8
Addressing the Rebound Dilemma

Ernst von Weizsäcker

Introduction

Fundamentally the most pressing issue of the 21st century is that of managing 'growth'. The problem is that for the last three centuries the levels of growth in the consumption of resources (particularly oil, coal, water and timber) have steadily increased, in line with levels of economic growth. This has of course resulted in associated increases in the level of a range of environmental pressures, to the point that the environment's response to such pressures may actually impact on economic growth, now and for the foreseeable future. This is particularly the case for human-induced climate change. In the summary of the conclusions from the *Stern Review* it states that:

> *Our actions now and over the coming decades could create risks of major disruption to economic and social activity, on a scale similar to those associated with the great wars and the economic depression of the first half of the 20th century. And it will be difficult or impossible to reverse these changes. So prompt and strong action is clearly warranted.*[1]

However, delivering such prompt and strong action in practice is incredibly complicated, and even though the previous Sector Studies show what is possible, broad implementation involves a range of inter-related factors, each having varying effects on the outcome.

A particular complication, being the focus of this chapter, is that the increase of resource productivity does not always lead to reduced resource consumption. It can even lead to an overall increase in consumption levels. This phenomenon is commonly referred to as the 'rebound effect'. It means

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that improving resource productivity alone is not sufficient to address overall consumption levels. Complementary efforts need to be made to adjust policy mechanisms, affect resource prices, educate communities and account for increased population or affluence levels. Improving resource productivity may buy some time but eventually without a systemic approach the overall levels of consumption will continue to rise, along with the associated environmental pressures.

Factors affecting total resource consumption include:

- background levels of population growth (productivity may double but if population does also then the overall impact may be negligible);
- social norms and cultural practices (these may impact on choices for particular activities such as preferences for particular food types, along with social trends for the latest and greatest technologies);
- levels of affluence (with different levels of affluence leading to different behaviours).

The level of affluence is a particularly sensitive issue. Those living in poverty will find it unfair if environmental reasons are used to stop growth just before they benefit from it. But then resource productivity may serve as an unexpectedly simple way out of this social tension by allowing the poor to have better lives with stagnant resource consumption while inducing the rich to stabilize their economic well-being and reducing their resource consumption. Hence what was at first a technical issue is now a social and political issue, and will require a sophisticated and holistic approach.

The Khazzoom-Brookes Postulate

In short, we are talking about growth. Resource consumption has always grown with economic growth, or nearly. Jeff Rubin writes in his introductory leader to the more detailed paper by Rubin and Tal:[2] 'To date, there has only been one sure-fire way of reducing energy consumption – shrink the economy.' He continues: 'reducing energy consumption per unit of GDP has not been a viable policy option. From gasoline demand to the energy requirements of an average American home, the legacy of energy-efficiency improvements is ever-greater energy consumption.' Rubin does not say the policy option of reducing energy consumption per unit of GDP is not available, but he does say it has not prevented energy consumption from growing. Here we are. This is the 'rebound effect'. Unless and until we overcome this rebound effect, we will not reach any of the ecological goals that we and the community of climate experts consider necessary. This is the reason why we devote one full chapter to the phenomenon of the rebound effect. The phenomenon has been well known since the 1980s, chiefly through empirical work by Daniel Khazzoom in the US and Leonard Brookes in Britain, and it got a name, the Khazzoom-Brookes Postulate.[3] Independently the two researchers found that after the dramatic increase of oil and gas prices during the 1970s considerable efficiency gains

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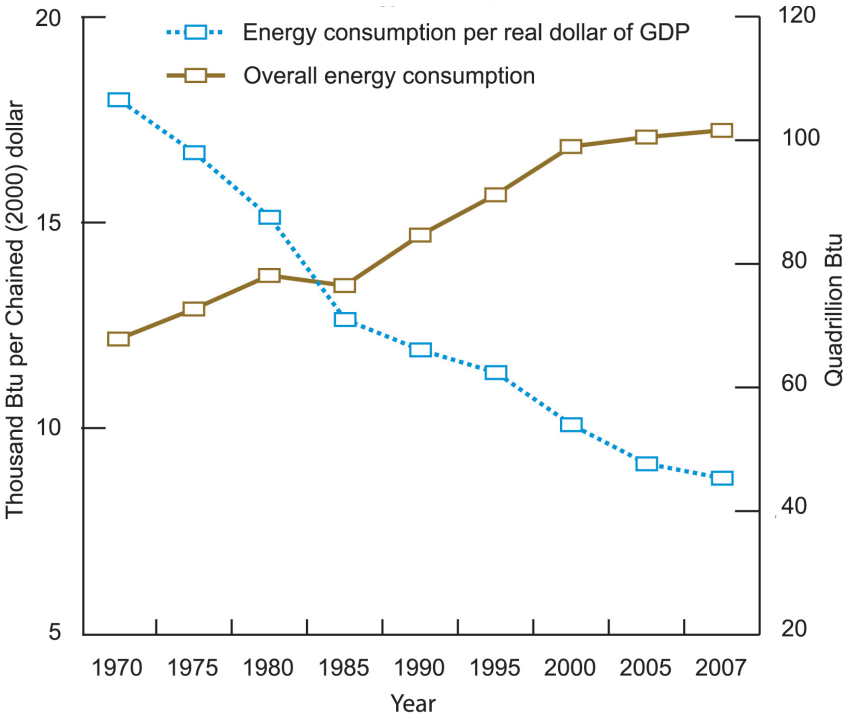

Source: Drawn from data sourced from EIA[4] (Cited in Rubin and Tal (2007))

Figure 8.1 *A comparison of the overall energy consumption and the energy consumption per GDP for the US between 1949 and 2007*

were made, but that these efficiency gains were reducing the monthly cost of energy consumption and had the effect of more money being available for economic growth and indeed for energy consumption.

What was rather a visionary observation at that early time (1979 and 1980, respectively), became a very conspicuous and massive reality since the late 1980s until quite recently – when the 2008 economic crisis began to hit. Rubin and Tal present a number of striking trends from the US, including the trend seen in Figure 8.1 – which shows that following the 1974 OPEC oil crisis and up to 2007, US energy productivity doubled, but the overall energy consumption rose by 37 per cent.

The most commonly known story about the rebound effect is that of the CAFE (Corporate Average Fuel Economy) standards adopted in the US in 1975 and introduced in 1978. They brought average fuel efficiency of ordinary automobiles up to roughly 27 miles per gallon from the earlier 18mpg. This happened within some 20 years, more or less the lifetime of an automobile in the US. However, this improvement in fuel economy, combined with one of the lowest prices for oil in December 1986, led to a marked overall increase in driving miles that continued through to the mid 1990s. Rubin and Tal also point out that there was a significant shift away from the CAFE-regulated passenger cars to unregulated sport utility vehicles, or SUVs – which also enjoyed a tax advantage over passenger cars. The US government, notably under Ronald Reagan (1981–1989), refused the introduction of gasoline taxes, which are commonplace in most other industrialized countries, and even accepted a generous tax advantage for the new SUV fleet. The housing and automobile industries boomed no end, which was, of course, very welcome after the uncomfortable 'stagflation' of the previous period. Also, electricity use by household appliances rose between 1990 and 2005 while their efficiency increased, such as the refrigerators (with efficiency improving 10 per cent and use increasing 22 per cent) and air-conditioners (with efficiency improving 17 per cent and use increasing 35 per cent).[5]

There are, of course, assertions that the rebound effect does not hit as hard as Khazzoom and Brookes believe. For example, John 'Skip' Laitner[6] from the US Environmental Protection Agency (EPA) offers extremely optimistic figures, saying that:

> *the rebound effect might reduce overall savings by about 2–3% compared to a pure engineering analysis. In other words, an economy-wide, cost-effective engineering savings of 30% might turn out to be only a 29% savings from a macroeconomic perspective.*

Such assertions make it necessary to go a bit deeper than Rubin and Tal into the partly contentious issues of the rebound effect. One of the best modern analyses of the issues came from Horace Herring, a visiting research fellow at the Open University with over 25 years of investigating energy efficiency and the rebound effect.[7] He reviewed the controversies between Daniel Khazzoom and Amory Lovins in the US, and between Len Brookes and Michael Grubb in the UK, with Lovins and Grubb assuming that efficiency will lead to less energy consumption due to, as Grubb[8] puts it, 'saturation rates', resulting in limited levels of energy demand. Saturation means that additional consumption yields negligible marginal benefits. In line with Len Brookes' concerns, Hilliard Huntingdon's review of Grubbs work led to his conclusion that:

> *While saturation of individual appliances can be expected, rapid economy-wide saturation need not occur as new energy services and energy-using appliances are constantly emerging. The volume offers no evidence, historical or otherwise, for its assumptions about saturation rates.*[9]

In the American debate, Amory Lovins[10] has maintained that the 'rebound' effect by consumers of energy efficiency gains is small, whereas Khazzoom[11] argues that Lovins' analysis does not take into account macroeconomic responses to implicit changes in energy price caused by efficiency improve-

Table 8.1 *Summary of empirical evidence for direct rebound effects in the US residential sector*

Device	*Potential size of rebound (percentage)*	*Number of studies*
Space heating	10–30	26
Space cooling	0–50	9
Water heating	<10–40	5
Residential lighting	5–12	4
Appliance	0	2
Automotive transport	10–30	22

Source: Greening et al (2000)[12]

ments. This answer perhaps, also defeats Skip Laitner's proposition of a mere 2–3 per cent rebounding, as this also does not take macroeconomic responses into account. Laitner, Lovins and Grubb also have a point though. The empirical economists confronting them are in danger of inducing cynical conclusions on the part of business or politics, such as, 'All those noble efforts lead nowhere! The human nature is unchangeable. Let's just go ahead with more production and consumption until – well, we don't know.' This type of cynical rhetoric is quite widespread and is influential and often lumps all types of efforts into one broad assumption. However, the reality is that rebound effects are different for different types of efficiency improvements. For example the direct rebound effects in the residential sector have been studied extensively in the past two decades and the results from over 65 empirical studies are summarized in Table 8.1, showing considerable variation in the scale of the effect.

On the other hand, if we want to make progress on climate and other environmental challenges, we cannot ignore the trends presented above, for example in Figure 8.1. These trends clearly indicate that for all the merits of efficiency, energy and resource consumption has been rising, not falling – and in one of the richest country of the world! One factor, which has hardly been touched by Khazzoom, Brookes and their followers is the influence resource prices may have on consumption. Figure 8.1 shows that the period of steeply rising energy consumption were the years from about 1982 to 1999, which have been the years of cheap oil and gas. Although Khazzoom's and Brookes' first observations were published earlier, the big evidence in support of their papers, oddly, arrived a few years later when significant reductions in the price of oil occurred. The signal of low energy prices, particularly after oil prices were lowered in 1986 by Saudi Arabia, has greatly contributed to the propensity of Americans and others to consume more energy.

Seemingly contradictory findings by Sam Schurr, then Deputy Director of the Energy Study Center at the Electric Power Research Institute, that energy efficiency increased more rapidly at times of *low* energy prices can be explained by the double fact that, 1) much of the efficiency innovation was motivated by and developed during the previous oil price crisis, and 2) the spreading of the inventions was helped by the optimistic mindset that emerged after the nightmare of those extremely high oil prices had disappeared.[13] And Schurr did *not* say that energy consumption dropped when oil got cheap.

Moreover, this chapter is based on the same understanding as that George Monbiot communicated in his recent book, saying:

> *I wish to try to make my proposals as watertight as possible, so I will assume that Khazzoom and Brookes got it right. If they are wrong, it does my proposals no harm. But if they are right and we ignore them, we are in danger of devising a scheme for reducing carbon emissions which does not work.*[14]

So far, much of the rebound discussion has been restricted to energy. However, this is an incomplete picture, and once alert to the phenomenon, it can be found in many instances, including the following:

- Water efficiency gains in dry areas in the US, which we applauded in *Factor Four*, were strategically used to allow for additional housing, leading eventually to more water demand and consumption. Here you can even say the rebound effect was made on purpose.
- Innovation in the use of fibre optics, in an attempt to make telecommunications more materials efficient, saw the use of copper dramatically decrease, resulting in a decreasing market price. However, with this lower price came thousands of new copper applications, as copper consumption rapidly spread to the newly industrialized countries, temporarily leading to soaring copper prices.
- Agricultural land-use efficiency increased dramatically since the 1950s to supply the rapidly growing economies of the world, leading to the notorious overproduction in the EU. The EU set-aside payments for retiring farmland, until population growth – more meat consumption, more urban land-use and more bio-fuels – led to new land shortages, rising land prices and a new food crisis.
- The first mobile phones weighed several kilograms and were installed in police and managers' cars. Within 25 years they got fabulously light using less than 5 per cent of the material the pioneer machines needed. But the newly won smallness and low price made them more useful and attractive so that hundreds of millions were sold, instead of the few thousands of the first generation. The material flows from mobile phones are likely to have increased a millionfold over the past 25 years.

Hence, the evidence is clearly on the side of the rebound effect, in that efforts to improve efficiency have been fraught with increasing overall levels of consumption. It is important to understand that efforts to reduce the effect need to be considered through a systems approach. This means that a range of influences needs to be considered – such as the impact of population increases, technology trends, social movements and levels of affluence – when trying to understand the impacts on overall consumption from specific efficiency and productivity

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improvements. For instance, the rebound effect fundamentally cautions that if something is more efficient, meaning that it is cheaper to run, then the user will use more. However, this issue is also an issue of sociology. Those who are not using something as often as they would like to (because they cannot afford to), are of course likely to use it more if it's cheaper, but those that can afford to use it as often as they like, or have chosen not to use it for various reasons, are less likely to increase use. Hence, this 'rebound dilemma' makes policies addressing global warming, and other global challenges, quite a bit more difficult. But there is scope for such policies and this will be discussed in the second half of this chapter, and in subsequent chapters.

The Industrial and the Neolithic Revolutions

The modern rebound effect and the Khazzoom-Brookes Postulate are much in discussion in our days. Sometimes the impression is created as if the effect was a new phenomenon. The opposite is true and Khazzoom and Brookes have always acknowledged that. They refer to and quote William Stanley Jevons, whose lucid and famous book *The Coal Question*[15] clearly described a similar phenomenon for the first half of the 19th century. For instance, Jevons showed that improvements to iron production that reduced coal consumption by two-thirds led to a tenfold increase in total consumption in Scotland between the years 1830 and 1863. Jevons further discusses the long-term effects of James Watt's steam engine, certainly one of the greatest inventions in human history, and a device making far more efficient use of coal energy than Thomas Newcomen's archaic machines,[16] which were in use before. It was its elegance and efficiency that made James Watt's invention such a breakthrough for the use of coal-fired engines. They could be made considerably smaller than the Newcomen pumps and thus could be used to power ships and rail locomotives, not to mention dozens of new industrial applications. Watt's steam engine, through its energy efficiency, opened up a range of new applications and hence created enormous additional demand for coal to power the rapid growth.

This is what Jevons described some 80 years after James Watt's invention. He showed that Britain's impressive new wealth was closely associated with the rise of coal burning. Electricity was not yet in the picture during his time. He noticed that the steam engine, after a very short period of reduced demand for coal, enabled Britain to accelerate its development and led to steeply rising use of the fuel. Between 1830 and 1860 alone, coal use increased tenfold in Britain. Jevons is fully aware of the mechanism behind this 'paradox' – that is, industrial power became much more affordable through the efficient machines, which in turn allowed ever more industrial activity and innovation. Discussing measures to curb what he diagnoses as unsustainable consumption of coal, he clearly discards a coal tax, quoting other authors who paint horror pictures of the effects of such a tax. (We do not follow this logic of horror!) Instead, he positively considers a ban on coal exports, saying that Britain should not support her competitors with the fuel on which her entire wealth seemed to be resting. The most philosophical and perhaps most interesting chapter in Jevons' book is Chapter IX, 'Of the Natural Law of Social Growth', where he sees the growth of prosperity as a natural law, or nearly, and associates it with ever increasing coal consumption. But he also sees the limits of this expansion and predicts a gloomy end, saying:

> *We are growing rich and numerous upon a source of wealth of which the fertility does not yet apparently decrease with our demands upon it. Hence the uniform and extraordinary rate of growth which this country presents. We are like settlers spreading in a rich new country of which the boundaries are yet unknown and unfelt. But then I must point out the painful fact that such a rate of growth will before long render our consumption of coal comparable with the total supply. In the increasing depth and difficulty of coal mining we shall meet that vague, but inevitable boundary that will stop our progress.*[17]

To Jevons, efficiency gains are available but will be overwhelmed by the 'natural law' of expansion. Quoting Malthus, who was one of the most influential celebrities of his time, Jevons expresses fear about population growth while recognizing the fact that coal will for a long time to come allow further population growth.

Industrialization has meanwhile occurred in all continents and in all sectors, including agriculture, and made it possible to feed and house more than six billion people, an unimaginable feat at the time of Malthus and Jevons. But unless something quite extraordinary happens regarding our ability to deal with limited resources, humanity will end up meeting 'that vague, but inevitable boundary that will stop our progress', and as unforeseen by Jevons, this impact on our progress is more likely to be the reaction of the global environment to the associated pollution, than the exhaustion of the fuels that we rely on.

This leads us to a more general remark about the rebound effect. The effect appears to be a characteristic feature of human civilizations since time immemorial. Industrial rebound effects of Jevons' kind are the latecomers in a long history of humankind that has expanded based on the innovations of its predecessors. Humans learned to use and exploit nature, and if the resource efficiency of doing so increased, the result was additional population growth. Humans emerged from pre-human creatures as hunters and gatherers. At this time, the human population could grow to just a few million, an impressive number for a species on the top of the nutrition pyramid. But the carrying capacity of the Earth was more or less exhausted at this population size. Further population growth beyond the ecological limits did happen here and there, such as in the now famous case of Easter Island, but invariably led to severe effects caused by the eradication of game animals or other overuse of resources. It was not until the Neolithic Revolution, that is, the invention of

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farming and the corresponding intensification of land use, that more humans could inhabit the Earth. Farming made land use at least ten times, eventually a hundred times, more efficient in terms of output per hectare. And what was the effect? Human population grew at least tenfold, later a hundredfold, and the efficiency revolution resulted in the dire need for more land, not less, to support the booming population. Sedentary cultures (villages, cities, states) also allowed for elaborate social hierarchies with some privileged on the top being allowed to consume more food, employ slaves or servants, own more land, and organize progress towards harnessing natural resources such as water or minerals more efficiently, with a view of allowing additional consumption, or luxury. This can be also seen as the basis of social envy, one of the strongest forces of non-ending consumption increase.

Overcoming the rebound effect

At first glance, such considerations seem to render it impossible to use efficiency as a key part of efforts to combat environmental threats from overuse of resources. The success story of pollution control (see the Introduction to the book) does not come as a big relief because pollution control and resource consumption are two very different issues. The concept of 'cleaner' production has rather encouraged societies to go on consuming ever increasing amounts of resources. While most of the rebound effect literature debates the extent to which negative rebound effects exist, and what can be done to reduce them, Alan Pears makes the key point that there is in principle just as much potential for money saved from energy-efficient initiatives to be invested in new positive sustainable initiatives.[18] This could include investments in the home such as solar hot water systems, solar PV systems, purchasing accredited green power, investing in third party certified carbon-offsetting schemes, water efficiency and onsite rainwater harvesting, storage and treatment options, all leading to a positive amplification effect rather than a negative rebound effect. Hence, as such efforts require upfront investments, energy efficiency savings can help the average citizen, who may have many other important costs (mortgage repayments or rent, expenses on children, childcare etc.) to be able to save money to afford the upfront costs of these sustainability initiatives. Almost all of the best practice case studies featured in the Sector Studies of this book are of companies who have first invested in significant energy efficiency improvements and then used the financial savings from these to enable them to also invest in renewable energy and additional water-saving initiatives.

In order to achieve Factor Five we have to invent and introduce new mechanisms specifically addressing the negative sides of the rebound effect in order instead to encourage the use of energy efficiency as a strategy to enable positive amplification effects. Essentially, we see three quite different, but not mutually exclusive, approaches that are available, namely:

1 *Reducing or removing the damages done by resource consumption*: This is an agenda closely related to pollution control and has been dealt with in Chapter 6. Wind and solar energy, properly incentivized, replacing coal is surely part of the answer. Carbon capture and storage (CCS) is another option, although less attractive than renewable energies because it does not by itself create added value and its reliability is largely unproven. For materials, there is the concept of the 'cyclical economy', emerging from Japan with the Basic Law for Establishing a Cyclical Society (Cyclical Society Law) enacted in 2000,[19] imposing quite restrictive regulation regarding the use of materials and processes to ensure that materials can be easily and cost-effectively re-used. As a more far-reaching concept, there is also the 'cradle to cradle' approach by William McDonough and Michael Braungart,[20] which is actually quite generous in terms of efficiency but suggests very clear restrictions on materials that may be used in manufacturing. Its ultimate goal is also the cyclical society.

2 *Investing in capital funds for future prosperity*: That is, the establishment of funds to provide capital stock for posterity after resources may have been depleted. This approach is not targeted at avoiding resource depletion but at compensating losses caused by depletion. Norway, conscious of the limited reach of its North Sea oil, decided to create a Petroleum Fund in 1990, out of the proceeds from oil, later renamed 'Norway's Government Pension Fund'.[21] It currently has assets of about €160 billion invested in 3000 publicly traded companies in over 30 countries.[22] This approach is not without its problems external to the country, as well as some internal problems for its politicians and citizens. Externally, the presence of one large fund could be seen to unduly influence or manipulate world or regional markets to its own benefit, thus requiring transparency and linkages to key international bodies.[23] Internally and among citizens, the fund can generate a 'resource curse' where 'abundance of natural resources stimulates dysfunctional economic policy choices ... and creates conflicts over the distribution of wealth'.[24] This 'resource curse' was found to be mild in the Norwegian case. Nevertheless, it increased citizen's political distrust, with voters critical of tight economic policy and wanting more of the fund spent immediately on health, education and aged care.

3 *Making resource consumption ever more expensive*: Ultimately, resource consumption should be so expensive that total resource consumption rests in a perfect balance with sustainable supplies of renewable (or recycled) resources, and the resulting ability of the biosphere to assimilate the associated pollution and by-products. Chapter 9 will take this challenge up.

Notes

1 Stern (2007).
2 Rubin (2007); Rubin and Tal (2007).
3 Brookes (1979); Khazzoom (1980); Brookes (1990); The term 'Khazzoom-Brookes postulate' was introduced by Harry D. Saunders in Saunders (1992).

4 EIA (2007).
5 Rubin (2007) p1; Rubin and Tal (2007).
6 Laitner (2000).
7 Herring (1998).
8 Grubb (1990).
9 Huntingdon (1992).
10 Lovins (1988).
11 Khazzoom (1989).
12 Greening et al (2000).
13 Schurr (1985).
14 Monbiot (2007).
15 Jevons (1865).
16 From the Internet information available to us, we see no clear evidence that Newcomen's steam engine needed coal at all. If that is the case, Jevons' argument about coal-related efficiency gains sounds somewhat dubious. But for the flow of the argument in this subchapter, this point is of lesser importance.
17 Jevons (1865).
18 Pears (2004a).
19 Fumikazu (2007).
20 McDonough and Braungart (2002). Based on these ideas, a trade fair was organized in Frankfurt, Germany, in November 2008, featuring dozens of commercial success stories of cradle to cradle: Braungart and McDonough (2008).
21 Norges Bank (2006) 'Government Pension Fund', www.norges-bank.no/nbim/pension_fund/, accessed 14 May 2008.
22 International Monetary Fund (2003) 'IMF concludes 2002 article IV consultation with Norway', IMF Public Information Notice, 18 March 2003.
23 Austvik (1999).
24 Listhaug (2005).

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