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End of previous Forum article

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More Productive, Less Sustainable? On the Need to Consider Material Resource Flows

In environmental policymaking, the figurative cake that is wanted both to have and eat lies in achieving dematerialisation, i.e. reducing material resource use, and simultaneously pursuing a pathway lined with economic growth.

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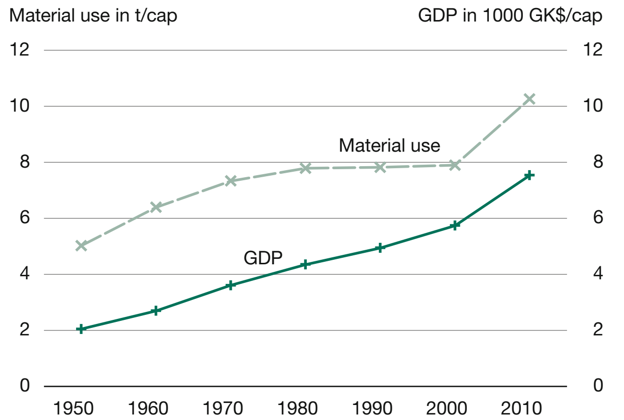
Under such a scenario, we could have it all: increasing production and international convergence at the highest levels of consumption with a reduced impact on the environment in a lifestyle which could also be enjoyed by generations to come. In the following, we make a case for considering the evidence in contemplating the feasibility of such a utopia by taking social metabolism i.e. the material and energy input of society, into account. An advance warning: we will not (and cannot) provide a blueprint for this cornucopia economy; instead, we outline where we must look in order to define the realm of possibilities when it comes to the economically required growth and the environmentally required dematerialisation. This leads us to a research agenda which can be successfully tackled only if we combine insights on the biophysical and monetary development of our global economy.

Figure 1
Global per capita material use and GDP per capita, 1950-2010



Notes: Material use measured in tonnes per capita. GDP measured in Geary-Khamis dollars per capita.

Source: A. Schaffartzik, A. Mayer, S. Gingrich, N. Eisenmenger, C. Loy, F. Krausmann: The global metabolic transition: Regional patterns and trends of global material flows, 1950-2010, in: Global Environmental Change, Vol. 26, 2014, pp. 87-97.

The world looks different in material terms

From the post-World War II boom to the explosion in material resource use early in the 21st century, the global economy has been on a long pathway of rapid growth. Between 1950 and 2010, global material use increased from approximately 13 to 71 billion tonnes per year,[1] and while it is common to associate this growth with developing economies catching up to the levels of resource use exhibited by the early industrialisers, the data on global material resource use suggests that there may in fact be other factors at play. If, instead of absolute material use levels, we consider per capita material use, we find that while this indicator increased noticeably between 1950 and 1970, from a global average of five tonnes per capita (t/cap) to more than seven t/cap, it hovered just below eight t/cap from the late 1970s to the middle of the first decade of the 21st century (Figure 1). The material flow data provides us with an important insight into the development of the global economy that we would have missed if we had only examined the gross domestic product (GDP): in monetary terms, we do not find any evidence of stagnation at the aggregate level of global GDP.

Since the 1950s, global GDP has experienced stronger growth than global material resource use, which means that resource productivity, i.e. the amount of GDP generated per unit of resource used, has been increasing. This development is commonly referred to as the "decoupling" of economic growth from resource use.[2] Economies which manage to achieve economic growth without using ever greater quantities of resources in the process are studied by policymakers and researchers alike in the hope that they may provide information on a development pathway that would be more sustainable globally.[3]

When we take a closer look at the development of material use at the level of world regions, we find that the global stagnation in per capita material resource use beginning in the late 1970s was caused almost exclusively by those countries in Europe, North America and Asia that industrialised comparatively early on (referred to as Industrial countries or economies in the following). While starting at levels of material resource use which were very high by international comparison, these economies have experienced stagnation and even reduction of per capita material use since the 1970s, accompanied by continuous growth in material productivity (Figure 2a). The reduction in material use which occurred in these Industrial countries between 2000 and 2010 is, in contrast to the stagnation in the preceding decades, no longer visible at the global level (Figure 1). This can, in large part, be explained by the veritable explosion in material resource use in Asia during that decade (Figure 2b). In Asia, too, material productivity increased between 1950 and 2010, although to a level that remains significantly below the productivity of the Industrial economies in 1950 (Figure 2).

We compare and contrast these two country groupings here to draw attention to the occurrence of what Wiedenhofer and colleagues have previously termed the "1970s syndrome" of the Industrial countries and to illustrate how this development strongly diverges from the trajectory which other (growing) world regions are on.[4] Since the early 1970s, following decades of growth, per capita material resource use stagnated and eventually even declined in the Industrial countries, while income, measured as GDP, continued to rise, as reflected in the growth of material productivity. This development occurs at a very high level of material use, a level which cannot be emu-

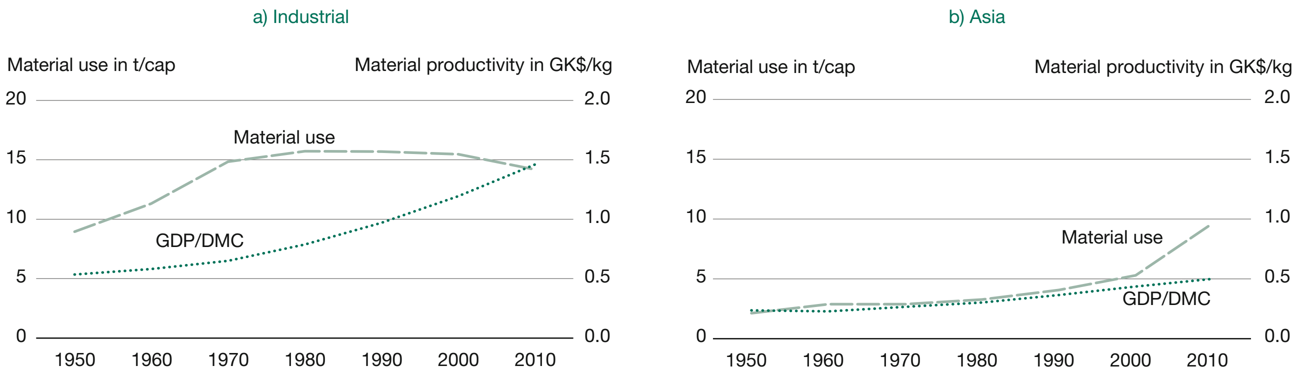
1 Global and regional material use patterns between 1950 and 2010 are described in detail by A. Schaffartzik, A. Mayer, S. Gingrich, N. Eisenmenger, C. Loy, F. Krausmann: The global metabolic transition: Regional patterns and trends of global material flows, 1950-2010, in: Global Environmental Change, Vol. 26, 2014, pp. 87-97.

2 UNEP-IRP: Decoupling Resource Use and Environmental Impacts from Economic Growth, UNEP, Nairobi 2011.

3 H. Schandl et al.: Global Material Flows and Resource Productivity. An Assessment Study of the UNEP International Research Panel, United Nations Environment Programme, 2016.

4 D. Wiedenhofer, E. Rovenskaya, W. Haas, F. Krausmann, I. Pallua, M. Fischer-Kowalski: Is there a 1970s Syndrome? Analyzing Structural Breaks in the Metabolism of Industrial Economies, in: Energy Procedia, Vol. 40, 2013, pp. 182-191.

Figure 2
Per capita material use and material productivity, Western Industrial and Asian countries, 1950-2010



Notes: Material use measured in tonnes per capita. Material productivity denotes GDP per domestic material consumption (DMC = domestic extraction plus imports minus exports) and is measured in Geary-Khamis dollars per kilogram.

Source: A. Schaffartzik, A. Mayer, S. Gingrich, N. Eisenmenger, C. Loy, F. Krausmann: The global metabolic transition: Regional patterns and trends of global material flows, 1950-2010, in: Global Environmental Change, Vol. 26, 2014, pp. 87-97.

lated by the rest of the world without surpassing planetary boundaries.[5] The 1970s syndrome can be observed in all high-income industrial countries. In Japan, which exhibits levels of material use only slightly above the international average of approximately ten t/cap, material use has been stagnating since the 1980s and declining since the Asian crisis. In the United States, marked by much higher resource consumption (approximately double the global average in 2010), resource use per capita has remained stable for the past 40 years, similar to the entire OECD area as a whole. In the 27 member states of the European Union, per capita resource use has been declining slightly since the early 1990s. While per capita material resource use has stagnated, absolute levels of material use in the Industrial countries has continued to increase. This increase was essentially driven by population growth, while it appears that the material requirements of day-to-day life may have approached saturation level.

The development of material use seems to be strongly related to the phase of a country's economic and industrial development. With the exception of the mature industrialised economies, we cannot find other examples of a 1970s syndrome internationally. Coupled with this is the observation that many other economies seem to be following the trajectory of the Industrial countries, not just in terms of increasing levels of material resource use but also in terms of the composition of that resource use. This involves increases in the shares of fossil energy carriers and, during a take-off phase in large-scale industrialisation and urbanisation, of construction minerals, coupled with declining shares of biomass.

The 1970s syndrome: stagnating resource use in the Industrial countries

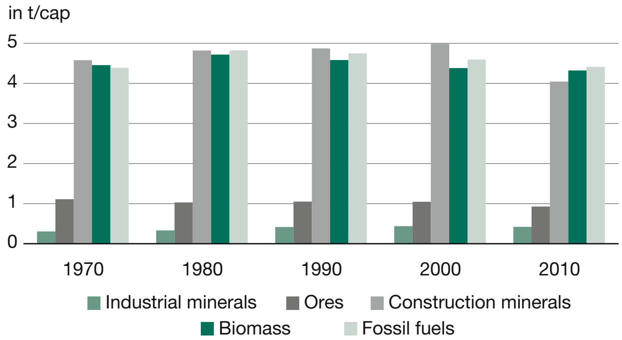
What, then, allowed for the stagnation of per capita material use in the Industrial countries and what, if anything, can we learn from this stagnation that may be useful in understanding sustainability options (or a lack thereof)? When we examine the period of stagnating per capita material use in the Industrial countries more closely, we find that not only the magnitude but also the composition of that material use has remained fairly consistent from the 1970s onwards: industrial minerals made up less than 0.5 t/cap in this metabolic profile, ores accounted for approximately one t/cap, and construction minerals, biomass, and fossil fuels each contributed between four and five t/cap to overall material use, dominating this profile (Figure 3).

In contrast to this pattern exhibited by the Industrial countries, countries currently undertaking rapid infrastructure build-ups tend to use higher amounts of construction minerals. We estimate that in 2010, China was using approximately ten t/cap of construction minerals, more than twice the amount used in the Industrial countries. Even though in-use buildings and infrastructure continue to require construction mineral inputs for their maintenance and repair, these figures suggest that after the decades of rapid infrastructure build-up which the Industrial coun-

5 J. Rockström et al.: A safe operating space for humanity, in: Nature, Vol. 461, No. 7263, 2009, pp. 472-475.

Figure 3

Material use by category in the Industrial countries, 1970-2010

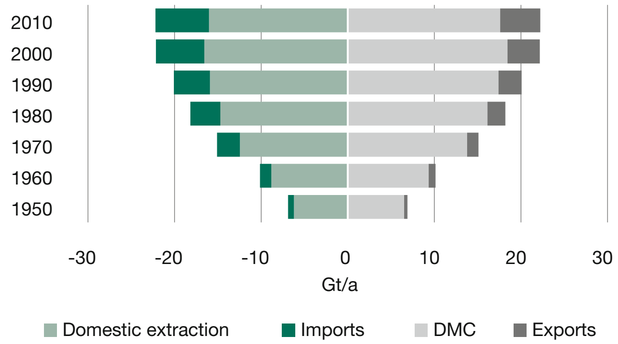


Note: Material use measured in tonnes per capita.

Source: A. Schaffartzik, A. Mayer, S. Gingrich, N. Eisenmenger, C. Loy, F. Krausmann: The global metabolic transition: Regional patterns and trends of global material flows, 1950-2010, in: Global Environmental Change, Vol. 26, 2014, pp. 87-97.

Figure 4

Sources and destinations of material flows in Industrial countries, 1950-2010



Notes: Sources consist of domestic extraction and imports; destinations consist of domestic material consumption (DMC) and exports. Both are measured in gigatonnes per year (Gt/a).

Source: A. Schaffartzik, A. Mayer, S. Gingrich, N. Eisenmenger, C. Loy, F. Krausmann: The global metabolic transition: Regional patterns and trends of global material flows, 1950-2010, in: Global Environmental Change, Vol. 26, 2014, pp. 87-97.

tries experienced, especially following World War II, a saturation level may have been reached, causing the per capita use in this material category to stagnate.

Out of the material categories presented here, biomass use has been shown to most closely follow population development, and the average use of biomass in the Industrial countries was only one t/cap higher than the world average.[6] Even among the Industrial countries, those economies which focus on the extraction of biomass for export (mainly agricultural or forestry products) tend to exhibit the highest shares of biomass in their metabolic profiles.

Fossil fuel consumption is higher in the Industrial countries than in almost all other countries; only the “oil states” exhibited much higher rates of use in this material category, at around ten t/cap in 2010. Even if it is at a very high level, the stagnation in fossil fuel use as part of the 1970s syndrome may be due to the response of the Industrial countries to the oil price shocks of the early 1970s. These shocks can be linked to significant improvements in energy efficiency (in production processes as well as consumer products such as automobiles).[7] The level of fossil fuel use is sensitive not only to energy costs but also to changes in economic structure. Heavy industry, for example, tends to require higher direct energy inputs than the tertiary sector, and the more bulk material (construction minerals, ores) that is mobilised in an economy, the more energy is required. Hence, the increasing orientation of Industrial economies towards the secondary and tertiary sectors combined with the saturation in construction activity may also be linked to the stagnation in average fossil fuel use.

Accounting for the fragmentation of international supply and use chains

The economic focus on activities in the secondary and tertiary sectors is typically enabled by the extraction of primary materials and the material- and energy-intensive initial processing of these materials in other economies. The supply of material resources through imports constitutes an integral part of the 1970s syndrome in the Industrial countries. The stagnation of average material use coincided with increasing material inputs via imports, so that the relative role of domestic extraction in supplying the raw materials required by the Industrial economies declined (Figure 4).

At the same time, exports also became an increasingly important “destination” for material flowing through the Industrial economies, though at a lower level than imports, so that the Industrial countries were the only

6 A. Mayer, A. Schaffartzik, F. Krausmann, N. Eisenmenger: More than the sum of its parts – patterns in global material flows, in: H. Haberl, M. Fischer-Kowalski, F. Krausmann, V. Winiwarter (eds.): Social Ecology – Society-Nature Relations across Time and Space, Cham 2016, Springer, pp. 217-233.

7 V. Draxler: Veränderungen im sektoralen Energieverbrauch ausgewählter europäischer Länder von 1960 bis 2005, Social Ecology Working Paper 140, Institute of Social Ecology, 2014.

country grouping which was a net importer of materials throughout the entire period from 1950 to 2010. Put in global perspective, these net imports mean that the "rest of the world" (inadequately named in this context, because it is home to the majority of the global population) provided net exports. With the exception of Asia in 2010, all other major world regions were net exporters at all other points in the period studied. Although in very simple terms, this relationship makes abundantly clear that we cannot study the material use patterns of economies engaged in trade relations independently of one another: there can be no net imports in one part of the world without net exports somewhere else. For our understanding of the 1970s syndrome, it means that, regardless of the mechanisms which may have triggered the stagnation of material use in the Industrial economies, this development pathway cannot serve as an international blueprint. For one, the high levels at which material use in the Industrial economies began to stagnate cannot be achieved globally without serious destructive implications for the environment. In addition, the economic structure underlying the 1970s syndrome in the Industrial countries seems to rely on net imports and thus cannot be detached from the extraction and processing of raw materials for export elsewhere.

The materiality of the economy, the economics of material flows

The need for more growth is frequently claimed as a prerequisite to enable those who currently earn, consume or own less to catch up. The brief overview of global and regional material flow data which we have presented here exposes the fallacy of this argument. The stagnation in global average per capita material use between 1970 and 2000 was caused by stagnation in the Industrial countries. If, during this period, other regions and countries had been significantly catching up, we would have seen continuous growth at the global level, in spite of the 1970s syndrome. In addition, the environmental implications that current levels of global resource use already have (anthropogenic climate change being a prominent example) mean that any kind of business-as-usual and convergence at high levels of resource use would be unsustainable, to say the least. An important research strand which emerges here and requires the integrated study of the global economy in monetary and biophysical terms is that of the role of inequality, both in terms of resource use and of income, and considering the interlinkages between the two.

We find that the material use profile which appears to have become stable in the Industrial countries is dominated by three material groups: construction minerals, biomass and fossil fuels. Of these three, we find the links between the use of construction minerals and fossil fuels and the economic structure and current stage of development especially noteworthy. The pivotal role of the construction sector in times of economic crisis when capital investments in infrastructure still tend to be the go-to actions of economic policy, additionally highlights the need to focus research on this particular intersect of monetary and material flows. With its direct implications for anthropogenic climate change, fossil fuel use already features much more prominently on the research agenda than can be said of the other material categories. Nonetheless, the ubiquitous use of fossil fuels throughout production and consumption poses the particular challenge of identifying what changes, if any, can be made in the economic structure so as to achieve the necessary reductions in this particular type of material use.

Finally, we are accustomed to framing the particular trade patterns in which the Industrial countries are engaged as a form of "off-shoring", particularly for material- and energy-intensive production. As Jakob and Marschinski have convincingly pointed out with regard to the role of trade for carbon emissions, however, this view tends to oversimplify international trade relations, leading us to potentially lose sight of the underlying drivers and thus the points of intervention.[8] The level of energy and material inputs required in the production process is the result of the economic structure, the currently in-use technology and the scale of an economy. This constitutes an entirely different perspective than does the assumption that an economy might specialise in producing energy-intensive goods for export (even if the outcome appears to be the same).

European economic policy shapes the role of this continent in global resource use. We find evidence for this link in considering not only the monetary and financial aspects but also the material prerequisites to and implications of these policies.

8 M. Jakob, R. Marschinski: Interpreting trade-related CO_2 emission transfers, in: Nature Climate Change, Vol. 3, No. 1, 2012, pp. 19-23.