# Circular Economy and Employment

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# I. Circular Economy as one of the main Elements of Greening an Economy, Green Growth and Eco-Innovation (WP 1)

In the following, we analyze the main definition elements of a circular economy with their relationships to other concepts, such as green growth and eco-innovation.

The circular economy principally focuses on savings on the shares of material, labor, energy, and capital embedded in the product. In finite systems, it is intended to design out waste and material (Ellen MacArthur Foundation 2013a and b, 2014). An important difference is made between consumable (one or few times usage) and durable (years of usage) products. In a circular economy, consumable products shall principally consist of biological ingredients that can be easily returned to the biosphere. Moreover, they satisfy basic needs, such as food, water and energy. It is important to note that a circular economy only works if the consumption of these goods is not faster than the regeneration of materials. Durable products are made out of mineral and non-mineral materials which are non-regenerative, such as housing, cars, electronic equipment and so forth. In a circular economy, it is crucial that the raw material of durable products retains its value through multiple usages and does not cause any negative externalities or leakages in its use (Ellen MacArthur Foundation 2013a, Rossé 2015). Regarding durables, households are supposed to change their role, not being a consumer any longer but a mere user of the product. Savings of raw materials within durable goods may be achieved by recycling, refurbishment, remanufacturing, reusing or by substituting a less wasteful product. In fact, these concepts have been already discussed in the eighties (see for instance Faber et al. 1988) and have been applied with more or less success. More recently, new ways of achieving a circular economy are explored and analyzed. The general digitization of the economy may also result in a reduction of material and energy use. In a recent study, Rexhäuser et al. (2014) find that an increase of ICT capital is associated with a reduction of energy demand. The substitution of printed photos by solely digitally distributed ones or electronic newspapers serves as a further example. The so-called "sharing economy" (Heinrichs 2013) also promotes the realization of a circular economy. As an example, car sharing may result in a higher utilization rate of cars and thus in less material consumption. In general, a greater relative importance of the service sector may also lead to a reduction of energy and material.

In comparison to the approach of a circular economy, the terms "green growth" or "greening of the economy" denote broader concepts. The OECD (2011:4) defines green growth as follows: "Green growth means fostering economic growth and development, while ensuring that natural assets continue to provide the resources and environmental services on which our well-being relies. To do this, it must catalyze investment and innovation which will underpin sustained growth and give rise to new economic opportunities."

The UNEP (2011) and the World Bank (2012) even broaden this concept by including a social dimension: "A green economy is one that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities. In its simplest expression, a green economy can be thought of as one which is low carbon, resource efficient and socially inclusive." (EEA 2014:12)

Following these definitions, the EEA (2014:11) formulates three objectives of a green economy:

- Improving resource-use efficiency: A green economy is one that is most efficient in its use of energy, water and other material inputs;
- Ensuring ecosystem resilience: It also protects the natural environment, the structures of its ecosystems and flows of ecosystem services; and
- Enhancing social equity: It promotes human well-being and fair burden sharing across societies.

In line with the aforementioned OECD definition, the Green Growth Knowledge Platform (2013:3) emphasizes the role of "… innovations as a means of breaking with unsustainable growth paths." Furthermore, it accentuates the importance of "… the creation and dissemination of new, more environmentally sustainable technologies, goods, and services." Eco-innovations are therefore crucial for the realization of green growth. In a widespread definition resulting from the MEI (Measuring Eco-Innovation) project of the EU, "Eco-innovation is the production, application or exploitation of a good, service, production process, organizational structure, or management or business method that is novel to the firm or user and which results, throughout its life cycle, in a reduction of environmental risk, pollution and the negative impacts of resource use (including energy use) compared to relevant alternatives." (Kemp, Pearson 2008) This broad definition departs from the output of *all* innovation activities, including those that were not initially intended to improve the environment.

**Figure 1: Green growth and the circular economy: Drivers and relationships**

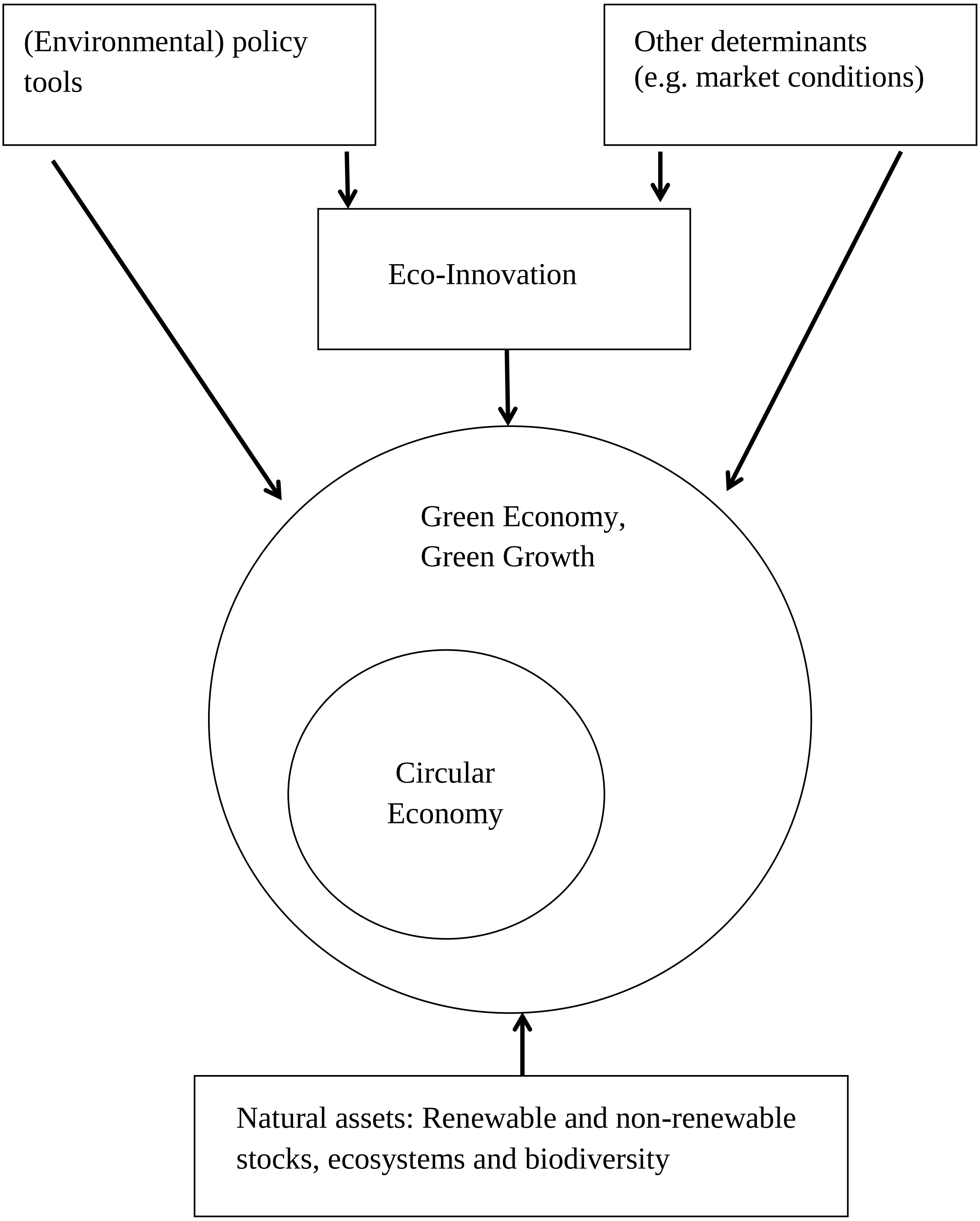



Figure 1 shows the relationships between eco-innovation, green growth, the circular economy and the role of regulation activities. According to the analyses of EEA (2014) and OECD (2015), moving towards a circular economy may be understood as a tool to achieve a green economy. A circular economy is one of the main elements of greening an economy. The circular economy "… refers mainly to physical and material resource aspects of the economy - fuel, minerals, water, biomass, etc. It does not place emphasis on human well-being or social inclusion rather it focuses on recycling, limiting and re-using the physical inputs to the economy, and using waste as a resource, leading to reduced primary resource consumption." (EEA 2014:11) Therefore, the circular economy may be understood as a subset of the green growth or green economy concept.

This may also be illustrated by considering the following classification of environmental fields:

- Prevention of water pollution, waste water treatment,
- Waste disposal, recycling,
- Prevention of air pollution, climate protection,
- Noise abatement,
- Removal of hazardous waste,
- Soil protection,
- Treatment of dangerous substances,
- Radiation protection,
- Nature protection, protection of species.

Whereas the green economy comprises all aforementioned fields, fields such as noise abatement, soil or nature protection are not in the main focus of a circular economy.

The green economy is based on the availability of natural assets (OECD 2011). At this point, the link to the sustainability concept becomes clear: If a green economy is able to fulfil the famous management rules (Daly 1996), shortly summarized by "keeping natural capital intact for future generations," then it may be described as sustainable.

With regard to the drivers of a green and circular economy, eco-innovation plays a crucial role as key determinant for a positive development. However, following the results of a broad empirical literature analysis (see e.g. Horbach et al. 2012), eco-innovation is highly dependent on regulation activities and different (environmental) policy instruments.

# II. Literature Overview of the Existing Studies on the Economic Effects of a Green (Circular) Economy with a special Focus on Employment Effects (WP 2)

**Structure**



## 1. Employment Effects of Green Growth from a Theoretical Perspective

### 1.1 Definition of Green Jobs (or "Circular Economy Jobs")

In a quite general formulation, the UNEP (2008:3) defines green jobs as "… jobs that help to protect ecosystems and biodiversity; reduce energy, materials, and water consumption through high efficiency strategies; de-carbonize the economy; and minimize or altogether avoid generation of all forms of waste and pollution." This definition seems to capture all relevant aspects, but it is not operational in terms of calculating green jobs. Following the OECD (2012), the definition of green jobs is still a work which is in progress since there are heterogeneous concepts. The so-called industry approach relies on counting jobs in the Environmental Goods and Services Sector (EGSS), but as this sector can also be defined in different ways, the estimations of the number of green jobs differ as well. Furthermore, a restriction to the EGSS does not consider the "green" employees using environmentally friendly processes and practices. Therefore, the International Labour Office (ILO) emphasizes the difference between employment in production of environmental outputs for consumption outside the producing unit and employment in environmental processes for consumption by the producing unit in its definition of “employment in environmental activities” (ILO 2013). Furthermore, the ILO (2012) introduces a more narrow definition of green jobs by adding a “decent work dimension” to the environmental dimension. In the sense of the ILO definition, green jobs include only employment in environmental activities that fulfil the conditions of decent work.

The European Commission (2012:4) focuses on the dynamic character of greening the economy and defines green jobs as: “…covering all jobs that depend on the environment or are created, substituted or redefined (in terms of skills sets, work methods, profiles greened, etc.) in the transition process towards a greener economy.” Following this definition, green jobs may be newly created (for instance, by increasing the renovation rate of buildings or carbon capture and storage technologies), created by substitution (electric cars replace traditional ones) or redefined (for instance, chimney sweepers as emission controllers).

## 1.2 Measuring the Employment Effects of the Green Economy

There are different concepts for measuring the employment relevance of a green economy. Gross employment focuses on the number of employees within the EGSS and related sectors. The aim of these studies consists of showing the quantitative importance of green employees in an economy without taking job losses of green policy into account. These gross employment effects can be divided in direct and indirect effects (see for instance Meyer, Sommer 2014). Direct employees belonging to the EGSS sector contribute to the production of environmental goods and services. As the EGSS needs intermediate goods from other sectors, it is also useful to calculate indirect employment effects via Input-Output analyses. Besides direct and indirect gross employment, induced green employment effects have to be considered as well. These induced jobs “… are created through additional consumer spending from direct and indirect job earnings.” (Meyer, Sommer 2014:7) The estimation of gross employment is beneficial in order to capture the scope and the importance of a green economy, but it is not able to assess the impact of environmental policy measures on overall employment in an economy. To answer such a question, a calculation of net green employment is necessary. Net employment effects account for the problem that environmental policy may create jobs, for instance in the EGSS, but these job gains are usually accompanied by job losses, for instance in fossil and nuclear energy production. A reason for this might be reduced consumption due to higher energy prices or job losses in other sectors. It may be the case that environmental policy leads to highly positive gross employment effects but in the worst case even to negative net employment. Net employment effects are frequently calculated by Computable General Equilibrium (CGE) or related models. Treatment effects models might offer a valuable alternative to these models.

**Specificities of the Measurement of Green Jobs in the CE**

The measurement of gross employment effects in the Circular Economy is only partially possible. On the one hand, the number of employees in the waste and recycling sector or in the car sharing sector is quite easy to count. On the other hand, "… employment in new technologies, business practices or shifts in professions that yield improved energy efficiency are difficult to separate from regular employment, as they occur in existing industries and achieve the same economic output and level of well-being but with less energy." (Meyer, Sommer 2014:6)

The OECD (2015:57) confirms this diagnosis: "Comparable information about the economic opportunities, in terms of jobs and competitiveness, arising from improved resource productivity remains scarce. This is because the dynamic aspects of resource productivity policies are difficult to capture statistically, and because many measurement efforts have been focusing on the waste management phase, rather than on the overall efficiency of the economy and of supply chains."

All in all, only parts (such as the recycling or the car sharing sector) of the employment effects of the CE may be directly captured by existing statistics and other available information, whereas the effects of less material or energy consumption may be estimated by CGE or similar models.

## 1.3 Eco-Innovation and Employment[1]

As eco-innovation is one of the main trigger factors for the development of a circular economy. An analysis of the resulting employment effects is essential. Eco-innovation can be defined as "… the production, application or exploitation of a good, service, production process, organizational structure, or management or business method that is novel to the firm or user and which results, throughout its life cycle, in a reduction of environmental risk, pollution and

[1] This section is partly based on Horbach, Rennings (2013).

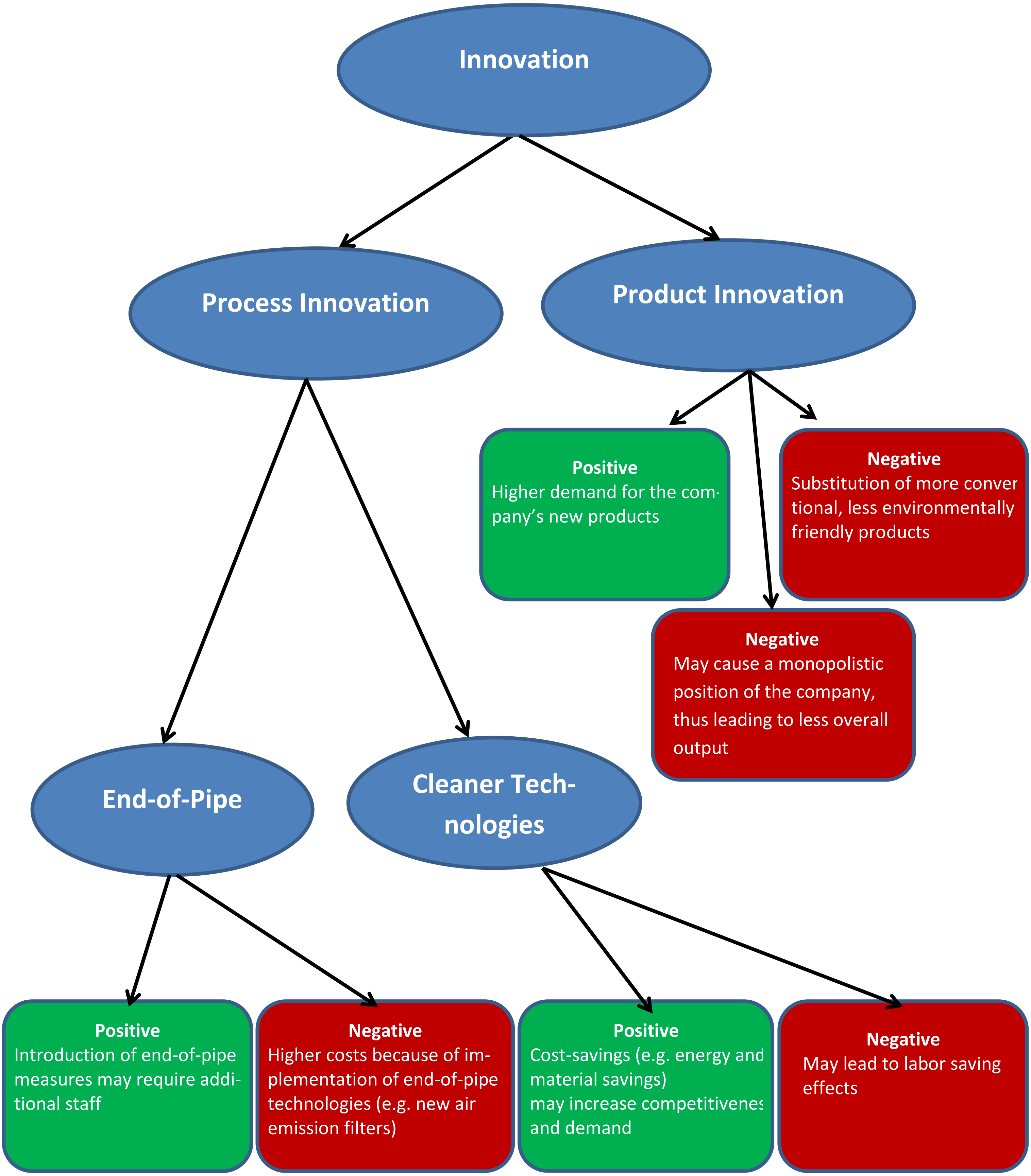
the negative impacts of resource use (including energy use) compared to relevant alternatives." (Kemp, Pearson 2008)

The relationship between (eco-) innovation and employment within a company strongly depends on the nature of innovation, especially between process and product innovation (see Pfeiffer, Rennings 2001 and Figure 2). Concerning process innovations, a further distinction between end-of-pipe and cleaner technologies is crucial.

Process innovations are often suspected for inducing negative employment effects (see for instance Edquist et al. 2001, Harrison et al. 2008). This might be the case if process innovations result in higher labor productivity within the company, accompanied by a given output. The case of environmentally oriented process innovations requires a more detailed argumentation by making a difference between end-of-pipe and cleaner technologies: Cleaner production technologies are integrated into the production process which often causes less pollution, material or energy savings (Frondel et al. 2007). These cost-savings may lead to an increase of factor productivity in total (including labor, capital and energy) of the company. It depends on the individual case whether the cost-saving process innovations also affect the share of labor of the corresponding production process. A higher efficiency of capital induced by cleaner technologies may lead to a substitution of labor by capital since labor becomes relatively less valuable to the company which is accompanied by lower wages. On the other hand, lower wages may moderate negative employment effects. Cleaner technologies may also be supported by organizational innovations and/or human capital growth. Then, the cost-saving effects may be achieved by recruiting more specialized and high qualified employees who are able to reorganize production processes in a more resource-efficient way.

All in all, depending on the specific cleaner production technology, a higher, constant or lower labor share is the potential result. In any case, an increase in total factor productivity caused by cleaner technologies strengthens the competitiveness of companies and thus may lead to positive employment effects by lower prices and a higher demand (see also Edquist 2001) which is also in line with the famous Porter hypothesis (Porter and van der Linde 1995).

**Figure 2: Employment effects of eco-innovation at the firm level**




Source: Based on Horbach, Rennings (2013).

On the other hand, we have to discuss the case of end-of-pipe oriented process innovations, for instance the introduction of an additional filter system for the production process. The construction, the installation and the maintenance of a filter system may require additional staff and thus result in positive direct employment effects. The indirect effect, however, may be negative since end-of-pipe technologies cause higher costs connected with a lower competitiveness and a decline of output and employment. All in all, the effects of environmental process innovations on employment remain an empirical question.

The employment effects of environmental product innovations also remain theoretically unclear. On the one hand, product innovations may induce new demand for the company's products if they create completely new markets or if they substitute products of competitors. In this case, the effect for employment at the company level is positive. On the macroeconomic level, the effect is not determined and depends inter alia on the labor intensity of the substituted products. Negative employment effects of product innovations may also arise as the introduction of the new product may cause a monopolistic position leading to a reduction of overall output (Hall et al. 2006).

## 2. Empirical Results: Different Strands of Literature

### 2.1 Gross Employment Effects of the Green Economy

Studies on gross employment in the green economy are already available for various countries (see Table 3 for examples, GHK 2009 and Bowen, Kuralbayeva 2015 for literature reviews). The different employment figures for several countries are hardly comparable due to different methodological approaches. Mere supply side approaches "count the heads" in the Environmental Goods and Services Sector without calculating indirect or induced employment effects. Furthermore, multi-purpose products, such as screws that may be used for environmental or other purposes, make the calculation of green jobs difficult. Demand-side approaches try to estimate all environmentally related investment and current expenditure. These figures are then used to calculate direct and indirect employment effects via Input-Output analysis. As the data on environmental expenditure is not exhaustive, for instance, the German "official" calculation of green jobs complements the results of the IO-analysis by a supply-side approach (Edler, Blazejczak 2014).

**Table 1: Methods for measuring the gross employment effects of the green economy**

| | **Supply-side approaches** | **Demand-side approaches** |
|---|---|---|
| Methods | Quantification of employees in the EGSS (production and services) | Estimating all environmentally related investments and current expenditures.<br><br>Measuring employment by the use of Input-Output analysis |
| Shortcomings | No indirect effects<br><br>Multi-purpose products | Environmental expenditure not fully covered by existing data leading to an underestimation of green jobs. |

Source: Own elaboration.

Unfortunately, studies on gross green employment only partially cover the circular economy, such as the waste and recycling sector and more recently the renewable energy sector. However, the employment effects of energy or waste saving measures or the digitization of the economy are not considered due to methodological reasons.

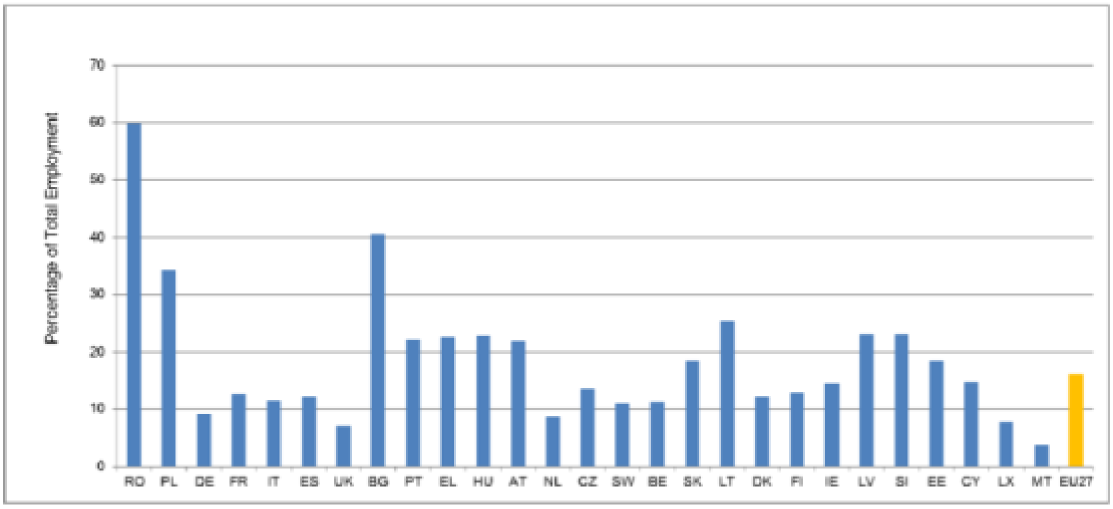
ECORIS (2012) updates the GHK (2009) study and calculates direct, indirect and even induced (by using multiplier analysis) green employment for the EU 27 (2008). The results (see Table 2) demonstrate a high importance of CE-related sectors, such as the waste or recycling sector. However, it is important to note that improving the performance of CE, for instance a drastic reduction of waste following the principle from “cradle to cradle,” might even result in a reduction of these figures. The ECORIS results are also separately available for all EU 27 countries (see Figure 3).

**Table 2: Total green employment figures for the EU 27**

| | Employment 2000 | Employment 2008 | Employment 2010 | Growth rate 2000 -2008 (per year) | Total growth 2000 - 2008 |
|---|---|---|---|---|---|
| Air | 33.668 | 30.816 | 29.598 | -1,10% | -8,47% |
| Wastewater | 390.138 | 418.324 | 417.002 | 0,88% | 7,22% |
| Waste | 1.111.613 | 1.361.160 | 1.339.923 | 2,56% | 22,45% |
| Soil & groundwater | 14.460 | 21.111 | 21.029 | 4,84% | 46,00% |
| Noise | 11.688 | 9.005 | 8.018 | -3,21% | -22,96% |
| Biodiversity and Landscape | 40.123 | 47.746 | 53.025 | 2,20% | 19,00% |
| Other | 144.861 | 180.399 | 177.309 | 2,78% | 24,53% |
| Water supply | 375.981 | 367.943 | 348.481 | -0,27% | -2,14% |
| Recycling | 238.774 | 425.373 | 480.056 | 7,48% | 78,15% |
| Renewable energy | 160.136 | 280.394 | 568.002 | 7,25% | 75,10% |
| **Total** | **2.521.442** | **3.142.272** | **3.442.443** | **2,79%** | **24,62%** |

Source: ECORIS 2012:27.

**Figure 3: Employment in environmentally related activities as a share of total working age population**




Source: ECORIS 2012 based on calculations of Cambridge Econometrics.

Further examples of gross green employment are shown in Table 3. Unfortunately, the comparability of the figures is rather limited due to different methodologies.

**Table 3: Gross employment in the green economy in different countries**

| Country | Results | Responsible for the study |
|---|---|---|
| Austria | 162,986 green jobs in 2008, 5.8% of employment | Institute of Advanced Studies |
| Canada | 640000 green jobs in 2006 Based on Census Data, 4% of the whole workforce | Government of Canada |
| Finland | 5,888 employees in companies having mainly green activities (no indirect effects), 0.2% of employment | Statistics Finland |
| France | 1.6% of total employment in 2010 corresponding to 411,000 green jobs | Ministry of Ecology and Sustainable Development |
| Germany | Nearly two million jobs in 2010 based on combined supply-demand-side approach, 4.8% of employment | German Federal Environment Agency<br>Edler, Blazejczak 2014 |
| Korea | 604,400 green jobs, 2.6% of Koreas total employment in 2008 | Korean government |
| Portugal | 0.4% of total employment in 2008, corresponding to 20,600 green jobs | Statistics Portugal |
| Spain | 531,000 green jobs in 2009, 2.6% of total employment | Ministry of Environment |
| United States | According to the Bureau of Labor Statistics (BLS), green employment accounted for 3.1 million jobs or 2.4% of total employment in 2010 and 3.4 million jobs or 2.6% of total US employment in 2011 | Elliott, Lindley (2014)<br>See<br>http://www.bls.gov/green/ |

Source: OECD 2012, ECORIS 2012, Bowen, Kuralbayeva 2015, Edler, Blazejczak 2014, ILO 2012, Elliott, Lindley 2014; own compilation.

The scoping study of the European Commission (DG Environment) (2014c) attempts to identify potential circular economy actions, priority sectors and material flows as well as value chains. The study contains a broad literature overview on case studies (for instance, on textiles, metals and plastics), estimations of the potentials of a CE, barriers of the realization of a CE and policy options. For instance, an analysis for the Dutch economy shows that the circular economy could amount to 7.3 billion Euros annually in market values (or 1.4% of today's GDP) and could create 54,000 jobs (Bastein et al. 2013:53). In fact, these figures have to be interpreted with caution as they are not based on a model that is able to account for net employment effects.

Two recent studies on the economic effects of a circular economy for Sweden and Great Britain are based on sector analyses and Input-Output models. The Swedish study (Wijkman, Skånberg 2015)[2] uses an Input-Output model and focuses on the social, economic and envi-

[2] The authors announce that similar studies for the Dutch and the Spanish economy will be available in July 2015.

ronmental effects of a transformation from a linear to a circular economy. The results of the Swedish analysis are summarized in Table 4 assuming a time horizon to 2030. In fact, one has to bear in mind that it is problematic to talk about "additional jobs" since the methods applied by the authors do not allow for the calculation of net employment effects.

**Table 4: Main results of the Swedish CE Study**

| | Renewable Case | Energy-efficiency | Material-efficiency | All Three Combined |
|---|---|---|---|---|
| Emission Reduction | -50 % | Almost -30 % | -10 % | Almost -70 % |
| Additional Jobs | Over + 5 000 | + 20 000 | Over + 50 000 | Over + 100 000 |
| Trade Balance Effects | + 1 % of GDP | + 0,3 % of GDP | Over + 2 % of GDP | Over + 3 % of GDP |

Source: Wijkman, Skånberg 2015:27.

The British study (Morgan, Mitchell 2015) includes the CE dimensions reuse, recycling, repair and remanufacturing and servitization. By using an analysis of CE related sectors, the authors calculate direct jobs created by circular economy activities. Their results for Great Britain show that over 200,000 gross jobs may be created by 2030.

Concerning the share economy as an element of a circular economy, there are also descriptive analyses calculating its economic potential. Following Stephany (2015), the market volume may grow to a $335 billion market by 2025. In fact, there is still a lack of model based research on the (net) environmental and employment effects of the share economy.

## 2.2 Net Employment Effects: Results from CGE and Related Models

In the following, the main studies on estimations on green net employment effects are summarized with a special focus on analyses related to the circular economy. The studies will be summarized regarding their scope (whole green economy or parts, such as renewables), the methods (CGE or related models) they used and their main results with a special focus on net employment effects.

In a recent study of the European Commission (2014a) realized by Cambridge Econometrics and BIO Intelligence Service, the economic and environmental impacts of raw material consumption have been analyzed. The analysis uses the macro-econometric E3ME model of Cambridge Econometrics. The model allows analyzing the linkages between the economy, materials, environment and energy. "E3ME is an econometric model. Its specification gives the model a strong empirical grounding and means it is not reliant on many of the assumptions common to Computable General Equilibrium (CGE) models. E3ME combines the features of an annual short and medium-term sector model estimated by formal econometric methods with the detail and some of the methods of the CGE models, providing analysis of the movement of the long-term outcomes for key E3 indicators in response to policy changes. It is essentially a dynamic simulation model estimated by econometric methods." (Cambridge Econometrics 2015) Approximately 50 material categories which are grouped in the main sections biomass, metal ores, non-metallic minerals and fossil fuel resources are considered. The analysis follows Eurostat's economy-wide material flow accounts aligned to the E3ME macroeconomic model.

Within a scenario of a 2% improvement of resource productivity per annum, the model predicts approximately two million additional jobs in the EU by 2030. The employment increases are due to the fact that (1) "…[an] increase in material input costs provides incentives for firms to substitute material with labour input", (2) "… investments in resource and energy efficiency are likely to benefit the relatively labour-intensive construction and engineering sectors" and (3) " … revenue recycling via lowering employers' social security contributions results in lower labour costs to industries, generating additional employment demand." (European Commission 2014a:42) In all estimated scenarios, consumer prices will rise, but GDP will increase as well. The distributional effects will remain low.

From a sector perspective, sectors with high raw material consumption will face higher material costs leading to a loss of competitiveness. This may be compensated by lower labor costs (lower labor taxes are assumed), reductions in imported material input and higher consumer demand. Furthermore, sectors may profit from higher material resource productivity. Those that sell raw materials such as agriculture and mining will reduce their economic outputs due to less raw material input requirement from other sectors.

The analysis has some limitations since potential gains from cutting down material waste, the reduction of waste management and landfill costs are not considered in the model but might lead to less employment in these sectors. Furthermore, recycling as a means to increase resource productivity is not included in the model. The analysis was carried out using simple and transparent, yet arbitrary policy assumptions. As the sensitivity analysis shows, these assumptions can have significant impacts on the final economic outcomes.

There are many studies considering the employment effects of renewable energy and different energy policy instruments on employment and other economic variables (for an extensive meta-analysis of the effects of renewable energy see Meyer, Sommer 2014, for a discussion of the crucial role of available energy for economic growth see Ayres, Warr 2002).

Lehr et al. (2012) analyze economic impacts of renewable energy in Germany using the PANTA RHEI model, a macroeconomic simulation and projection model. Almost all considered scenarios show positive net employment effects, but the results are sensitive to assumptions about the development of renewable energies on the world markets and on German exports to these markets. Under a realistic scenario, net employment of an increase of renewable energies will reach approximately 150,000 in 2030. Gross employment will increase from 340,000 in 2009 to between 500,000 and 600,000 in 2030 (Lehr et al. 2012).

Using the 'Sectoral Energy-Economic Econometric Model' (SEEEM), Blazejczak et al. (2011) analyze and quantify the net balance that economic effects have on the expansion of renewable energies in Germany until 2030. SEEEM is an econometric multi-country model which, for Germany, contains a detailed representation of industries, including 14 renewable energy technology sectors. The results show a positive net effect on economic growth and employment in Germany.

The study of Böhringer et al. (2013) is more pessimistic about the employment effects of renewable energies.  The authors apply a Computable General Equilibrium analysis of subsidized electricity production from renewable energy sources. Following their results, the prospects for employment and welfare are rather limited and highly dependent on the respective subsidies. "If RES-E subsidies are financed by labor taxes, welfare and employment effects are strictly negative for a broad range of subsidy rates." (Böhringer et al. 2013:277)

A similar pessimistic view on the employment effects of feed-in-tariffs in the German state Baden-Württemberg can be found in Heindl and Voigt (2012). The results are based on a regional Input-Output table. "Our findings suggest that policy actions promoting renewable energy types do not necessarily create new jobs and additional turnover for the whole economy. They rather induce a structural change of the economy since other investments might be crowded out by investments in installations of renewable energy and the demand in other sectors might decrease." (Heindl, Voigt 2012:1)

For the US, Wei et al. (2010) analyze the effects of more renewables and higher energy efficiency on the labor market. The authors develop an analytical job creation model for the US power sector from 2009 to 2030. Net employment effects are considered by modeling job losses in the coal and natural gas industry. Non-fossil fuel technologies (renewable energy, higher energy efficiency) appear to create more jobs per unit energy compared to coal and natural gas. “Aggressive EE measures combined with a 30% RPS target in 2030 can generate over 4 million full-time-equivalent job-years by 2030 while increasing nuclear power to 25% and CCS to 10% of overall generation in 2030 can yield an additional 500,000 job-years.” (Wei et al. 2010:919)

Godin (2012) analyses the employment effects of a green-jobs-employer-of-last-resort program based on a stock-flow consistent model with three productive sectors (consumption, capital goods, and energy) and two household sectors (wage earners and capitalists) in the United States. “The employer of last resort (ELR) is a proposal for a federally-funded program in which the government employs all of the jobless who are ready, willing, and able to work in a public sector project at a base wage.” (Tcherneva 2012:2) The study concentrates on energy saving via insulation and a more efficient use of electricity. The results show that an increase of the energy efficiency of dwellings and public buildings causes a shift from energy consumption toward a higher consumption of goods resulting in a higher employment, a lower poverty rate and less carbon dioxide emissions.

Chateau et al. (2011) use a CGE model (OECD ENV-linkages model) to assess the employment effects of greenhouse gas mitigation policies in 15 countries, each with 26 economic sectors. The model takes labor market imperfections into account. “It is shown that imperfect wage adjustment increases the cost of mitigation policy since unemployment increases in the short-run, but that the carbon tax revenue generated can be recycled so as offset some or all of this effect, notably when it is used to reduce wage-taxes.” (Chateau et al. 2011:3)

Cai et al. (2011) analyze the effects of greenhouse gas mitigation policies in China using analytical and Input-Output models. Due to the positive indirect employment effects, the authors show that the mitigation policies resulted in 472,000 net job gains.

Using a CGE model framework, Bouzaher et al. (2015) analyze the impact of selected green policy instruments including market-based incentives in the Turkish economy. “Overall, our results indicate that an integrated employment and urban greening policy strategy that combines a green jobs program with a set of earmarked tax-cum-innovation policies towards R&D-driven growth, mainly targeted to strategic industrial sectors and agriculture, developing market economies can achieve significant reductions in gaseous emissions and urban waste while maintaining significant gains in productivity and employment." (Bouzaher et al. 2015:49)

By means of a meta-analysis, Meyer and Sommer (2014) analyze the employment effects of renewable energy deployment based on 23 selected impact studies from peer-reviewed journals. These studies comprise both gross and net analyses of green employment effects. The authors find that the majority of the studies detect positive employment effects of a higher share of renewables, despite the fact that the studies are difficult to compare due to different calculation and estimation methods. Another meta-analysis exploring net employment effects of energy efficiency and renewable energy conducted by UKERC (2014) concludes that "… there is reasonable evidence from the literature that renewables and energy efficiency are more labour-intensive than fossil-fired generation, both in terms of short-term construction phase jobs, and in terms of average plant lifetime jobs. Therefore, if investment in new power generation is needed, renewables and energy efficiency can contribute to short-term job creation so long as the economy is experiencing an output gap, such as is the case during and shortly after recession." (UKERC 2014:4)

Summing up the results of the studies on net employment effects specifically for the circular economy, it is important to mention that the already existing studies only cover parts of the broad concept. The effects of energy savings, the introduction of more renewables or the savings of (raw) material are widely analyzed, whereas the net employment effects of more recycling or refurbishment activities remain an open research question.

## 2.3 Employment Effects of Eco-Innovations[3]

From an empirical point of view, there are various papers analyzing the general link between innovation and employment but relatively few analyses for the specificities of eco-innovations. Eco-innovations may be regarded as the most important driver of a circular economy especially concerning innovations causing higher resource productivity. For the assessment of the employment effects of a CE, it is therefore crucial to consider the relationship between eco-innovation and employment.

Econometric studies on general innovation and employment rely on different methodologies. There are cross-sectional studies such as Entorf and Pohlmeier (1990) that cannot address the dynamic character of the relationship between innovation and employment. Most analyses use

[3] This section is partly based on Horbach, Rennings (2013).

growth rates between two different points in time (for instance, RWI 2005, Peters 2005, Harrison et al. 2008). Other authors use panel data over a longer period of time and apply corresponding (dynamic) panel data models to analyze the data (for instance, van Reenen 1997, Smolny 1998, 2002, Smolny and Schneeweis 1999, Rottmann and Ruschinsky 1998, Piva and Vivarelli 2005, Lachenmaier and Rottmann 2007 and 2011).

Most of these studies on Germany that focus on general innovations find positive effects of product innovations on labour demand (see for instance RWI 2005, Peters 2005, Smolny 1998, 2002, Piva and Vivarelli 2005, Zimmermann 2009). Similar results are detected for the UK (van Reenen 1997), for France (Greenan and Guellec 2000) and in a comparative study for France, Great Britain, Germany and Spain based on harmonised data of the Community Innovation Panel (CIS) (Harrison et al. 2008). Bogliacino and Pianta (2010) use a sectoral database including CIS data from 1994 to 2004 for eight European countries. Interestingly, they find different roles of innovation, wages and demand for employment across different types of industries.

Analyses on the employment effects of environmental innovations are still rare due to data problems. In general, these studies also detect positive effects of eco-innovations on employment (Bijman and Nijkamp 1988, Pfeiffer and Rennings 2001, Rennings and Zwick 2002, Harabi 2000, Rennings 2003). Rennings and Zwick (2002) find a small positive employment effect at the company level. The positive effects relate to both product and service innovations. The study considers more than 1500 companies from five European countries. In this study, further significant determinants of employment development are the market share as an innovation goal, innovation size and the strictness of environmental regulation. Pfeiffer and Rennings (2001) show that cleaner production is more likely to increase employment compared to end-of-pipe technologies. This result is confirmed by Rennings et al. (2004) where econometric results show that product and service eco-innovations have a positive effect on the probability of an employment increase, whereas end-of-pipe measures cause a decline.

Mazzanti and Zoboli (2009) analyze the relationship between environmental efficiency and labor productivity. In most cases, their econometric analyses confirm a positive correlation between these two variables. Horbach (2010) shows a positive and significant influence of eco-product innovations on employment. The positive effects of eco-innovation appear to be greater compared to other non-environmental innovation fields.

Horbach and Rennings (2013) use the database of the Community Innovation Survey (CIS) 2009 allowing the analysis of employment effects in specific technology fields, such as recycling, energy and resource efficiency which are all highly relevant for the CE. The econometric analysis shows that innovative companies are in general characterized by a significantly more dynamic employment development. Especially the introduction of cleaner technologies as process innovations cause higher employment within the firm. The theoretical background of this finding is that cost savings induced by this type of process innovation improve the competitiveness of companies. This has positive effects on demand and thus also increases employment. Especially material and energy savings are positively correlated to employment as they help to increase the profitability and competitiveness of the company. On the other hand, air and water process innovations that are still dominated by end-of-pipe technologies have a negative impact on employment. Hence, the results of this study confirm the positive employment potentials of a circular economy.

Licht and Peters (2013, 2014) also use the CIS data of 2009 to analyze employment effects of products and process innovations for different European countries and for Germany in a more detailed analysis. The authors find that both environmental and non-environmental product innovations trigger employment growth, but that still non-environmental product innovations are more likely to increase employment. Following their estimation results, the displacement effect of process innovations seems to be rather small.

A recent paper of Gagliardi et al. (2014) also analyses the link between eco-innovation and job creation at the company level for 4,507 Italian companies matched with patent records for the period from 2001 to 2008. The results show a strong positive impact of eco-innovation on the creation of long-run jobs. The effects are substantially greater than the effects of other innovations.

### 2.4 Green (Employment) Effects of the Digitization of the Economy

There are still research deficits concerning further elements of the circular economy, such as the environmental and economic effects of the digitization of the economy. In fact, the productivity effects of ICT are widely explored (see e.g. Bertschek et al. 2014 for an overview), whereas the respective literature on the environmental and energy effects still remains limited.

The OECD (2010) differentiates between direct impacts (first order), enabling impacts (second order) and systemic impacts (third order) of ICT. “Direct impacts of ICTs on the environment (or “first-order effects”) refer to positive and negative impacts due to the physical existence of ICT products (goods and services) and related processes.” … Enabling impacts of ICTs (or “second-order effects”) arise from ICT applications that reduce environmental impacts across economic and social activities. ICTs affect how other products are designed, produced, consumed, used and disposed of.” … Systemic impacts (third-order-effects) impacts of ICTs and their application on the environment are those involving behavioural change and other non-technological factors. Systemic impacts include the intended and unintended consequences of wide application of green ICTs.” (OECD 2010:9) The OECD report also shows the quite heterogeneous study results about the impacts of ICT in several countries.

Takase and Murota (2004) analyze the effects of IT investment on energy consumption and $CO_2$ emissions in the US and Japan. The authors show that an increased use of IT investment lowers energy ($CO_2$) intensity. An increase or decrease in overall energy consumption depends on two conflicting effects: “ … the income effect caused by economic vitalization from increased IT use (increasing energy consumption) or the substitution effect by change in the industrial structure as seen in the shift away from smokestack industries (decreasing energy consumption). According to our calculations, Japan would conserve more energy by promoting IT than not.” (Takase and Murota 2004:1291)

Rexhäuser et al. (2014) analyze the relationship between information and communication technology (ICT) and energy demand. Using a cross-industry panel data set for 10 OECD countries their regression analyses show that the increased use of ICT capital is negatively correlated to total energy demand. This result does not hold for electricity demand since an increase of ICT use results in higher electricity consumption. The paper does not consider employment effects.

The GeSi (2012) report shows positive employment effects of ICT. Following their results, ICT-enabled solutions may create 29.5 million jobs worldwide and reduce greenhouse gas emissions by 16.5 % until 2020. A shortcoming of the study is that the calculation methods for the estimated figures remain partially unclear.

## 3. Summary

Our literature overview shows the potential employment effects of a circular economy, differentiating between gross and net employment. Furthermore, different types of eco-innovations (process vs. product innovations) as well as the digitization of the economy as very important fields for employment effects have been analyzed. All in all, the analysis of the economic and especially the employment effects of a circular economy remains an open research field as the available studies only cover parts of this broad concept. The effects of energy savings, the introduction of more renewables or the savings of (raw) material are comprehensively analyzed, whereas for instance the employment effects of increased recycling, refurbishment activities, the sharing economy or the digitization of the economy still need to be further examined. Nevertheless, in most cases, the already existing studies point to the positive employment effects occurring in case that a circular economy is implemented.

# III. Discussion of different Environmental Policy Instruments with respect to their Relationship and Effects on a Circular Economy (CE) (WP 3)

In the following, the relevance of several environmental policy instruments is discussed regarding their potential effects on the realization of a circular economy (CE). The environmental effectiveness and the economic impacts of the different instruments are in the focus of the analysis. Furthermore, the role of these instruments as incentives for eco-innovations will be analyzed. Due to the broad range of products and services concerned by a circular economy (for instance, reduction of electronic waste or car sharing), an in-depth analysis is a challenge at this stage. The ultimate choice and the fine-tuning of political instruments are solely possible at the level of specific products or services. In the following, the instrument categories taxes/subsidies, standards and regulations (for instance, take-back obligations, European regulation on electronic scrap) as well as tradable permits and information policy are considered.

*Taxes for material and energy use*

From the environmental economics literature (for instance Endres 1994), it is well-known that eco-taxes are cost-efficient and that they are able to trigger eco-innovations. On the other hand, since eco-taxes are price instruments, they are not able to have an effect on exactly defined quantities of emission reduction. Bye and Klemetsen (2014) show that positive and persistent environmental effects may only occur if environmental taxes increase over time. Therefore, material or energy related taxes seem to be particularly suitable for the implementation of a circular economy. Heine et al. (2012) also confirm the high relevance of taxes for a reduction of material and energy. However, they claim for a better alignment and targeting of tax rates with values for externalities. Taxes may be used for nearly all aspects of a CE, examples are:

- Higher taxes for material and/or energy use,
- Different taxation for the use of recycled versus new material,
- Charges for packaging, and
- Higher waste charges.

**Table 5: Environmental policy instruments and their effects on the circular economy**

| Policy instruments | Pros | Cons | Relevance for CE: ++ high, + medium, or low |
|---|---|---|---|
| Taxes and subsidies<br>- Charges for packages<br>- Higher waste charges<br>- Higher taxes on material and energy use<br>- Subsidies for recycling activities | Long-lasting incentive for energy and material saving, good eco-innovation incentives<br>Cost-efficient<br>Double dividend: Both positive environmental and employment effects | Negative competition effects, negative distribution effects, danger of relocation of firms<br>Green Paradox: From an international perspective, eco-taxes may even lead to negative effects | ++ |
| Regulations<br>- Deposit obligations<br>- Take-back obligations<br>- Re-use quotas<br>- Recycling quotas<br>- Prohibition of one-way systems | In general, high environmental effectiveness | No cost-efficiency, falsely designed regulations may lead to negative environmental effects | + |
| Tradable permits<br>- Licenses for packages | High environmental effectiveness | Difficulties of practical implementation and of the determination of quantities | + |
| Information policy<br>- Consumer-oriented<br>- Producer-oriented | Useful in the long run | Weak instrument | <br>+<br>o |
| Voluntary self-commitments | - | Only effective if companies have additional incentives | o |

Source: Own compilation.

On the other hand, taxes on energy or material consumption seem to be less advantageous if the supply of energy or raw material in connection with an international dimension is taken into account. The "green paradox" literature (Sinn 2012) points out that a reduction of energy demand in a country induced by a strict environmental policy may lead to lower energy prices on the world market due to an increase of the available energy supply. Consequently, higher energy consumption in other countries may be observed. From this perspective, the effects of energy taxes might be even negative for the environment. In fact, the empirical relevance of this argumentation still remains an open research question.

A further argument against the introduction of additional energy or material taxes is the potential loss of competitiveness for the affected firms in the tax-raising country, resulting in a difficult political enforceability of such taxes. Furthermore, national solutions may induce relocation effects in pollution haven countries so that, consequently, de-materialization is solely observable at a national level, while internationally pollution levels do not decrease and may even increase. In contrast, emissions would decrease in a country with high material and energy taxes, whereas the material or energy use would increase in countries with a lax environmental regulation so that the net environmental effect may be zero or even negative. Furthermore, negative distributional effects of higher energy taxes are observed on the household level (see Heindl, Löschel 2015 for a recent analysis).

*Regulations and Standards*

In general, environmental regulations are not cost-efficient since they do not take care of the individual marginal abatement costs of the regulated companies. In many cases, the ecological effectiveness of regulations is still higher when compared to taxes. Especially in Germany, regulations have a long tradition for the waste and recycling sector as one major part of the CE. The advantage of standards, take-back obligations, reuse quotas and the phasing out of certain materials is that a new, protected market is created for less harmful substances. To give an example, Germany has made good experiences with this tool: Its favorable position on the world market of environmental goods and services can be principally explained with tools, such as the German Emission Reduction Policy (TA Luft) (Rennings, Rexhäuser 2011).

Selected relevant examples of these instruments will be discussed in the following. With the introduction of *take-back obligations*, companies have incentives to increase the recyclability of their products or to introduce reuse systems (for instance for bottles), but it is also possible that companies merely try to raise their prices. Furthermore, the effectiveness of this instrument depends on the willingness of consumers to give their old products back (Baum et al. 2000). Thus, additional measures such as a *deposit obligation* are necessary, but these obligations will only work if the deposit charge is higher than the transaction costs of the product return. For instance, in Germany the introduction of a deposit obligation for one-way bottles led to a paradox result since the share of reused bottles decreased from 2004 (71%) to 2012 (47%) (BMU 2014). An explanation could be that the deposit is too low such that a too small proportion of consumers return the bottles. For retailers, this causes an additional incentive to offer one-way bottles due to these "deposit gains". Another reason could be that one-way and reusable bottles are now harder to distinguish for consumers. A potential solution might be a much higher deposit on bottles that would be given back to the consumer only partially so that one would have an incentive to buy reusable bottles.

*Reuse quotas* are solely efficient if they are implemented at the firm level, whereas an introduction at the level of a whole economy may induce free-rider behavior.

*Tradable Permits*

From a theoretical point of view, tradable permits are a nearly perfect environmental policy instrument especially concerning the ecological effectiveness, as the quantity of regulated emissions can be well controlled. An important pre-condition is that the optimal or, respectively, feasible amount of emission or waste reduction is known. Concerning the CE, one example for tradable permits are *package licenses*: The regulator restricts the quantity of one-way packages in a region or society. The rights to use one-way packages are then distributed by auctions. A problem of this instrument consists in the difficulty to determine the "right" quantity of licenses. Thin markets may be the result of "false" quantities. Furthermore, the determination of actors and the control of the whole systems are difficult. In addition, license systems for a big variety of products would induce high administrative costs (Baum et al. 2000).

*Information Policy and Voluntary Self-Commitments*

*Information policy,* for instance on the possibility of energy saving measures, does in fact complement other "hard" instruments. In the long run, information policy is very important as it helps to increase the environmental consciousness especially of consumers. *Voluntary self-commitments* are efficient in cases where companies also see a potential for an improvement of their green image or if future regulations are already announced. Similarly, "inducement prizes", as proposed by the European Commission (2015) can promote firms' green innovations and help the diffusion process of best practices.

*Conclusions*

In summary, there are some generic economic considerations which suggest material- or energy taxes as the preferred instrument for a circular economy. However, some context factors such as existing regulation have to be taken into account. For Germany and Europe, emission trading exists for $CO_2$-emissions, but as a general instrument for the regulation of thousands of potential substances it is not sufficiently specific. Thus, emission trading may be considered as a core instrument for climate policy. For a circular economy, however, taxes can be recommended as a preferred global steering instrument. Regarding the rich history of standard settings at the European and German level, this instrument should also be considered for the fine tuning of a resource policy. Within Computable General Equilibrium (CGE) models, different scenarios with taxes, standards and tradable permits should be calculated to analyze the overall economic effects of a circular economy.

## IV. Proposals for Future Econometric Analyses on Effects of a Circular Economy on Employment and the Environment

Despite the large amount of existing literature on the employment effects of a Circular Economy presented so far, many questions need to be investigated. This concerns in particular the employment effects in the areas of the

- sharing economy,
- digitization of the economy,
- recycling, and
- refurbishment

whose effects are underexplored due to lack of data. Therefore, we initially discuss existing data suitable for research before turning to suggestions for a targeted survey in the following. Finally we propose econometric analyses of the behavior of multinational companies to identify which policies work best towards achieving a circular economy.

A starting point is the Community Innovation Survey (CIS) which contains a special module on eco-innovation including items on CE-related environmental fields. The rich questionnaires of the CIS 2008 and 2014 allow an in-depth analysis of the determinants of the realization of material and energy savings, the substitution of dangerous substances or the recycling of material, waste or waste water – all fields that are crucial for the implementation of a circular economy. As concerns the determinants, the role of present and anticipated regulation, subsidies, product demand or self-commitments may be analyzed. Furthermore, the questionnaire contains a rich set of control variables, such as R&D, competitive situation, export orientation, market share, product and process innovations, organizational innovations, investment, and information sources. This richness in data allows for an in-depth analysis of employment and other economic effects. An analysis for many European countries is possible and a comparison between 2008 and 2014 will also soon be feasible. Besides the econometric analysis of the determinants of material and energy savings, technology fields and products that promise high material savings potentials may be identified. These results may be used for identifying products with an over-proportional importance for a circular economy. These may then be further analyzed by time series of patent activities or recycling quotas.

However, the module on eco-innovations in the CIS data starts with a filter question on whether or not companies realize eco-innovations at all. This is a disadvantage of the data set for an analysis of the circular economy because this procedure excludes companies that contribute to a circular economy without knowing, for instance recycling firms. Moreover, while the CIS data is well suited for many questions on the important field of eco-innovations, some other aspects of the circular economy are not considered in that survey. Therefore, we propose a new survey in order to specifically address some open questions concerning the employment effects of the circular economy.

Specifically, the effects of the sharing economy as well as of the digitization of the economy on material and energy use and on employment should be further investigated. We propose carrying out a well-targeted survey on these issues among relevant firms. This aims at answering questions targeted specifically at the circular economy, such as:

- How large are savings in energy and material from the sharing economy, in other words from sharing equipment?
- Does sharing equipment reduce employment, for instance because less employees are needed for maintenance, or does it, instead, increase employment, for instance because employees can work more efficiently?
- How large is the task share of recycling and other activities of the circular economy among all tasks performed by employees?
- How do companies respond to policy tools such as environmental taxes or tradable permits?

A survey on these topics could preferably be conducted among business and industry as well as among innovative service businesses, such as form part of the Circular Economy 100 program of the Ellen MacArthur Foundation. This would allow for an international perspective. In addition, in order to get an even broader picture, survey data could potentially be supplemented by official figures, such as from Eurostat.

Finally, we propose an analysis that is targeted more specifically at understanding the effects of different policy instruments. The question of how companies respond to policy tools is crucial for understanding and thus designing optimal policies worldwide. One option to answer this question is to analyze the behavior of multinational companies. Operating in different markets internationally their products and stores/ warehouses are highly comparable worldwide. At the same time the material and energy use will surely differ worldwide even between stores of the same company. Therefore, the interesting question is: Why do multinational firms such as Coca Cola, Ikea or H&M use different amounts of energy, material and labor in their factories or warehouses over the world? Answering this question is of great relevance to gain a better understanding of which policies work best in order to achieve a circular economy? It is also important for businesses to find out where they could realize even further savings in terms of material and energy consumption in the production process. It is important to analyze these questions using micro-econometric methods so as to depart from one-time effects within a single company and thus gain a broader understanding on the functioning of the entire economy. For the same argument it is indispensable to analyze not one single multinational firm but several. The empirical analysis needs to be supplemented with a systemic view on the joint set of regulations in each considered country. This perspective must not be limited to environmental regulations but needs to take into account employment regulations as well.

A thought experiment illustrates what could be learned from an international comparison. If we had two countries that only differed in those policies that concern a circular economy, then we would simply compare the material and energy use between companies that operate in these two countries and draw conclusions about which policies are most effective. As this pair of countries does not exist, we instead have to rely on comparing a set of several different countries and a set of companies across countries. Therefore multinational companies are an interesting subject to study as the products are naturally (nearly) identical.

A survey among these multinational companies should ask detailed questions about their material and energy use as well as employment. These questions should be supplemented by questions on recycling and refurbishment as well as on the digitization and sharing. The relevant topics for this particular survey on the circular economy have been developed above. The relevant expertise could be provided by the Centre for European Economic Research (ZEW) and the University of Applied Sciences Augsburg.

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