacity of the world overall and more than 150 countries from 1961 to the present day. Data availability issues mean that a time difference of three years is normal.
Natural resources	Water, soil, air, climate, biodiversity (genetic diversity within a given species, diversity of species and diversity of ecosystems). The Footprint looks at natural resources, but not mineral resources such as ores and fossil energy.

New renewable energies	New renewable sources of energy are the same as renewable energies, but exclude hydropower. In Switzerland, around 60 percent of electricity is traditionally generated using hydropower. It therefore makes sense to exclude this energy source when assessing progress on renewable energies in Switzerland.
Overshoot	Global overshoot occurs when humanity's demand on nature exceeds the biosphere's supply, or regenerative capacity. Such overshoot leads to a depletion of earth's life-supporting natural capital and a build-up of waste. At the global level, ecological deficit and overshoot are the same, since there is no net import of resources to the planet. Local overshoot occurs when a local ecosystem is exploited more rapidly than it can renew itself..
Pattern of specialisation	See Sector mix
Primary energy	Total domestic output of energy, plus imports and changes in reserves, less exports and fuels for aircraft and shipping on international routes.
Primary product (primary resources)	Biological material which has undergone minimal processing. In contrast, raw materials include the entire biomass present on a given area. Human usage is key to this distinction. A fallen tree represents a raw material, for example, but it becomes the primary product of timber when all leaves, branches and bark have been removed.
Productivity	See Efficiency, intensity and productivity
Prosperity	Prosperity refers to material standard of living, and is often measured in terms of gross domestic product, wages, etc.
Raw materials	Non-renewable raw materials: fossil sources of energy (e.g. oil), metals (e.g. copper, lead, zinc, indium), uranium, phosphates. Renewable raw materials: plant-based products (grain, oil seed, cane sugar, cotton, wood, etc.).
Relative income	A country's relative income is the share of global income accounted for by the income of each citizen of the country concerned.
Renewable energy	Renewable energies describes energy sources which are practically inexhaustible within the human time horizon, or which renew themselves relatively quickly. They distinguish themselves in this way from fossil-based sources of energy, which take millions of years to regenerate. Renewable energies include hydropower, wind energy, solar power, geothermal power and renewable raw materials.
Risk	Risk describes a situation in which there is incomplete information about whether or not a situation will occur, and the potential problems in achieving targets that this entails.
Secondary products (secondary resources)	All products which are the result of a primary product or another secondary product passing through at least one stage of processing.
Sectors	A sector describes a group of companies which manufacture similar products, trade in similar items or offer similar services. Companies are allocated to the different sectors in accordance with version 02 of the NOGA General Classification of Economic Activities system.
Sector mix, pattern of specialisation	The sector mix, or pattern of specialisation, describes the composition of sectors within an economy. The main difference between the specific sector mixes of different economies will be the differing sizes of individual sectors within the overall composition. This also describes the economy's pattern of specialisation.

Territorial CO_2	CO_2 emissions within a country's borders.
Tipping points	Tipping points are negative feedback effects that cannot be reversed. This describes changes in connection with the climate system which have the potential to change the global climate at the fundamental level, such as ocean acidification and the resulting decline in the oceans' capacity to absorb carbon dioxide.
Yield	The volume of a primary product which humans are able to harvest or extract per year from a particular biologically productive land or water area. It is usually stated in tonnes.

10 Appendix

10.1 Sector methodology

The data on energy and CO_2 that are used in the international comparison originate from the World Input-Output Database (WIOD), which unfortunately does not contain any data on Switzerland. The WIOD data was therefore expanded with SFSO data on Switzerland, which are more detailed in some respects. Data from Eurostat was thus also consulted for the CO_2 statistics. These estimate the CO_2 emissions of individual sectors, in accordance with their particular share of the aggregate, while the WIOD figures present the aggregates alone.

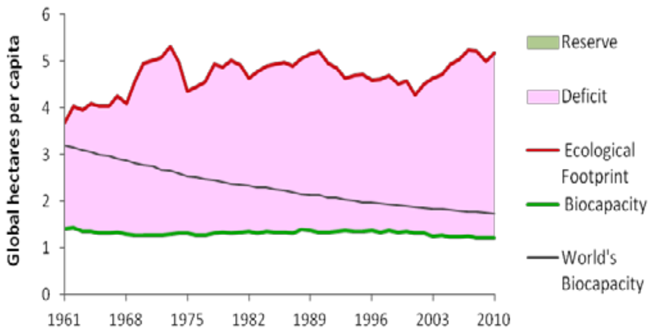
Energy consumption and CO_2 emissions figures were drawn from homogeneous output segments. As such, they are not entirely compatible with the value added figures that are allocated to the different sectors in accordance with the company principle. If wastewater treatment is organised and conducted by a state agency, the value added created by this agency is allocated to the public sector. However, energy consumption and CO_2 emissions are allocated to the wastewater treatment sector in accordance with the output of the activity.

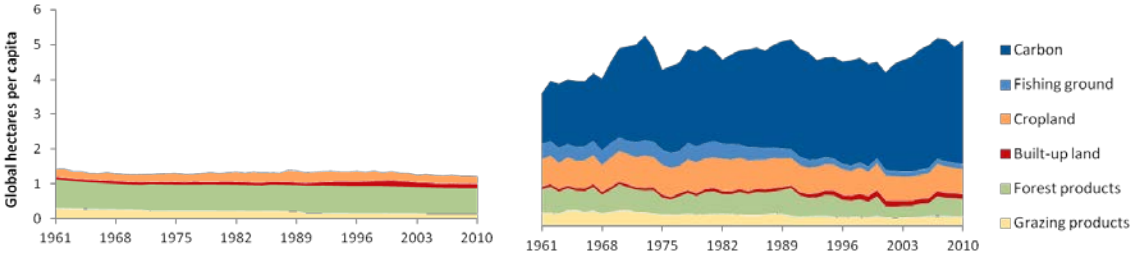
In this study, Western Europe – as an average region – is created from figures for Switzerland, Germany, France, Italy, the United Kingdom, Spain, Sweden, Belgium the Netherlands, Denmark, Ireland, Luxembourg, Austria, Portugal and Finland.

The data on particulate matter per sector are recorded using the NOGA 8 economic classification system or the NACE (revision 2), which is consistent with it. In the interests of comparability, figures have been converted into USD at purchasing power parity. The available data series for Germany and the Czech Republic extend only as far as 2010. Ireland, Spain and Finland do not publish any data on particulate matter. For this reason, the Western European average for data on particulate matter comprises only Belgium, Denmark, Germany, France, Italy, Luxembourg, the Netherlands, Austria, Portugal, Sweden, the United Kingdom and Switzerland.

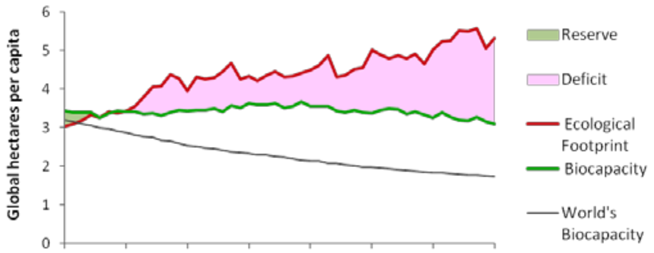
10.2 Ecological Footprint

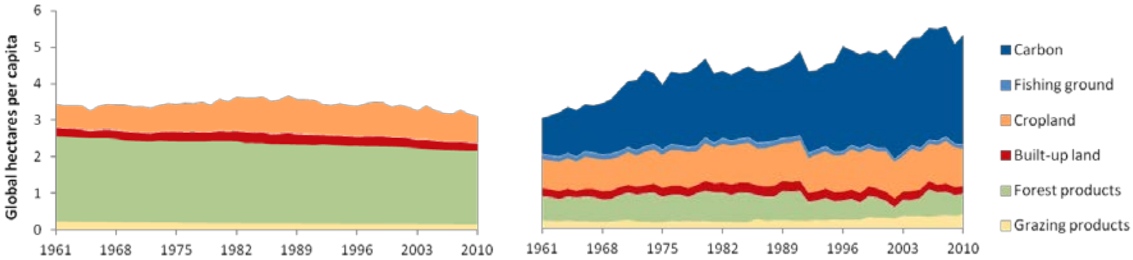
Switzerland



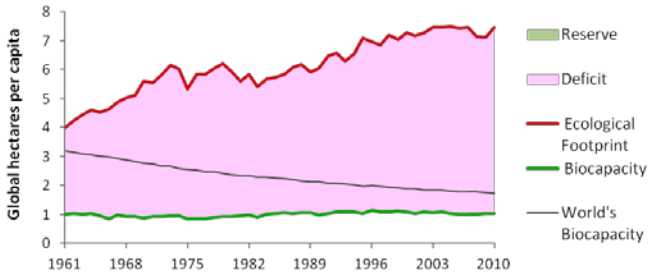


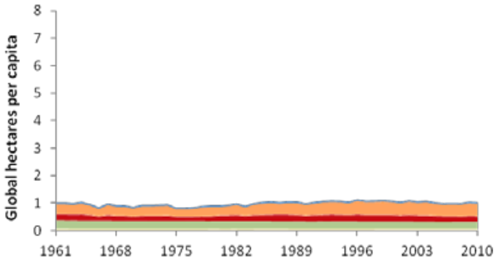
Austria

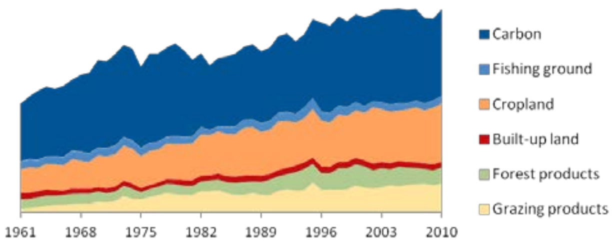




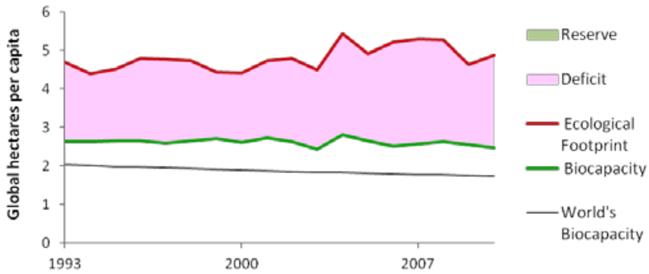
Belgium

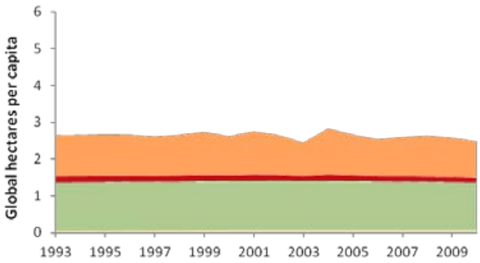


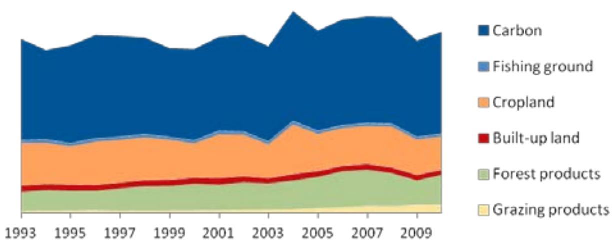




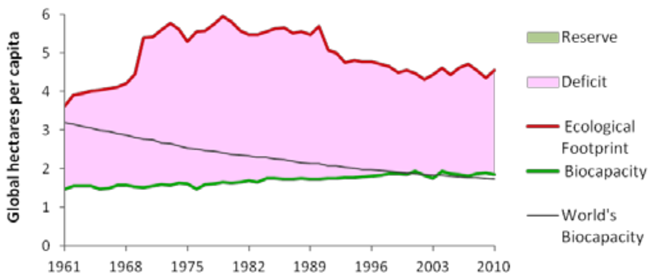
Czech Republic

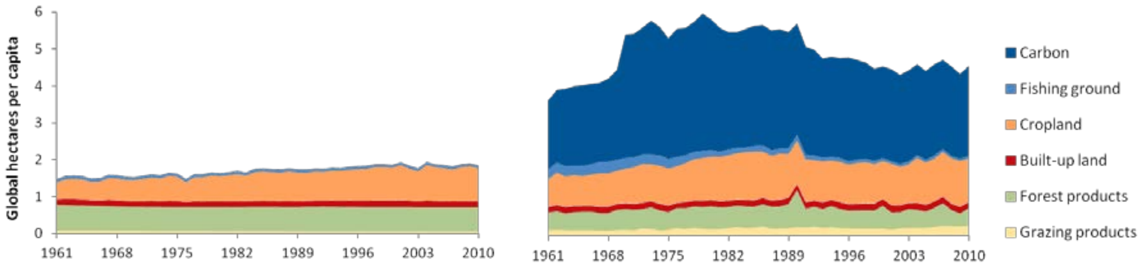




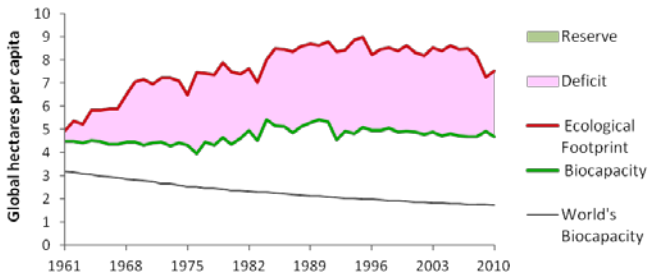


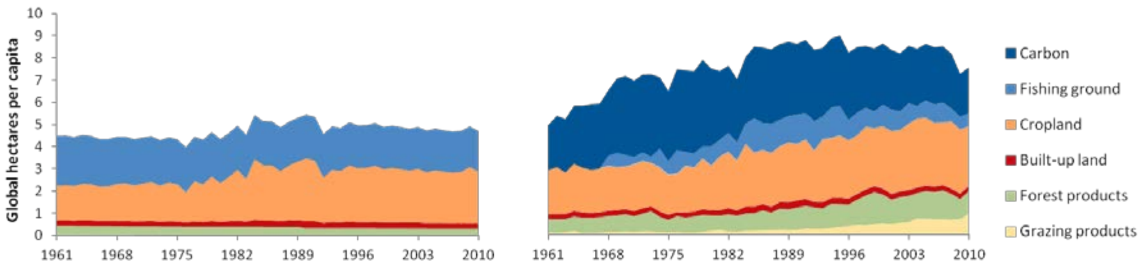
Germany



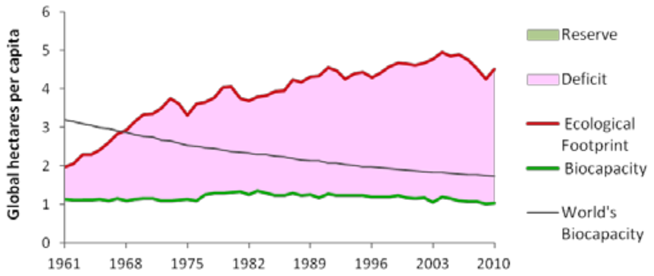


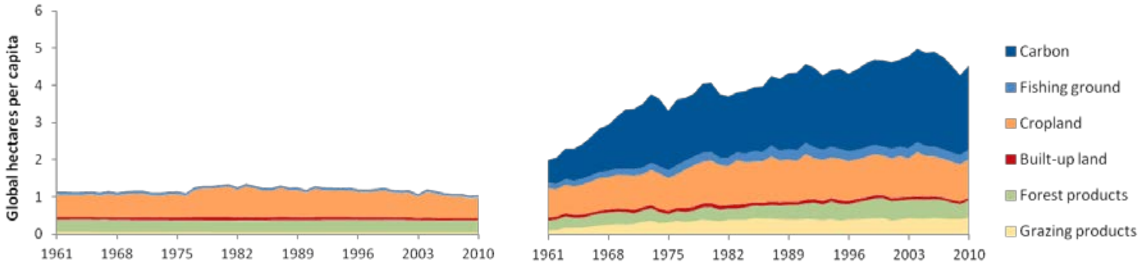
Denmark



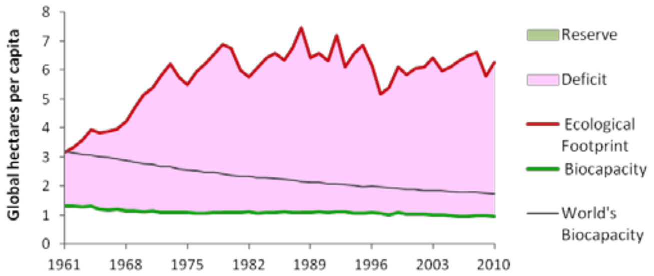


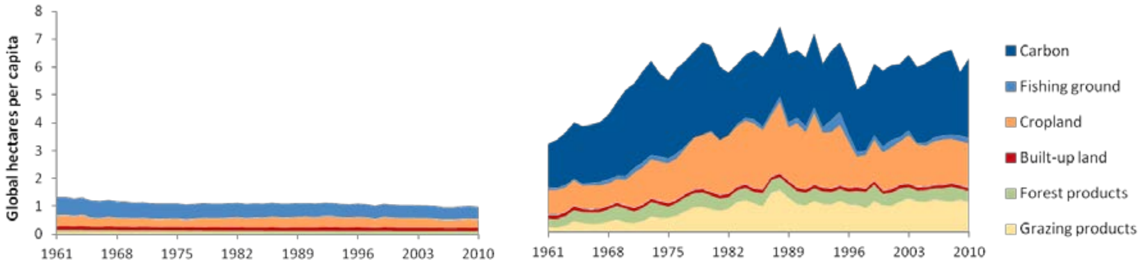
Italy





Netherlands





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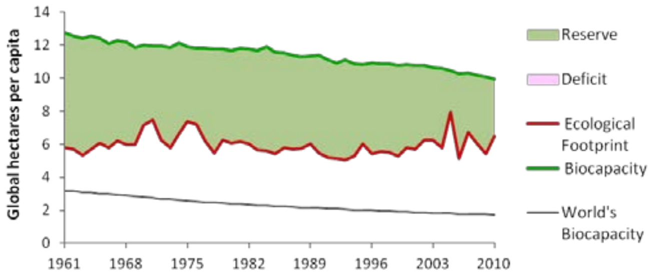
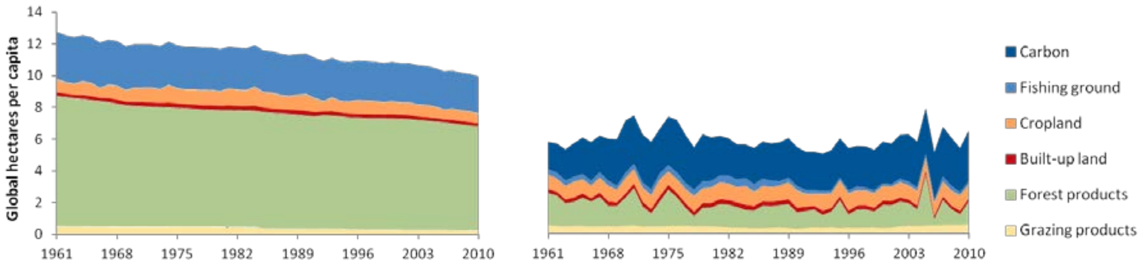
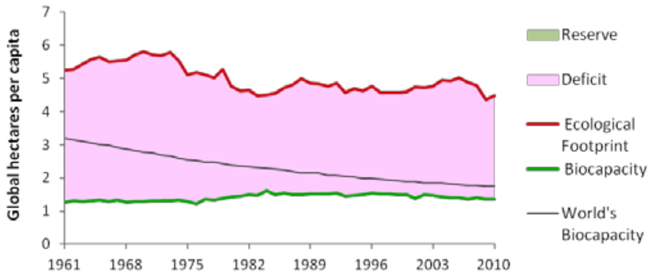
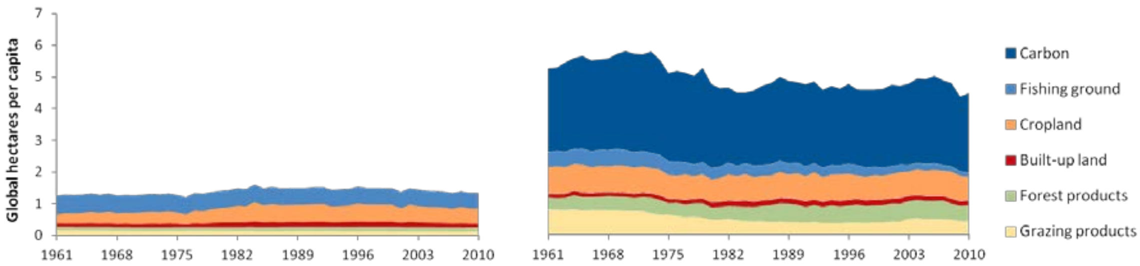




United Kingdom





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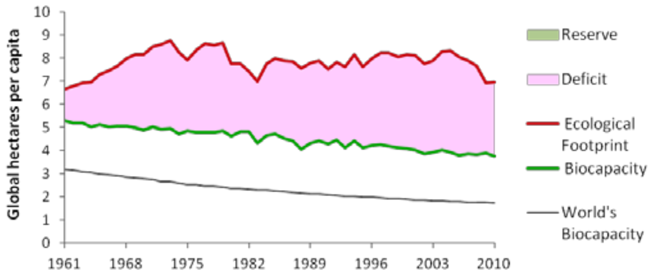

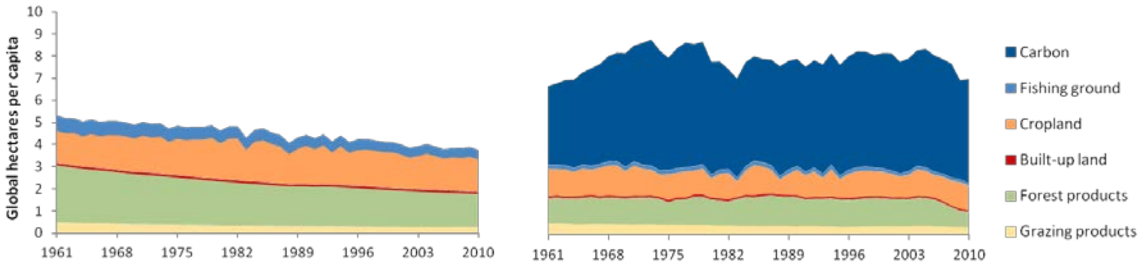

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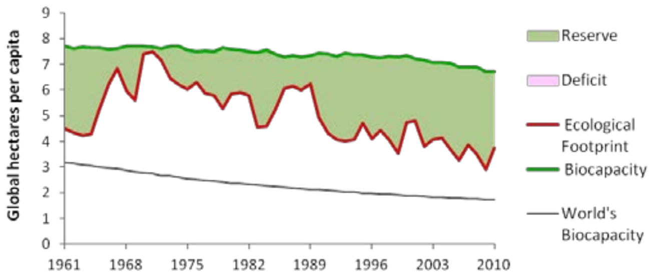

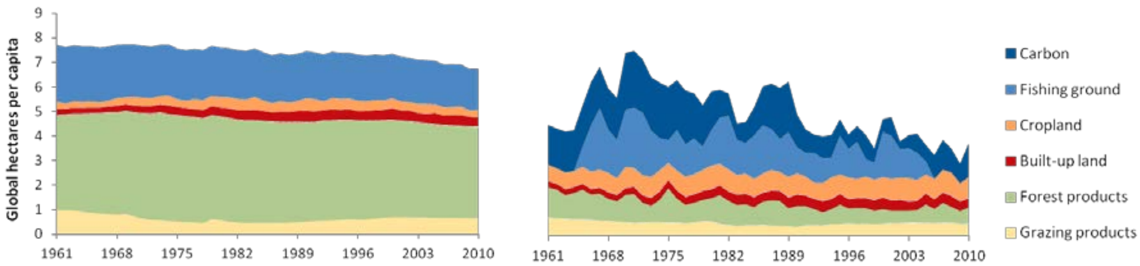

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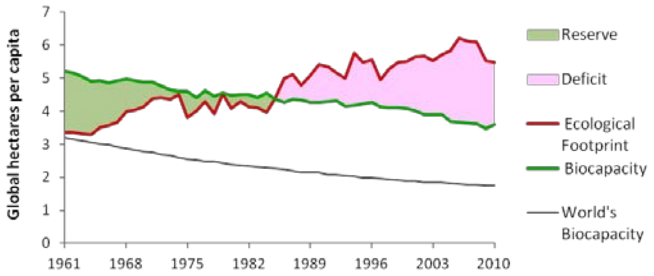
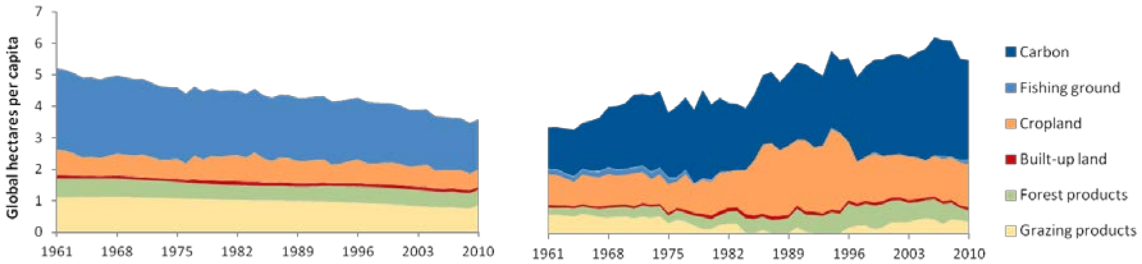
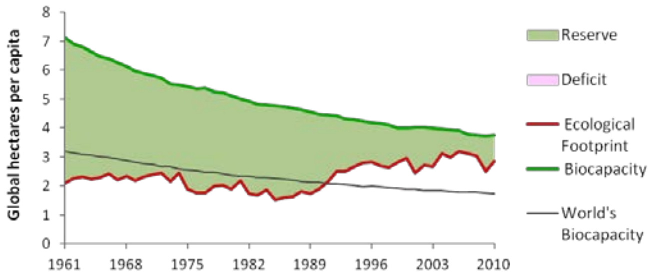
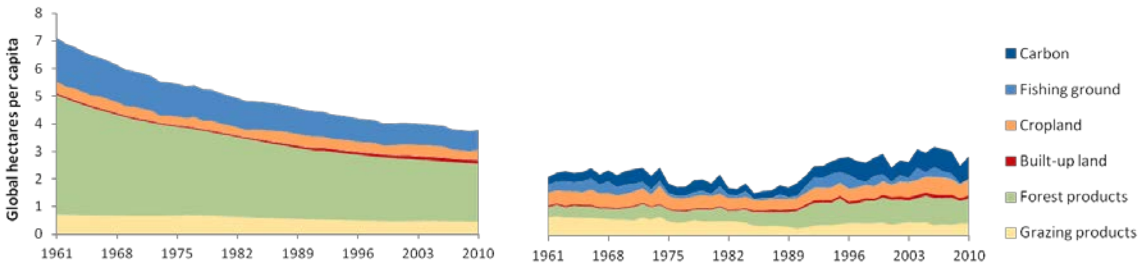


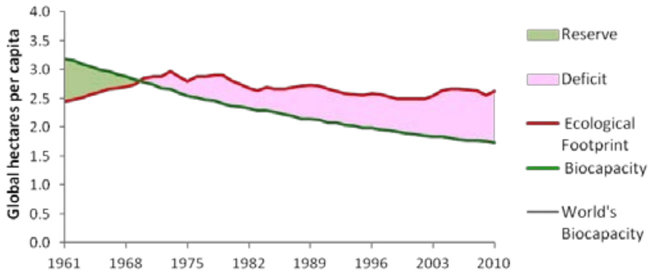


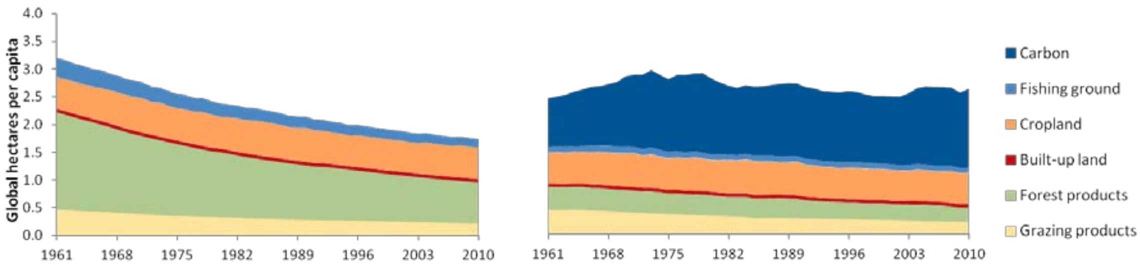
Chile





World


Global hectares per capita
Reserve
Deficit
Ecological Footprint
Biocapacity
World's Biocapacity


Global hectares per capita
Carbon
Fishing ground
Cropland
Built-up land
Forest products
Grazing products