CIRCULAR IMPACTS

Methodologies for Measuring the Macroeconomic and Societal Impacts of the Circular Economy

AUTHORS

Geert Woltjer, Senior Researcher, Wageningen University and Research

With gratitude for useful feedback from:

Marie-José Smits, Researcher, Wageningen University and Research

Aaron Best, Senior Fellow, Ecologic Institute

Rob Dellink, Coordinator Modelling and Outlooks, OECD

Lucas Porsch, Senior Fellow, Ecologic Institute

Vasileios Rizos, Research Fellow, CEPS (Centre for European Policy Studies)

Laurens Duin, Researcher, Ecologic Institute

Document title	Methodologies for Measuring the Macroeconomic and Societal Impacts of the Circular Economy.
Work Package	
Document Type	Deliverable
Date	6 April 2018
Document Status	Final

ACKNOWLEDGEMENT & DISCLAIMER

Neither the European Commission nor any person acting on behalf of the Commission is responsible for the use which might be made of the following information. The views expressed in this publication are the sole responsibility of the author and do not necessarily reflect the views of the European Commission.

Abstract

This report assesses methodologies that are used to measure the macro-economic and societal impacts of the circular economy. It provides insights relevant for relating circular opportunities as analysed in case studies to GDP growth, employment, competitiveness and welfare. Macroeconomic effects of circular-economy changes may differ in the short- versus long-term perspectives. Case studies can be viewed as elements in a list of circular business opportunities that are not realised in a baseline scenario due to barriers. A circular economy scenario consists of a number of policies to reduce these barriers. In the literature, a large number of studies suggests that GDP and employment will rise as a consequence of circular opportunities being realised or circular policies being implemented. The methodologies used in these studies are critically evaluated, and it is concluded that several assumptions are necessary in order to reach such results. Especially, it is important to consider to what extent the relevant comparison between the baseline and circular scenarios is being made. Is the point of reference that no measures are taken that reduce barriers to profitable business opportunities, or that instead of reducing barriers for only circular opportunities policy is focused on reducing barriers for all business opportunities? In the latter case, it is much more difficult to prove that circular opportunities generate an increase in GDP or employment. Therefore, a thorough investigation of the methodology behind macro-impact evaluations of the circular economy, though difficult, is important to undertake. Based on the analysis, possible indicators are suggested, both at the level of circular business opportunities and at the macro level.

Table of Contents

List of Figures

Executive Summary

In the project CIRCULAR IMPACTS, four case studies are carried out and these case studies are meant to be used in an economic and societal impact evaluation of a circular-economy scenario compared with a baseline scenario. This report investigates methodologies that have been used in the literature for this purpose, and has a particular focus on those methodologies that start with a listing of circular opportunities. Therefore, we start the analysis with a description of how studies make listings of circular opportunities that are not expected to happen in the baseline scenario, sorted by profitability. This profitability may be either private profitability, or social profitability (i.e. including externalities).

The sorting on private profitability implies that well-informed profit-maximising agents without financial or other restrictions would implement all profitable opportunities. This raises the question of why these opportunities are not realised. The answer is that barriers exist in the baseline. Barriers may be economic in character, like barriers to financial investment in new technologies, market failures like externalities and imperfect information, regulatory failures like unintended consequences of regulation for other purposes, and social factors like political and social resistance. In those cases, one may design policies to solve these barriers. However, there may also be hidden barriers that, though not included in the profit calculation made in the case study for the circular opportunity, actually do exist in practice.

Policies may be designed to remove barriers to circular opportunities. Subsidies, regulation, investment in infrastructure, public procurement, organising information and coordination and creating finance facilities are one way to categorise these policy instruments. Because a listing of the profitable circular opportunities not included in the baseline actually needs policies to be realised, it is important to be aware in aggregating circular opportunities to national results that the realisation of these circular opportunities requires policies.

In most reports, positive GDP effects are generated by the following drivers: increases in factor productivity; greening of taxation wherein green tax revenues are used to reduce externalities in the labour market; and effects caused by extra investment that is not crowding out other investment. In addition, solving some externality problems like congestion or price increases of imported resources may increase GDP. If models assume a baseline wherein resource scarcity increases costs, then in the long term the circular economy may be beneficial for GDP.

A more circular economy will have consequences for the import of raw materials into the EU, and this will influence the real exchange rate and perhaps net investments in the economy. It may be that benefits for the EU of reducing imports and lower prices of imported raw materials have negative consequences for resource-exporting countries. Finally, development of new circular technologies may potentially provide a competitive advantage for the EU, both for exporting the technologies and exporting the products produced with the new technologies.

A fundamental question to be posed when evaluating a scenario with circular policies is what the reference scenario should be. If the reference scenario is one without extra policies, then when only profitable opportunities are selected, the circular scenario will increase GDP automatically, while if the reference scenario is one wherein the improvements are focused on general removal of barriers for a list of both circular and

non-circular opportunities, then the outcome is uncertain and the calculation will be very difficult.

Employment effects in most analyses are not based on the circular economy in itself, but on the effect of policy changes or mechanisms that are not specific for the circular economy. First, extra investment or investment in more labour-intensive technologies may increase employment in cases of circular unemployment or quantitative structural unemployment. However, there is an issue of timing and targeting these impulses. In case of long-term cyclical unemployment (as after the crisis of 2008 and which the OECD projected will continue until about 2020) or secular stagnation, then increases in spending may increase employment.

Second, employment may increase as a result of greening the tax system, i.e. reducing the wage gap for potentially unemployed people, where it is important to have the tax reductions for people who are difficult to employ because current wage levels are too high. This may be because of social-security benefits or collective agreements, minimum-wage laws or because institutional dynamics set minimum wages that are above the equilibrium wage.

Third, if the circular-economy opportunities generate jobs in regions or skill categories with high unemployment, then this may reduce qualitative structural unemployment. However, as far as the circular economy is disruptive, it reduces the number of jobs in traditional industries where the people who are fired do not automatically have the right skills for the circular economy. This means that labour-mobility programmes may be essential for a smooth transition to a circular economy in order to prevent increases in qualitative structural unemployment.

Fourth, sometimes unemployment is reduced by providing low-paid work in the recycling industry to people with less ability to work, i.e. a choice is made to develop circular projects in social-employment programmes.

It is necessary to keep in mind that GDP increases are not the primary purpose of the circular economy. Many positive welfare effects from the perspective of cost-benefit analysis are not included in GDP. Therefore, it is relevant to include these positive effects in the context of a welfare concept broader than GDP, which was never intended as a measure of welfare.

The evaluation of the environmental effects of circular opportunities may be complicated because the introduction of the circular opportunity may have consequences for the whole value chain and because of rebound effects. These latter effects may be reduced if externalities are priced.

A broader welfare analysis would include the benefits of reducing external costs or increasing external benefits that have no consequence for market activities as measured in GDP, but increases utility. Effects on health, for example, may reduce losses of effective employment as a consequence of illness, which has consequences for GDP, but the main effect is a better life due to reduction in these illnesses. Even the reduction in health-care costs is not included as a benefit for GDP, because health-care activities add to GDP. It may also include broader issues like the reduction of dependence on states with high geopolitical risks, and reduction of the uncertainty with respect to future scarcity of essential raw materials or ecosystem services. Important indicators that are relevant from the perspective of case studies are:

- Changes in factor productivity, i.e. input requirements per unit of output, where one has to be aware that also the quality of the output may change

- Changes in trade flows, especially imports of raw materials
- Amount of investment needed
- Changes in employment quantity, wherein it is important to prove that the generated jobs are additional to baseline employment
- Composition of labour demand compared with scarcities in the labour market
- Externalities in production that may be reduced by the circular opportunity (e.g. better waste management may imply less external costs)
- Welfare effects of the externalities that may be reduced
- Does the circular opportunity create skills and/or knowledge that provide a competitive advantage or that can be exported to other regions of the world?

With respect to macroeconomic evaluation, it is concluded that a broader welfare measure than GDP is needed; one that includes at least changes in natural capital and changes in other environmental externalities. Furthermore, investigating the macro-effects of the implementation of circular opportunities requires insights into technological change as a consequence of changes in regulation or by large-scale implementation of new technologies. Finally, from the perspective of the European Semester, which is an important policy context for this report, the consequences for government finance are also important, and these depend on the type of policies implemented to realize the circular opportunities.

1 ::   Introduction

The circular economy is an organising concept for how to reduce primary resource use and the environmental impacts of economic activity, including climate change. In previous work (Rizos et al. 2017), the CIRCULAR IMPACTS project examined various definitions of the circular economy, combining these into a set of key processes that constitute the circular economy framework (see Figure 1 for an overview)[1]. Each process falls into one of three overarching strategies: 1) use less primary resources; 2) maintain the highest value of materials and products; and 3) change utilisation patterns.

Figure 1. Main circular economy processes (Source: Rizos et al. (2017).

USE LESS PRIMARY RESOURCES

· Recycling
· Efficient use of resources
· Utilisation of renewable energy sources

MAINTAIN THE HIGHEST VALUE OF MATERIALS AND PRODUCTS

· Product life extension
· Remanufacturing, refurbishment and re-use of products and components

CHANGE UTILISATION PATTERNS

· Product as service
· Sharing models
· Shift in consumption patterns
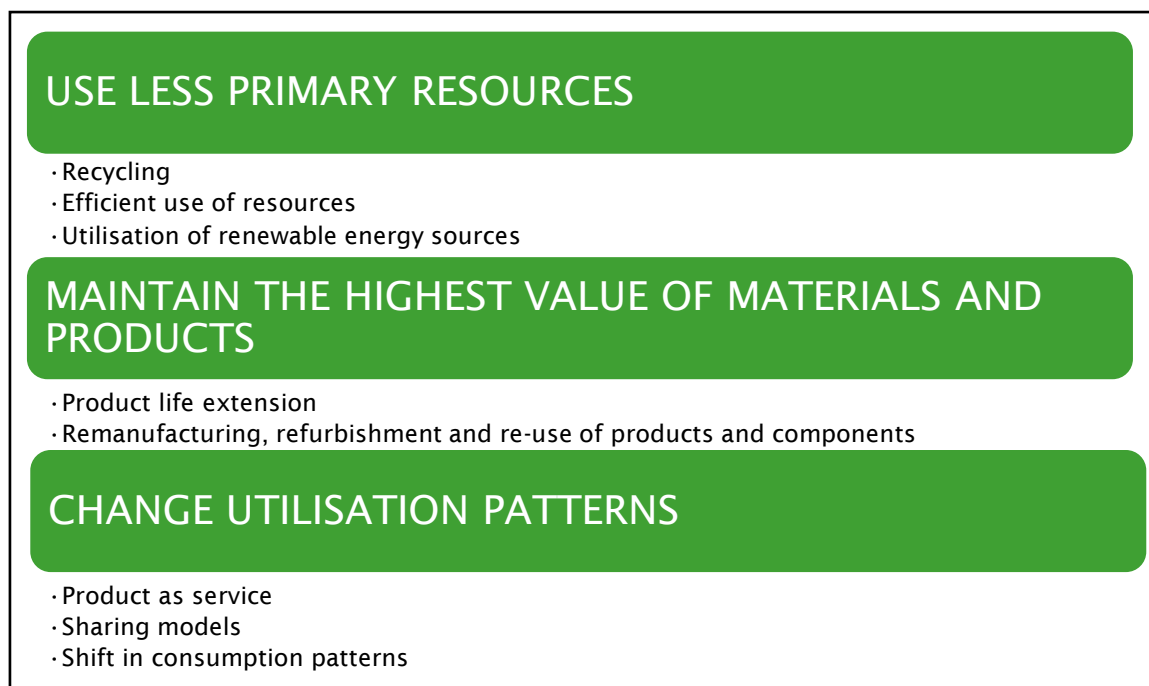
In several current EU policy documents, the circular economy is also seen as a way to increase growth, employment, and international competitiveness (EC 2015). This is one reason behind efforts to include progress towards the circular economy in the communication between Member States and the EC in the European Semester. See Behrens & Rizos (2017), Deliverable 2.2 of the project, for an extensive discussion of the interplay betwen the circular economy and the European Semester).

The objective of this report is to assess methodologies for measuring the macro-economic and societal impacts of the circular economy and to derive possible indicators from this framework. The standard methodology for measurement of macro-economic impacts is to use an economic model such as a general equilibrium model or an econometric model. A baseline scenario is run next to a circular-economy scenario and the consequences for GDP, employment and other indicators are calculated. The

---

[1] See (OECD 2017b) for an alternative framework.

difference between these indicators for the circular and the baseline scenario is a measure of the macroeconomic impacts of the circular economy.

This report is organised as follows:

Section 2 describes the first step in analysing the macro-effects of new circular opportunities: listing them in a consistent manner according to some criterion of profitability. Case studies developed in work package 4 of the CIRCULAR IMPACTS project may be seen as examples of elements in such a list. After having made the list, the main question is why they are not part of the baseline development of the economy if they are as profitable as suggested. Different barriers are mentioned, wherein externalities are important ones. In order to guide the economy on a circular pathway, policies are needed and in many studies, these policies determine to a large extent the macro-effects of the circular economy.

After making clear what the circular economy scenario is about, available approaches on the macroeconomic and societal impacts of the circular economy are discussed by putting them in a general theoretical context. First, the main purpose of the circular economy is the reduction of primary resource use and negative environmental impacts. Because GDP growth and employment are important focuses of the European Semester, we start the impact assessment with GDP, employment and international trade effects (Sections 3 and 4).

However, the central purpose of the circular economy is environmental. If you include the societal benefits of these environmental effects in a broader welfare analysis, the circular economy may generate positive welfare effects that are not included in GDP, employment or competitiveness analysis (Section 5). This is consistent with the idea that for the circular economy, one should be agnostic with respect to effects on GDP (van den Bergh 2017, Raworth, 2017).

Based on the methodologies discussed in this report, some ideas are developed around indicators that may be relevant on the micro-level of circular opportunities and on the macro-level of countries, the EU or the world (Section 6).

2 ::   Circular Opportunities and Policies

2.1 Introduction

In the CIRCULAR IMPACTS project, four case studies are undertaken and these case studies are meant to be used in an economic- and societal-impact evaluation of a circular-economy scenario compared with a baseline scenario. This report investigates methodologies that have been used in the literature for this purpose, and has a special focus on methodologies that start with a listing of circular opportunities. Therefore, the starting point for such an analysis of the macro effects of the circular economy is a listing of circular opportunities, which is discussed in this section. In many studies, these opportunities are assumed to be profitable. However, an essential question to consider is the following: why do these investments not occur already in the baseline if they are so profitable? Once this question has been satisfactorily answered, well-targeted policies can be designed to make these specific circular opportunities happen. A macro analysis of the benefits of a circular economy must always include the mechanisms that transform the baseline into a more circular economy and therefore the policies involved. This fundamental question must be answered before the macro-consequences of the circular economy can be analysed.[2]

2.2 Listing of the circular opportunities

An economy grows and changes due to technological change, changes in relative prices, and changes in population. This implies that at any moment in time, new profitable investment opportunities arise, either because demand for specific commodities is increasing, new technologies can be implemented that improve efficiency or generate new commodities or because at new prices, other technologies become profitable. From a social point of view, one may sort all these business opportunities based on their return on investment, either the private return or the social return. In theory, one would expect that the most profitable investment opportunities are accomplished, but in practice, markets are not that flexible. However, in the baseline at every moment in time there are profitable investment opportunities.

Characteristically, in some studies on the impacts of the circular economy, circular investment opportunities are explicitly mentioned (the same for resource- and energy-efficiency studies). These investment opportunities can be defined in euros spent per unit of resource efficiency or in another way, such as the return on capital for various investment opportunities. The results of such analyses will depend on the market prices and discount rate used. A much-cited example is Dobbs et al. (2011), which provides the cumulative resource efficiency increase (in U.S. dollars) sorted by net cost per unit of resource-efficiency improvement. The figure presented there (see Figure 2 below) suggests that US$ 2 trillion of resource benefits per year can be generated by investments that are above the hurdle rate, i.e. the investments have a positive return (Dobbs et al., 2011, p. 75; UNEP, 2017, p. 92-3). These resource benefits are the microeconomic

---

[2] The case studies carried out in the CIRCULAR IMPACTS project are elements of such a list of circular opportunities. The relationship between the list of circular-economy opportunities and the macro outcome is there extremely relevant in the context of the project.

benefits for private investors. When external costs and benefits are also included, welfare gains are even larger (see Figure 3 below).
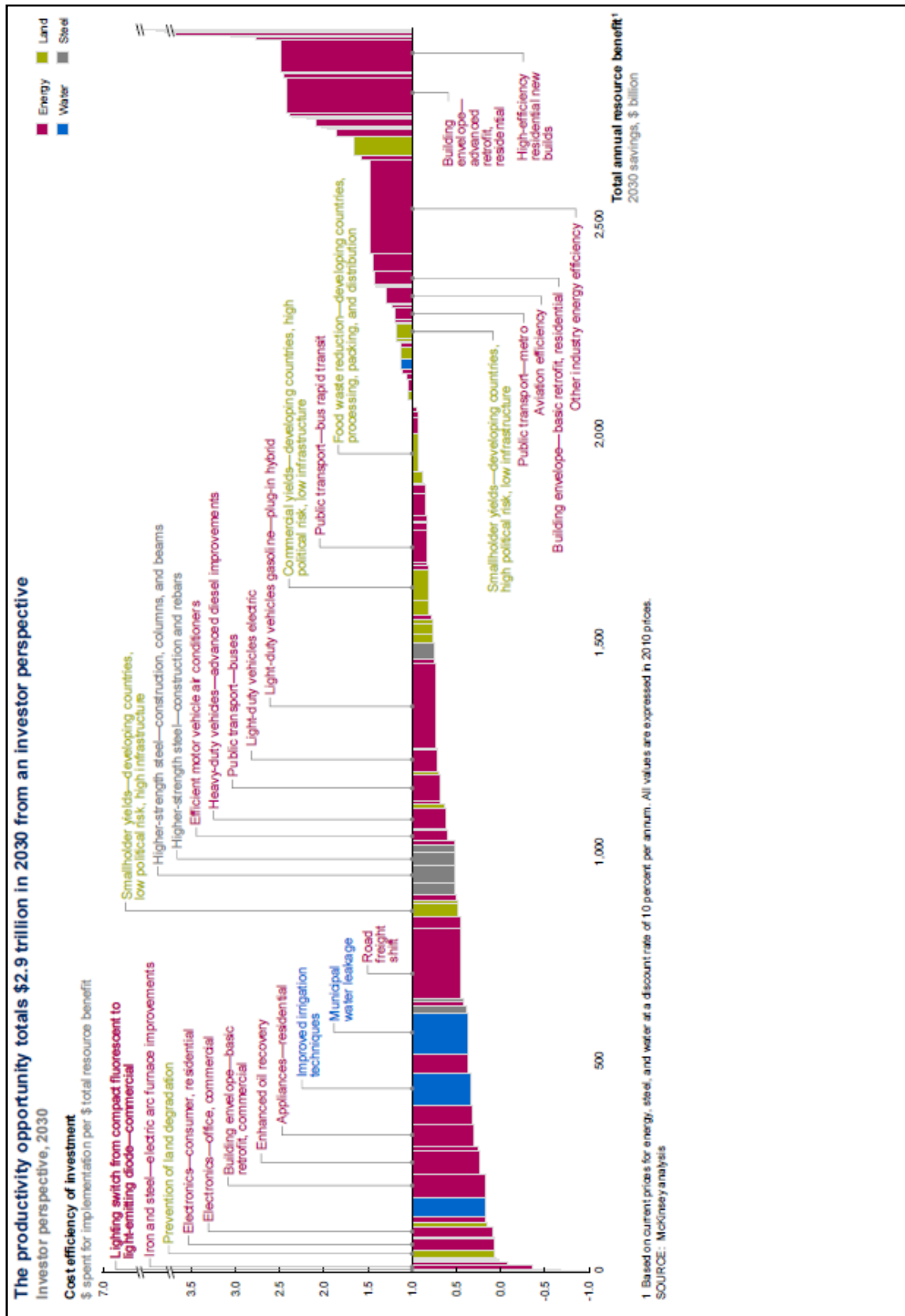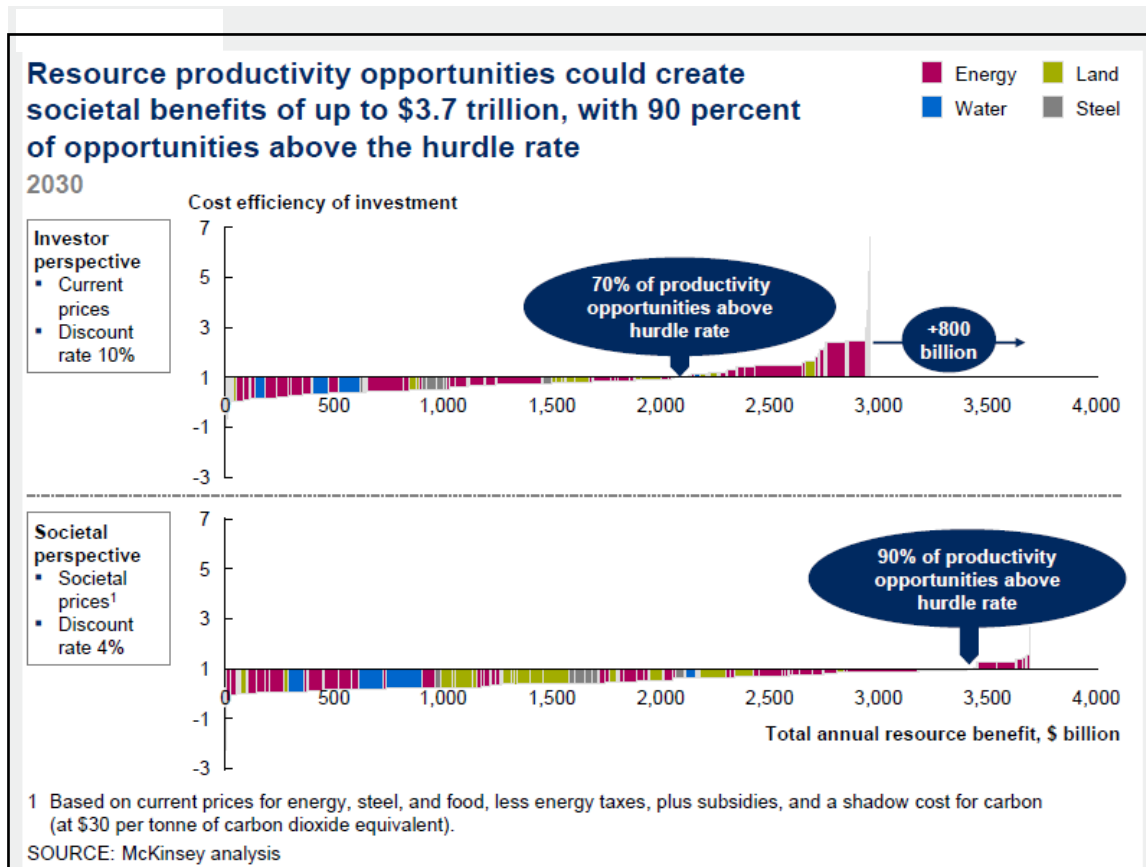
Figure 3. Micro versus macro resource productivity opportunities (Source: Dobbs, 2011, Exhibit 23, p. 77)

As described above, there will be circular opportunities that have negative costs (i.e. positive returns on investment) even in the baseline situation. Many of these opportunities may be implementable already in the baseline, meaning that no additional policy intervention is required. Additional policies for fostering the circular economy become relevant whenever some barriers prevent circular opportunities that would be profitable from either a private or a societal perspective from being implemented in the baseline.

An example of such an approach can be found in the report "Assessment of Scenarios and Options towards a Resource Efficient Europe: An Analysis for the European Built Environment" (EC 2014). It analyses a number of options for resource savings in construction (including road building), including options to increase sharing. In evaluating these effects, results of life-cycle analyses (LCA), life-cycle cost analyses (LCC), environmentally extended input-output analyses and expert insights about net cost per tonne of material saving are used (EC 2014, Table 0.1, p. 6). Specific policies are mentioned to realise those options, including green public procurement; eco-labelling and certification; standards, including quality standards and building codes; specific criteria for demolition and building permits; education; and training (EC 2014, Table 3.1, p. 24).

As a last example, we may refer to the report "Growth Within" of the Ellen MacArthur Foundation (EMF, 2015), which explicitly differentiates between the realisation of circular opportunities within the baseline situation and the realisation of additional circular opportunities due to implementation of additional circular policies.

2.3 Barriers to the circular economy transition

An assumption in many circular-economy studies is that there are untapped sources of increases in resource productivity that also reduce costs, meaning win-win strategies are possible. However, mainstream economics is cautious about these so-called "free lunches" because assuming well-functioning markets, the current economic situation should already be based on decisions that economic actors think are optimal. In such a situation, what might appear to be underutilisation of capital goods (like private ownership of washing machines instead of hiring washing hours) may actually be a deliberate choice stemming from consumer preferences for greater flexibility and lower transaction costs (Böhringer and Rutherford, 2015).

If profitable opportunities are not implemented in the baseline, then barriers must exist in the baseline that are not included in the profit calculation. These barriers may be caused by market failure or organisational failure, but may also be hidden costs that are not included in the profit calculations but are relevant in practice. Examples of hidden costs are differences in quality, overhead costs, training cost, disruption of production cost or the cost of processing and gathering relevant information (UNEP, 2017: p. 92-94). Several other taxonomies of barriers for circular opportunities are available, some of them more detailed (Dobbs, 2011; Scorell et al., 2014; UNEP, 2017; IEA, 2012b; Amoc and BioIS, 2013).

The Ellen MacArthur Foundation (2015b) provides a categorisation of potential barriers that we use as inspiration for the categorisation below:

- Economic
  - Profitability
    - Further innovation and learning by doing are required to reduce costs or realise benefits
    - Realistic projections of the profitability of the technology in the long run are difficult to make
  - Barriers to financing the new technologies
  - Uncertainty about future costs and revenues
  - Technology is not available at scale
- Market failures
  - Externalities (societal costs and benefits that are not reflected in market prices)
  - Insufficient public goods, including infrastructure
  - Insufficient competition on markets; competition on the wrong criteria
  - Imperfect information, e.g. asymmetric information
  - Split incentives (agency problems) when parties have different goals
  - Transaction costs, such as the costs of bargaining
- Regulatory failures

- - Inadequately defined legal frameworks
  - Poorly defined targets and objectives
  - Implementation and enforcement failures
  - Unintended consequences of existing regulation that hamper circular practices
- Social factors
  - Capabilities and skills
  - Customs and habits
  - Social resistance
  - Political resistance

Reducing these types of barriers would address key challenges hindering the development of a more circular economy.

In situations where market imperfections are generated over time or due to improper government regulation, realigning regulatory policies consistent with the circular economy may improve the efficiency of the economy. This may be seen from a static perspective, but also from a dynamic perspective. From a dynamic perspective, changes in regulation may create opportunities for the development of new technologies to solve problems around resource constraints and environmental degradation (EMF, 2015, p. 3).

If barriers for introducing circular-economy measures exist, the costs of removing these barriers would have to be included in any proper cost-benefit analysis of circular opportunities. Most economic models do not include the cost of removing barriers or the cost of transition like retraining costs and migration costs. These models show what would happen if the change were made without these costs, which is not a realistic assumption. The costs of stimulating technological changes, or solving inefficient policy implementations should also be taken into account (UNEP, 2017, p. 108/9). However, if the costs of technological changes are low, the model outcomes may be approximately correct.

Listing circular opportunities that are profitable does not mean that these alternatives are more profitable than a listing of both circular and non-circular opportunities would be. If one has more choices, it seems plausible that a higher number of profitable opportunities exists. Thus, the question to answer becomes the following: why would a list of profitable circular economy opportunities have higher macroeconomic benefits than a broader list that includes profitable non-circular opportunities, where also barriers for implementation can be removed?

2.4 Policies for the circular economy

In order to develop scenarios for the circular economy, it is important to include policies explicitly. In many quantitative macro-economic studies, GDP and employment effects of the circular economy are caused by policies for the circular economy. Therefore, it is important to have an idea of the main policies. The discussion of circular policies below is only meant to be a sketch, and is especially relevant for understanding what may be behind the circular-economy scenarios for which the macroeconomic societal benefits have to be evaluated.

Externalities are one of the main reasons why beneficial circular opportunities do not happen. Therefore, it seems logical to first search for solutions to these externality problems. Many externalities are negative externalities, and these require adequate pricing or the definition of new property rights, for example through tradable permits. As far as pricing is concerned, this may be accomplished through setting taxes that are roughly equivalent with the negative externality. The revenue generated may be used to reduce other (distorting) taxes or to finance public expenditures beneficial for the economy. Green investment could be an example of such a public expenditure.

Several categories of policy instruments are available to address barriers to the circular economy:

- **Subsidies.** With respect to innovation, positive externalities may exist, and this may be a good reason for subsidies. While many subsidies (e.g. subsidies on fossil fuels) generate externalities and should be abolished, subsidies on innovation may help to overcome barriers in situations where R&D costs borne by private enterprises generate benefits disseminated across the whole economy. Even some infant technologies may be worth subsidizing due to positive externalities stemming from cost decreases arising when the new technology is applied on a larger scale and experience is gathered over time (i.e. learning by doing).

- **Regulation.** A second category of instruments is intelligent and targeted regulation. In general, regulations that prescribe specific processes have the risk of lock-in in less efficient solutions. On the other hand, it may be efficient to set restrictions on technologies or externalities that are not consistent with a green economy. For example, governments may set maximum pollution or resource-use requirements per unit of output. Governments may set minimum standards for circularity or energy use of buildings, especially if they are floating standards, i.e. standards that adjust to changes of technological knowledge over time. A specific type of regulation is setting responsibility for producers like minimum guarantee periods or mandating they be responsible for paying the costs of recycling after disposal of the product.

- **Infrastructure.** A third category of instruments is infrastructure development. For example, electric cars require an infrastructure of possibilities to charge the cars; public transport requires networks of infrastructure, etc. Providing infrastructure by government or organising institutions that regulate the provision of infrastructure by private companies may be important to realise the network that is required for new opportunities to develop.

- **Public procurement.** A fourth category of instruments is green public procurement. Governments are large customers for many products and services. If governments focus on green procurements, innovators may get a market to develop their new products and services. For example, if governments focus on lifetime costs, this may provide benefits both to government and to the sellers of energy-saving or repairable products, or sellers of products as a service.

- **Information.** A fifth category of instrument is the organisation of relevant information for users. This may be through regulations requiring provision of information on energy efficiency or on lifetime costs, or information on environmental sustainability that can be easily compared across products.

- **Coordination**. A sixth category of instrument is coordination of different agents. For example, in the Netherlands green deals between governments and private agents are made to reach certain green goals and to coordinate activities and adjust legislation when necessary for this purpose.

- **Financing.** A seventh type of instrument is solving financing problems stemming from imperfect information. Examples of these may be insurance by government of risks related to new circular opportunities.

One must be aware that a rapid change towards a circular economy may create a mismatch of supply and demand of available labour and capital. For capital, this is referred to as stranded assets, while for labour this generates qualitative structural unemployment (see Section 4.2). For labour, it may be important to generate a flexible labour market, wherein training and other measure to stimulate labour mobility could be important policy tools (OECD, 2017).

One should be aware that the above listing of circular policies is not meant to be a complete description of policies; it is intended to identify policy categories that must be modelled in order to build realistic circular-policy scenarios. Furthermore, the list of policies is not specific to a circular economy; the policies are as relevant for removing barriers towards a circular economy as for removing barriers to better macroeconomic performance in general.

2.5 Conclusion

The methodologies for measuring the macroeconomic impacts of the circular economy that start with a listing of circular opportunities are an obvious starting point for the development of an aggregation methodology that builds from individual case studies. In listing circular opportunities one must be aware that also a more extended list of all business opportunities could be conceived and that one has to show that the choice from only the circular opportunities is better compared with the more limited list. Furthermore, listing business opportunities that could be realised after the barriers that prevent their execution are addressed, is not sufficient to prove the benefits of those business opportunities. In addition, the policy changes required in order to realise circular opportunities should be included in the analysis.

3 ::   GDP Effects

3.1 Introduction

Although increasing GDP is not the fundamental idea behind the circular economy, the idea that the circular economy also increases GDP is an important motivator for embracing the circular economy (Rizos et al. 2017; OECD 2017b; EC 2015). In this section, we analyse the mechanisms through which more circularity in the economy may also increase GDP. First, we discuss the main mechanisms involved in theory, and then discuss what is accomplished in a selection of the literature. Because trade and competitiveness issues are also relevant for the outcome, we discuss possible mechanisms that may lead to increased GDP through reducing the need for imported raw materials and increases in competitiveness via knowledge generation for the circular economy. In addition, the GDP effects of reducing political dependence are briefly addressed.

3.2 Theory

The introduction of circular opportunities in an economy may generate GDP increases by various means:

1. **Through the environmental effect.** The purpose of resource-efficiency measure is "to reduce risks of resource disruption and environmental damage" (UNEP, 2017, p. 99). However, in most baseline scenarios, these problems are not included, so they are also not included as a benefit in most policy simulations. If it were to be included, this would imply that circular opportunities reduce pollution and therefore may reduce costs of cleaning resources for other sectors. For example, if natural water is cleaner, this reduces costs for tap-water companies and therefore increases productivity of the tap-water companies. Furthermore, reduced pollution may increase health and this may increase GDP because less labour days are lost, or reducing traffic congestion may increase productivity in transport and increase the effective number of hours available for productive work. As a footnote, one should be aware that costs of health care and costs of cleaning the environment are part of GDP, and therefore reduction of these costs will not increase GDP.

2. **Reducing demand for primary resources may reduce their relative scarcity.** Changes in resource prices tends to be a race between technology and scarcity. Most baselines do not assume that prices increase (UNEP 2017), implying that the effect of introducing circular opportunities on resource prices is not very big. Especially if resources are imported, a lower price for resources implies that less has to be paid for the resources for the same amount of value created, implying an increase in value added and therefore factor productivity. However, the extra productivity in the EU may be at the cost of resource-exporting countries.

3. **Additional productivity increases.** It may be that a focus on the circular economy reveals some potential for win-win improvements that were not recognised without this lens of looking at the world. The basic question is,

however, to what extent comparable improvements would not be found without this specific lens.

4. **Reduction in externalities via the tax and regulatory systems.** For example, when taxes on resources increase, distorting taxes on labour may be reduced, which may increase employment and therefore GDP. However, one must be aware that labour-tax reductions do not automatically increase employment. A reduction of labour taxes will increase employment and GDP only when labour taxes are reduced for categories of labour that would otherwise be unemployed.

5. **Effect of increased demand.** If the circular economy generates new investment opportunities that are not crowding out other investments, then this may create extra demand that brings unused resources into use. This effect will only happen if demand restrictions determine GDP growth in the baseline, which may happen in the short or medium term, but seems not very plausible in the long term. The circular economy is in this case used as a type of anti-cyclical policy (see for example OECD, 2017).

3.3 Literature

Having defined the main mechanisms that may explain the positive GDP effects of the circular economy, let us investigate what mechanisms are applied in the current literature, where we do not limit ourselves to studies of the circular economy, but also include studies on issues related to the circular economy, like energy and resource efficiency. We examine here a sample of studies that are representative in the sense that they include the main mechanisms found in the literature. We then investigate the methodology that each of the studies uses for measurement of macroeconomic effects of the circular economy.

Ellen MacArthur Foundation

The report "Growth Within" of the Ellen MacArthur Foundation (EMF 2015) is a well-known example of a study arguing that the circular economy generates additional GDP growth. It is also an important source of inspiration for the EU action plan for the circular economy (EC 2015). Therefore, we take a detailed look at their methodology used to analyse the effects of the circular economy on GDP.

Their results on GDP growth are based on a Computable General Equilibrium (CGE) modelling exercise by Böhringer and Rutherford, wherein a standard CGE model is extended with explicit modelling of private transportation, private housing and food production, i.e. the sectors for which the circular innovations are analysed in the study "Growth Within" (Böhringer & Rutherford, 2015, p. 10-11). Traffic congestion is modelled by differentiating between rural and urban transport services and an exponential relation between traffic volume and congestion (Böhringer & Rutherford, 2015, p. 13). Driving time is modelled explicitly and has consequences for effective labour supply (Böhringer & Rutherford, 2015, p. 15). Also, revenue-neutral green tax reforms are modelled, reducing labour taxes as compensation for increasing green taxes (Böhringer & Rutherford, 2015, p. 11). Involuntary unemployment is modelled through the wage curve, i.e. a curve that relates unemployment and real wages. Such a wage curve may be defended by wage-bargaining processes and efficiency wages (p. 12). However, for disruptive technology shocks this curve is switched off (p. 13) because it is assumed to be relevant only in the medium term. So, Böhringer & Rutherford (2015) argue that it is

not correct to include this effect into an analysis of the benefits of the circular economy. Voluntary labour supply seems to be influenced by time requirements of transport (p. 20), but this is not explicitly mentioned in the model description. Only exogenous technological change is modelled, because drivers and mechanisms of endogenous technological change are theoretically and empirically too uncertain (p. 14).

The basic line of simulation is that the model starts with the situation in the base period (BAU) and then models the developments according to the linear models and circular models respectively through exogenous technological shifts, i.e. implying that the technological shift is at no additional cost (p. 17) and has no opportunity cost with respect to other technological changes (p. 18). This is not without problems; for example, such a modelling approach would not be correct for the switch to solar energy in Germany that had a cost of more than 20 billion euros annually (p. 18).

The results of the simulations are explained by a combination of dynamic effects as a consequence of technological change and green taxation. Let us try to calculate roughly how the assumptions for 2030 for the linear and circular models translate into the final model results.[3] The estimates of the cost reductions to be realised are derived from the case studies.[4] For transport, for example, transport costs are assumed to be reduced by 20%, and travel time by 30% in the circular model compared with the linear model. For housing, it is a reduction in costs of 3.3% and for food a cost reduction of 25%. The shares in GDP are roughly 8%, 22% and 12% respectively, totalling 42%. These three sectors together, being a little bit more than 40% of GDP, and having about a 10% cost reduction, implies an increase of GDP of about 4.2%, wherein for our calculations we implicitly assume that the rebound effects are such that the share of these sectors remains the same. For external costs being about 10% of GDP, the reduction is assumed to be about 20%, adding an extra 2% to GDP. The reduction of costs of the whole model is about 6.3%. Therefore, most of the GDP effects in EMF (2015) are based on the assumed productivity increases in combination with a reduction in externalities on the labour market as a consequence of conversion of unproductive time to productive time due to less congestion. Greening of taxation has no consequences for GDP. In summary, the positive GDP results of Böhringer and Rutherford are the consequence of the estimates by the Ellen MacArthur Foundation that the introduction of circular opportunities will increase factor productivity.

Böhringer & Rutherford (2015) warn explicitly that economic costs like R&D or opportunity costs of foregoing other technological changes are not in the model, i.e. the cost cuts come for free. Real "hidden costs" or costs to reduce the barriers to increased efficiency may reduce the benefits of the circular opportunities. Therefore, the GDP effects are quite likely overstated or may not exist.

Resource efficient scenarios for the built environment
The study "Resource efficient scenarios for the built environment" (EC 2014) build their analysis from a list of opportunities for increasing resource efficiency in the built environment.[5] They select a number of options that have negative net costs compared

---

[3] We calculated all results in the text using the assumptions in table C1 of Böhringer & Rutherford (2015) where we interpret the benchmark equilibrium roughly as share in GDP and where cost reduction in the linear model are not corrected for a possible decrease in the share of GDP (although through the rebound effect the share of housing may increase, while the share of transport and food may decrease).

[4] So, the methodology is consistent with the proposed methodology for the CIRCULAR IMPACTS project.

[5] So, this methodology is also consistent with the proposed methodology for the CIRCULAR IMPACTS project.

with the baseline, and therefore will increase GDP (EC, 2014, table 4.3, p. 35). The main cause of the increase in GDP in the report is the implied general efficiency increase. The report mentions explicitly that if options for resource efficiency that increase cost prices are included, GDP may not rise at all.

International Energy Agency

IEA (2012) use the general equilibrium model ENV-linkage to analyse climate scenarios with respect to the energy sectors. The focus is on energy efficiency. The spending on more energy-efficient capital goods reduces expenditure on energy consumption and therefore increases disposable income. Energy-importing countries benefit and energy-exporting countries have a disadvantage (UNEP, 2017, p. 100). IEA (2012) describe an efficient-world scenario wherein all economically sensible GHG-saving energy measures are implemented. In this scenario, primary energy savings are 13%, requiring an investment of US$2.2 trillion over the period. This investment saves US$4.9 trillion on energy expenditures for consumers in the period 2012-2035. Consequently, GDP rises by 1.1%, i.e. US$0.3 trillion in 2035. This means that the GDP increase is caused by the reduction in the net present value of foregone energy expenditures (caused by less energy use and lower energy prices) being more than the investment expenditures required to achieve those cost savings. This benefit is already implicitly assumed by the definition of the scenario, wherein only economically sensible investments are considered, implying that they are profitable from a commercial perspective and therefore add to GDP.

Econometric models

Econometric models use estimated equations, increasing input of empirical information, but without guaranteeing that equilibrium happens. Because labour markets may be out of equilibrium, this type of model has the potential that employment increases through demand effects. They are mainly used for short- and mid-term analysis of macroeconomic policies (UNEP, 2011, p. 509), but are sometimes also used for long-term analyses.

The E3ME model from Cambridge Econometrics is an example of an econometric model. Although most econometric models are mostly used for short- or medium-term analyses, the authors suggest that E3ME can also be used for long-term analysis because equations of the model are estimated by co-integration and error-correction methods with instrumental variables allowing also for long-term dynamics. The Post-Keynesian structure of the model allows for disequilibrium, where Keynesian stimulation may increase employment and production and may have long-term consequences through endogenous technological change (learning by doing and extra R&D). CE & BioIS (2014) use this model to investigate the effects of resource-efficiency improvements. They model market-based instruments, privately funded measures such as recycling and publicly funded capital investments to improve efficiency. Extra tax income from environmental taxes is used to reduce labour taxes. Marginal-cost information of the different abatement options is included in the model as abatement cost curves, but based on top-down information, because little bottom-up information is available. In the end, the GDP effects are caused mainly by the environmental tax reform, not the efficiency improvements (UNEP, 2017, p. 103).

GINFORS is also an econometric model used for resource-efficiency evaluation (Distelkamp & Meyer, 2016; Meyer et al., 2015, pp. 53-54). It has food and raw-material

price increases as well as unemployment in its baseline. Furthermore, it is assumed that lower material inputs reduce total cost in manufacturing while costs are also reduced due to lower ore and fossil-fuel prices. This generates an increase in GDP for resource-importing regions at the cost of GDP in resource-exporting regions. However, the main GDP effects in the model are caused by increased investment that does not crowd out other investment, and uses unemployed resources (UNEP, 2017, p. 104). This implies that there is cyclical unemployment or a type of structural unemployment that can be solved through extra aggregate demand (see Section 4.2 for the definitions of different types of unemployment). With respect to the methodology to measure the macro-impacts of the circular economy, this implies that one only has to show that the implementation of the circular economy requires extra investment. However, one should also evaluate to what extent extra investment opportunities could be generated with policies that do not have the specific circular-economy lens for selecting investment opportunities.

The same GINFORS model is used by Lutz & Lehr (2015), who analyse the macroeconomic effects of renewable energy and increases in energy efficiency. They report GDP increases due to extra consumption as a consequence of efficiency increases and therefore lower prices, generating extra demand. This implies that the GDP increase is caused by increases in efficiency. Therefore, despite the difference in structure, the model does not have fundamentally different results from the CGE model that is, for example, used for the "Growth Within" study of the Ellen MacArthur Foundation (EMF, 2015).

System-dynamics models

System-dynamics models implement causal relationships of different types as differential equations, and are used to analyse complex systems. There is no guarantee that economic logic is implemented as in general-equilibrium models, but it is potentially possible. In contrast with general-equilibrium models, system-dynamics models are inherently dynamic. However, dynamics can also be built into general-equilibrium models.

UNEP (2011) uses the system dynamics Threshold 21 World model (p. 509), being a global model without differentiation among regions. It generates increases in GDP by having natural capital in the production function, and also includes land, water, energy, waste and emissions as relevant for costs. Decline of natural capital (fish stocks, forestlands, fossil fuels) reduces GDP growth in the baseline, and also reduces employment. By reducing the decline of natural capital, GDP growth in the circular-economy scenario can be higher.

Summary

In most models, positive GDP effects are generated by: 1) increases in factor productivity; 2) greening of taxation, wherein green tax revenues are used to reduce externalities in the labour market or increase green investment; and 3) effects caused by extra investment that is not crowding out other investment. In addition, solving some externality problems like congestion or price increases of imported resources may increase GDP. If models assume a baseline where resource scarcity increases cost, then in the long term, the circular economy may be beneficial for GDP.

3.4 International trade and competitiveness

Although not explicitly discussed in the literature, the circular economy may also increase GDP through international trade and competitiveness. The circular economy focuses on the reduction of resource use, and in many cases, these resources are imported by the EU. Therefore, without further adjustments, net exports of the EU will increase. This implies that either net foreign investment must increase (through an increase of the interest rate or because the extra funds are needed for implementation of the circular-economy opportunities), or the real exchange rate must rise because foreign countries need euros to buy the exported goods, generating a reduction in exports and an increase in imports. In the first case, the extra investment may increase labour productivity and therefore GDP, while in the second case, national income will increase because the real exchange rate is higher, making imported goods cheaper and raising revenue in local currency terms for the exported goods.

Another frequently mentioned issue is that the EU may develop new competitive advantages if the EU is an early adopter of new circular technologies and these technologies become mainstream in the world. The EU may export the commodities that have been developed or the knowledge that has been created. This again must be put into a broader perspective, by taking into account that trade balance, investment and savings are related. Therefore, if exports of circular commodities or knowledge increases, the real exchange rate may adjust, with the consequence that other commodities will be exported less or imports will increase. Should the factor productivity of the newly exported goods be higher than the exported or imported goods they replace, GDP may increase.

If more knowledge becomes available in the EU, this may imply that more profitable investment opportunities emerge. Consequently, the inflow of foreign capital may increase, thereby reducing net savings. This requires smaller net exports, according to the equation:

Exports – Imports = Savings – Investment

This means that the investment effect will increase demand for European currencies and therefore increase the real exchange rate, reducing exports and increasing imports.

Finally, a reduction of imports of resources may have important geopolitical consequences and therefore reduce uncertainty. Many primary materials are mined in a limited number of regions, making price and perhaps even availability uncertain. When the EU imports less of them, the consequence of sudden price increases or political pressures will be less. We have seen the type of risk involved during the first oil crisis (1974/75) when a quadrupling of oil prices brought the global economy into a recession. To the extent that companies see this as a real risk, this may already reduce factor productivity and therefore GDP, but when it happens, it may have negative consequences for GDP directly because of disruption of production or firms going bankrupt due to price changes. Reducing supply risks and preventing political pressure using supply reduction as a means, is one of the reasons behind the focus on the circular economy.

3.5 Conclusion

The GDP effects of a circular economy may be attributed to: 1) the assumptions that higher resource productivity also generates higher factor productivity; 2) reduction of environmental externalities; 3) greening of the taxation system reducing externalities of

labour taxation; 4) increases in demand due to circular investment; and 5) reductions in prices of scarce resources in the long term. We have shown by the example of one scenario that a rough estimate of the model outcomes can be made through direct calculations based on the assumptions in the model. It is not automatically required to put these assumptions in a model, although such an exercise can be useful to create consistency and to include the interaction of a large number of process changes.

In most reports, positive GDP effects are generated by increases in factor productivity, greening of taxation where green tax revenues are used to reduce externalities in the labour market and effects caused by extra investment that is not crowding out other investment. In addition, solving some externality problems like congestion, consequences of illness for labour productivity, or price increases of imported resources may increase GDP. If models assume a baseline wherein resource scarcity increases cost, then in the long term the circular economy may be beneficial for GDP.

A more circular economy in the EU will have consequences for the import of raw materials by the EU, and this will influence the real exchange rate and perhaps also net investments in the economy. It may be that benefits for the EU of reduced import requirements and lower prices of imported raw materials have negative consequences for resource-exporting countries. Finally, development of new circular technologies may potentially provide a competitive advantage for the EU, both for exporting the technologies and exporting the products produced with the new technologies.

A fundamental methodological question to be posed whenever a scenario with circular policies is evaluated, is what the reference scenario should be. If it is assumed that a number of profitable circular opportunities are not realised in the baseline but are realised in the circular economy, the circular scenario will increase GDP automatically. However, if it is a scenario wherein the improvements are focused on the general removal of barriers for both circular and non-circular opportunities, then the outcome is uncertain and the calculation will be very difficult.

One should also keep in mind that GDP increases are not the primary purpose of the circular economy. Many positive welfare effects from the perspective of cost-benefit analysis are not included in GDP. This topic will be discussed further in Section 6.

4 :: Employment Effects

4.1 Introduction

The main reason for attention to employment growth is the reduction of unemployment. In order to understand the potential effects of the circular economy on employment, it is important to understand the unemployment problem first. The idea of green employment is briefly discussed, but the focus is on the question to what extent total employment may increase as a consequence of the circular economy.

4.2 Unemployment and the circular economy

In order to understand the effects of the circular economy on unemployment, it is important to understand the causes of unemployment. First, there is *frictional* unemployment, which is normally short term. This happens at the start of a career, during switching between careers, after moving to a new region or after a period of being outside the labour market. Second, there is *structural* unemployment, which can be long term. This is when the skills of workers or their minimum income requirements don't match the jobs available. This may be caused by insufficient education. It may also be caused by skills becoming outdated because of technological change or outsourcing to other countries without the labour force being trained for the requirements of the new jobs or not having the capability to do these jobs even with proper training. In these cases, this may be called *qualitative structural* unemployment, implying that there may be vacancies for some types of jobs and unemployment for other types of jobs while aggregate demand for jobs equals aggregate supply. If income requirements of workers are higher than productivity this maybe called *quantitative structural* unemployment, i.e. aggregate demand for jobs is smaller than aggregate supply of jobs because the wage to be paid to workers is higher than the equilibrium wage. The income requirements may be individual, set by government, set in collective wage agreements, or just because firms want to motivate workers by paying them above equilibrium wages to improve efficiency (efficiency wages).

Finally there is *cyclical* unemployment, i.e. unemployment caused by insufficient demand. According to Say's law, cyclical unemployment is temporary. However, as Keynes (1936) mentions, lack of aggregate demand may be long term in some cases. The latter is called "secular stagnation" (Teulings & Baldwin 2014).

4.3 Green employment

A great deal of literature exists on gross green-employment effects, i.e. increases in employment in new activities of the green or circular economy without considering that jobs in other sectors may be lost.

Jacob et al. (2015) provide an overview of the literature on employment in the green economy, with a specific focus on developing countries. They distinguish the sector-based and macro-economic green job concept, where the first is focused on gross employment effects of expanding green sectors and the second is focused on net employment effects (Jacob et al., 2015, p. 42). The sector-based green job concept can be either the number of jobs in green sectors (Eurostat and OECD, 1999), or all jobs in

businesses that have more environmentally friendly production methods (US Bureau of Labor Statistics), or even include decent working circumstances (ILO 2012; Jacob et al., 2015, p 20).

Direct employment effects are relatively easy to measure. The indirect employment effects include the employment effects in the upstream and downstream sectors in the value chain and are called multiplier effects in input-output analysis. Finally, even induced employment effects are sometimes included, these being the employment generated through spending of the extra earned income by the additionally employed people (Jacob et al., 2015, p. 42-43). Employment factors are defined as gross employment per million euros of investment (Jacob et al., 2015, p. 43). Jacob et al. refer to the political importance of the sectoral green job concept and therefore suggest that no internationally recognised definition will emerge (Jacob et al., 2015, p. 60).

Wijkman and Skänberg (2015) of the Club of Rome conclude that unemployment can be reduced if the trade surplus increase that is generated by smaller import of fossil fuels and materials is invested. This implies that exporting countries will see a reduction of employment. This is based on input-output analysis. However, an input-output analysis ignores potential feedback effects through the labour market, credit market or otherwise. This type of effect is included in general equilibrium analyses. Wijkman and Skänberg (2015, p. 35) acknowledge that these general equilibrium effects should be included but are not (p. 107). As mentioned earlier, the effect will only happen if unemployment is caused by a lack of demand, i.e. in the case of cyclical unemployment.

Dobbs et al. (2011) calculate employment effects of resource efficiency by using numbers derived from another study, i.e. the Federal Highway Administration (2007), that uses input-output analysis to derive the employment effects of extra investment. The fundamental idea behind it is that extra expenditures (in this case through investment) generate extra jobs. The calculation is basically a gross employment effect that is only compensated if unemployment is low. They conclude that one year of employment will be created per US$ 45,000 to US$ 1,000,000 spent on investment (in infrastructure).

A further step in the analysis of green employment may be to subtract the employment in the sectors that are replaced. For example, if wind and solar energy are at the cost of fossil energy, the net effect may be calculated.

In conclusion, counting jobs in activities that are directly or indirectly related with the circular economy gives an impression of the dynamics that are generated by the introduction of the circular economy. However, it does not tell us to what extent the circular economy also reduces unemployment. For this, net employment effects must be calculated.

4.4 Net employment effects: theory

In order to investigate net employment effects of the circular economy, a consistent view on the labour market is required, wherein it is made very explicit what type of unemployment is influenced by the circular economy. Horbach et al. (2015, p. 19) investigated studies on green employment and conclude that not many have a consistent economy-wide view with a consistent labour market, and no one analyses the net employment effects of more recycling or refurbishment activities.

Empirical studies on net employment effects use economic models. Computable general equilibrium models, system dynamics models and econometric models may be distinguished (Jacob et al., 2015, p. 11). Most studies show no or only small employment

effects (Jacob et al. 2015, p. 60), but it may be that when price effects of increasing resource scarcity are included, the growth effects of green policies can be positive in the long term (Jacob et al., 2015, p. 61). However, extra growth does not automatically generate reduction in unemployment. Even worse, because of potentially negative effects for the sectors that have to shrink, unemployment may even increase in the short term. Therefore, it is important to have labour-market and social-policy instruments in place to increase labour mobility. If a green policy is accomplished through green taxation, the revenues of the green taxes may be used to reduce distortionary labour taxes or to pay for labour-mobility programmes (Jacob et al., 2015, p. 62).

The reasons for positive net employment effects can be distinguished as being a result of one or more of the following drivers:

- Reduction of distorting labour taxes through green taxation, reducing structural unemployment.
- Increase in profitability that in case of quantitative structural unemployment increases labour use at fixed minimum wages.
- Increase in investment or other spending, reducing circular unemployment.
- Better adjustment of available jobs to skills of workers, reducing qualitative structural unemployment.
- Reduction in qualitative structural unemployment by increasing geographical labour mobility through less congestion, better infrastructure, or a healthier population.
- Social programmes focused on the circular economy, giving people a subsidized job that saves on social-security payments and at the same time makes repair or recycling cheaper.

When analysing the final effects on employment, one has to take into account the whole economy. This implies that if investments in the circular economy are made, one must be aware that investment is determined by the circular flow of income in the economy. If investment is done for one purpose and savings and money creation do not change, then this will crowd out other investment, including the employment that may have been generated by the alternative investment. If employment opportunities are created for the circular economy, then this implies extra demand for labour and if the labour market was in equilibrium before, some other labour may be crowded out.

4.5 Net employment effects: literature

After having defined the main mechanisms that may explain possible positive employment effects of the circular economy, let us investigate what mechanisms are applied in the current literature, wherein we do not limit ourselves to studies of the circular economy, but also studies on issues related with the circular economy, like energy and resource efficiency. We take a sample of studies that are representative, in the sense that they include the main mechanisms found in the literature. This gives the opportunity to investigate the line of reasoning in each of the studies a little bit more in-depth.

Neither IEA (2012) nor Böhringer & Rutherford (2015) report employment effects in their general equilibrium analyses, probably because it is not significant (UNEP, 2017, p. 107). Böhringer & Rutherford (2015) state explicitly that the main employment generating mechanism—the labour supply curve—is switched off because their purpose

is to analyse long-term effects, implying also that changes in taxation will have no effect on employment. However, in an older study, Böhringer et al. (2013) use the model with a labour-supply curve and gradually adjusting wages, allowing for structural unemployment and therefore generating some employment effects. They analyse the effect of subsidized renewable energy and conclude that if these are financed by wage taxes, the employment effect will be negative.

CE & BioIS (2014) using the econometric E3ME model from Cambridge Econometrics investigate scenarios with increased resource productivity, wherein the resource-productivity increase is coming from three sources:

- 1/3 publicly funded investments in the capital stock to improve resource efficiency
- 1/3 privately funded business measures (such as recycling systems)
- 1/3 market-based instruments (such as taxes).

They report employment effects that are mainly the result of using revenues from resource taxes to reduce labour costs (UNEP, 2017, p. 108), implying that they implicitly have a rising labour supply curve, something that has been explicitly switched off in the CGE model of Böhringer & Rutherford (2015) because it is not plausible that labour supply is rising in the long term.

UKERC (2014) analyses the effect of more labour-intensive renewables compared with their fossil-based alternatives, and concludes that this may create jobs in the short run during a recession. Their employment effects are possible because of the existence of cyclical unemployment. OECD (2017) is even more explicit, and assumes that until 2020, governments may increase investment for climate policies by generating a budget deficit because of the existence of cyclical unemployment during that period.

Chateau & Saint-Martin (2013) and Château et al. (2011) use the CGE ENV-linkages model of the OECD with lagged wage adjustment to analyse greenhouse-gas mitigation options and conclude that in the short term, unemployment may even rise because of adjustment processes for wages, but that in the long term, the income of the environmental taxes can be used to reduce taxes on wages. This may increase employment.

Morgan & Mitchell (2015) analyse the British economy with respect to the mismatch of labour supply and demand with respect to skills and regions in the UK, including potential trends, and then compare this with labour demand for circular-economy sectors with respect to skill and region, based on current statistical data and expert interviews. The outcome is presented in Figure 4 below, wherein net job creation of a circular economy scenario is compared with (current) unemployment, suggesting that the circular economy creates jobs in the type of jobs where unemployment is high. A comparable exercise is done for the regional distribution of unemployment. Based on the characteristics of employment in the circular economy compared with the baseline, they argue that qualitative structural unemployment can be reduced.
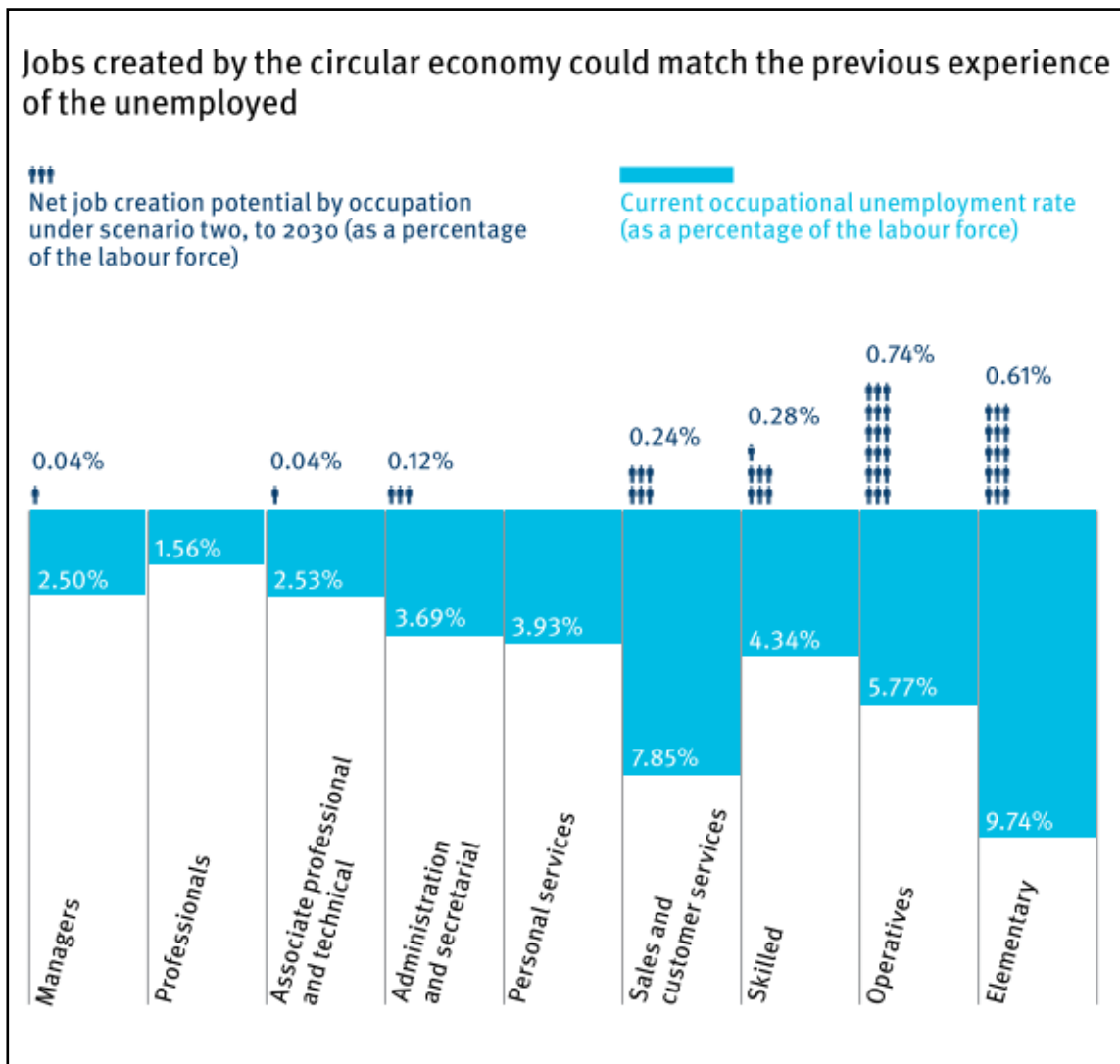
In summary, the studies discussed above have as their line of argument that if the circular economy has effects, it may be either in case of cyclical unemployment, or because it either reduces or increases qualitative structural unemployment depending on the change in job composition. In case there is quantitative structural unemployment, it may be increased or reduced depending on the question of to what extent the circular economy reduces or increases factor productivity. Circular-economy policies like greening taxation and spending the tax income either on reduction of taxes on low-paid jobs or investment, may also increase employment. As far as the circular economy reduces net imports, it may give a boost to investment that may reduce unemployment, in cases of cyclical unemployment.

4.6 Conclusion

Employment effects in most analyses are not based on the circular economy in itself, but on the effect of policy changes or mechanisms that are not specifically for the circular

economy. First, extra investment or investment in more labour-intensive technologies may increase employment in case of circular unemployment or quantitative structural unemployment. However, there is an issue of timing and targeting these impulses. In case of long-term cyclical unemployment (as after the crisis of 2008 and which the OECD projected will continue until about 2020) or secular stagnation, increases in spending increases employment.

Second, employment may increase because of greening the tax system, i.e. reducing the wage for potentially unemployed people, where it is important to have the tax reductions for people who are difficult to employ because current wage levels are too high. This may be because of social security benefits or collective agreements, minimum-wage laws or because institutional dynamics set minimum wages that are above the equilibrium wage.

Third, if the circular economy opportunities generate jobs in regions or skill categories with high unemployment, then this reduces qualitative structural unemployment. However, as far as the circular economy is disruptive, it reduces the number of jobs in traditional industries, wherein the people who are fired do not automatically have the right skills for the circular economy. This means that labour-mobility programmes may be essential for a smooth transition to a circular economy in order to prevent increases in qualitative structural unemployment.

Fourth, sometimes unemployment is reduced by providing low-paid work in the recycling industry to people with less ability to work, i.e. a choice is made to develop circular projects in social employment programmes.

As a comment, it may be that scarcity on the labour market stimulates not only labour productivity but also the efficiency of technology in general because with high wages companies will not survive if they do not increase efficiency. Furthermore, the extra investment or the higher labour intensity of production may also generate employment if it induces extra immigration of labour or creates incentives for people in the labour force to acquire the necessary skills.

As a final comment, one must be aware that employment in the old industries will be reduced, which may have political consequences.

5 :: Environmental and Welfare Effects

5.1 Environmental effects

Important arguments in favour of a more circular economy are to save on primary resources, to prevent scarcity of these resources in the long term, to reduce dependence on uncertain imported resources, and reduction of environmental pollution. Therefore, evaluation of the environmental effects of the circular economy is one of the main issues.

Calculation of environmental effects is at first sight straightforward. One must simply calculate the resource inputs and environmental effects of the sector under investigation with and without the circular opportunity.

However, in practice this is more complicated. First, there are interactions in the value chain. Therefore, a life-cycle analysis of the two alternatives is required. Second, the production of the output may have consequences for the pollution and resource use of the value chain that is replaced by the new value chain. If this is the case, this must be evaluated as well.

Added to this may be the effect that is called indirect land-use effects in the case of biofuel policies (Woltjer et al. 2017). In the case of biofuels, the direct land-use change may involve, for example, replacement of a food crop to produce a biofuel crop in Europe. However, the food crop that is replaced has to be produced somewhere else. Where the final expansion of cropland occurs determines in that case the final effect of the production of biofuels on greenhouse-gas emissions through land-use change. This very complicated process of substitutions makes the environmental evaluation of the effect of creating a biological circle through biofuels very complicated.

The next issue is the rebound effect. Three levels of rebound effects may be distinguished (UNEP, 2017, p. 106). First, direct rebound effects are about the goods where the efficiency improvement is; i.e. if the good becomes cheaper demand for it may increase resulting in more demand for the good. Second, indirect rebound effects are the consequence of lower prices of the resources, generating increases in production in other sectors that are using these resources. Third, macroeconomic rebound effects include also further effects like a possible increase in income that may be used to buy resource-using or polluting commodities. Rebound effects are the consequence of reductions in cost. To what extent these happen depends on the policies implemented and the technologies available. For example, if biofuels are more costly than fossil fuels and the increase in cost is included in the fuel prices, the rebound effect is negative for regions where the policy is implemented, even though it is positive for the regions that have no biofuel policy implemented and therefore have the benefit of lower fossil fuel prices.

An extra thought on the rebound effect may be that some aspects of the indirect land-use change (ILUC) effect of biofuels can also be considered as similar to the rebound effect. In standard calculation of ILUC, agricultural land expansion is less than the direct land use for the biofuel because of price-induced yield increases and consumption reductions. These changes are the consequence of market-mediated shifts in production and demand for other commodities, just as in the rebound effect.

Policy measures may mitigate rebound effects (UNEP, 2017, p. 106). For example, if the circular opportunities are realised due to taxes on resources instead of subsidies on the

circular opportunity, the rebound effect will be eliminated for the regions where the taxes are, although on a global level they may still exist.

In summary, the evaluation of the environmental effects of circular opportunities is complicated because the introduction of circular opportunities has consequences for the whole value chain and because of rebound effects.

5.2 Welfare effects

We have to keep in mind that GDP increases are not the primary purpose of the circular economy. Many positive welfare effects from the perspective of cost-benefit analysis are not included in GDP. Even if the circular economy has no positive effects for GDP and unemployment, welfare may increase. The fact that external costs are not priced is a fundamental cause of extensive resource use and environmental damage. Internalisation of these costs may solve the problem and therefore increase welfare. However, this increase in welfare is not automatically visible in GDP, because some external costs are not included as expenditures in GDP calculations (UNEP, 2017, p. 92). Even worse, some external costs like health-care costs are included as a benefit in GDP, so reduction of these external costs is an increase in welfare, but not in GDP. In addition, reduction of consumption through sharing and other means may sometimes imply a reduction in GDP.

Unpriced externalities may be seen as implicit subsidies. Coady et al. (2015) estimate the explicit and implicit subsidies of fossil fuels at 6.5% of GDP in 2015 (UNEP, 2017, p. 96/7). These unpriced externalities include global warming, air pollution, local factors like congestion, accidents and road damage, and these are very large compared with explicit subsidies. Based on such information, Coady et al. (2015) estimate the benefit of eliminating all explicit and implicit fossil energy subsidies, including reduction of CO_2 emissions and less premature deaths from air pollution (using a simple static cost-benefit analysis) as 2% of global GDP. The benefit of using the green-tax revenue to reduce distorting taxes or to raise public expenditures with high social value is not included in this number.

Reduced dependency on imports of resources is seen as an important argument for the circular economy. This could be included in a broader view on welfare, where such dependency and the risk of sudden price increases of important resources have negative consequences for society in the EU as a whole. Less resource use reduces risks related to resource price increases, price fluctuations and less dependence on a limited number of sometimes politically unstable regions. Less resource dependency may also reduce geopolitical conflicts. Many conflicts seem to be related to international dependencies with respect to crucial sources like crude oil and gas.

6 ::   Indicators

Indicators are relevant on two levels. The first level is the micro level, i.e. the level of the circular opportunities in the list of circular opportunities. What indicators are relevant from the level of circular opportunities in order to get information that can fruitfully be used in an aggregation exercise? The second level is the type of indicators one would like to have to evaluate the macroeconomic and societal consequences on a national or EU level.

6.1 Indicators for circular opportunities

Case studies in the CIRCULAR IMPACTS project can be seen as elements of the list of circular opportunities that define a circular-economy scenario compared with a linear scenario. It is obvious that the case studies will only be a small sample of the circular opportunities that may emerge. Case studies are meant to show the general principles of investigating the aspects of circular opportunities that are relevant from a macro-economic and societal perspective.

The starting point of the listing of circular opportunities is the question of to what extent the circular opportunity could be part of the baseline. Therefore, defining this baseline is an important first step in the analysis of a case study. When one knows this baseline, it is important to know what the characteristics of the circular opportunities in the case study are, and especially to what extent they are profitable under baseline circumstances, both in the case that externalities are included and in the case wherein they are excluded. If the circular opportunities in the case study are not profitable without valuing externalities, but are profitable if externalities are included or the economic structure is changed towards a circular world, then it is important to analyse the barriers and the possible policies to address the barriers. In order for the circular opportunities in the case study to be relevant in a circular economy scenario, it is important that policies are implemented that are sufficient for the circular opportunities to be realised. We have seen that many macroeconomic and societal benefits of circular scenarios arise because of the implemented policies.

If the circular opportunity is realised, it is important to have an impression of the sectors that are influenced, including the sector that may be replaced by the circular economy, the sectors in the value chain, and available income left for other spending. For environmental evaluation, all these aspects are relevant, because pollution and resource use of all parts of the economy involved determines the final effect on the environment and resource use.

Based on the analysis above, the following list of indicators for circular opportunities may be relevant for the macroeconomic evaluation:

- Changes in factor productivity, i.e. input requirements per unit of output, where one has to be aware that also the quality of the output may change
- Changes in trade flows, especially imports of raw materials
- Amount of investment needed
- Changes in employment quantity, wherein it is important to prove that the generated jobs are additional to baseline employment
- Composition of labour demand compared with scarcities on the labour market

- Externalities in production that may be reduced by the circular opportunity. For example, better waste management may imply less external costs.
- Welfare effects of the externalities that may be reduced
- Does the circular opportunity create skills and/or knowledge that provide a competitive advantage or that can be exported to other regions of the world?

This list is an indication of the information that is relevant. Everything should be compared with the baseline. What specifically is needed depends also on the type of circular opportunity being analysed.

6.2 Macroeconomic and societal indicators

Direct measurement of the macroeconomic consequences of the circular economy is not possible. Therefore, in practice, models are used to calculate indicators that show the changes that are caused by a transition towards a circular economy in comparison with a baseline development.

The circular economy does not automatically increase GDP and employment in the short run. However, when one is focused on those circular processes that are useful to reduce primary resource use, including prevention of natural-capital degradation, this may have consequences for GDP and employment. With respect to employment, circular processes will generate new employment at the cost of employment in traditional sectors. By comparing these transitions with labour supply, one may get information on the extent to which employment is created in regions or for skills with excess supply of labour and therefore where employment may increase. On the other hand, the transition may also generate a loss in jobs and especially if the transition is fast, labour mobility programmes are needed.

With respect to GDP, this indicator is relevant in political practice, and with that provides some information on economic activities. Especially if future resource scarcity or environmental problems arise in the future, some benefits of the circular economy may have consequences for GDP. Also, in the short term, the circular economy may generate benefits if externalities are reduced that generate increases in productivity or production in other sectors. Examples are effects on labour productivity and labour supply due to reduced illness or reduction of transport costs due to reduced congestion.

However, the main benefits from the circular economy are not captured by GDP. A broad welfare concept is needed for this that includes at least changes in natural capital and changes in other environmental externalities.

Some regulation that guides the process towards the circular economy may stimulate innovation. Eco-innovation is an important aspect of the development of the circular economy. This implies that it may be relevant to measure the consequences of the circular economy for eco-innovation. However, endogenous technological change is not implemented in most models, and if it is implemented, empirical validation is extremely difficult.

For the evaluation of environmental consequences of the circular economy, including the rebound effects, it is important that social-accounting matrices used in economic models are coupled with the System of Environmental-Economic Accounting (SEEA) and that footprint indicators are derived from this coupling. If this information is correctly included in models (which is extremely difficult), then one could use shadow prices for environmental variables like greenhouse-gas emissions or particulate-matter formation

to estimate the environmental benefits (and costs) generated through the introduction of the circular economy in terms that can be compared with GDP.

From a macroeconomic perspective, especially in the context of the European Semester (which is the policy background for this report) the budgetary consequences for governments are also relevant. These budgetary consequences are the consequence of the specific choice of policies to guide the transition process. For example, it makes an important difference if circular investments are financed by subsidies or are initiated through stricter regulation or taxes on externalities.

The ideas in this section on indicators are derived from the analysis in this report. In-depth analysis of indicator development would be an additional project.

7 :: Conclusion

The discussion in this report shows that it is not easy to define exactly what the circular economy path is and what its macro-impacts are. The first step in any analysis of a circular-economy transition is to get a clear view on the circular opportunity under investigation and to show that this circular opportunity is not part of the baseline development of the economy. The case study must show the current or potential benefits from the perspective of a social cost-benefit analysis, and must also show the private costs and benefits in order to get a good impression to what extent it may be profitable if some institutional conditions, for example regulations, are changed. If the opportunity is profitable from a private perspective, then win-win situations are possible and therefore it is important to analyse how the barriers to its implementation can be removed. If it is not profitable under current circumstances, then further policies are needed, of which the introduction of environmental taxation could be one.

For the analysis of the environmental effects of the circular opportunity, it is important to have clear data on the inputs and outputs of the circular opportunity and compare this with the baseline opportunity. This analysis includes indirect effects through input-output relations and perhaps also induced effects (if incomes are changed) and rebound effects (if relative prices are changed).

For the analysis of GDP effects, insights into productivity changes compared with the baseline are relevant, because this is the main mechanism by which GDP changes. To analyse employment effects, it is important to get insights into what extent the circular opportunity changes qualitative mismatches on the labour market or helps to reduce unemployment that is caused by low aggregate demand or a lack of flexibility in wages. If employment effects happen, then this may influence GDP as well.

With respect to international trade, it is important to get a grasp on the effect of the circular opportunity on import and export flows. As far as resource use is reduced, imports of the resource -importing and exports of the resource-producing countries will decline, with consequences for investment, savings, employment and the exchange rate. With respect to international competitiveness, the circular opportunity may generate a competitive advantage through increased skills and knowledge, either by R&D; diffusion of knowledge; or learning by doing.

Finally, evaluation of welfare effects is a more integral evaluation of the circular opportunity with respect to all aspects of welfare and many aspects of welfare are not included in GDP. Examples of these effects are effects on health, stress, social relations and happiness. Estimates of these consequences could potentially be derived by coupling social accounting matrices used in economic modelling with the System of Environmental-Economic Accounting (SEEA) and calculating economic values based on those by applying shadow prices that are calculated independently.

What is not included in the report are the consequence of less resource dependency on price stability, international financial stability and political stability. These issues may be very important incentives for a circular economy, especially from the perspective of the European Semester.

References

Behrens, A. & Rizos, V., 2017. *The Interplay between the Circular Economy and the European Semester An assessment*, Available at: https://www.ceps.eu/publications/interplay-between-circular-economy-and-european-semester-assessment.

van den Bergh, J.C.J.M., 2017. A third option for climate policy within potential limits to growth. *Nature Climate Change*, 7, p.107. Available at: http://dx.doi.org/10.1038/nclimate3113.

Böhringer, C., Keller, A. & van der Werf, E., 2013. Are green hopes too rosy? Employment and welfare impacts of renewable energy promotion. *Energy Economics*, 36, pp.277–285. Available at: http://dx.doi.org/10.1016/j.eneco.2012.08.029.

Böhringer, C. & Rutherford, T.F., 2015. *The Circular Economy – An Economic Impact Assessment*, Available at: https://sunstiftungsfonds.files.wordpress.com/2015/06/report-circular-economy.pdf.

CE & BioIS, 2014. *Study on modelling of the economic and environmental impacts of raw material consumption*, Available at: http://ec.europa.eu/environment/enveco/resource_efficiency/pdf/RMC.pdf.

Chateau, J. & Saint-Martin, A., 2013. Economic and employment impacts of climate change mitigation policies in OECD: A general-equilibrium perspective. *International Economics*, 135–136, pp.79–103. Available at: http://www.sciencedirect.com/science/article/pii/S2110701713000322.

Château, J., Saint-martin, A. & Manfredi, T., 2011. *Employment Impacts of Climate Change Mitigation Policies in OECD: A general equilibrium perspective*, Available at: http://www.oecd-ilibrary.org/environment/employment-impacts-of-climate-change-mitigation-policies-in-oecd_5kg0ps847h8q-en.

Coady, D. et al., 2015. *How Large Are Global Energy Subsidies?*, Available at: https://www.imf.org/external/%0Apubs/cat/longres.aspx?sk=42940.0.

Distelkamp, M. & Meyer, M., 2016. *Quantitative assessment of pathways to a resource-efficient and low-carbon Europe*, Available at: https://www.econstor.eu/bitstream/10419/156301/1/875723381.pdf.

Dobbs, R. et al., 2011. *Resource Revolution: Meeting the world's energy, materials, food, and water needs.*, Available at: http://www.mckinsey.com/Insights/MGI/Research/Natural_Resources/Resource_revolution.

EC, 2014. *Assessment of Scenarios and Options towards a Resource Efficient Europe An Analysis for the European Built Environment*, Available at: http://ec.europa.eu/environment/enveco/resource_efficiency/pdf/TP_report.pdf.

EC, 2015. *Closing the loop - An EU action plan for the circular economy*, Available at: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52015DC0614.

EMF, 2015. *Growth within: a circular economy vision for a competitive europe*, Available at: https://www.mckinsey.de/files/growth_within_report_circular_economy_in_europe.pdf.

Federal Highway Administration, 2007. *Employment impacts of highway infrastructure investment*,

Horbach, J., Rennings, K. & Sommerfeld, K., 2015. Circular Economy and Employment. , (May), pp.1–39. Available at: https://sunstiftungsfonds.files.wordpress.com/2015/06/ce_employment_1305201

5.pdf.

IEA, 2012. *World Energy Outlook 2012*, Available at:
http://www.iea.org/publications/freepublications/publication/WEO2012_free.pdf.

ILO, 2012. *Working Towards Sustainable Development: Opportunities for Decent Work
and Social Inclusion in a Green Economy*, Available at:
http://www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/---
publ/documents/publication/wcms_181836.pdf.

Jacob, K., Quitzow, R. & Holger, B., 2015. *Green Jobs: Impacts of a Green Economy on
Employment*, Available at:
http://www.greengrowthknowledge.org/sites/default/files/downloads/resource/Ja
cob%2C Quitzow%2C Bär 2014 Green Jobs_ENGLISH.pdf.

Lutz, C. & Lehr, U., 2015. Macroeconomic effects of renewable energy and energy
efficiency policies with a focus on Germany. In L. Bernard & W. Semmler (Eds.),. In
*L. Bernard & W. Semmler (Eds.), The Oxford Handbook of the Macroeconomics of
Global Warming*. pp. 477–496. Available at:
http://www.oxfordhandbooks.com/view/10.1093/oxfordhb/9780199856978.001.
0001/oxfordhb-9780199856978-e-020.

Meyer, B., Distelkamp, M. & Beringer, T., 2015. *Report about integrated scenario
interpretation GINFORS / LPJmL results, Deliverable D3.7a for the FP7 project
POLFREE (Policy Options for a Resource- Efficient Economy)*, Available at:
www.polfree.eu.

Morgan, J. & Mitchell, P., 2015. *Employment and the circular economy Job creation in a
more resource efficient Britain*, Available at: http://www.green-
alliance.org.uk/resources/Employment and the circular economy.pdf.

OECD, 2017a. *Investing in Climate, Investing in Growth*, Paris: OECD Publishing.

OECD, 2017b. *The macroeconomics of the circular economy transition: a critical review
of modelling approaches*,

Rizos, V., Tuokko, K. & Behrens, A., 2017. *The Circular Economy: A review of
definitions, processes and impacts: Deliverable 2.1 of project Circular Impacts*,

Teulings, C. & Baldwin, R., 2014. *Secular Stagnation: Facts, Causes and Cures*, Available
at: ht.

UKERC, 2014. *Low carbon jobs: The evidence for net job creation from policy support
for energy efficiency and renewable energy*, Available at:
file:///C:/Users/woltj004/Downloads/Low Carbon Jobs.pdf.

UNEP, 2017. *Resource Efficiency : Potential and Economic Implications* -, Available at:
http://www.resourcepanel.org/sites/default/files/documents/document/media/re
source_efficiency_report_march_2017_web_res.pdf.

UNEP, 2011. *Towards a Green Economy: Pathways to Sustainable Development and
Poverty Eradication*, Available at:
https://www.unep.org/greeneconomy/sites/unep.org.greeneconomy/files/field/im
age/green_economyreport_final_dec2011.pdf.

Woltjer, G. et al., 2017. Study Report on Reporting Requirements on Biofuels and
Bioliquids Stemming from the Directive (EU) 2015/1513. Available at:
https://dspace.library.uu.nl/handle/1874/358650#.Wov596ZQCGk.mendeley
[Accessed February 20, 2018].

List of partners

Ecologic institute

CEPS
The Centre for European
Policy Studies

Wageningen University and Research