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Dealing with environmental savings in a dynamical economy —how to stop chasing your tail in the pursuit of sustainability

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Abstract

In most countries people are urged to change their pattern of consumption and lifestyle in a less-energy consuming and more environmental-friendly direction. But gains in ecoefficiency are likely to be annihilated by a larger consumption — the so-called rebound effect — resulting in an increased throughput in the economy. Here is an obvious contradiction. Another contradiction entails from the fact that most governments strive to promote economic growth which includes increased consumption. The paper takes a look at various means to handle these contradictions in order to avoid or balance the rebound effect. Environmental policies (including such measures as green taxes) may redirect consumption from one kind to another but this demands that the alternative spending is less harmful than the one dissuaded from. Two other tested means are to alter the sector mix of the economy and to shorten the working hours — work sharing — to match the increasing efficiency.

1. Introduction: can we manage thriftiness?

Most people are aware that saving natural resources, recycling material or driving a fuel-efficient car is good for nature. Many people are also prepared to be thrifty in these respects, in particular when it means a saving for themselves as well. But economists have been impertinent enough to point out that with a more fuel-efficient car you are also likely to drive further. This offsets the environmental gain from increased efficiency — the so-called "take-back" or "rebound effect". At worst, technological improvements in the pursuit of sustainability are like chasing your own tail.

Higher efficiency or productivity[2] provides us with more or better goods and services with less input (and "more is better" according to the ruling paradigm of economics). For that reason higher efficiency is regarded as more or less synonymous with progress. But the rebound effect highlights that the medal of progress does have a reverse side. Higher efficiency can no longer be regarded as unequivocally good unless it is used wisely in the economy. When it is used to increase the volume of production, the absolute amounts of resources consumed may continue to grow even if less input is required per unit. The efficiency gains conflict with the ceiling imposed by nature as a sink and source for human production.

Efficiency as thriftiness with resources is closely related to the understanding of economics as the science of using scarce resources. Two meanings of resources seem to be at play here. Mainstream economic theory accepts budgets as temporary limits but not natural resource limits as ceilings. In an ecologically finite world this ceiling for the utilisation of nature's services demands that the concept "efficiency" is accompanied by the moral concept of "sufficiency". The economist's observation that a lower price leads to higher consumption (and the adherent valuation that this is good) cannot be passively accepted; it must be countered by a conscious policy of moderation.

The paper takes a look at this thorny issue, starting with the meanings of the rebound effect, from first order to transformation effects in society. It is claimed that economic policy will either have to face the unfamiliar

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[1] The paper describes work in progress and comments on how to proceed are welcome.

[2] The terms are very close in meaning; a difference sometimes used is that efficiency refers to the fulfilment of a stated goal while productivity is the rate of production per unit of input. Thus a military operation may be efficient while a factory line may have high productivity.

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task of having to absorb an economic surplus or divert it in a less harmful direction in the economy or, in the end, preclude that the surplus ensues in the first place by turning down production in parallel with the growing efficiency.

This approach leads to the problem of economic growth. A standard production function includes the three factors capital, labour and technology, i.e. efficiency. The last one of these factors represents the essence of progress made possible through human ingenuity. To balance it — in the face of ecological restrictions — one issue here is to render the surplus created in the production inaccessible as capital. Another issue is the amount of labour supplied; the problem arises when higher efficiency is combined with rigid social structures which favour continued high labour input in the production.

It is worth noting that the post-modern market economy society displays a remarkable Janus face in relation to economic growth. On the one hand, citizens are urged to show prudence in their consumption in regard of nature's limits. On the other hand, large political efforts are made to expand production. By all evidence, such an expansion will have adverse ecological effects. Sorely lacking is a responsible economy which can manage thriftiness by combining efficiency with a policy of sufficiency.

2. Principal deliberations

2.1. The rebound effect

In a famous text from 1865, the British economist Stanley Jevons argued that "it is a confusion of ideas to suppose that the economical use of coal is equivalent to diminished consumption. The very contrary is the truth". Jevons' statement was based on theoretical insights but was also supported by empirical evidence. (Jevons, 1865)

This early formulation of the rebound effect theory entails that higher technological efficiency in the use of energy — corresponding to a lower price for energy services — will create an increased demand for such services. This may offset, fully or partly, the initial gain. Jevons' fear was that England might run out of coal. A century later we fear global warming from burning too much fossil fuel. The rebound effect suggests that efficiency measures might worsen the situation rather than improve it.

The rebound effect can also be interpreted in a wider sense. The taxonomy used by (Greening *et al*., 1998) includes four categories:

- *direct rebound effects*: which relate to an increased use of the goods or service affected by the price drop;
- *secondary rebound effects*: if the direct effect is limited (less than unity), it means a real income increase for the customer which will lead to increased demand for other goods and services (within the same budget restraints);
- *economy-wide effects*: following economic theory, the changes of any price is likely to lead to readjustments of other prices and produced quantities at the macro-level of the economy;
- *transformational effects*: changes in technology (and concomitant changes in price) also tend to alter consumers' preferences, the social institutions and the organisation of production and in this indirect manner also demand and consumption.

For each of these, it is useful to distinguish between the reaction of the (human) consumer and the firm. Humans — as "economic men" — supposedly sense that "more is better". But this may be countered by satiation effects which have to do with the multiple goals humans have — apart from goods also such things as leisure, social recognition and beauty. Satiation may not inhibit the profit-seeking firm (although there are small-scale business which, for good reasons, lack the urge to expand). For humans and firms alike, the effect may differ between the short run and the long run. Humans are bound by social habits and commitments; firms have a limited substitutability between their factors of production. Economy-wide and transformational effects are more likely after a period of adjustment.

2.2. How large is the rebound effect?

The saying "nobody buys two refrigerators because they are cheap" reflects that certain goods are very price inelastic. In the best-studied area, energy, there is also a growing confidence that the rebound effect is quite moderate. This conclusion in recent studies attempts to settle a long academic discussion whether efforts of energy efficiency are justified (Greening *et al*., 1998; Saunders, 1992; Herring, 1998). Rebound effect for fuel-efficient cars is reported to be no more than $+0.2$, i.e. only 20% of the gain is converted into more driving (Greene *et al*., 1998). This indicates that satiation effects and other restraints (such as time) are at play. As a further indication that the rebound effect is not an obstacle to energy preservation, several authors also point out that energy services make up a rather limited part of the normal household budget. The same applies for most units of production and service: the price of energy has a rather marginal importance which implies a rather inelastic volume. This evidently works two ways: neither price drops from efficiency improvements, nor price hikes (from taxation or shortages) are likely to have a large effect.

But if the primary rebound effect is limited, the secondary effect is correspondingly large. A 20% direct rebound effect entails an 80% budget replenishment for the household. This is available for alternative uses. Unless the household chooses to invest it as capital or transform it

into increased leisure — options which in practice seem rare — it will mean increased consumption.

This offers a household perspective on economic growth. In society, the inputs of labour and capital — the conventional factors of production — change only slowly and most of the economic growth can be attributed to increasing efficiency or productivity (sometimes called the "technology factor"). More is produced per unit of input and this can be distributed at less cost. The seeming advances should however be discounted for the substitution of (cheap) energy resources for (expensive) labour or by intensified exploitation of labour elsewhere in the globalised production.

While annual efficiency/productivity improvements usually are moderate, the accumulated effects over decades are astonishing. An often-cited example of the transforming power of this process is the domestic use of electricity. In the early century, it was mainly used for illumination. The efficiency of electric energy for this purpose has since increased by more than a factor 10. This includes the harnessing — "production" — of energy, the transmission to the customer and the resulting emission of light. (Rosenberg, 1982) Meanwhile households have widened their use of electricity and also use it more lavishly. Our homes are not only brighter but electric energy is also used for motors in numerous applications, for entertainment equipment, etc. In countries where electricity is cheap — like Sweden and Norway — most kitchen stoves are electric and electric energy is even used for space heating which was unthinkable at the outset (in warm countries increasingly also for cooling). This is not only due to the rebound effect but also to an exchange of factors in the household work. Every layman carpenter quickly learns that electric power is a convenient substitute for other inputs.

2.3. Rebound effects as a threat for sustainability

The rebound effect writ large is all of this: the ever-increasing efficiency of the production system utilised for an ever-growing production with large-scale use of natural resources and a larger emission of pollutants. But this sets efficiency on its head, making it a threat to (ecological) sustainability. The very scale of production becomes too large to accommodate within the limits set by natural conditions.

This is not to say that economic growth must stop. The concept "economic growth" is formally based on values — the prices that goods and services catch in the market. It is conceivable to have economic growth without spending more material (natural) resources. More elaborate products, with more functions or a more attractive design, usually carry a high price. This may reflect the embodiment of more labour or more exquisite labour in the product as in art and handicraft work. It may also reflect the positional character of the objects which are attractive because they are rare or singular. This is often independent of the requirement of natural resources.

Miniaturisation is another case in question. Many products, especially electronic ones, tend to grow smaller in order to become more convenient (and cheaper; the compression is also a simplification of the manufacture). There is, however, a risk that the manufacturing process still demands many resources; it has been reported that producing a personal computer results in 300 kg waste and requires 33 T of water.[3]

Leaner production and leaner products are often used to claim a progressive "dematerialisation" of the economy. The main factor behind this trend is, however, a shift in demand from goods to services which (presumably) demand less natural resources (see more below!). In the early-industrialised countries, the ratios of energy and steel to the gross national products are now falling. But other basic and more modern materials — such as aluminium — are still on the rise. And there is no record of an economic growth with constant or diminishing use of natural resources or energy in general (Kågeson, 1997).

This is not to dispute that the "over-consuming" countries of the West are beginning to manage some threats to the environment. Local pollution, such as smoke (particles) or sulphur dioxide or polluted watercourses, which characterised the (early) industrial society generally diminishes with growing national income. But energy consumption and emissions of carbon dioxide, as well as the total use of natural resources continue to grow in all countries with economic growth.[4] This means that the dematerialisation cannot be used in defence of a laissez-faire attitude to business.

The most glaring example of how efficiency gains enhance production is labour. By conventional estimates — in discounted money terms and disregarding the fact that the development has required more inputs of other resources such as energy — the result of labour has increased at least 10-fold over the past century. But this development has only resulted in a rather limited change in hours of work. Over the period the weekly hours for "full-time" have dropped from 60 to 40 h or one third. Accounting for other changes in the conditions of work (length of working life, vacations) as well as the composition of the work force (occupational rate of men and women), gives a similar result: the input of paid labour from the population has only dropped by one third in hundred years in spite of the stunning growth in wealth. (Sanne, 1995).

[3] See *http://www.wired.com/4.06/*. Other unconfirmed information claims that the production of a PC carries the same environmental load as producing a car.

[4] Statistics must be used with caution. The improvements in these "well developed" countries can also be explained by a certain relocation of dirty industries to less-advanced countries.

The resulting politics and the social consequences of this development were already described many years ago by Bertrand Russell in a still valid (and rather amusing) narrative:

> Suppose that, at a given moment, a certain number of people are engaged in the manufacture of pins. They make as many pins as the world needs, working (say) 8 h a day. Someone makes an invention by which the same number of men can make twice as many pins as before. But the world does not need twice as many pins: pins are already so cheap that hardly any more will be bought at a lower price. In a sensible world, everybody concerned in the manufacture of pins would take to working 4 h instead of 8, and everything else would go on as before. But in the actual world this would be thought demoralising. The men still work 8 h, there are too many pins, some employers go bankrupt, and half the men previously concerned in making pins are thrown out of work. There is, in the end, just as much leisure as on the other plan, but half the men are totally idle while half are still overworked. In this way, it is insured that the unavoidable leisure shall cause misery all round instead of being a universal source of happiness. Can anything more insane be imagined?
>
> From "In praise of Idleness", first published in 1932.

This account — with obvious references to Adam Smith's famous description of the division of labour in pin making — describes the social reaction to a genuine progress in manufacture. The failure to improve the general welfare due to the social stratification and private interests is a point to return to later.

2.4. The need for change and the need for intervening

The task prompted by the rebound effects is to prevent beneficial gains in efficiency being translated into an ecologically maleficent consumption. Two principal ways are open: relying on the consumer and intervening with legal or administrative measures; in other terms changes in individual preferences or changes in the conditions which people encounter. This will be briefly and principally described here (and with examples in the next section).

The theory of the market economy sets the consumer in the driving seats. He (or more often "she") presumably dictates the course of the economy with his/her preferences. Many consumers also do consider environmental aspects with a combination of reasons. "Alternative" products may be preferred because they are assumed to be more healthy or safe. Or these products may be chosen because they are produced in a manner gentle to the environment. In both cases they may carry a higher price because they are produced with non-competitive methods. Examples are biodynamic vegetables, often involving extensive labour rather than chemical fertilisers and pesticides, and fish caught in the sea rather than cultivated ones. Both could be said to represent a step back in the conventional train of efficiency (which is the base for the lower prices and the rebound effect). Even if the choice is based upon conceived personal advantages, it may also contain a commitment to a general cause. The wary consumer may even kill three birds with one stone: get a product she believes is good, promote what she considers a good cause and on top of that gain the distinction among peers for her consumption choice.

But even if many people indicate a willingness to pay extra for ecologically sound products, such "green" products have to date only captured small shares of the market. Compared to the scope of necessary change, this appears to be a route of development with rather limited prospects. In the interest of (ecological) sustainability, consumers must be guided into a beneficial direction by public intervention. This is quite consonant with the "social, i.e. government-regulated market economy" typical of Continental Europe (Vlek *et al*., 1999) where the state sets the rules within which the market forces act. Such regulatory measures are not to be conceived as bureaucratic exercise of power but rather as rules of order agreed upon in public assemblies. The measures derive from people, mirroring their values, but not in their role as customers but as citizens deciding upon the course of society.

The appropriate choice of means for this control depends on two principal factors, *importance*, in terms of ecological and economic function and *reversibility* of decisions taken. King suggests a three-step ladder. On top are the collective decisions involving prohibitions which are warranted for the most important or virtually irreplaceable resources. Coral reefs are a good example. Next follow a medium group where restoration of damage is possible. They require far-reaching control of market decisions with standards and quotas constraining individual choice. Issues of good reversibility and moderate importance can be left to market decisions only governed by financial instruments (King, 1994).

This scheme covers the most obvious means of public intervention. But it fails to mention the intermediate zone where public efforts are directed to change the values of the citizens (which guide their consumption decisions). Some cases are rather successful such as garbage separation, reuse of glass bottles, education of young and old, etc. The scope for such measures is, however, limited because they must eventually conflict with the political will to expand production.

3. What to do about the dilemma

To achieve an ecologically and socially desired result in a setting where ever-higher efficiency tends to enhance

the volume of production, three principal ways are conceivable. The resources released can be taken out of circulation (to prevent them from being used harmfully) or they can be diverted in a less-harmful direction in the economy. Or one might refrain from realising the resources by limiting the production. Means to these ends — partly overlapping as different perspectives on the same measure — to be discussed are:

- remove resources from the economy;
- invest in natural capital;
- affect the circulation and use of resources with administrative and economic means;
- change the structure of production;
- reduce the volume of work.

3.1. Potlatching and fair global redistribution

Removing resources from circulation has a peculiar ring since our innate conception is based upon the discipline of economics, which assumes that resources are scarce and procured with a sacrifice of efforts. To take them out of circulation sounds counterintuitive to the striving for welfare. The task recalls the habits of Northwest American Indians who are reported to have arranged ceremonial feasts — potlatches — where a major concern was to publicly destroy goods; the rationality of this competition in destruction being to demonstrate one's superior fortune.[5]

Modern society also offers many, slightly less spectacular ways of rendering produced goods passive in the economic circulation. The construction of memorials, religious buildings, palaces and other monuments without economic functions (albeit often social and psychological) are common, in history but also today. Work applied to the preservation of historical artefacts or, generally, the work of the kind performed by museums may also be regarded in the same way (although museums may also be economical institutions geared to produce an income). Individuals' consumption of — or "investment in"? — precious goods, jewellery, art, etc, have much of this character.

Removing resources from circulation is also conceivable for one economy versus the rest of the world. Foreign aid is an example in its basic meaning of donating money, goods or services to another country. Another possibility is "fair trade". Much of present goods are produced by low-paid labour in developing countries, often under appalling working conditions. This is made possible by the existing skewed distribution of economic power, a situation far from the theory of exchange between equals assumed in the theory of trade. To counteract this, some voluntary organisations organise a "fair trade" by importing goods from selected producers in the third world paying a "decent" price. This principle of a reasonable remuneration is known from medieval economy where the "correct price" determined by the guilds was very important (Thompson, 1971). It is obvious that both these cases — foreign aid and fair trade — rest on a strong moral component.

3.2. Investing in natural capital

Ecological economists offer a perspective on these issues dressed in economic terms. The claim is that the present rate of consumption — without even considering that it is still growing — will eventually exhaust the natural resources. A move toward sustainability might then be to use the surplus in the efficient economy to preserve these resources. Daly and other economists regard the natural resources as a "natural capital". This, Daly reminds us, allows us to relate sustainability directly to the Hicksian demarcation (from 1946) of income: "the maximum amount a community can consume over some time period and still be as well off at the end of the period as at the beginning" (quoted by Daly, 1994).

Daly refers to the use of a stock of resources which tallies with a functional definition of capital as "a stock that yields a flow of goods and services into the future". This stock may consist of natural resources as well as man-made means of production which can provide service to humans. To secure an anticipated future — with an even greater population and justified demands for a decent quality of life by all humans — will require not only that we preserve nature but also enhance its power to serve humans by "investing in natural capital". This implies a rather different approach than for instance, the construction of factories and infrastructure, typical man-made capital. We can distinguish two kinds of natural resources: renewable and non-renewable.

In the pure sense, investing in *renewable resources* amounts to waiting. Given time, nature — and nature alone — can accomplish what is needed, e.g. to replenish the stock of fish after human harvesting or break down waste emitted into effluents. These are processes basically inaccessible to intervention. Sometimes, but not in all cases, is there an option not only to maintain the capital — allowing the same offtake in coming periods — but also to net-invest to let the capital grow to allow a future larger offtake.

Investing in renewable resources can also mean to intensify their use by cultivation in one sense or another. An evident example is agriculture but also silviculture and aquaculture. Genetic engineering is yet an intensification which tends to blur the border between natural and man-made capital. It has been argued, however, that

[5] A most efficient way of destroying property is of course to wage a war and it has been claimed that wars are a precondition for the survival of capitalism. Evidently all military expenses may be regarded as a divesting of productive resources.

this intensification has a price in terms of reduced biodiversity which renders the resource less resilient, increasing the risk of losing the capital.

Non-renewable resources can, by definition, only be diminished, never increased (but in a geological time frame). For that reason, Daly and others suggests that every project of non-renewable exploitation should be regarded in twins, one generating a (true) income, the other generating a stock of renewable assets which eventually will produce the same yield (income) sustainably as the non-renewable one that is being exploited. A possible example is that extraction of petroleum should be conditioned on the planting of forests which can supply raw materials when the oilwells runs dry. Evidently this rule would lead to a lower return on projects of resources depletion and/or higher prices for the yield. In both cases, that will make the resource last longer. A shortcut to this principle is to demand that the price for a non-renewable asset should correspond to the nearest renewable substitute. In the case of fossil fuels, such a substitute may be alcohol from biomass. (Daly, 1994)

A related option for action — for renewables as well as for non-renewables — is to regard measures which increase the efficient use of the resource as investments in natural capital. The logic is that they can reduce the pace of exploitation. The resource will last longer; the creation of a renewable substitute for non-renewables becomes less demanding and the price can drop. An objection which Daly does not consider is that this assumes an inelastic demand or that the rebound effect somehow is encapsulated.

The perspective offered here evidently presumes public intervention. Investing in renewable assets will amount to administrative measures as with present fishing quotas. And although economic theory claims that with proper property rights, the owner will limit the offtake of natural resources to get a sustainable income, it is hardly credible that this will result in sustainability over generations in a market economy with current rates of interest. The proposal to invest in substitutes is also hard to find in practice. In most cases, economic signals are insufficient and measures for sustainability have to be supported by legal means. Thus forest owners are required to replant after cutting and to achieve this, strict laws are in force. If stewardship is not practised by moral force, it may be reinforced by legal means.

3.3. *Intervening with prices and the "divisor effect"*

Consumers are supposedly price sensitive and the most common public remedy to counteract the rebound effect — from a technologically induced price drop — is to restore the initial price by meddling with a tax on the consumption. Taxes may of course also be used to dissuade from consumption independently of any technology change.

Initially it should be noted that such taxation is not equivalent with environmental measures based on the logic of "the correct price" in economic textbooks. That idea is to incorporate unaccounted-for inconveniences born by others, "externalities". The value, interpreted with some kind of willingness-to-pay analysis, of side effects like emissions, noise, visual intrusion, etc. should be included as a cost in the price to induce consumers to take the "right" decisions. This may take the form of a taxation which is used to compensate those affected. The result will be a more fair distribution of benefits and burdens. But this "correct price" is just a reflection of individually expressed preferences and will not guarantee a sustainable development (and it is not to be confused with the medieval conception of a correct price) (Jacobs, 1997).

A consequence of taxes with particular bearing here is that they provide the state with an income. This income is normally recirculated in the economy. "Green taxes" are often proposed on the assumption that they should be "neutral" — those affected by the tax are to be reimbursed. One example is a raised fuel tax replacing the vehicle licence. Principally this will encourage fuel-efficient cars (and efficient use of the car) without hampering the accessibility of cars. Thus one obtains a more precise measure in relation to the initial aim of getting at the exhaust emissions. Neither will this affect the household economy (although "green" taxes may also be used to achieve a social redistribution, leaving the single household better or worse off but the set of households unaffected). Evidently the state revenues can also be used for environmental protection or any other governmental activity.

The particular issue here is that (money) resources, when circulated back to the consumers, will again be used for consumption. Even in case they pay for government activities, in the environmental protection sector or any other sector, they pay for goods or salaries which are eventually used for consumption, at last partially. This creates a cascade of economic transactions which successively release money for consumption. As the aim here is environmental improvement, this spending should have a gradually diminishing environmental load. We desire a "divisor effect" (with the same logic as the multiplier effect in conventional economic policy aiming at job creation) which gradually decreases the environmental load. Money resources are deviated from identified detrimental activities to an average set which are less detrimental per amount spent. It is important to note that such a policy requires a solid knowledge of the environmental effects of various activities and their price and income elasticities. To make this cascade environmentally efficient may require more knowledge than is at hand today.[6]

[6] Some of the activities mentioned above under "potlatching" create the same problem if they are the result of funds spent for wages which then do enter the economic circulation.

3.4. Changing the shape of economic activities

Different human activities carry varying environmental load and a policy for energy efficiency might consider adjusting the activity pattern in regard to ecological limits. No doubt this is a rather bold proposition, challenging the common assumption that the existing pattern has developed naturally from people's preferences. In addition, our knowledge about the connections is sketchy (as mentioned above).

All the same the idea carries considerable weight. There is a strong sense that the Western consumption-oriented societies with their resource demanding lifestyles have to give in for other patterns. But this will not only save natural resources. It is also likely to affect other aspects of the development. Fig. 1 illustrates this with the reservations that the present knowledge is limited. Major sectors of the economy are described in terms of three factors of major concern: economic contribution, employment and pollution.

Thus three "wind roses" describe for each economic sector the turnover (share of gross national product), the share of the employees in the sector and the emissions of greenhouse gases (GGE). It can be seen that manufacturing and energy supply are the dominant polluters with transport as third. Manufacturing and school/health/social work employ most people with trade as third. Manufacture and financial intermediation are the largest contributors to the economy (with trade as number three).

Although the diagram is only indicative, the difference between the patterns of the three parameters is striking. Altering their proportions in the economy could make production — "the economy" — less polluting (and more energy efficient). But at the same time, it would also change the employment and the economic turnover because the labour force would switch to other sectors with "lower productivity" Tables 1 and 2 illustrate this with rather brutal examples of changes in the sector set-up. The first two alternatives reduce the emissions with approximately one third while retaining the same (or almost same) employment. The turnover is reduced in the same order as the emissions. The last alternative is a pronounced "clean" alternative with emissions almost halved. Here GDP is down with approximately 40% and employment down 15%.

The alternatives feature a doubling of employment in school/health/social work and a halving in manufacturing and some other sectors. The latter amounts to no more than 3% annually for the next quarter century. In view of numerous forecasts (see Rifkin, 1995), such a pace is not very upsetting. But on other grounds, it is perhaps overly optimistic to believe that this could be balanced with a doubling of the mainly public sectors. Even if most people might favour "soft" activities like health and social care over material goods, it seems very hard to find the means to finance a system where nearly half the working population is employed in these sectors.

But the diagram also highlights that other judgements than mere ecological ones have to be applied — the present situation appears to be abnormal in welfare terms. Most glaring is perhaps the fact that the sector "financial intermediation" reports high turnover but low emissions. Does that indicate that it is an ideal sector to boost? Would more banks, insurance agents and financial advisors increase the future welfare in society? Or is the sector in fact largely a taxing one, drawing resources from other, nourishing ones? This demands another analysis — beyond the scope of this one — which would explain the inputs of each sector and relate them to a desirable state of affairs.

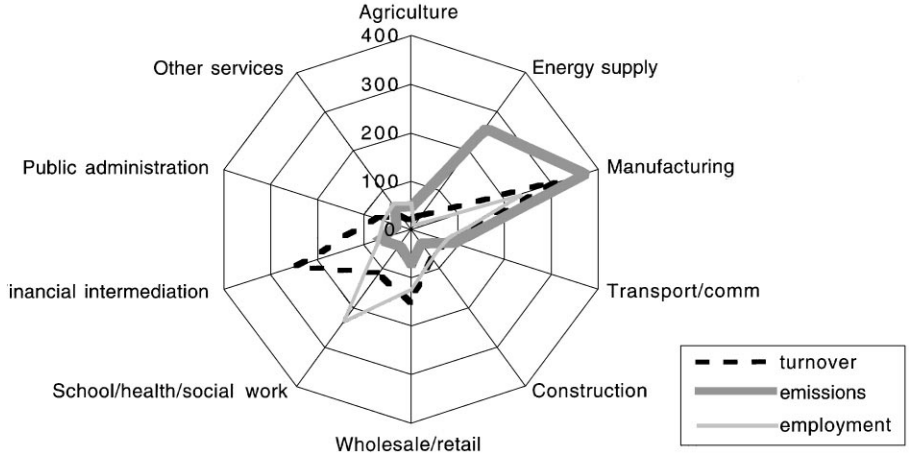

Fig. 1. Relative importance of economic turnover, emissions and employment in production sectors. The diagram is composed from British (emissions and turnover, see Vaze, 1997) and Swedish (employment) data with definitions somewhat uncertain. It is also important to stress that this condensed presentation of the economy cannot describe the great variation between kinds of goods and services; neither can knock-on effects of structural changes be described.

Table 1
Estimated effects of changing the structure of production

	Turnover	Emissions	Employment	Emissions/turnover
Base estimate	1145	1070	100	935
Alt 1 "saving" (reducing most sectors, doubling in education/care)	828 (72%)	715 (67%)	95	863
Alt 2 "full employment" (more agriculture, more services than 1)	790 (69%)	681 (64%)	100	862
Alt 3 "clean" (further reductions in most sectors in order to reduce emissions)	704 (61%)	555 (52%)	85	788

Table 2
Assumed changes in employment

	Base	1	2	3
Agriculture	100	80	150	60
Mining/quarrying	100	50	50	40
Manufacturing	100	60	50	40
Electricity, gas, water supply	100	60	40	40
Construction	100	40	50	40
Wholesale and retail	100	60	70	40
Transport/communication	100	50	40	40
Financial intermediation	100	50	30	50
Public administration	100	80	80	60
Education, health and social work	100	200	200	200
Other services	100	100	150	100

This also goes for the issue of employment. The immediate options are hardly appealing. To let the manufacturing production grow — to "save the jobs" — defies all environmental limits. But if the sector production is limited, it will cast off employees. The immediate options are to employ these in less-harmful sectors (as suggested above and leading to the associated problems) or to add to the unemployed cadres. But if we widen the perspective, and loosen the common idea of the organisation of work, new possibilities open up.

3.5. Shortcutting the scope of the economy by work sharing?

The scenarios sketched above underline that the cherished political goal of full employment seems increasingly impossible to attain. This has already led to a tendency to redefine the meaning of the goal, either by letting it embrace a more limited segment of the population or by redefining the meaning of full time. But the table above indicates that the scope of the issue is enormous. It goes without saying that no society can accommodate a double-digit rate of unemployment for long without serious social effects. The prospects for returning to an old model of gender division of labour are equally poor.

This suggests a revival of the long-standing proposals for a reduction of the working time of each employee. Technological progress would be directly transformed into leisure as an alternative form of welfare, in contrast to higher consumption. The issue is well known from history but the reference to the ecological limits can be added to the previous, still valid arguments. Notions of material saturation, which are held by many people, can be lined up with their concern with nature.

4. Conclusions

The concept of the rebound effect offers an opportunity to take a fresh look at the governance of the economic system in societies faced by ecological limits. The rebound effect is taken to mean the overall effects of technical, organisational and social progress which increase the efficiency of the economy and give room for more consumption. This is usually hailed as progress but it also constitutes a threat to the ecological balance.

The advances in technology and social organisation which lead to efficiency gains are obviously welcome. It is however crucial to distinguish the achievements which make the rebound effect possible from the social conditions which prevail in the consumption-oriented market economies and create this perilous situation. The tale by Bertrand Russell about pin-making describes the dilemma in a simple but very relevant form.

A series of possible ways to deal with the situation is suggested:

- paying one's way fairly in the global trade;
- maintaining the natural resources for a sustainable yield;
- diverting production and consumption in a sustainable direction; and
- reducing the input of labour.

None of these is sufficient to achieve the goal by itself but each can contribute to a better situation. It is also important to say that the various means are central to the future shape of the economy and society. Considerations

of ecological issues go hand in hand with social ones and the recipes for a sustainable society may also apply for a socially fair society.

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