From green growth towards a sustainable real economy[1]

The myth of decoupling, rebound effects, and the $I = P \cdot A \cdot T$ equation

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Abstract

Taking the simple static equation: *I* (impact) = *P* (population) ·*A* (affluence) ·*T* (technology) as the point of departure, this paper discusses the delusion of decoupling economic activities from environmental impacts (*I*) by resorting to simply reducing eco-intensities (*T*), (i.e. increasing efficiencies) through technological advancement. It is argued that the rebound effect reflects some dynamic interdependence between the factors. For instance a higher efficiency in the use of resources will partly be turned into growth in the economy i.e. (*A*) and (*P*) rather than into lower environmental impact (*I*). This is both a natural consequence of the growth dedicated society, and a driver of further economic growth. Through rebound effects, eco-efficiency efforts in the growth society tend to contradict and counteract the goal of environmental sustainability. To address the global environmental problems properly, our critique should therefore be redirected towards the growth ideology and growth policy itself. Drawing on the global inequity and emerging degrowth debates in the affluent countries, the paper proposes pathways towards a degrowth strategy by discussing the respective roles of population *P*, affluence *A*, and technology *T*. Overall, it is suggested that given an analysis not confined to monetary terms, but with *real cost and real benefits* represented by *environmental damage* and *human satisfaction,* respectively, sustainability in today's affluent countries might be achievable at no net cost.

Keywords delusion of decoupling, rebound effect, degrowth sustainability

The equation $I = P \cdot A \cdot T$, which combines population (*P*), affluence level (*A*), and technological eco-intensity (*T*) in the consideration of environmental impacts (*I*), has been well-known for a long time. Since the equation's development by Ehrlich and Holdren in 1971, the relative focus on the three factors has shifted. Although Ehrlich and Holdren at the initial stage emphasized the impacts of population (*P*) on the environment (Ehrlich & Holdren, 1971), today, the factor (*T*) almost totally dominates debates about solutions to resolve environmental deterioration (e.g. Weizsäcker et al., 1998; WCED, 1987; OECD, 2011). Population (*P*) is often tabooed and rarely included as a variable in the analyses and debates, although it obviously is still a key factor. In more recent debates, particularly in affluent regions, the factor (*A*) is sporadically being highlighted as a key to solve the ecological crisis

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(Martinez-Alier et al., 2010). For instance, a call for reducing affluence levels is *well captured* in current discussions on "degrowth".

The quest for reducing the affluence (*A*) in rich nations, measured as per capita level of consumption of goods and services, is partly based on the impossibility of reducing resource consumption and pollution (*I*) to a level necessary for environmental sustainability by resorting to technological advancement (*T*) alone. This failure is to some extent attributed to the ignorance of the rebound effects from increasing resource use efficiency, which pushes up (*P*) and (*A*). In other words, the right-side factors in the equation are not constants, but mutually interdependent and dynamic (Alcott, 2008; 2010). This paper goes beyond this explanation, and points to the constant political quest for economic growth, i.e. growth in ($P{\cdot}A$), as the fundamental problem. This suggests that it is difficult to eliminate rebound effects and sufficiently reduce environmental impacts without addressing directly the (*A*) and (*P*) factors, in addition to lowering the eco-intensities (*T*). Invoking the term "degrowth", we also propose for affluent, unsustainable regions alternative economics beyond the ideology of growth, and indicate desirable pathways down towards a sustainable level. In this paper, environmental impact (*I*) is mostly exemplified by energy consumption and carbon emissions, but (*I*) does refer as well to all other degradation of nature, such as biodiversity loss, resource depletion, and pollution of air, water and soil. By definition, a degrowth society "challenges the hegemony of growth and calls for a democratically led redistributive downscaling of production and consumption in industrialised countries as a means to achieve environmental sustainability, social justice and well-being" (Demaria et al., 2013). Degrowth therefore calls for strategies to reduce the aggregate impact from $P{\cdot}A$ in addition to the efficiency improvements (*T*). A degrowth society cannot be interpreted merely as a downscaled economy in the quantitative sense. It implies a qualitatively different society with different socio-economic structures and institutional settings (Asara et al., 2015). In addition, degrowth carries the ethical premise of distributive justice and intergenerational equity. Although the *P* factor is not given sufficient attention in the degrowth debates today, and propositions on population development among degrowth proponents are inconsistent (Kerschner, 2010; Latouche, 2009; Martinez-Alier, 2009), we believe that reducing the global population is essential for bringing human economic activity down to a sustainable level and thus should be advocated as a strong part of the solutions.

The paper will proceed as follows. In section 1, the 'growth and decoupling' approach for environmental sustainability is criticised as a delusion. Section 2 analyses how rebound effects are associated with the growth economy, and proceeds by arguing that attempts at enhancing labour and resource efficiencies in a growth dedicated society tend to contradict the goal of environmental sustainability. We therefore call for shifting the focus of critique from rebound effects to the growth ideology and policy in order to resolve environmental problems. This is followed by proposing a degrowth society. Drawing on the equation $I = P{\cdot}A{\cdot}T$ as an analytical framework, in sections 3, 4, and 5 we discuss options for degrowth of all three right-side factors, as well as some of their dynamics. Finally, the concluding section provides some reflections on the need for a concerted degrowth strategy taking into account capping the left-side factor *I,* and emphasizing the importance of addressing the deep socio-economic structures as part of the degrowth transformation, apart from the factors in the $I = P{\cdot}A{\cdot}T$ equation.

1. The delusion of decoupling economic activities from environmental impacts

During the 1960s and 70s ecological crises attributed to an exponential economic growth triggered a critical discussion on the environmental and social consequences of growth. This culminated with the publication of the report from the Club of Rome, *The Limits to Growth* (Meadows et al., 1972), together with other reports and books presenting similar growth critique (e.g. Daly, 1973; Goldsmith & Allen, 1972; Schumacher, 1973). During the 1980s, the growth critique was played down as the economy regained momentum, and was gradually replaced by the view of 'decoupling' economic growth from environmental deterioration. This 'decoupling' view was emphasized, for instance, by the World Commission on Environment and Development as a key strategy of sustainable development in their report *Our Common Future* (WCED, 1987) as well as in a number of publications that developed the concept of 'Ecological Modernization' (Huber, 1985; Spaargaren & Mol, 1992; Hajer, 1995). More recently, however, the possibility of maintaining environmentally sustainable economic growth through decoupling has been questioned by critics. Together with multiple socio-economic-political crises, this has revitalized the criticisms of economic growth, manifested in the increasingly heated debates on degrowth (Asara et al., 2015; Jackson, 2009; Martinez-Alier et al. 2010).

According to the decoupling view, economic growth and environmental sustainability are *not* incompatible, but can be combined. To illustrate the decoupling notion with the $I = P \cdot A \cdot T$ equation, it means that ecological impact (*I*) can grow at a lower rate than the growth in economic affluence level of a whole population, i.e. $P \cdot A$. In order to materialize such decoupling, the *T* factor is the key. The belief in decoupling was based on good efficiency progress in the wake of the 1970s' oil crises. Many analyses then showed remarkable potentials for increasing the efficiencies of energy use (e.g. Goldemberg et al., 1985; Lovins, 1977; Nørgård, 1979 a). In the 1990s, the concepts of Factor 4 (Weizsäcker et al., 1998), and Factor 10 (Schmidt-Bleek, 2001) emerged and provided a broad basis for now widely agreed national policies. Factor 4 means that the same amount of commodity being produced with only a quarter of the previous resource consumption (thus, factor 10 means using one tenth of the previous resource consumption). At an aggregate level, Factor 4 could imply "doubling wealth while halving resource use".

These large potentials in reducing eco-intensities were mainly low-hanging fruits resulting from the neglect of efficiency options during the post-war period of almost free oil. The efficiency boom, however, then resulted in a strong faith in the possibility of decoupling economic growth from environmental damage. "Reviving growth" was pointed out as an essential objective, the suggestion being that only the quality of growth should be changed (WCED, 1987). The Western faith in technology as the overriding solution has now shaped environmental policies for half a century.

This decoupling notion can be challenged in several different ways and is subject to serious criticisms. The conventional use of the decoupling term distinguishes "relative decoupling" from "absolute decoupling". If the ecological impact (*I*) grows at a lower rate than economic growth measured as GDP or $P \cdot A$, this is expressed as relative decoupling. The term absolute decoupling has been used when growth in GDP - or $P \cdot A$ - does not result in increase in the overall ecological impact, i.e. (*I*) is kept stable or even declines (Jackson, 2009). What matters for ecological sustainability is whether the absolute environmental impacts, (*I*), increase or decrease. From this perspective, absolute decoupling is of fundamental concern.

However, a broad range of empirical evidence indicates a low achievement of absolute decoupling. At the aggregate economy level, the total emissions of CO_2 in OECD countries showed relative decoupling from economic growth during the 1990s (OECD, 2002), and similar modest relative decoupling has been observed in traffic volume versus CO_2 emissions (Tapio, 2005), as well as in housing sector's growth versus growth in residential energy consumption (Xue, 2014). However, the overall picture is that such reductions in environmental impacts *per unit* of product are cancelled out by the increases in volumes within any growing economy. Only if the speed of *T* going down equals the growth rate of *P·A*, can environmental impacts *I* be stabilized.

But stabilisation will not suffice.

Among environmentally concerned scholars it is generally agreed that the present global environmental impact is not sustainable. Taking Ecological Footprint as the indicator, we are presently overloading the Earth by a factor of around 1.5 (WWF, 2014), implying a need to reduce the global ecological footprint by 35 percent. Another study shows that four out of nine planetary boundaries have already been crossed by human activities, including climate change, biosphere integrity, biogeochemical flows and land system change, which might push the Earth system into a new state (Steffen et al., 2015). This means that for some specific environmental damages, a more drastic reduction is required. For the emissions of CO_2 and other greenhouse gases, the reduction has to be "net 100 %" by 2100 if we are going to achieve the goal of keeping global warming below 2 degrees (IPCC, 2014).

By acknowledging the enormous inequity in the world and ascribing all humanity equal environmental rights, it is argued that people in affluent countries, such as USA, EU, and Japan, would need to reduce their impacts (*I*) down to only around one tenth of present levels to ensure world-wide sustainability (Schmidt-Bleek, 2001). To achieve this in the course of 50 years given an annual GDP growth of 3 % would require eco-intensity (*T*) to be reduced by a *factor of around 40* (Nørgård, 2009; Jackson, 2009). For comparison, the much praised efficiency efforts in Denmark's energy system have over the past 25 years managed only to reduce (*T)* by a *factor of 1.4 !* (Danish Energy Agency, 2015). And this has been achieved by implementing the easiest and most cost-effective options. Could all technologies, in all sectors, possibly over the next 50 years become 40 times more efficient? Hardly!

Similar conclusions are reached by several other studies and examples, summarized by Trainer (2016). It therefore seems even theoretically implausible to reduce the environmental impacts *I* to reach and maintain a sustainable level by relying on reducing the *T* factor alone while simultaneously maintaining growth in GDP, i.e. $P \cdot A$.

Linguistically, decoupling implies that the two parameters – economic activity and environmental impact – are separated (Webster, 1986) with no coupling at all. OECD (2002) in their energy analyses define "decoupling" as breaking the links between "environmental bads" and "economic goods". Physically, however, there will always be some amount of 'coupling', since every economic activity is – directly or indirectly – reliant on a minimum of resource supply from nature and emission of wastes back into nature. And *vice versa*, all eco-impacts have their roots in economic activity. The fact that economic activity and the eco-impacts grow at different rates does not imply that the two parameters are not coupled.

The misleading term "decoupling" should therefore *not* be used in analyses and debates about economic growth and the environment. Instead, the term "relative decoupling" should be referred to as a *change in eco-intensity* (*T*), while the term "absolute decoupling" should be referred to simply as a *change in overall eco-impact* (*I*). These are not just linguistic trifles. The real problem is that the very use of the term "decoupling" might – probably sometimes intentionally – leave the false perception that we can let economic activities grow forever, without having to worry about any ecological constraints. The use of the term "decoupling" can be seen as a false "peacemaker" between environmentalists and growth-dedicated politicians, and thereby contributes to the maintenance of growth far beyond the economy's optimal size (Nørgård, 2009).

2. Rebound effects in a growth dedicated society

Normally the concept "rebound effect" depicts the phenomenon that eco-efficiency improvements through technological advancement do not reduce the adverse environmental impacts as expected from simple calculations, because the efficiency induced increases in production and consumption. For example, consumers who make their house technically more energy efficient and hence save on the energy bill are often tempted to take out that saving by more energy use in other ways, e.g. higher indoor temperature or an overseas flight for a holiday. The effect was first observed in the 19th century by British economist Jevons, who noticed that increasing efficiency in the use of coal was not accompanied by corresponding reduction in the use of that resource at the aggregate level, – rather the opposite (Alcott, 2005).

Rebound effects from using energy and other natural resources more efficiently has since the 1980s been a key dilemma of the energy efficiency debate, (Herring and Sorrell, 2009; Weizsäcker et al., 2009).

Here, we extend efficiency improvements to embrace other production factors, which we merge into one factor, *labour input*, by considering capital as accumulated stored labour input. Throughout industrialisation, technology has increased labour efficiency (productivity) in the sense of less work being needed per unit of output. A substantial part of the labour efficiency gains during early industrialization were utilized to reduce the more than 80 hours weekly work time. However, later on, more and more of the labour efficiency gains were turned into growth in overall production and consumption $A \cdot P$. In recent decades this rebound effect has in some affluent regions approached 100 percent, as illustrated by the average work time in the USA, which has been frozen since the 1930s at around 40 hours per week despite large gains in labour productivity (Schor, 2005). Almost all labour productivity gains are presently used to increase GDP – and consumption in general, – rather than to relieve the environmental impacts by lowering work input and consumption. Instead of reducing the input of labour, during the past 50 years the global *workforce* has enlarged substantially, partly by general population growth, and partly by absorbing ever more men and (in particular for the case of affluent countries) women into the economic (monetary) production sectors.

The direct and micro-level causes of rebound effects from eco-efficiency technologies can be largely ascribed to facts, that the estimates for savings were overlooking the socio-cultural elements and individual subjectivity in consumption behaviour (Santarius, 2016a; Peters and Dütschke, 2016; Santarius 2016b). In addition, increasing productivity through technological advancements involves a general trend of social acceleration, where the speed of production, consumption, and mobility increases, leading to more consumption of resources (Suffolk and Poortinga, 2016). Nevertheless, there is nothing deterministic about the growth impact of improving resource and labour efficiency through technologies. As shown above, labour productivity gains could instead be employed to shorten work time instead of increasing production and consumption. We do, in fact, have choices as to how we utilize the benefits of efficiency improvements.

Arguably, the conversion of efficiency gains predominantly into more production and consumption is due to the ideology of economic growth and the structural growth imperative of a market-dominated socio-economic system. In the growth society, "quality of life" and 'well-being' are still very broadly interpreted as possession of material wealth, and hence, consumerism is a dominant value entrenched in society. Continuously enhancing material living standards becomes a widely accepted social norm without being questioned. When basic needs are satisfied, as in affluent societies, positional goods and conspicuous consumption are promoted as new momentums of growth through advertising and consumption-stimulating policies (Hirsch, 1976). This growth path was (with pressure from business) "deliberately" chosen in 1933 by US President F.D. Roosevelt as a way out of the economic depression (Hunnicutt, 1988; Cross, 1993). For consumers under the hegemony of the growth discourse, it is very likely that reduced costs due to lower *resource intensity* per unit of product is used to secure higher material standards, just as the case with rebound from higher *labour efficiency*. In other words, the growing purchasing power derived from either of the two efficiency gains has to be channelled to somewhere; often to higher levels of consumption (Schneider, 2008).

Furthermore, the fact that most efficiency improvements are turned into drivers of growth is highly associated with the market economy with its structural necessity of growth. Several authors have pointed out that the growth imperative is intrinsic to the market-dominated socio-economic system (Gordon & Rosenthal 2003; Griethuysen 2010; Harvey 2010). Fierce competition in the market economy sets a "grow or die" dynamic in motion. By enhancing both resource and labour efficiency, businesses are able to reduce the costs of products so as to earn more profits than their competitors and increase their market shares (Buhl and Acosta, 2016). Therefore, the rebound effect on the production side is an intentional pursuit by producers towards higher profitability. Not only business, but also governments seek high rebound effects. The Danish government has directly *required* that *"Energy savings should contribute to growth and commercial development"* (Danish Energy Agency, 2004).

Based on the discussion above, it can be argued that the rebound effect is both a natural *consequence* of a growth society and an important *contributor* to further economic growth. It is welcomed in current growth dedicated society and cannot be understood as a problem from a perspective of economic growth. Only when examined from an environmental perspective is rebound regarded as a problematic side effect, since it increases the level of production and consumption thus offsetting intended environmental gains from efficiency strategies. For societies, committed predominantly to perpetual growth in output, the rebound effect is not bad, rather the opposite. What remains as the fundamental problem is this commitment to economic growth and its contradiction with environmental sustainability. Both labour- and eco-efficiency strategies tend to be "co-opted" by the growth ideology and serve the purpose of maintaining growth. The more we reduce the eco-intensity (*T*), the more difficult it will be to decrease the aggregate impact of $A \cdot P$, because implementing technologies for resource efficiency and productivity are key drivers of economic growth. Attempts at enhancing labour and resource efficiencies *in a growth society* tend to contradict the requirements for environmental sustainability. Hence, it appears patently impossible to reduce environmental impacts as much as needed by resorting only to technological eco-efficiency strategies in a growth society. It is imperative to address directly the growth issue in order to achieve long-term environmental sustainability (Nørgård, 2009).

This suggests the adoption of a degrowth strategy that seeks to stabilize or even lower the affluence level (*A*), and the population size (*P*). In addition to lower eco-intensities, the technology factor (*T)* will be redirected towards prolonging the durability of products. How would such a degrowth society look like? What policies would be needed in order to avoid problems like unemployment, poverty and inequality, during the shrinkage towards a sustainable steady state economy? The following sections sketch some suggestions for achieving a prosperous degrowth society by exploring the role of each of the right side factors in the $I = P \cdot A \cdot T$ equation.

3. Population development in a degrowth society

Global population has over recent decades moved from exponential growth into what appears more like linear growth. But this is still adding a staggering 80 million people annually to a limited planet. With continued population growth, a desirably low level of environmental impact can hardly be reached or maintained. Despite the environmental impact of the world's population, there is a taboo about including population as a variable when analysing future options for sustainability (Nicholson-Lord, 2008). Analyses and future scenarios typically start by just referring to the latest UN medium estimate of future population development (see Figure 1), and accept this one scenario as a fact. This lack of scientific and political vision or courage amongst experts to include a reduction of population as one possible, if not essential, contribution to solving this *man-made* impact, is one of the most glaring flaws in present environmental debates.

When European politicians and scientists in rare cases do touch on the issue of population, it is usually from a growth *promoting* viewpoint; for instance by encouraging higher birth rates to secure sufficient workers and consumers – again, to maintain GDP growth. As was historically hinted at by philosophers as long ago as the 1700s (Lütken, 1760; Malthus, 1798), this strategy must sooner or later result in ecological and human misery and starvation for parts of the world population.

Most demographers and politicians still contend that as standards of living in developing countries approach a Western level, birth rates will drop and thus prevent global overpopulation. One problem has been that in some poor regions, economic growth could hardly keep pace with population growth, which has resulted in stagnating or even declining standards of living, blocking the way for that "automatic" decline in birth rates. Furthermore, it is often forgotten that the European population "explosion" in the 1800s and 1900s was partly "resolved" by millions of Europeans migrating and taking control of "empty" continents: North and South America, Australia and parts of Asia and Africa. In recent decades similar population "explosions" have crowded other world regions, not least in Africa, but there are no more "empty" continents for these people to migrate to.

What then is an *optimal* number of people that could live comfortably on the planet with a sustainable natural environment? It seems evident that such optimisation must be a trade-off between the two aspects, since more people (*P*) imply reduced options for a good life.

A number of studies have under certain assumptions estimated optimal world population sizes. One such analysis from the 1990s was based on the energy needed for high quality of life versus the environmental problems from using fossil fuels. Given the average energy consumption of 7.5 and 1 kW per capita in respectively industrialized and developing nations at that time, researchers suggested 3 kW to suffice, and found an optimal world population of 1.5 - 2 billion people (Daily et al., 1994). More recent analysis, based on ecological footprint versus the earth's bio-capacity found that future optimal population levels range from 2.7 to 5.1 billion people (Desveaux, 2008), depending on average footprints, maintenance of bio-capacity and allowances for biodiversity. The lowest figure, 2.7 billion, allows for a 20 % margin for biodiversity. Obviously estimates of an *optimal* population are highly subjective, but it is worth noticing that they all indicate an optimal population size far below the present 7.5 billion.

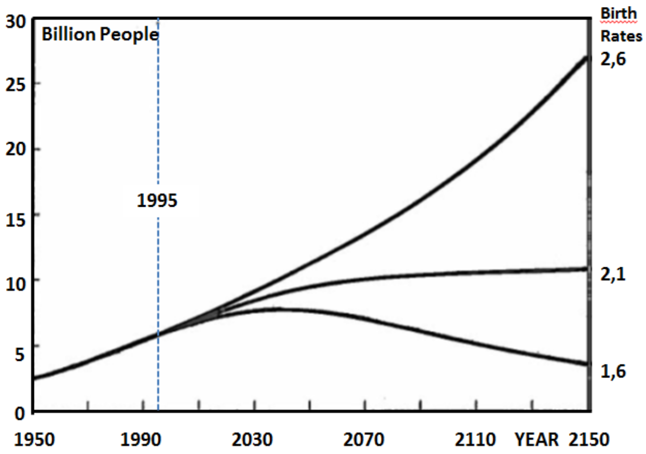
One recent estimate of how world population will actually develop if no extra actions are taken, suggests it will peak around 2040 at above 8 billion, followed by a very slow decline (Maxton and Randers, 2016). This seems to imply an overpopulated planet for a long time to come and underlines the urgency of aiming at a more optimal path by supporting a gentle reduction of the number of people on the planet.

The taboo on the population issue is widespread among decision makers, who wish to appear neutral on the sensitive issue of people's choice of family size. But no policy can be neutral on population development. All political decisions have indirect effects on fertility rates through tax systems, education, health care, social security, etc. Some decision makers defend their silence on active population limitation policies by the fact that such policies mainly have long-term effects. This is an odd way to justify *postponing* actions to secure the future of our descendants.

Imagine mankind decides to aim for half as many people on the planet as today, which is here suggested as the lowest UN scenario for world population development (Figure 1). If we act now, we could reach this goal around 2150 by convincing all women to have on average 1.6 children, rather than the present average of 2.6. Reaching a worldwide birth rate of just 1.6 should not be ruled out, considering that it is in fact the present average birth rates in two politically quite different regions of the world, Europe and China. In Europe the low birth rate and the resulting future contraction of population has been reached unintentionally (politically speaking) and voluntarily as a consequence of the general economic and welfare policy. In China it has been reached by a more conscious and direct active family planning policy.

Although China's family planning policy is effective in slowing population growth, it has been criticised for its authoritarian and coercive approach (Dietz & O'Neill, 2013). Later optimistic experiences from a number of developing countries, mainly in Asia, have shown how similar effects as those in China has been achieved based on non-coercive means, including education and empowerment of women (Kingholz & Töpfer, 2012).

Figure 1 UN scenarios for future world population development as a consequence of three average fertility rates (Source: The Population Division of the UNs Secretariat, 1998)



It is hard to see *disadvantages* of living in a future world with say half as many people as today. On the contrary, the basic problems mankind is facing today would be easier to solve. Even in monetary terms, reducing population is the most cost-effective strategy for mitigating climate change. This also applies to biodiversity loss and other resource and pollution problems. International conflicts too are often linked to shortages of land, food and resources. Lowering fertility rates to below the replacement rate of 2.1 would facilitate improved standards of living in general and provide environmental benefit through the reduced ecological footprint of fewer children and all their future descendants.

Mainstream politicians mainly associate low birth rates with the *transition problems, when* an ageing population will need more care to be provided by a shrinking productive workforce. Given a gentle pace of transition, these problems are, however, manageable, especially when remembering that a shrinking population will require less need for child care and educational services and that infrastructures like highways, buildings, power systems, libraries, schools, etc. inherited from the earlier, larger generations will be more than enough.. This inherited "overcapacity" will need maintenance and replacement, but the huge investments for *growth-induced expansion* are avoided, reducing also environmental impacts.

4. Affluence and work in a degrowth society

In the Western economies, average consumption per capita (*A*) has reached a level which qualifies as a dominant, very obvious factor in the environmental impact $I = P \cdot A \cdot T$. According to the *Living Planet Report 2014* (WWF, 2014), the ecological footprint per capita of high-income countries is about five times more than that of low-income countries. Furthermore, the high income countries often rely on the bio-capacity of other nations or the global commons to meet their consumption demands. Growth in such affluence does not primarily serve to satisfy human basic needs or even deeper needs, but rather to satisfy the "basic needs" of a debt-based financial economy designed for unlimited GDP expansion. This explains why not only financial actors in private business, but also governments insist on encouraging people to consume still more. The tools include massive advertising, key trade and tax policies, and also the goals of education and research systems. It is not hard to imagine, that consumer preferences would shift somewhat, if these growth biased measures were slowed down or even reversed towards more equity and sustainability.

In general, when aiming for a degrowth economy many goals will be contrary to those of a growth economy. Fortunately, curbing excessive consumption offers rewards in return, mainly in the form of more free time, less stress, better health, more options for meaningful life, in addition to a better rather than worse environment.

It is notable that reducing affluence levels whilst improving life quality is a key focus in many successful sustainability initiatives at the community level (Butters, 2010).

The affluence level (*A*) is not only coupled to environmental impact but also affects our health. Economic growth in wealthy countries might still bring new health improvements through better technology and medicine, but excessive consumption is in many regions also causing huge *negative* health impacts in the form of lifestyle diseases; such as obesity, caused by overconsumption of food and sedentary, motorized lifestyles. Others are smoking, alcohol and drug abuse. Around the year 2000, overconsumption alone in the USA was found to result in more than one million premature deaths every year. With "a slip of the tongue", the USA's Secretary of Health stated that these and other "social problems and complaints stem from our affluence, not our poverty" (Samuelson, 2004), exposing such severe and rising human cost of the growth policy.

If we assume that consumption can be expressed by people's annual income, studies comparing different nations indicate that increase in income gives a diminishing return in the form of well-being or happiness. This is particularly clear when average annual income exceeds $10,000 per person, and beyond $ 15,000 the extra benefit seems negligibly (Jackson, 2009). Moreover, the same study shows that countries with the highest score of happiness, such as Iceland, the Netherlands, Denmark and Sweden have lower incomes than USA. When observing the historical relationship between economic growth and happiness in USA, it is found that the percentage of people who report being "very happy" stabilized at around 30 % during the years 1945-2005, although income more than tripled (Dietz & O'Neill, 2013). This indicates that other aspects of life are more important for people's wellbeing than their level of consumption or income. Some of these are equity, education, job guarantee, etc. (Wilkinson & Pickett, 2010). An increasing number of such studies show that further economic growth in the developed countries is *not a necessary condition* for progress in human well-being.

Apart from arguing for continuously increasing affluence levels in terms of social benefits, a key political argument for increasing consumption in affluent nations is to avoid increasing unemployment resulting from productivity increases. In general, there are three ways to accommodate this: 1) increase public and private investments, 2) increase consumption, and 3) reduce labour input in terms of lowering annual work time and/or labour productivity to fit the production wanted. The simplest long term solution to avoid unwanted unemployment without growth in investment and consumption is to share the work to be done annually by lowering the work time.

Annual working time in various nations is quite different, with people in USA, Russia, South Korea and Japan working about 20 % more than Europeans. This suggests that Europeans, as in the population issue, are on a positive track towards degrowth and sustainability. In addition, in a future aimed at sustainability, pressure for continuously increasing labour productivity can be relieved and even reversed as a means for both adapting production to declining consumption and simultaneously making working conditions better and more meaningful in various ways.

Lowering affluence can appear an impossible task, given the dominance of the growth ideology. After lifelong exposure to intensive commercial advertising and political encouragement to buy ever more, plus the peer pressures of neighbours' new cars and bigger house, it is understandable that people may be reluctant to reduce their consumption. On the other hand, surveys on work time preferences have actually indicated an increasing wish among people for less work time (Gorz, 1983; Hayden, 2000; Sanne, 2000; Schor, 1991). A series of surveys conducted in Denmark over some decades showed that the fraction preferring less work over more income increased from 44% in 1964 to 73% by 2007 (Nørgård, 2009).

People's preferences for more leisure over more income, as illustrated above, might well be based on personal concerns, not our common environmental benefits of their choice (Hayden, 2000). With this argument added, preferences would probably be higher. However, increase in leisure activities cannot be anticipated to necessarily lead to fewer environmental problems, due to the possibility of time-use rebound in terms of resource use (Santarius 2016). Not all spare-time activities are environment friendly (Aall, 2011). However, stabilization or even decline in income due to reduction in working hours constitutes one of the mechanisms counteracting consumption. In addition, tax policies can be shaped to encourage people to engage in leisure activities that are relatively less resource intensive or environmentally harmful.

The fact that most people in affluent Western nations express a wish to use productivity gains to get more free time rather than more income, if given the choice, should be seen as a welcome opportunity for politicians to gently change economic paths away from the money dominated growth economy towards a degrowth economy. In a degrowth society, the environmental impact from the affluence level could decline in combination with an improvement in quality of life in the form of better health, more freedom and non-material sources of happiness. (Nørgård 2013).

5. Technology in a degrowth society

Having considered population (*P)* and affluence (*A)* above, we now return to the third factor (*T)*. The rebound effects of eco-efficiency in technology should not lead us to dismiss technological advancement as an obvious part of strategies for environmental sustainability in a degrowth society. A key problem with technical solutions is that they often overshadow many more effective "soft" solutions, including political instruments and social innovations. Arguably, technological advances in a degrowth society with a cap on affluence level (*A*) and population size (*P*) will not lead to net rebound effects and thus will at last contribute to *reducing* environmental impacts.

Besides seeking higher efficiency in *direct use* of resources, this section will also address how technologies on the consumer side can be utilised in interplay with lifestyle and behavioural issues to contribute substantially to reducing also the *indirect* resource use and pollution. The potential of technologies in these aspects include enhancing consumer efficiency by sharing and prolonging the useful life expectancy of consumer goods, policies which have been neglected or counteracted in economies dedicated to growth.

People's material affluence (*A*) can be expressed by the consumption of three types of goods and services: 1) flows of non-durable goods, defined as consumption of goods, the value of which lies in actually being consumed, such as food, water, electricity, heat etc., 2) stocks of durable goods, defined as physical goods including houses, clothes, appliances and cars, the value of which lies in having a stock of them at one's disposal, and 3) services, such as trade, entertainment, education, administration, health care, administration, which are provided to people by durable and non-durable goods outside their daily sphere (Nørgård, 2006).

Most focus on energy saving options has been devoted to the non-durable flow of *direct energy* used for providing services like transport, light, comfort, meals, etc. by operating energy consuming durables like cars, lamps, houses, refrigerators, TVs, etc. In these fields, substantial room for energy efficiency improvements has been identified and to some extent implemented. These efficiency gains hold many examples of rebound effects, by increasing the sale of durables.

However, investigating *indirect* energy consumption, defined as the energy used to produce and provide the durable goods, opens up more room for reduction in environmental impacts, in particular when technological improvements are integrated with behaviour and lifestyle changes. The potentials for these savings lie in 1) improving energy efficiency in the whole chain of the system providing the durables; 2) reducing the number of durable goods people possess, e.g. by more sharing of goods; 3) extending the useful lifetime, and finally, when scrapped, 4) recycling components or materials in a circular economy system. In the following the focus is on the product lifetime. These considerations apply not only to energy but to resource use in general.

The useful lifetime of durable goods is determined by three factors (Nørgård, 1979b): *technological obsolescence,* meaning the physical wear and tear and inability to fulfil the basic purposes of the products; *functional obsolescence,* in the sense that new products can fulfil the purpose in a better way, for instance by being more energy efficient or providing better service options; and *psychological obsolescence,* e.g. by becoming out of fashion compared to novel designs on the market. The most striking example of fashion driven purchase is clothes. But today sale of most items, including cars and houses, is to a large extent promoted by changing fashion. Obviously, the first occurring obsolescence of a product will determine the factual useful lifetime of the product.

In the growth economy, *planned obsolescence* that deliberately makes products obsolete faster in any or all of the three obsolescence factors is a business strategy to accelerate capital accumulation and at the macro-economy level boosting growth in GDP (Slade, 2006). There is therefore a basic conflict between increase in the consumption of durable goods and preservation of the environment. In a growth dedicated economy, public campaigns aimed at saving energy or the environment have been lukewarm in also emphasizing the *indirect* use of energy, because this would imply a general curb on economic activities. This argument can obviously not hold if sustainability is given higher priority.

In contrast to the call for speeding up the flow of durable goods in the growth society, a degrowth society aims at slowing down this flow and reducing the total amount of durable goods people possess.

Extending the useful lifetime of durable goods might be the most fruitful way of lowering environmental impacts, through combining behavioural and technical changes. This could apply to, e.g. electronic products, clothes, buildings, plastics. Manufacturers could use their technical expertise to design more durable and repairable products with longer intervals between functional and fashion changes. Sharing various goods also constitutes a significant potential for saving energy and other environmental impacts, since this reduces the size of the stock of durable goods. Besides examples like cars, tools, and clothes, this thinking also include architectural design to facilitate flexibility and co-housing (Lietaert, 2010).

The main obstacle on the path towards such indirect resource saving is not the technology, which is almost readily available. We do not have to wait for new invention before starting a transition. As an example, electronic devices like mobile phones now scrapped after a year or two can easily last for ten or more years. Similarly with clothes. In certain areas, e.g. urban sustainable development, it is also a matter of designing for, and reinvigorating, old environmentally friendly technologies, such as bicycles, buses and communal building facilities to replace the relatively new but more environmentally harmful solutions, including the universal goal of private cars (Næss &Vogel, 2012). What seems to be more important is the necessary change in economic and financial targets, in work patterns as discussed in section 4, and in culture and lifestyle. Fashion and advertising can, as demonstrated in recent decades, be quite effective in changing people's lifestyles with satisfaction through faster obsolescence replacement. Alternatively one could use the same advertising expertise to convey to consumers, little by little, the benefits of focusing more on the physical services or use values provided by the car, the clothes, and the other durable goods, and less on fashions and novelty.

To summarize, attempts at enhancing eco-efficiencies through technological advancement should not be abandoned in a degrowth society. However, technological innovation should to a higher degree be reoriented in the direction of focusing on use values and longevity of durable products, along with far more emphasis on cultural and lifestyle change, which, where achievable, are in addition entirely free.

6. Concluding remarks

In this paper we have argued that since the phenomenon of rebound effect constitutes a complicated indirect barrier to achieving environmental sustainability in affluent, growth dedicated economies, we should instead devote our critical attention directly to the growth paradigm itself, which is both a fundamental causal mechanism of the rebound effect and partly a consequence of it.

Throughout the paper, we have employed the $I = P \cdot A \cdot T$ equation to illustrate and develop our argument. We first criticised the belief in decoupling economic growth from environmental impacts and the misleading use of the very term "decoupling" that seems to suggest the material independence of economic activities. We then argued that the options for utilizing efficiency improvements in the use of resources and labour hold much larger potentials than just being rebounded into increased levels of production and consumption. It is the growth ideology and the structural necessity of growth of the market economy that converts efficiency gains into drivers of further economic growth. Hence, rebound effects in a society dedicated to growth in the case of poor, developing countries, are more than welcomed, whilst efficiency improvements in affluent growth economies are likely to contradict the goal of environmental sustainability. In the light of this argument, we further proposed a degrowth society which addresses simultaneously decreasing population size, reducing affluence level through work sharing, and redirecting technology towards prolonging the functional longevity of goods in addition to increasing resource use efficiency, as pathways towards reducing environmental impacts to a sustainable level. Such an economy geared towards a sustainable steady state is not only beneficial for environmental and resource problems, but may also contribute to a happier and more meaningful life by e.g. more sharing of the fewer work hours and more relaxed work conditions.

Apart from addressing the right-side factors in the equation, it is also an essential pathway towards the degrowth society to combine this with policies of directly capping the resource use and environmental impacts (*I*) on the left side of the equation. As Alcott (2010) suggested, the cap strategy can take the form of 1) production caps where limits are imposed on the input of raw materials to production, 2) consumption caps restricting the end-use of energy and other resources, and 3) pollution/emission impact caps. A multi-scalar cap system can be developed where individual and municipal caps are deduced from the national and global maxima. A capping strategy should be adopted in a concerted and coordinated way with the right-side factors. This will prevent the potential rebound effects which are generated by focusing separately on the factors regardless of the dynamics between them.

To build a degrowth society also requires a profound socio-economic transformation apart from adopting the strategies targeting the four factors in the equation. As discussed, the growth commitment and the consumerism culture emanate from the “grow or die” dynamic in the market economy. Without confronting the hegemony of this economic structure, it is hard to eradicate the growth imperative. The necessary measures like implementing policies aimed at slowing down labour productivity, curbing or discouraging demand for consumption, redirecting technologies towards use value and durability, will all meet resistance from conventional business and finance. The current propagation of a neoliberal agenda all over the world is at odds with policy suggestions for a sustainable society. The weaknesses of the present systems have been increasingly manifested through its failures in tackling the social, ecological, political and economic crises it has generated. It is urgent to transform the economy and society not only for a better environment but also for long-term human prosperity.

A degrowth transformation should be first pursued in the developed, affluent countries where the current economic volume can be qualified as “uneconomic growth” with negative interest rates (Daly, 1999; Daly, 2016; Trainer, 2016). For the least developed countries where economic growth still plays an important role in enhancing people’s wellbeing, increase in consumption levels is thus still needed, but only temporarily. After a period of growth in these developing countries to a point placed safely within the planet’s ecological capabilities, these countries should also aim for a long term development with a steady state economy. Whether a steady state economy can be run as a conventional capitalist economy, is a question still discussed (Trainer, 2016).

The cost for a degrowth transition can be very low or negative if analysed in *real economy terms,* i.e. not confined to what happens to be measured in money. In the real economy, the *real benefits* are measured in people’s satisfaction and the *real cost* in the destruction of the natural environment. In that case, most of the actions needed in the affluent nations to take towards humane and environmentally sustainable societies proposed in this chapter are available at no *real net cost.* If people prefer to have no more than two children, it makes no sense to ascribe a real human *cost* to this essential ecological *benefit*. Similarly, if people at a certain affluence level are convinced to prefer more relaxed work conditions over more materiel consumption, a degrowth economy can give them more of what they really want, again at no real *cost*, and with *benefit to* the environment and quality of life. And if technological development is directed towards longevity and eco-efficiency in general, it is possible to provide decent and comfortable lives to all humanity and preserve or restore the natural ecology. Only when mankind insists on monetary cost-benefit analyses do we seem to have a real problem.

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