DECOUPLING AND REBOUND

An analysis of the economic mechanisms

Raffaele Fabio Ciriello
University of Zurich, Department of Informatics
raffaelefabio.ciriello@uzh.ch

ABSTRACT

In this report, I will outline the most relevant economic mechanisms that follow a technical efficiency gain in the context of environmental resources and the energy market. For many years, the impact of a decoupling from GDP growth and the consumption of natural resources on macroeconomic savings has been overestimated by both economists and politicians. It was widely believed that the overall reduction of production costs caused by an increase in production efficiency is more or less equal to the collective savings of an economy. In reality however, the consumption of natural resources and the environmental burden have continuously grown in almost every country within the course of the twentieth century, in spite of the ever-proceeding technological progress. Hence, the question why none or not all of the savings have actually been made is repeatedly raised by both scientists and politicians and is now a major subject to economic research. I will give an overview of the most recent surveys that examine the counter-rotating mechanisms of *decoupling and rebound effects* and will outline the positive and negative impacts they have on both the economy and the environment. Last but not least, I will raise questions how politics could take counteracting measures when defining goals for sustainable development.

1. INTRODUCTION

The goal of sustainable development is to increase wealth – measured by GDP – while reducing the absolute consumption of resources by achieving *qualitative* growth rather than *quantitative* growth. [1,2] In times of ever-accelerating technical innovation and productivity gain, one may expect that economies make use of resources more and more efficiently and that they therefore need less and less of them.

This is however not commonly the case, even in highly developed countries. In fact, even though in many countries the consumption of most resources grows slower than the GDP (*relative* decoupling), the absolute consumption of resources almost never decreases (*absolute* decoupling). [1]

In the last years, people realized that decoupling only measures the relative wealth we extract from a resource and took efforts to understand why the actual goal – namely an environmental relief by the absolute reduction of resource consumption – could not be achieved.

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2. DEFINITIONS

Decoupling

Decoupling describes a relative shift between two values. Here I will only consider decoupling in the context of GDP and consumption of resources. An economy is said to be decoupled if a) both grow, but GDP grows faster than consumption b) both sink, but GDP sinks slower than consumption c) GDP grows while consumption sinks or stays at its level or d) the consumption sinks while the GDP grows or stays it its level. The last alternative is the one sustainable policy wants to achieve [1].

Rebound

Rebound is a measurement for expected engineering savings resulting from a gain in technical efficiency when the underlying system does not change. This happens e.g. when a light bulb creates the same brightness while consuming less energy, when a car reaches the same distance while consuming less fuel or when producers reduce costs by optimizing their production processes. [1] Those expected savings are only theoretical. In fact, the underlying system grows as technical efficiency increases. People can afford more extensive use of light bulbs, cars, radiators etc. as they become more energy-efficient. Produces can afford higher outputs of goods and therefore use more energy inputs. So the expected savings are held down by a lack of sufficiency. If our needs were fully-satisfied, we wouldn't *want to* consume more of the increasingly efficient goods.

Elasticity

Elasticity in general terms expresses how changing one variable affects the value of others. In economics, its most common application is to measure the price-elasticity of demand ("how does the quantity demanded of a good change relatively to its price?"). In the context of this paper, elasticity refers in particular to the efficiency-elasticity of energy demand.

Backfire

Backfire happens when the rebound exceeds the expected engineering savings. That is, the absolute consumption of resources is actually higher than it was before the efficiency increased. In this case, the policy that aims at increasing efficiency is even counterproductive. This is also known as the Jevons paradox. [3,4]

3. DECOUPLING

3.1 The resource consumption over GDP ratio

As mentioned in section 2, decoupling takes place when the quantities of input and output diverge. The subject of academic research on decoupling and rebound is whether that divergence supports sustainable development.

To answer that question, we need to have a deeper understanding of the different economic mechanisms that work together. As pointed out by [1], it is important to reason about decoupling in terms of environmental *intensity* (consumption of resources per GDP) or environmental *efficiency* (GDP per consumption of resources). Decoupling in the broadest sense means every shift in the relationship between the two values, but of course sustainable policy has a narrower understanding of decoupling, namely the reduction of environmental intensity or the increase of environmental efficiency. However, achieving this goal actually involves two tasks, namely the reduction of energy consumption (which can be achieved via caps or environmental taxes) and GDP growth (which can be achieved by the mentioned efficiency gains). [1] argues that sustainable policy will fail to achieve that target as long as both tasks are conducted in an isolated manner.

It is very important to distinguish between technical efficiency gains and an increase in macroeconomic efficiency (that is, a reduction of environmental intensity). Environmental policy nowadays acts mainly as an accelerator for technical efficiency. Standards for subsidies are formulated in terms of CO_2 per km, joule per kilowatt etc. whereas the monetary units of the GDP are disregarded. It is crucial for having a better understanding of decoupling to point out that technical and macroeconomic efficiency are by no means strictly correlated to each other.

One reason is that there are production factors beside natural resources that affect the output – namely work and capital. The assignment of additional workers increases the GDP as well as extended machine time, without any technical innovation. Furthermore, the resources/GDP ratio might as well decrease when prices simply increase – e.g. for fuel.

To summarize, it is essential that rebound can be *overestimated* when non-technical factors remain disregarded and it can be *underestimated* when engineering savings are considered proportional to the macroeconomic intensity reduction. [1]

3.2 The efficiency paradigm

How can decoupling be measured? The GDP is well documented in many statistics for most countries, but how do we measure consumption? In particular, how do we allocate the consumption of resources (and the accompanied environmental burden) and the production of intermediate goods that took place in one country and have been shipped to another?

The environmental input/output analysis (EIO) measures each amount of water, dung, commodities etc. that is necessary to produce one euro of a good (a banana, a t-shirt, a car etc.). Taking that into account, it can be shown that highly developed countries have to take much higher responsibility for CO_2 emissions than it is widely believed – Switzerland for example has been mentioned to cause 93 tons of CO_2 emissions per year or 12,5 tons per person in a 2004's survey by the United Nations Framework Convention Of Climate Change (UNFCCC). This is equal to an additional amount of 40 tons "imported" CO_2 compared to the inland emissions Switzerland made in 2004, namely 53 tons. [5]

[1] points out that the tenor of today's sustainability policy is to focus on technical efficiency gains and GDP growth. The perception of engineers is preferred to the perception of economists. Recent discussions about decoupling mostly concentrate on relative decoupling. This is however only a result of production cost optimizations, which in reality do not make any contributions to the environmental relief. The environment "does not care" about relationship shifts, unless there is a causality between efficiency and an absolute reduction of consumption (which is, as we have seen, not the case).

Because the engineering perception dominates, efficiency is regarded as "less input, same or more output" on a macroeconomic level. However macroeconomic data shows that "more output, same or more input" is actually the case. The question that remains from an economic point of view is therefore: Where did the expected engineering savings go?

Decoupling is a subordinated task of economic growth in today's sustainability policy. Thus, *absolute* decoupling is mainly disregarded as it would not fit into that perception. However, if we want to analyze counterbalancing mechanisms, the only way is to segregate the two.

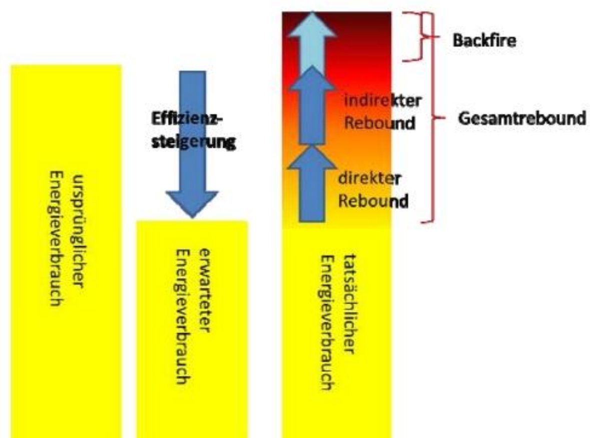
4. REBOUND

4.1 Shapes

In the following section I will summarize [1]'s interpretation of direct and indirect rebound, price effects and income effects.

Direct Rebound and Indirect Rebound

Rebound scopes all effects of an increase in technical efficiency on macroeconomic demand. Many surveys have observed that people tend to drive more kilometers when they buy a care that's more fuel-efficient or that they increase heating when their house isolation became better. Direct rebound covers all phenomena where consumers buy or use more of the good that became more efficient or where additional consumers buy the good after its price sank. Indirect rebound occurs when consumers afford buying a more expensive good instead of the more efficient one that got cheaper.



Rebound and Backfire [1]

Price effect

[1] sketches the functional chain of the price effect as follows:

1. The demand for the more efficient good sinks. That also reduces its price, due to the efficiency-elasticity of demand (EED) and the demand-elasticity of input prices (DEP).
2. The price reduction attracts marginal consumers and therefore the demand grows, due to the price-elasticity of demand (PED).
3. Again, due to the DEP, producers may sink the market output of that good.
4. Another producer that needs that good as input can afford sinking output prices without profit setbacks, due

to the EED and PED. That price reduction again attracts marginal consumers.

5. The increased output demand causes the producers to demand more input, due to the output-demand-elasticity of input demand.
6. That increased demand then leads to increasing prices for the good that originally became more efficient (DEP).

Income effect

Consider a household that faces lower monthly bills for fuel, heating and electricity after a technical efficiency gain. Assuming the members of the household do not work less and therefore their income does not change, they have more money left which they use for buying other energy-consuming goods.

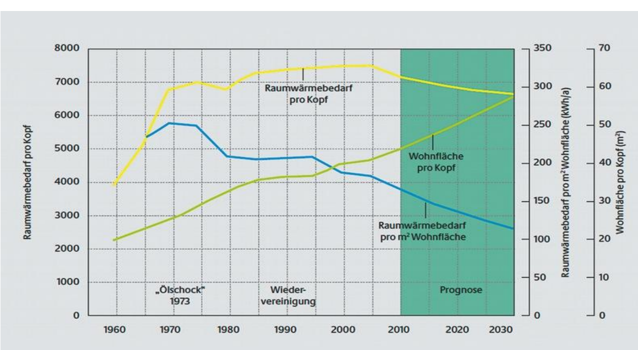
At the same time, the income of fuel, heating oil and electricity sellers sinks and they pay less loans or dividends – a zero-sum game. The *production possibilities frontier* of the economy as a whole however has grown and it can produce more goods and services.

Where does that stop? It seems like the human desire for luxury, prestige and economic safety make it impossible that sufficiency can ever be reached, even if all basic needs are satisfied. As long as this condition holds, it is very improbable that efficiency effects will ever outrun growth effects.

4.2 Research

Direct Rebound

Empirical research on direct rebound is mostly based on econometric estimations of the negative price-elasticity of energy demand. Recent surveys [6] have examined direct rebound of heating in German households and have shown that there's a higher divergence for tenants (31-49%) than for landlords (12-14%). One possible explanation is that Germans have been constantly increasing their habitable surface since the 1960's [7].



Habitable surface and heating demand in Germany [7]

Indirect Rebound

Sorrell [8] recently gave an overview of several research results on indirect rebound. As methodologies and measurements differ, the estimated percentages of indirect rebound highly diverge, e.g. from 7% to 300%. As it tends to be a subject of heavy speculation, many economists refuse to give definite statements about the indirect rebound and focus on the direct one.

Macroeconomic Rebound

Macroeconomic rebound is defined as the sum of indirect rebound and the effects on all economic sectors that result from a technical efficiency gain. Barker et al. [9] have examined macroeconomic rebound effects resulting from energy efficiency policy for the United Kingdom from 2000-2010 and have determined it to 11%. Together with the expected direct rebound of 15% they assume that the overall rebound resulting from energy efficiency policy in the UK adds up to 26%. With the same methodology they estimated the overall rebound to be 51.3% in 2030 [10], showing that rebound estimations tend to ascend.

5. SUMMARY

20 years ago, people decided to challenge environmental problems by decoupling GDP growth from the consumption of natural resources. The dominating strategy for achieving this target was to constantly increase technical efficiency instead of introducing restrictive rules such as caps or taxes. Although some measures have been officially defined – the Kyoto protocol[1] or the European Union Emissions Trading System[2] being only a few to mention - there is no scientific or political consensus on how to reach those targets so far.

Recently this efficiency strategy has been heavily questioned due to the fact that in spite of constant decoupling, the consumption of resources never sank *absolutely*. The discussions are held against the background of rebound phenomena, which have already been investigated for three decades. These phenomena, namely the consumption of goods, services and resources that has been *enabled* by technical efficiency gains, explain why a larger part of the expected savings has not been reached. Nevertheless, researches couldn't even agree on an approximate percentage for macroeconomic rebound up to now.

Claims for more drastic governmental measures arise. But even if those measures were taken, there are a lot of other predictable problems that would arise. Increasing energy prices would worsen the situation of the poorest, the competitiveness of an absolutely decoupled economy would suffer and introducing higher taxes rapidly exceeds the tolerance of the voting population.

How much sufficiency can be demanded from society? Are there enough resources or technical innovations to sustainably maintain our wealth in the future? Is there a way to bridge the gap between sustainability and growth, a satisfying equilibrium in the trade-off between economic prosperity for our and upcoming generations? I think that these questions should be at least more widely asked than they are today.

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[1] The Kyoto protocol was signed in 1997 and states that from 2008-2012, the participating countries have to reduce their greenhouse emissions by 5,2% with respect to the year 1990. Note that the USA never signed that protocol.

[2] The EU EIS follows the principal of *cap&trade* – emissions can be limited and emission "rights" can be traded. That should provide an economic incentive to reduce emissions.

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