Policy for material efficiency—sustainable taxation as a departure from the throwaway society

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The present economy is not sustainable with regard to its per capita material consumption. A dematerialization of the economy of industrialized countries can be achieved by a change in course, from an industrial economy built on throughput to a circular economy built on stock optimization, decoupling wealth and welfare from resource consumption while creating more work. The business models of a circular economy have been known since the mid-1970s and are now applied in a number of industrial sectors. This paper argues that a simple and convincing lever could accelerate the shift to a circular economy, and that this lever is the shift to a tax system based on the principles of sustainability: not taxing renewable resources including human labour—work—but taxing non-renewable resources instead is a powerful lever. Taxing materials and energies will promote low-carbon and low-resource solutions and a move towards a ‘circular’ regional economy as opposed to the ‘linear’ global economy requiring fuel-based transport for goods throughput. In addition to substantial improvements in material and energy efficiency, regional job creation and national greenhouse gas emission reductions, such a change will foster all activities based on ‘caring’, such as maintaining cultural heritage and natural wealth, health services, knowledge and know-how.

1. Introduction

Previous patterns of growth have brought increased prosperity, but through intensive and often inefficient use of resources. The role of biodiversity, ecosystems and their services is largely undervalued, the costs of waste are often not reflected in prices, current
markets and public policies cannot fully deal with competing demands on strategic resources such as minerals, land, water and biomass. This calls for a coherent and integrated response over a wide range of policies in order to deal with expected resource constraints and to sustain our prosperity in the long run.

This statement by the European Commission analyses today’s resource efficiency and policy shortcomings. But it does not show roads to solutions, it does not address work as a resource and it leaves out a number of challenges which most industrialized countries are confronted with at the beginning of the third millennium, such as how to

- integrate sufficiency strategies and renewable energies to mitigate climate change,
- identify new business opportunities in the saturated markets for many durable consumer goods in Europe,
- balance rapidly ageing populations, the potential of ‘silver workers’ and the influence on pensions, and
- tackle the sovereign debt problem in light of the need to renew ageing infrastructure in a time of austerity.

Economic actors in the circular economy have started to tackle many of these issues in a bottom-up approach by introducing new private sector business models of the circular economy, such as ‘re-use, repair and remanufacture instead of replace’, and ‘selling goods as services’.

A shift to a sustainable taxation constitutes a giant booster to multiply the benefits of a circular economy within a national economy. Other taxation and public procurement policies that would further benefit national economies and enhance the circular economy will be detailed later. The emphasis of this paper is on the efficient use of labour as a renewable resource with a qualitative edge, and ‘an economy as if people mattered’.

The multiple advantages of a circular economy have been described decades ago by Stahel & Reday, and have started to transcend into policymaking, as for instance in the 2008 European Union (EU) Waste Directive. However, politicians’ reflexes are still geared to overcome economic problems by promoting growth in the industrial production economy—witness the ‘cash for clunkers’ initiatives in 22 countries in 2010—or by focusing on singular issues, such as environmental solutions. The quest for sustainable (holistic) solutions, which would simultaneously address economic, social and environmental issues, is jeopardized by the ‘silo’ structures of public administrations, academia and many corporations. Stahel showed that most sustainable solutions are intersectoral and interdisciplinary and thus contradict existing regulations, do not fit into academic career structures and demand a ‘new think’.

This paper shows the characteristics of, and advantages inherent in, the circular economy and argues that the shift to a circular economy can be accelerated by one simple shift in public policy—adapting the tax system to the principles of sustainability by not taxing renewable resources including work. This will bring about a rapid expansion not only of the circular economy for manufactured capital (infrastructure, equipment and goods) but equally of all other economic activities based on stock optimization and ‘caring’, such as health services, education, organic agriculture, and producing goods from such locally available renewable materials as leather, wood and wool. Caring is also the foundation for maintaining our cultural heritage.

The author’s previous paper for the Royal Society ‘The service economy: “wealth without resource consumption”?’ had proposed such a change 15 years ago but underestimated the inertia of public policymaking, as the abstract of the 1997 paper shows:

The present economy is not sustainable with regard to its per capita material consumption in the industrialised countries. A dematerialisation of the economy of industrialised countries can only be achieved by a change in course, from an industrial economy where success is measured in throughput and its exchange value, to a service economy where success is measured in wealth (stock) and its usage value. Wealth management, new corporate and industrial design strategies and different economic policies can lead to a higher sustainability as well as an increased international competitiveness due to substantially higher resource productivity.
A higher sustainability will not only result from a change in public policy, but the principles of sustainability can be the driver to defining the framework conditions of a future public policy (see also [8]).

The term ‘material efficiency’ was coined by Allwood et al. [9]. The concept of a circular economy has many similarities with related concepts, such as closed loop economy, lake and loop economy, industrial ecology, cradle to cradle, and material efficiency.

2. A circular economy is about economics and profit maximization

This section details the circular economy, its focus on stock optimization and its structure of two loops of different nature and five principles. It explains why reuse and service-life extension of goods are the most profitable and resource-efficient business models of the circular economy. From an economics view, maintaining value and performance of stock replaces value added of flow, and utilization value replaces exchange value as a central notion of economic value.

Before 2012, few studies existed which analysed the economic benefits of a circular economy on a national or supranational level. In time for the World Economic Forum 2012 in Davos, the London-based Ellen MacArthur Foundation [10] published a report which calculates that a circular economy (better design and more efficient use of material) could save European manufacturers US$630 billion a year by 2025. The report produced by consultancy McKinsey only covers five sectors that represent a little less than half of the gross domestic product (GDP) contribution of EU manufacturing, but still calculates that greater resource efficiency could deliver multi-billion euro savings equivalent to 23 per cent of current spending on manufacturing inputs.

The following abstract of ‘the product-life factor’ [11] for the topic on ‘the role of the private sector in a sustainable society’ [12] is still an excellent summary of the circular economy:

This paper attempts to show that the extension of the use-life of goods is, first, a sensible point at which to start a gradual transition towards a sustainable society in which progress is made consistent with the world’s finite resource base and, second, a strategy consistent with an active and independent role for the private sector. Product-life, or the period over which products and goods are used, governs their replacement speed and thus the consumption of natural resources required for their manufacture and the amount of waste they create. Shortening product-life increases demand for replacement goods where these can be afforded. Extending product-life optimizes the total life-span of goods and reduces depletion of natural resources and consequently waste; it builds on and increases wealth. Longer use of products will thus contribute to the transition towards a sustainable society. Compared to fast-replacement, product-life extension is a substitution of service activities for extractive and manufacturing industries, and a replacement of large-scale capital-intensive companies by smaller, labour-intensive, locally integrated work units. The private sector, whether R&D, manufacturing or finance, will find innumerable business opportunities in product-life extension activities—Reuse, Repair, Reconditioning and Recycling. Indeed, while increasing the number of skilled jobs available and reducing our dependence on strategic materials, such activities will provide the private sector with fresh impetus to make cheaper goods available as part of a self-replenishing economy built on a spiral-loop pattern which allows a substitution of manpower for energy. In this way, unemployment and poverty which certainly aggravate the fundamental instability of the world economy might be substantially reduced. The private sector has, moreover, resources and skills that uniquely qualify it to initiate this transition towards a sustainable society where a balanced use of resources and other societal goals are achieved. Potential disincentives and obstacles can, we believe, be overcome with appropriate education and fiscal and policy measures. [11]

A circular economy is about stock optimization. New metrics to measure changes in the quantity and quality of stock—wealth in the form of manufactured capital stock, but also of health, education and skills—are needed to manage stock. We know how much money governments spend on building schools and employing teachers, but we do not know if as a result the students are better prepared for life. The stock of buildings in a given country and their qualitative
junction 1: product-life extension versus new goods
cost advantage product-life extension

MANUFACTURING

RESOURCES → BASE MATERIALS

UTILIZATION → WASTE

1

reuse and remarketing

junction 2: virgin materials versus recycling materials
cost advantage virgin materials

loop 2: recycling of materials    loop 1: reuse of goods, repair of goods, reconditioning of goods, and technological/fashion upgrading of goods

Figure 1. The main loops of a circular economy (adapted from Stahel & Reday-Mulvey [4]).

conditions (thermal insulation, annual energy consumption) are not known, nor the residual service-life of infrastructure or technical equipment—which makes a national stock and thus wealth management difficult.

(a) The economic logic of loops

Turning the linear industrial economy into a loop or circular economy is, by definition, reducing the economic importance of resource extraction and waste management, and also reducing the environmental impairment caused by these industrial sectors. This change of focus from a linear throughput to a stock management opens opportunities in three loops of different characteristics, which are described in this section and shown graphically in figure 1: (i) a reuse and remarketing loop for goods, (ii) a loop of product-life extension activities of goods, and (iii) a recycling loop for molecules (secondary resources).

A circular economy is characterized by a number of principles which do not exist in the linear industrial economy. Policymakers and economic actors of the manufacturing economy therefore do not know them, nor their impact on the economy.

(i) Principle 1: the smaller the loop (activity-wise and geographically) the more profitable and resource efficient it is

Activity-wise, this means ‘don’t repair what is not broken, don’t remanufacture what can be repaired, don’t recycle what can be remanufactured’ (loop 1), and geographically ‘the small loops (reuse, repair and remanufacture) are best done locally or regionally’, avoiding packaging and transport costs, and, if ownership is maintained, avoiding multiple transaction costs.

Recycling—the large loop 2—is by contrast a global business based on the principles of industrial production, such as economies of scale, specialization and employing the cheapest labour, and an activity whose efficiency is restrained by entropy (the second law of thermodynamics), material complexity (alloys, leading to down-cycling) and abuse. For instance, sending used electronic goods to Africa for remarketing but ending up in cheapest and most polluting ‘incineration-recycling’. The Basel Agreement allows exports of used goods for remarketing, but forbids exports of wastes.
(ii) Principle 2: loops have no beginning and no end

The concept of maintaining value, quality and performance of goods through stock management replaces the concept of value added in the linear economy; the values preserved include the materials, water and greenhouse gas (GHG) emissions embedded in the goods.

Utilization, usage or replacement value replaces the concept of residual or depreciation value in the linear economy. The loops remain transparent; new economic actors can enter at any transaction point.

(iii) Principle 3: the speed of the circular flows is crucial: the efficiency of managing stock in the circular economy increases with a decreasing flow speed

Material recycling of such short-lived goods as beverage cans leads to fast circular flows and a rapid loss of the material stock (the ‘reversed resource compound interests’): 50 per cent recycling means 50 per cent of the original material is recycled in the first cycle, 25 per cent in the second cycle, 12.5 per cent in the third etc. This means the total loss of the original material in a short time.

Reusable glass bottles used for mineral water in Switzerland, by contrast, are refilled 27 times, corresponding to a product-life of one and a half years, before being recycled. This success may partly be due to the fact that the bottles are used within a deposit scheme.

The most profitable and resource-efficient business models of a circular economy—the lake economy of fleet management and selling goods as services—operate with a slow flow speed in a regional economy to maximize profits.

A speed differential of a different kind exists between remanufacturing in the circular economy and manufacturing in the industrial economy: all but two of the battleships sunk at Pearl Harbor were remanufactured and recommissioned within one year and contributed to win the war in the Pacific. The shipyard and steelmaking capacity to build new ships to replace the losses was simply not there, and would have taken much longer.

(iv) Principle 4: continued ownership is cost-efficient: reuse, repair and remanufacture without a change of ownership save double transaction costs

Retreading and regrooving used truck tyres is the norm. Tyre ownership remains with the fleet manager and retreading is done by a third-party contractor as a service. In the case of tyres sold as a service (tyre manufacturers selling tyre usage), tyre manufacturers have developed mobile workshops to provide an optimal on-site service to the tyre users. Extending the service-life of tyres at the lowest cost, according to the principles of the circular economy, or in this case the performance economy, increases the tyre manufacturer’s profits.

The case is different for used car tyres in industrialized countries, which are collected by waste dealers, and possibly sold to retreaders, which after extensive quality control and retreading sell them to individuals. However, most used car tyres are not retreaded or recycled as materials but incinerated in cement kilns. There are two reasons for this product-life abortion: state subsidies for incineration and the mistrust for retreaded car tyres by buyers doubting their quality ‘as good as new’. The fact that the tyres are a third cheaper than new ones of similar quality—despite the transaction costs—is reinforcing this belief, rather than taken as proof of a more sustainable solution.

(v) Principle 5: a circular economy needs functioning markets

In this aspect, the circular economy does not differ from the industrial economy; it needs efficient market places where supply and demand can meet. This concerns services for the service-life extension of goods, such as component repairs, remanufacturing and technological upgrading, as well as to remarket used goods and components.

Functioning markets are also needed to achieve the lowest cost. In the linear economy, goods are depreciated and, for instance, in the case of a liability insurance claim, reimbursed at the residual value; insurers have no interest in a functioning second-hand car market and a customer
who has shown a caring attitude will feel punished. In the circular economy, where quality of stock, not age, determines value, the insurer will have to replace the damaged good, for instance, a car, with a vehicle of similar quality and age, or pay the customer the replacement value. Insurers now have an interest in a second-hand market with a wide offer of cars of all ages and qualitative condition to minimize their payments for losses.

Service-life extension services to repair manufactured capital—vehicles, equipment, aircraft, ships, buildings and infrastructure—exist locally worldwide. Remanufacturing services for one-off jobs are also offered locally in urban areas; remanufacturing on an industrial scale, however, is done regionally to achieve a certain economy of scale—witness Caterpillar’s remanufacturing factories for diesel engines in the USA, UK and China.

Reuse and remarketing services for used mobile investment goods—vehicles, equipment, aircraft and ships—and buildings exist in most countries, and these goods have been traded on international markets for a long time. Cultural goods, such as paintings, antique furniture and artworks, have traditionally been repaired periodically and traded at auction houses.

Market places for used consumer goods have typically flourished through advertisements in local newspapers and at stationeries, as well as in flea markets. Their international remarketing, however, has only taken off with the emergence of electronic market places, such as eBay.

The remarketing of used goods and components by fleet managers is only picking up when they realize their key role in remarketing goods which they no longer need. Lufthansa is a pioneer in this respect, devoting half a page of its in-flight magazine (see the World-Time page) to advertise the fact that it sells used aircraft seats (during a D check, all seats and other fittings are changed for safety reasons). Instead of paying a recycler to destroy these seats, Lufthansa now receives money for the reuse of these seats in, for instance, theatres and cinemas—an example of the ‘new think’ necessary to fully exploit the opportunities of the circular economy.

(b) Impacts of sustainable taxation on the economy

Not taxing renewable resources including work and taxing non-renewable ones instead (i) speeds up the economic transformation from flow to stock optimization, (ii) broadens the application of the circular economy to new economic actors and new sectors, and (iii) increases the competitive advantage of existing economic actors of the circular economy.

The relevance of a circular economy to solving today’s problems is its high-labour but low-carbon and low-resource nature, its reliance on small and medium-sized enterprises and regional activities, and its objective of preserving existing manufactured capital with its embedded resources (value preserved).

At junction 1, used goods in the loop economy today already have a cost advantage of about one-third compared with new goods. Sustainable taxation will increase this comparative advantage in two ways, through lower labour costs in service-life extension activities and higher virgin material costs in competing manufactured goods.

At junction 2, taxing non-renewable virgin resources will make recycling—the reuse of molecules—more profitable for those materials where virgin resources today have a cost advantage. Furthermore, not taxing work will make the collection of end-of-life wastes (secondary resources) and sorting them into pure mono-materials cheaper, thus increasing the quality of secondary resources (by reducing down-cycling) and consequently the market prices for secondary (recycled) resources.

(c) Impacts of the circular economy on material efficiency

The key characteristics of a circular economy are its focus on stock optimization through value preservation and waste prevention [13], which enables it to provide ‘material services’ by extending the service-life of existing materials embedded in manufactured capital. The ultimate exploitation of existing materials is the business model of selling goods as services and maintaining resource ownership over the full product-life. It is detailed in §7.
3. A circular economy is about material and resource sufficiency and efficiency

This section presents new metrics to measure material efficiency, and quantifies the reductions in material consumption and emissions that can be achieved in the circular economy.

Stahel [14] showed that many different types of innovation to increase material efficiency exist in the circular economy, including technical, commercial and ‘utilization’ innovation. A longer utilization—long-life products, reuse and service-life extension of goods and components, as explained in this paper—is one option. A more intensive use of goods is another utilization innovation to achieve a higher material efficiency, for instance, through shared utilization (together, public transport) or serial utilization of goods (one after another, washing machines in self-service laundries and rental cars). These options need a ‘new relationship with goods’ and were extensively discussed in the early 1990s [15] but are only now finding a real interest on both the supply and demand side, for example, in car-sharing initiatives.

New metrics are needed to measure material efficiency in relation to other factors. Stahel & Zlotopolsky [16] developed the energy capital per unit of performance (ECUP) ratio to judge the engineering performance of different building materials (in kp cm$^{-2}$) related to the energy invested in their production (in kWh m$^{-3}$). ECUP represents the energy capital necessary to withstand one tonne of tension or compression. Allwood et al. [9] have developed a number of metrics including an embodied energy per cubic metre ratio. But more comparative metrics will be needed to help engineers include energy and material efficiency in their decisions.

Two distinctively different types of resource efficiency govern the circular economy: loop 1 in figure 1 is about resource sufficiency in the reuse and service-life extension of manufactured capital, loop 2 is about material efficiency in recycling materials (molecules).

The strategies of loop 1 are product specific—re-refining engine oil, solvents and other products with a catalytic function needs a different approach from the service-life extension activities for buildings or mobile durable goods. The latter’s resource efficiency can be improved by modular system design, component standardization and other eco-design (design for environment) approaches which are now well known and documented, for instance, by Charter & Tischner [17]. Some examples for the savings in resource consumption and reductions of environmental impairment achievable in extending the service-life of durable goods are given in §3a,b.

The strategies of loop 2 are material-specific—metals, ceramic materials and plastic use processes of physical and chemical recycling often derived from manufacturing processes, as well as new processes such as the depolymerization of polymers. Materials with a low price/weight ratio, such as brick and concrete waste from demolishing buildings, are best crushed, using mobile equipment, for reuse as recycling concrete on-site for new constructions.

All materials come with a multiple backpack (rucksack) of mining waste [18] and environmental impairment. These backpacks differ for each material and are highest for rare metals such as gold (with a backpack of 500,000), lowest for plastics (with a backpack of 0.1). Manufactured capital in the form of infrastructure, buildings, goods and components has individual accumulated backpacks of all the materials and energies they embed, which have to be calculated individually.

Manufactured capital contains, in addition to the backpacks of the materials it is made of, the sum of the embedded energy and GHG emissions as well as the embedded (virtual) water of the manufacturing steps from basic materials into finished goods and up to the point of sale.

The reuse, remarketing and service-life extension activities in a circular economy preserve the mining backpacks of water and energy inputs and related GHG emissions in the manufacturing chain up to the point of sale, which are embedded in the finished goods. In addition, they also prevent the environmental impairment of the material recycling and/or waste management processes. The exact percentages of preserved materials and emissions are substantial and vary between types of goods; two microeconomic examples can give an idea of the orders of magnitude achievable.
While loop 1 (reuse, repair and remanufacturing) preserves the mining backpacks of the basic material and the embedded energy and virtual water of the manufacturing phase of goods, loop 2 (material recycling) mainly preserves the backpacks of the basic materials. In a few cases, such as aluminium, recycling also maintains a major part of the embedded energy.

(a) The redesign of the German high-speed (ICE 1) trains [19]

The 59 ICE1 high-speed trains of the German Railways clocked up 15 million km each in the first 15 years of operation. The railways then decided to remanufacture and technologically upgrade the trains to bring them to state-of-the-art quality.

The cost of the redesign was €3 million per train, compared with procurement costs of €25 million for a new train. In addition, the redesign saved social costs of €1 million on a global level, taking into account the analysis of the Stern report.

The redesign conserved 80 per cent of materials and embedded water and energy—a total of 16 500 tonnes of steel and 1180 tonnes of copper—and prevented 35 000 tonnes of CO$_2$ emissions and 500 000 tonnes of mining waste backpacks. The redesign included a technologic upgrading of the trains and an increase in the number of seats. Each seat now offers individual power outlets and Internet connection.

This analysis did not take into account the sufficiency aspects of service-life extension, such as the prevention of environmental impairment in the phases of waste management and material recycling, which would have been realized if the trains had been replaced by new ones, nor the water consumption of these processes.

(b) Macroeconomic studies on the material efficiency of the circular economy

A sectorial study on industrial ecology savings by Smith & Keoleian [20] on restoring used automotive engines to a like-new condition showed lower economic costs (30–53%) and much lower environmental costs, compared with manufacturing engines.

Raw material consumption was down by 26–90%, waste generation by 65–88%, energy consumption by 68–83%. Emissions were also considerably lower: carbon dioxide (CO$_2$) emissions by 73–78%, CO by 48–88%, NO$_x$ by 72–85%, SO$_x$ by 71–84%, non-methane hydrocarbons emissions by 50–61%.

Another macroeconomic approach, based on the UK input–output model to calculate the prevention of CO$_2$ and GHG emissions in a circular economy, was used in a study for the UK Waste Reduction Action Plan [21]. It concluded that a circular economy could reduce UK national GHG emissions by 800 million tonnes annually. By comparison, the German law for energy feed-in tariffs to promote solar electricity has achieved an annual reduction of 100 million CO$_2$ emissions.

(c) Impacts of sustainable taxation on material and resource sufficiency and efficiency

Taxing the consumption of non-renewable resources provides financial incentives for economic actors to minimize resource consumption, losses and waste. Water and energy savings as well as waste prevention become profitable activities that impact the financial bottom line of corporations and to a rising degree if resource prices continually rise.

At junction 1, not taxing work as a renewable resource favours the reuse, repair and remanufacturing activities of the circular economy, which remanufactures worn components instead of producing new ones from virgin materials. This achieves a substantially higher material efficiency than manufacturing new components from virgin or even secondary resources.

In addition, the regional nature of the circular economy, in comparison to global manufacturing chains, substantially reduces the transport energy involved.

At junction 2, many used materials today have a higher price than virgin materials, because of a ‘Catch-22’ situation: the recycling of high-quality high-price material needs labour-intensive sorting into clean mono-materials, in order to achieve the highest prices in the secondary
resource markets. Alternatively, mass recycling can be done using machines but leads to
down-cycling (lowest grade material) and mixed secondary resources, which fetch a low market
price [22].
A sustainable taxation therefore promotes high-quality labour-intensive approaches by
lowering the labour cost in sorting used material, and simultaneously raises the price of
non-renewable virgin materials at junction 2 of the circular economy.

(d) Impacts of sustainable taxation on non-renewable material consumption

Taxing non-renewable resources should create virtuous loops of using materials more efficiently
to save money, and thus reduce consumption. A recent study has shown that taxes on natural
resources do reduce the use of raw materials. The study investigated how taxes on virgin raw
materials used in construction, such as gravel and sand, have reduced the use of these resources,
based on experiences in Denmark, Sweden and the UK. However, the study also suggests that
greater incentives to recycle these materials are still needed [23].

4. A circular economy is about an intelligent use of human labour—job
creation in a regional economy

This section explains why human labour—work—is different from the other renewable resources:
creative, versatile and adaptable, able to be educated but perishable if unused. The circular
economy needs workers familiar with past technologies and thus offers jobs for ‘silver workers’.

Roughly three quarters of all industrial energy consumption is associated with the
extraction or production of basic materials like steel and cement, while only about one
quarter is used in the transformation of raw material into finished goods such as machines
and buildings. The converse is true of labour, about three times as much being used in the
conversion of materials to finished products as is required in the production of material.

(a) The labour intensity of the circular economy

The reuse, repair and remanufacturing activities of the circular economy resemble the phase of
the manufacturing economy which transforms basic materials into finished goods. Before robots
replaced human labour in production, this phase was low-energy but labour-intensive.
But even compared with the traditional manufacturing process, the labour input of the circular
economy is higher as (i) its economies of scale are limited in geographical and volume terms
and (ii) remanufacturing comprises additional steps of dismantling, cleaning and quality control,
which are absent in manufacturing.

No estimations exist on the impact of a circular economy on a national labour market. The
not to give such estimations because the economic models available to McKinsey do not allow
such a calculation.

Few case studies on the substitution of manpower for energy through a long-term utilization
of goods have been done, except for a number of vehicles up to 30 years by the Geneva-based
Product-Life Institute [24]. Academic research has focused on prospective life cycle analysis, but
not on real cases, probably because of the time lag involved (who wants to do a PhD over a period
of 30 years?).

(b) Human labour as a resource

Employment is at the heart of the social pillar of sustainability. Furthermore, substituting labour
for other resources is also an intelligent solution for reasons which are inherent in human
labour—it is the only renewable resource with a qualitative characteristic. Work is the most versatile and adaptable of all resources, with a strong but perishable qualitative edge: (i) it is the only resource capable of creativity and with the capacity to produce innovative solutions and (ii) human skills deteriorate if unused—continuity of work and continued learning are necessary to maintain skills and upgrade capabilities. A person who has been unemployed for a few years risks becoming unemployable.

People at work are a desire for nation states. Governments invest on average 10 years in education and vocational training to teach young people marketable skills, and unemployment—wasted human resources—represents a high cost to governments and a lost opportunity for the national economy. In addition, labour is a zero-carbon energy; human CO₂ emissions are the same for working and unemployed people.

Furthermore, governments should give priority to human labour in resource use because a barrel of oil or a ton of coal left in the ground for another decade will not deteriorate, nor will it demand social welfare, and not taxing labour reduces incentives for black labour in the shadow economy and thus reduces the costs for governments to monitor and punish abuses.

Schumacher [2] went even further in chapter 1 of his book: ‘All history—as well as current experience—point to the fact that it is man, not nature, who provides the primary resource: that the key factor of all economic development comes out of the mind of man’. Schumacher goes on saying that progress comes through education: ‘in a very real sense, therefore, we can say that education is the most vital of all resources’.

(c) Impacts of sustainable taxation on employment

Not taxing labour as a renewable resource creates virtuous loops, which boost job creation, employment and occupation in all forms and in all labour-intensive economic sectors, including those involving caring or using local renewable resources, such as biological and organic agriculture, food from oceans, regional production of wooden furniture, wool textiles and leather shoes and goods.

As the knowledge and know-how of past technologies are necessary for retrofitting infrastructure and equipment, extending the service-life of equipment creates meaningful employment opportunities for ‘silver workers’, people beyond the traditional age of retirement. Continued (part-time) employment then provides a ‘fourth pillar’ of revenue to complement income from pension schemes and savings, whose future is uncertain (‘The Four Pillars’ is a research programme running since 1986 of the Geneva Association, http://www.genevaassociation.org/Research_Programme/Four_Pillars_Pensions.aspx).

(d) Impacts of job creation in a regional economy on material efficiency

Technological progress changes skills as much as goods. Maintaining manufactured capital also means maintaining the crafts and know-how that go with it: the upkeep of mediaeval cathedrals is only possible by masons capable of working dimension stone; driving old-timer cars also relies on mechanics capable of tuning a Solex carburettor; operating and maintaining electromechanical control rooms of hydroelectric power stations needs experts with the knowledge of electromechanical equipment.

The combination of maintaining technical skills and know-how and manufactured capital will enable a longer term exploitation of the opportunities of the circular economy, with a corresponding increase in material efficiency.

5. A circular economy is about caring

This section shows why the circular economy needs and creates a caring attitude to preserve the quality and value of existing stock; metrics are necessary to measure variations in wealth, which is a variation in the quantity and quality of stock.
One of the objectives of a circular economy is to preserve the quality, performance and value of the existing stock, wealth and welfare. This certainly concerns manufactured capital, such as buildings, infrastructure, equipment and goods.

Stock management needs statistics and metrics to measure the variations of wealth owing to variations in the quality of stock. GDP is a flow metric, ignoring if our wealth—the stock—has increased as a result of the flow. This situation has been compared with a bath tub where only the inflow of hot and cold water is measured, but the outflow and the water level are ignored [25].

And stock management includes people’s skills, education and health, knowledge and know-how. Preserving culture is also linked to stock, not flow management; maintaining the UNESCO world heritage sites, museums and examples of technological achievements will all profit from the shift in taxation towards the non-taxation of renewable resources. And caring is a high-quality world: Stradivari instruments and expensive watches do not live forever by design, but through periodic remanufacturing, motivated by caring.

Caring is a key characteristic of managing stock—caring for keeping up existing values and qualities. Most car owners will credit the manufacturer of their vehicle for its continued reliable functioning, rather than their mechanic who provides the maintenance and repair services. A change in popular values and beliefs would multiply the perception of caring as a pillar of the (circular) economy. The fleet of vintage and old-timer cars in the UK could be a point in case.

(a) Impacts of sustainable taxation on caring

Sustainable taxation will reduce the costs of activities involving ‘caring’ and also help in understanding the link between caring and our relationship with goods, which in turn might increase the number of activities involving human creativity in the circular economy.

(b) Impacts of caring on material efficiency

Stock optimization depends on high-quality operation and maintenance services, which are influenced by caring, visible in a husbandry and careful use of manufactured capital. This in turn increases material efficiency by reducing, for instance, material wastage (repair instead of replace).

6. Retained ownership of goods and embedded material provides future resource security

This section looks at why selling goods as service, or performance, is the most profitable and resource-efficient business model of the circular economy. By focusing on systems solutions, it internalizes the cost of risk and of waste; by retaining the ownership of goods and the embedded resources, it creates a corporate and national resource security for the future.

Many economists have a problem accepting that this is a discontinuity in traditional economic business models, and look at the sale of performance as an extension of the aftermarket [26].

Economic actors retaining material ownership over the full life of their products gain a future resource security but accept a liability for the performance of their goods. Such a performance economy [27] is based on the triple objectives of more growth and more jobs in combination with substantially reduced resource consumption. This triple objective can be achieved through three new business models: producing performance, selling performance and maintaining performance over time.

Success is measured using two new metrics in the form of absolute decoupling indicators: value per weight (UK£ kg$^{-1}$) and labour-input per weight (man-hours kg$^{-1}$).

In the performance economy, providing materials services can be achieved, for instance, by building residential housing without capital. The developer rents all material and equipment from the manufacturers, say over a period of 50 years, who in return receive a yearly rent, financed
by the rental income from the apartments. As the manufacturers have to give a 50 year guarantee for their material, they will make sure that the most appropriate material is used and applied correctly (renewable urban space initiative, see [27, p. 156]).

(a) Retaining ownership of goods and embedded resources by selling performance

Selling performance differs according to the characteristics of products and is widely present in today’s economy: selling goods as services by operating private and public networks (railways, telecoms, motorways, airports); chemical management services and rent-a-molecule; energy management and integrated crop management services; rental and operational leasing of real estate; selling custom-made indoor climate for energy companies; private finance initiatives as a strategy to sell the utilization of infrastructure according to the ‘consumer pays principle’, such as the French and Italian toll motorways; facility management of real estate and industrial plants; textile leasing (professional attire, hotel and hospital linen). These are but a few examples of the business model of selling performance.

In the 1990s, Stahel [28] called the concept of selling performance ‘the functional service economy’. This term is still used in French (l’économie de fonctionnalité) as a translation of the performance economy. The term was chosen because selling goods as services in the beginning focused on the function of investment goods, in contrast to fashion for selling consumer goods, also referred to as tools and toys. Today, the business model also includes renting fashionable consumer goods, taking the waste out of fashion (e.g. websites to rent ladies’ handbags).

Selling performance is the most profitable and most material-efficient business model of the circular economy, as it is built on exploiting the small loops. It focuses on utilization optimization and exploits resource efficiency as well as sufficiency and prevention options to gain financial advantages and higher competitiveness. Water and energy savings as well as waste prevention now become profitable activities that positively impact the financial bottom line of corporations. Whereas in the industrial economy, sufficiency and prevention options during the utilization phase of goods present a loss of income, and are thus undesirable.

For the same reason, the focus of industrial design shifts from products to designing systems solutions in order to achieve more profitable sustainable solutions. Xerox’s business model of selling customer satisfaction instead of copiers was a precursor of this strategy and was chosen by the Harvard Business School [29] as the first case study on the functional service economy; the case study was titled ‘Xerox: design for the environment’. Xerox is an excellent example that a leap in resource efficiency can be achieved by shifting from ‘design for environment’ to ‘designing sustainable solutions’, a strategy promoted by Stahel [5,6].

(b) Selling the performance of goods implies internalizing the costs of risk and of waste

Selling performance, results, utilization, services instead of goods means that economic actors

(i) internalize the cost of risk and of waste and

(ii) retain the ownership of goods and embedded resources.

By comparison, the industrial economy maximizes its profit by externalizing the cost of risk and of waste. After the point of sale, it offers a warranty for a limited period of time and limited to manufacturing defects. A liability for goods beyond the point of sale was only imposed recently, in the cases of the tobacco industry (liability for health impairments from cigarette smoke) and the asbestos industry (under an extended liability for workers’ health and safety). Since the beginning of the third millennium, there has been a generalization of liability claims, such as class action suits. According to Richard Murray, an expert in this field, society is confronted with a situation of accelerating ‘liability dynamics’. The next case could well be a liability of local CO\textsubscript{2} emitters.

\textsuperscript{1}Dr Richard Murray is a consultant on liability dynamics and other liability issues to a number of organizations including the Geneva Association (http://www.genevaassociation.org).
for global climate change. By internalizing the cost of risk and the cost of waste, economic actors selling performance have an economic incentive to prevent any future liability after the point of sale.

Furthermore, in times of rising resource prices as forecast (see the next section), corporations retaining ownership of their goods and embedded resources over the full life of their products gain a high future resource security and resource price guarantee and a competitive cost advantage against throughput-based competitors, according to the motto: ‘the goods of today are the resources of tomorrow at yesterday’s prices’.

(c) Buying performance as new green public procurement policy

On the demand side, the equivalent strategy to selling performance is buying performance. Buying goods as services creates the same resource efficiency advantages and can be regarded as a new green public procurement policy. Buying services instead of hardware is the preferred procurement option of parts of the US administration, such as NASA and the Pentagon, and has sparked a number of innovative start-up companies. NASA now buys exclusively orbital services from companies such as Space-X; the space shuttle was the last NASA-owned and operated hardware to provide Earth orbit services.

Michelin provides tyre-use services to all parts of the US armed forces: for aircraft tyres, a fee per landing is charged; vehicle tyres pay a fixed fee per 100 miles. This service of ‘pay by the mile’ is now also offered to French and US fleet managers of lorries, using a business model of mobile tyre service workshops to make tyres last as long as safely possible (http://www.michelintruck.com/michelintruck/services/MichelinFleetSolutions.jsp).

(d) Impacts of sustainable taxation on retained ownership and selling performance

Retaining resource ownership is best done by selling performance, which means reaching down to the customer in a local context, which is a labour-intensive business model. Not taxing work thus has a positive impact to foster a generalization of this business model.

Taxing the consumption of non-renewable resources will give corporations retaining the ownership of their products, and applying good resource husbandry and waste prevention, a financial bonus and increase their competitiveness.

(e) Impacts of retained ownership and selling performance on material efficiency

In a performance economy, the price per service unit is contractually fixed. The motto therefore is ‘to increase your profit, decrease your losses’. By internalizing the cost of risk and of waste, economic actors have strong economic incentives to prevent losses and waste, to promote sufficiency and loss and waste prevention, and to minimize resource consumption through reuse and service-life extension activities. All of these approaches inherently increase material efficiency.

7. Policy for material efficiency: the role of sustainable taxation and sustainable framework conditions

This section defines the sustainable tax and how it influences material consumption. The proposed sustainable tax offers a way out of the present transition period of contradictory policies. The circular economy substitutes manpower for energy and material; sustainable taxation is a powerful lever to accelerate its spreading throughout the economy.

Sustainable politics should build on simple and convincing principles, such as ‘do not tax what you want to foster, punish unwanted effects instead’, and it should promote solutions with an embedded sustainability. Ideally, sustainable solutions create self-reinforcing virtuous circles, which guarantee their longevity.
(a) Sustainable taxation

Not taxing renewable resources including work and taxing non-renewable ones instead would create virtuous self-reinforcing circles, by creating incentives to work more (no penalty for higher income) and by creating more wealth from less new resource input (increasing caring in resource use including long-term resource ownership).

Sustainable taxation should reward desired developments and discourage unwanted effects of activities. In a sustainable economy, taxes on renewable resources including work—human labour—are counterproductive and should be abandoned. The resulting loss of state revenue could be compensated by taxing the consumption of non-renewable resources in the form of materials and energies, and of undesired wastes and emissions. Such a shift in taxation would promote and reward a circular economy with its local low-carbon and low-resource solutions. These are inherently more labour-intensive than manufacturing because economies of scale in a circular economy are limited. Taxes on non-renewable resources could be charged in a similar way to today’s value added tax (VAT), also for imported goods.

Economic success does not depend on income taxes. Florida and Texas, the new powerhouses of the US economy, are two of the eleven US states that do not tax labour income; other nations and states have economic problems despite heavily taxing human labour. Germany receives one-third of its total tax income from labour (wages), another third from VAT, but less than 10 per cent from non-renewable resources.

And not taxing human labour would considerably reduce tax administration—labour tax is based on a large number of small incomes—and reduce incentives for black work in the shadow economy, which accounts for a double-digit percentage of many national GDPs.

The intelligent use of human labour has traditionally been discouraged through taxation, whereas the waste of it has been ‘encouraged’ in some industrialized countries through generous welfare. This shows that the role of work as a renewable resource in the economy has been misunderstood by policymakers.

Past initiatives for a more environmental and social taxation have been promoted for some decades by socialist politicians gathered in the Ökosoziale Marktwirtschaft especially in Germany and Austria. Also compare von Weizsäcker et al. [30], Ekins & Speck [31] and Rechsteiner [32]. As most of these initiatives have a ‘green-socialist’ flavour, they were never adopted by a political majority or a majority of economists (see Sinn [33]).

The present proposal is based on sustainability and the clear distinction between renewable and non-renewable resources, which is not politically biased, and on a fair treatment of labour as a sustainable resource. The redistribution effect of present labour taxes and other governing issues can be solved using other mechanisms.

Schöb has pointed out that the sustainable taxation proposed in this paper does not directly help the unemployed nor the retired. The economic situation of these people would be better served by a guaranteed minimal income scheme, proposed, for instance, by Ekins [35] 30 years ago. Sustainable framework conditions are therefore not limited to the proposals in this paper.

(b) Sustainable framework conditions

The forerunner of a policy framework promoting the circular economy is in the 2008 EU Waste Directive [36]. In chapter I, article 4, it defined the new waste hierarchy of:

(i) Prevention: measures taken before a substance, material or product has become waste, including through the reuse of products or the extension of the life span of products (including waste oils), i.e. repair, remanufacturing, reuse: any operation by which

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2 Forum Ökologisch-Soziale Marktwirtschaft e.V. (FÖS), Green Budget Germany, Berlin (http://www.foes.de).

3 Dr Ronnie Schöb, Professor at the School of Business and Economics, Chair of International Public Economics, Freie Universität Berlin. Presentation at the Zeppelin University Friedrichshafen, Germany, on 23 March 2012. For a list of his publications, see http://ideas.repec.org/e/psc185.html#top.
products or components that are not waste are used again for the same purpose as originally.

(ii) Preparing for reuse: checking, cleaning or repairing recovery operations, by which products or components...are prepared so that they can be reused. Reuse and repair networks: Member States shall take measures to promote the reuse of products and preparing for reuse activities.

(iii) Recycling.

(iv) Other recovery, e.g. energy recovery.

(v) Disposal.

For the first time, lubrication (engine) oils are included in the 2008 Waste Directive and no longer treated in separate legislation. They are thus subject to the same priorities of reuse and service-life extension, for instance, through re-refining.

Priorities (i) and (ii) correspond to the smallest and most profitable loops of the circular economy (see figure 1), which also have the highest material efficiency—a perfect marriage of economy and ecology.

Furthermore, sustainable framework conditions should treat the circular economy on its own merits, by

(i) not charging VAT on such value preservation activities as reuse, repair and remanufacturing, with the possible exception of technologic upgrading activities. Major re-marketing activities, such as flea markets and eBay, are already de facto exempt from VAT and

(ii) giving carbon credits for the prevention of GHG emissions, not only for their reduction. The small loops (figure 1) constitute a prevention of GHG emissions (and waste) but receive no carbon credits under any of the existing or planned GHG emission programmes, such as the Kyoto Protocol, which are based on the linear thinking of the industrial economy: first pollute, then reduce pollution to receive carbon credits!

(c) Transition periods

Transition periods are characterized by a contradiction of old and new policies, such as waste legislation and economic growth imperative: the 2008 EU Waste Directive prescribes the priority of waste prevention (through reuse and extension of service-life of goods), whereas the growth imperative drives policies such as ‘cash for clunkers’ (subsidies for the destruction of cars in working order under the condition of purchasing a new car).

Another contradiction has been quantified in a recent study by the Organization of Economic Co-operation and Development (OECD), Paris and the International Energy Agency, Paris [37]. Governments and taxpayers spent about half a trillion US dollars in 2010 supporting the production and consumption of fossil fuels. Removing these inefficient subsidies would reduce national spending and GHG emissions. ‘As governments look for policy responses to the worst economic crisis of our lifetimes, phasing out subsidies is an obvious way to help governments meet their economic, environmental and social goals,’ said OECD Secretary-General Angel Gurría when presenting the report to the press. Annual fuel subsidies in the EU amount to €56 billion, according to Janez Potocnik.4

(d) The impacts of sustainable taxation on public policy

Sustainable taxation could be an elegant and future-building way to exit the present transition period with its contradictory policies and create a stable new economic base by promoting the low-carbon low-resource circular economy.

This change is facilitated by the fact that a circular economy needs no subsidies, in contrast to many ‘green’ technologies, and no detailed regulation; and it lowers consumer prices and thus dampens inflation.

(e) The impacts of sustainable taxation on material efficiency

Not taxing labour increases the competitiveness of labour-intensive activities of the regional circular economy compared with the global industrial manufacturing; regional activities mean less transport volumes and shorter transport distances in the processing chain.

Applying the principles of sustainability to the economy means decoupling wealth and welfare (stock) from resource consumption (flow). A shift in taxation from renewable resources including work to non-renewable ones will boost regional job creation, employment and occupation of all forms in labour-intensive industrial and service sectors. The competitiveness of labour-intensive activities in the circular economy will increase, leading to the adoption of corporate strategies of ‘repair instead of replace’ in, for instance, insurance. But sustainable taxation will also make other labour-intensive activities based on ‘caring’ cheaper and more accepted in society.

8. Why change to a sustainable taxation now?

A number of societal changes, which have taken place in the last decade of the twentieth century and the first decade of the twenty-first century, have made the shift from a global linear industrial to a regional circular economy increasingly interesting for industrialized countries. Some of them are sketched out in the following.

The linear industrial economy is best in overcoming situations of scarcity of food, goods and shelter. But in a situation of saturated markets, a circular economy is best suited to manage existing stock. In 1980, the market penetration for durable household goods in France was already above 90 per cent for all social classes [38]. In Germany, from 1995 onwards, the number of cars scrapped each year has roughly been the same as the number of cars newly registered. Continued production in saturated markets constitutes a substitution of, not an addition to, wealth, at the cost of ‘intensive and often inefficient use of resources’ [1].

For the last 100 years, resource prices for energy and material have constantly decreased; maintaining ownership of materials to assure access to future resources made little sense. At the beginning of the twenty-first century, this trend has changed, and it is expected that resource prices in the twenty-first century will constantly increase—a theory formulated by experts at the European Commission and prominently by the asset manager Grantham [39] who called it ‘the big paradigm shift’. Resource security could therefore become a major political bone of contention; and economic actors maintaining resource ownership will enjoy a certain guarantee of resource availability and price in the future, at the same time providing resource security for nations.

The increase in Germany’s GDP from 2000 to 2007 was €381 billion, which is the same figure as the increase in German sovereign debt in the same period, according to Uchatius [40]. GDP growth may thus not have been created by the economy but by the increase in sovereign debt. Austerity measures to reduce government spending without changing the foundation of the economy, to increase jobs and wealth (stock) instead of increasing growth (flow), might lead to prolonged economic and social problems. The situation in other industrialized countries may be similar—but growth was not in the centre of this paper.

Persistent unemployment in many countries is still above the ‘comfort level’, with the percentage of unemployed youth considerably higher than of the population as a whole. According to OECD [41] latest figures, EU youth unemployment is 20 per cent, and in Spain and Greece it is above 50 per cent. This constitutes a Damocles’ sword for societal development, and job creation has periodically been declared a political imperative in many industrialized countries in reaction to persistent unemployment.
The necessity to mitigate global climate change was mentioned at the 1972 UN conference in Stockholm, and recognized at the 1992 UN conference in Rio. GHG emissions have been identified by the UNFCCC as the main culprit; as well as the fact that they are partly human induced. The Kyoto Protocol was formulated to mitigate climate change and reduce CO\textsubscript{2} emissions. However, in 2011, GHG emissions were at an all time high and growing faster than the economy.

This paper has shown that the circular economy simultaneously increases future resource security, creates regional jobs at all skill levels and substantially reduces CO\textsubscript{2} emissions, by reducing resource consumption and thus raising material efficiency.

A sustainable tax policy of not taxing renewable resources including work constitutes a very powerful lever to accelerate, boost and generalize the circular economy and its positive impacts on resource security and regional job creation, while simultaneously reducing GHG emissions, as summarized in figure 2.

To summarize, the present economy is not sustainable with regard to its per capita material consumption. A dematerialization of the economy of industrialized countries can be achieved by a change in course, from an industrial economy built on throughput to a circular economy built on stock optimization, decoupling wealth and welfare from resource consumption while creating jobs in a number of economic sectors. The shift to a tax system of not taxing renewable resources including human labour—work—but taxing non-renewable resources instead is a powerful lever to shift to a durable circular economy by creating virtuous self-reinforcing circles that give people incentives to work more and by creating more wealth from less new resource input.

I am most grateful to Professor Roland Clift (CBE) and the Faculty of Engineering and Physical Sciences at the University of Surrey, who in 2005 nominated me as Visiting Professor. This has given me the opportunity to present and discuss my ideas in an informal and challenging environment with students and fellow professors.

\textbf{Figure 2.} Sustainable taxation will promote the circular economy which in turn boosts resource security, regional job creation and the prevention of GHG emission.
16. Stahel WR, Zlotopolsky S. 1976 Final report on energy in construction (ECUP ratio). A report to the Battelle Memorial Institute, Columbus, OH, USA.

The number of self-citations is explained by the fact that the author was for a long time ‘a fool on the hill’—you cannot step into the footprints of your predecessors if you are a pioneer.