Profit without loss
November 2023

Evidence for part one: 'What would a UK circular economy look like?'

The differences between a 'linear economy', a 'circular economy' and 'resource efficiency'

Currently, our economy is structured around a 'take, make, use and throw' approach where raw materials are mined or grown and made into products which we then use and throw away. This is called the 'linear economy' and it results in unsustainable levels of raw material extraction, carbon emissions, biodiversity loss, water stress, pollution and waste. The UN estimates that raw material extraction, including biomass for food, is responsible for 90 per cent of biodiversity loss and 50 per cent of global greenhouse gas emissions.[1]

A 'circular economy' keeps products in use at their highest value for as long as possible, through reusing, repairing and remanufacturing, and then eventually recycling the materials. There are various definitions of a circular economy, but Green Alliance believes its ultimate aim is to reduce the amount of raw material needed to meet society's needs.

Resource efficiency activities include reducing waste during the process of producing a finished product or making lighter products that still perform the same function but need less material input. Each gramme of material is used more efficiently. Reuse, repair, remanufacturing and recycling can also be defined as resource efficiency activities, as each gramme of material is being used multiple times which is more efficient. As an economy-wide metric, resource efficiency is often assessed through resource productivity, calculated as a country's material footprint (normally raw material consumption, including all materials used in supply chains abroad) relative to GDP.

The main difference between a circular economy and resource efficiency is that,, even under an extremely efficient use of resources in production processes or a relative decoupling of resource use from GDP, total consumption can still increase across the economy. In a genuine circular economy – as we see it – the aim is to achieve an absolute decrease in raw material use.

The economic metrics we use

The health of the economy is most commonly assessed by gross domestic product (GDP) growth. This represents the monetary value of all the things a country produces in a period of time. The more goods and services a country produces, and the higher their value, the higher that country's GDP will be. GDP is the national sum of gross value added (GVA), which reflects the total value of all goods and services produced, minus the cost of all in the inputs required. Economists agree that GDP measure does not fully capture the value of all activities happening in an economy and is only a single flow measure that doesn't take into account a country's assets.[2] While alternative, additional measures of growth and economic progress and prosperity are clearly needed, that is not the purpose of this review, which seeks to investigate what impact a circular economy would have on accepted metrics of economic progress, including GDP.

Where does GDP growth come from? A major determinant is productivity. Productivity is a measure of the amount of input required to produce a given level of output. It depends on three main inputs: labour, land (or resources) and capital.[3] The productivity of labour is the amount of value added per hour of labour input. Productivity of resources is the amount of value added per weight of material input. Increasing resource productivity is necessary to reduce environmental degradation, as it enables the same outputs to be produced using fewer materials. The UK has suffered from particularly stagnant labour productivity growth over the past few decades.[4] For example, labour productivity in G7 countries was 16 per cent higher than the UK in 2021.[5] Increasing productivity, alongside reducing inequalities, will raise living standards in the UK and drive economic growth.[6,7]

The impact of labour on productivity and growth is a major concern for economists, but so is the net change in jobs and employment level. Job creation is an important metric for understanding the impact of the transition to a circular economy on livelihoods, communities and regional economic activity. As some industries decline and others grow, the location of job creation and losses, as well as the relative skill levels and quality of terms and conditions, will shape the economic geography of the country. It is the responsibility of the government to minimise distributional impacts and dislocation, for example through support for reskilling workers in affected sectors.

How are growth, productivity and jobs modelled?

To understand the impact of the transition to a circular economy at the macroeconomic level on future GDP growth, productivity and jobs it is helpful to consider multiple scenarios and model their outcomes. There are two main modelling approaches: bottom up assessments and top down macroeconomic models. For this research, we reviewed 29 studies, including 21 macroeconomic models, six bottom up assessments and two reviews (see table 1).

Economy-wide bottom up assessments are based on scaling up current jobs or productivity benefits from circular activities, using current data on labour intensity or gross value added (GVA) per job in each industry. Examples of this approach include assessments of the UK job creation potential of a circular economy of 470,00-550,000 by 2030 or 2035 and an increase in UK GVA of £82 billion by 2030.[8]

Sector specific bottom up assessments enable the particular challenges and structural differences in each industry to be captured. These approaches provide useful indications of the scale of the change and allow for sector specific details to be considered. However, they cannot fully model the interactions between different industries, or the impact on overall GDP growth. To capture both sector specific detail and national trade-offs, bottom up assessments can be combined with top down macroeconomic models.[9]

Macroeconomic models are designed to account for wider interactions, between industries and sometimes countries, to project net future GDP or employment. These projections are based on underlying assumptions about how the economy works, which differ slightly across the three main types of macroeconomic modelling approaches: computable general equilibrium (CGE), macro-econometric, and input-output models. Our review includes 11 CGE modelling studies, six econometric modelling studies and four input-output modelling studies.

CGE models are based on neoclassical economic theory, assuming market clearing (when demand and supply match up so that every product or service finds a buyer with no surplus or shortage) and that all people are rational, self-interested actors and companies are profit maximising, on the basis of complete information. This matters for modelling resource efficiency, because it leaves little room for inefficient use of resources in the baseline or reference case, even though we know this is prevalent in today's economy. In addition, technological progress in these models appears as 'manna from heaven', making products cheaper without any policy or R&D cost factored in.

Macro-econometric models are based on a combination of economic theory and econometric relationships between historical datasets. This leaves room for inefficient economic outcomes and allocation of resources in the baseline scenario, allowing greater room for improvement in resource efficiency.[10] However, as they are based on historical data and relationships between variables, this constrains the possibilities that can be modelled. For example, the productivity of new jobs in the circular economy is assumed to be equivalent to employment in today's waste management sector, despite research suggesting jobs in reuse and recycling are more labour intensive.[11] This also does not allow for potential improvements to labour productivity of circular activities as economies of scale are reached.

Input-output models are based on tables of data showing how outputs from one industry become inputs to another in a matrix. This allows for rapid quantification of the impact changes in demand for certain products would have on other industries, including through international trade. They can also be extended to include the impact on environmental variables including carbon emissions, pollution and material consumption. However, the relationships between sectors are fixed. If the price of a resource increases, or there is a supply shock, the same proportion of that resource will be consumed by each sector. These models therefore cannot model the structural change that would be expected from a transition to a circular economy.

All three of these model types are based on neoclassical economic theory with production and consumer preferences fixed as inputs to the model. This means the productivity gains from scaling up deployment of new technologies cannot be captured and, therefore, they risk overstating the cost of the transition, as they cannot take into account the economic gains from more efficient technology. These models are also unable to capture the economic benefits of reduced exposure to economic shocks that comes from restructuring supply chains. The models may be well suited to investigating the impacts of marginal policy changes, but not to capturing the benefits of a long term transition in the structure of the economy.[12]

Dynamic economic modelling of transitions may better represent the structural changes that would occur, in reality, during the transition to a circular economy, which will involve a combination of technological, productivity improvements and societal shifts. This modelling approach can account for technological innovation and positive feedbacks to productivity. For example, this approach has demonstrated that a rapid transition to green energy would provide net savings of billions of dollars compared to a fossil fuel based system due to forecasted cost reductions in green energy technologies.[13] A main research priority should be to conduct studies on the economic impact of the transition to a circular economy using a dynamic modelling approach.

Geographical coverage

There is a clear and strong bias towards studies conducted in Europe (see table 1). Of the modelling studies reviewed here, five are global, 12 are regional and ten look at specific countries. Of those 12 regional models, only one is outside Europe and considers Asia. All ten of the country level modelling studies are within Europe. Given that the implications of a transition to a circular economy for jobs and GDP growth are highly dependent on the structure of each country's existing economies, and the majority of the world's population does not live in economies structured like those in Europe, this bias in modelling needs to be resolved to understand the international impacts of a global transition to a circular economy.

Scope of modelled scenarios

Most of the scenarios we reviewed are modelling an increase in resource efficiency, where less material is used to create products, but overall raw material consumption increases, rather than a fully circular economy, where overall consumption decreases. M Meyer, et al (2018) explicitly acknowledge this, stating that none of the countries modelled achieve a per capita material footprint within the sustainable range set out by the UN.[14] The exception to this is the modelling by H Schandl, et al (2016) which does suggest that countries like the USA, Japan and those in the EU could halve or nearly halve their per capita material footprint by 2050, compared to 2010 levels.[15] However, globally, raw material consumption still increases relative to today due to expansion in consumption in other regions. This scenario is driven by a high carbon price combined with resource efficiency improvements and leads to a 1.6 per cent reduction in global GDP by 2050. Further exploration of scenarios achieving a sustainable material footprint through a more circular economy are needed, with national level data on both environmental and economic outcomes.

There are two main approaches to modelling resource efficiency, one assumes an annual rate of material efficiency improvement, and the other rebalances taxes between materials and labour, often called environmental tax reform. The first method imposes a constant rate of efficiency improvements. These improvements to resource efficiency are driven by technological change, often with no policy or R&D costs factored in.[16] Therefore, resource efficiency savings appear almost magically, as ‘manna from heaven’, providing cost savings across the economy.[17] In reality, there are many barriers to resource efficiency, not just in the cost of the investment in R&D and upfront capital, but institutional and cultural barriers which require policy support to overcome.[18] These scenarios do not provide evidence on the impact of particular policy measures as the basis for policy making or make an assessment of how achievable those rates of technological change are. If significant barriers to technological progress exist, and R&D is restricted, environmental and economic outcomes decline.[19]

The second common approach is to model a very specific set of tax policy interventions, called environmental tax reform. In these scenarios, taxes are levied on material use, to discourage it, and then revenues are recycled by lowering taxes on labour, such as income tax. All of the studies we reviewed with this approach show positive economic benefits in terms of GDP growth and job creation. However, this is a very specific way of modelling the circular economy, and reaping the economic benefits relies on doing both the material tax and revenue recycling. Without the revenue recycling, the impacts of simply raising material taxes are projected to be slightly net negative to GDP.[20] It is important therefore to differentiate the impact of a specific pathway to circularity through environmental tax reform from other policy routes.

Further modelling of scenarios with alternative policy mixes is needed to disentangle this and predict the impact of a shift that involves more than just taxes. H Boonman, et al (2023) has done this for the EU, by quantifying the impacts of circular economy innovation and policy plans. This enables a breakdown of which policies and innovations will deliver GDP growth in which areas of the economy. For the EU, strategies focused on circular industries bring greatest GDP benefits with a 3.9 per cent increase in 2030 compared to the reference case.[21] Cambridge Econometrics (2022) have also conducted this analysis for the UK, demonstrating strong GDP impacts from policies in construction and vehicles sectors.[22]

Main findings at the global level

Impact on GDP

The impact of resource efficiency scenarios on GDP are small, but mostly positive. A meta-analysis of 27 studies shows a median increase in GDP of three per cent by 2050.[23] To put this in context, the UK Climate Change Committee estimates that it will cost around one per cent of GDP to transition to net zero by 2050.[24] Action on the circular economy could reduce those costs as well as generate GDP to meet remaining investment needs.

The increase in GDP in macroeconomic models is driven by three factors: technological change, increased investment and higher consumer spending. In all models reviewed, technological change that improves resource efficiency happens for free, thereby reducing the cost of production. Cheaper products mean more money is available for businesses to invest and for consumers to spend, generating GDP growth. This additional spending creates the 'rebound effect' whereby consumption of the item that has become cheaper increases and, therefore, material use also increases, acting counter to a circular economy.

Some scenarios seek to reduce the rebound effect through policies which shift the additional consumption to less material intensive sectors, such as services. This can be done through material taxes, which tend to dampen GDP growth outcomes. To balance this effect, revenues from material taxes can be recycled via lower taxes on labour, which increases spending power and therefore GDP.

Impact on jobs

Most studies find that impacts on employment are positive, reflecting a shift in employment from material extraction and primary manufacturing to higher labour intensity activities of remanufacturing, repair and recycling. A meta-analysis of 27 studies showed a median increase in employment of 4.1 per cent in 2050.[25] However, most models assume current labour intensities for these activities will remain, which gives a useful indication of the scale of job creation and the types of jobs in different regions. However, technology could change this, for example through increased automation of sorting, processing and remanufacturing. This could lead to fewer, but more highly skilled jobs with higher productivity than current labour intensity estimates would predict.

Global distribution of benefits

Importantly, economic benefits at the global level are not evenly distributed. There are net positive gains to a circular economy that is efficient and productive, but there are also zero sum gains, where action from one country comes at the expense of another. S Hatfield-Dodds, et al, (2017) demonstrated that a resource efficiency scenario creates economic benefits for 17 out of 28 regions, largely high income countries and net resource importers, such as the UK. Disadvantaged regions include South America, Russia, Mexico, Brazil, South Africa, Central Europe, Eastern Europe and West Asia. In this case, redistribution of 50 per cent of net economic gains from high and middle income countries would enable a 'no loser' scenario.[26] However, the transition will happen at different rates in different regions. If the transition happens first in high-income countries, resource exporting countries could shift to new markets in the near term. More policy research on circular trade is needed, to ensure the transition does not perpetuate existing inequalities in the global economy.[27]

Trade impact

The implications of the transition for trade flows are generally not well captured in the models we reviewed, despite the significant impact on GDP, productivity and job creation. Countries such as the UK, which are net resource importers, could stand to gain from a strategy that aimed to onshore circular activities such as remanufacturing, repair and recycling. Once investments are made in building the infrastructure for a circular economy, this would lead to a reduction in the need for imports, boosting economic security and resilience, as well as GDP growth and job creation in the UK from the development of new industries. If the UK moves early in the transition, developing clusters of knowledge and supply lines in the UK, it will benefit from first mover advantage and export opportunities.[28] However, the UK will not be able to onshore all aspects of the circular economy, and there may be long term economic gains from increased productivity globally from more open trade in remanufactured and recycled goods based on regional comparative advantage.

Evidence gaps remaining

There are several constraints on our understanding of the economic impacts of a transition to a circular economy. First, the types of models used are not designed to assess structural changes to the economy or able to capture the economic dynamics of the transition. For instance, potential improvements to technology and, therefore, productivity are not accounted for. Crucially, the benefits from avoiding future economic shocks due to insecure supply chains cannot be captured by the models. These shocks can have dramatic economic consequences, as demonstrated by the Covid pandemic and war in Ukraine. Any assessment of the economic impact of the transition should consider those benefits from more circular supply chains.

Second, there is a severe lack of data available on material flows and access to economic data on current circular activities is limited. Better data collection and publication on material flows and circular activities would enable more accurate analysis of current economic and environmental impacts, as well as a stronger basis on which to project future impacts.

Thirdly, significant gaps remain in the range of scenarios that model a circular economy. For example, more scenarios are needed that reduce raw material consumption compared to today, to reach a sustainable material footprint by 2050. A greater variety of policy scenarios, beyond environmental tax reform, would help policy makers take action. Furthermore, macroeconomic modelling of changes to productivity from circular economy scenarios is needed. Currently, the only studies that quantify productivity gains are bottom up assessments, which are not able to capture economy-wide interactions and knock on effects. This is the missing piece that links GDP growth to labour and resources. In addition, greater geographical diversity of scenarios is needed, to better understand the economics of the transition for countries outside Europe.

Lessons for the UK

Only a single macroeconomic study has been conducted for the UK. This study found that a combination of resource productivity policies increased GDP by almost one per cent by 2035, compared to the baseline. Consumer prices decreased by 0.6 per cent. However, employment decreased by 0.5 per cent, contrary to most other studies of the circular economy, due to the impact of policies on the construction sector.[29] This may be due to the structure of this econometric model, based on historical relationships between sector output and employment. In reality, the transition may change these relationships. Dynamic modelling may provide additional insights into productivity gains during the transition in the UK and should be a priority for future research funding.

Given the similarities between the structure of the UK and other European economies, useful lessons may also be drawn for the UK from EU-wide analyses. In particular, over the next decade European countries may benefit from a trade surplus improvement of one to two per cent of GDP, due to reduced imports of raw materials.[30] For the UK, there is likely to be an initial increase in imports of equipment, as investments are made in circular infrastructure and machinery, before imports of raw materials start to decline. Innovation driven circularity also has the potential to increase regional competitiveness, by increasing regional output while reducing emissions.[31] In addition, modelling from H Schandl, et al, (2016) suggests that the EU could nearly halve its material footprint per capita by 2050, compared to 2010 levels.[32]

Taken together, these findings suggest that the UK, and other EU countries, are likely to be particularly well placed to benefit economically from the transition, in terms of GDP growth, lower consumer prices and trade surplus, as well as be in a good position to make a significant reduction in material footprints that would bring the UK closer to sustainable levels of consumption. More work is needed to test these assumptions together in a dynamic economic model of the circular economy. In the immediate term, first steps to improve resource efficiency in industry offer a clear win-win for both GDP growth, consumers and to reduce environmental impacts.

Summary of studies using macroeconomic models to investigate the impact of resource efficiency and a circular economy on GDP, productivity and jobs

Study (authors, date, title)	Type of model	Geographic scope and time horizon	Key findings
M Distelkamp, et al, 2010, *Quantitative and qualitative effects of a forced resource efficiency strategy*	Macro-econometric	Germany, 2030	Combination of tax changes (with revenue recycling), information campaigns and regulation on recycling leads to a 14 per cent increase in GDP compared to the baseline. Employment increases by 1.9 per cent. Material consumption decreases by 20 per cent. Resource productivity doubles from 2010 to 2030.
Cambridge Econometrics, 2014, *Study on modelling of the economic and environmental impacts of raw material consumption*	Macro-econometric	EU, 2030	Resource productivity improvements of 2.5 per cent per annum (equivalent to a 40 per cent improvement in resource productivity by 2030) increase GDP by 0.3 per cent by 2030. Employment also increases by 0.8 per cent. However, raising resource productivity by three per cent per annum has a negative impact on GDP (0.1 per cent decrease in GDP compared to the baseline) due to cost of implementing more ambitious measures. Resource productivity above two per cent per annum reduces overall raw material consumption in the EU from today.
F Groothius, et al, 2016, *New era. New plan. Europe. A fiscal strategy*	Macro-econometric	Europe, 2020	Introduction of material and consumption taxes with revenues recycled through reduced income tax leads to an increase in GDP of two

for an inclusive, circular economy			per cent in 2020 compared to baseline. Impact on material use not specified.
K Rademaekers et al 2017, *Environmental potential of the collaborative economy*	Macro-econometric	EU, unclear	Increasing collaborative business models to ten per cent of market share for accommodation, transport and consumer durables increases GDP by 0.02 per cent. This is largely driven by the rebound effect. Material consumption increases by 0.04 per cent. In the more moderate scenario where the rebound effect is not included, GDP decreases by 0.15 per cent, employment decreases by over 100,000 jobs and material consumption decreases by 0.04 per cent.
Cambridge Econometrics, 2018, *Impacts of circular economy policies on the labour market*	Macro-econometric	EU, 2030	Circular economy scenarios increase GDP by 0.3-0.5 per cent by 2030 compared to the baseline. Employment also increases by 0.3 per cent across both scenarios, with increases in waste management offsetting decreases in construction. Imports to the EU reduce by 0.3-0.8 per cent and consumer prices also reduce by 0.1 per cent by 2030 compared to baseline.
Cambridge Econometrics, 2022, *Economic analysis of policy pathways for increasing resource productivity*	Macro-econometric	UK, 2035	All resource productivity policies combined increase GDP by 0.9 per cent by 2035 compared to the baseline. The greatest gains in GDP come from the construction and vehicles sectors. Employment decreases by 0.5 per cent overall due to the impact of embodied carbon standards in the construction sector, which result in 50 per cent reduction in use of all products from 2023. Most other policies have no net effect on employment. Consumer prices decrease by 0.6 per cent.
Ellen MacArthur Foundation, 2015, *Growth within: a circular economy vision for a competitive Europe*	Computable general equilibrium (CGE)	Europe, 2030	Resource productivity increases of three per cent per annum leads to a seven per cent GDP increase by 2030 compared to baseline. The rebound effect could add 5-20 per cent consumption in food, mobility and housing by 2030. Overall positive impacts on employment (reviewed 65 studies) due to labour intensive recycling and remanufacturing, but some sectors lose out. Raw material consumption in selected sectors decreases by 32 per cent by 2030 and 53 per cent by 2050, compared to 2012 levels.
J Hu, et al, 2015, *Report about integrated scenario interpretation*	Computable General Equilibrium (CGE)	EU, 2050	Policies that reduce global raw material consumption by over 50 per cent by 2050 compared to the reference scenario have a small negative impact on GDP in the EU.

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F Bosello, et al, 2016, *Report on economic quantitative ex-ante assessment of DYNAMIX policy mixes*	Computable General Equilibrium (CGE)	EU, 2050	A materials tax with 50 per cent revenue recycling to reduce labour taxation leads to a two per cent increase in GDP by 2050 and 70 per cent increase in material efficiency (MEMO II model). Without revenue recycling, impacts on GDP are net negative.
S Tuladhar, et al, 2016, *An Economic Analysis of The Circular Economy*	Computable general equilibrium (CGE)	EU, 2035	Circular economy scenarios lead to an increase in EU GDP of 1.4-2.7 per cent by 2035 compared to the baseline. The largest impact comes from the construction sector, where cheaper inputs lead to greatest economic gains.
M Soderman, et al, 2016, *Integrated economic and environmental assessment of waste policy instruments*	Computable general equilibrium (CGE) model integrated with waste management and Lifecycle analysis (LCA)models	Sweden, 2030	Reducing VAT on services to encourage their consumption relative to goods resulted in a 0.1 per cent decrease in GDP and one per cent decrease in waste generation.
M Winning, et al, 2017, *Towards a circular economy: insights based on the development of the global ENGAGE-materials model and evidence for the iron and steel industry*	Computable general equilibrium (CGE)	Global, 2030	Small positive effect on global GDP by 2030 from increasing secondary steel production, compared to baseline. Regions with lower GDP include Africa and South Korea (0.7 and 0.6 per cent decline in GDP by 2030 respectively), and Mexico and Asia and Oceania. This is due to losses in primary steel production not compensated for by increases in secondary production.
S Hatfield-Dodds, et al, 2017, *Assessing global resource use and greenhouse emissions to 2050, with ambitious resource efficiency and climate mitigation policies.* [Modelling results are featured in UNEP	Computable general equilibrium (CGE)	Global, 2050	Resource efficiency plus climate action scenario increases GWP by 1.5 per cent by 2050 compared to baseline. Raw material consumption decreases by 28 per cent compared to the baseline. This reflects a 53 per cent increase compared to 2015. Resource productivity increases by 40 per cent. 'Resource efficiency plus' creates economic benefits for 17 of 28 regions, largely high income countries and net resource importers. Disadvantaged regions include South America, Russia, Mexico, Brazil, South Africa, Central Europe, Eastern Europe and West Asia. Redistribution of 50 per cent of net economic

International Resource Panel, 2017, *Resource efficiency: potential and economics implications*]			gains from high and middle income countries would enable a 'no loser' scenario. Resource efficiency alone leads to an increase in GWP of 6.5 per cent by 2050, but only reduces material consumption by 17 per cent.
D Lee, 2018, *Building evaluation model of biohydrogen industry with circular economy in Asian countries*	Computable general equilibrium (CGE)	Asia, 2040	Circular economy scenarios lead to GDP increase of around four per cent for Asia by 2040. The largest gains are in China and India, of around seven per cent, while Japan see losses in GDP of around four per cent.
M Beccarello and G Di Foggia, 2018, *Moving towards a circular economy: economic impacts of higher material recycling targets*	Computable general equilibrium (CGE)	Italy, 2020	Extended producer responsibility scheme to increase packaging recycling increases production by 15 per cent, job creation by 12 per cent and value added by 12 per cent compared to a reference baseline scenario.
H Boonman, et al, 2023, *Macroeconomic and environmental impacts of circular economy innovation policy*	Computable general equilibrium (CGE)	EU, 2030	Detailed quantification of EU circularity plans, split into four groups: circular cities, circular industries, closing the loop, resource efficiency on territory and at sea. All strategies combined leads to an increase in GDP compared to the baseline, but this is mostly driven by the circular industries strategy where resource efficiency makes products cheaper. Circular industries leads to a 3.9 per cent increase in GDP compared to reference in 2030. The other three strategies have a negligible impact on overall GDP, reflecting increases in activities in some sectors and decreases in others. All strategies combined also lead to a net increase in employment, driven by increases from circular cities and circular industries strategies. The other two strategies have no net impact on employment. Employment also increases outside the EU in reprocessing sectors in Middle East and Africa, despite the EU reducing waste exports.
A Wijkman and K Skanberg, 2015, *The circular economy and benefits for society*	Input-output	Finland, France, the Netherlands, Spain and Sweden, 2030	Material efficiency scenario leads to 50,000-300,000 jobs created across the case study countries. These countries also benefit from a trade surplus improvement of one to two per cent of GDP, but it is noted that once exporting countries also transition to circular economies these benefits would reduce.
M Meyer et al, 2018, *Contemporary*	Input-output	Global, 2050	Resource efficiency improvements of two per cent per annum increase GDP by four per cent by 2050, compared to a climate-policies-only

resource policy and decoupling trends—lessons learnt from integrated model-based assessments			baseline. Raw material extraction is reduced by 35 per cent compared to this baseline, leading to two Gt absolute reduction compared to 2015 (a slight absolute decoupling). It is noted that this is insufficient to reduce extraction to sustainable levels. The GDP increase is largest for India, then China and the EU. GDP declines for the US (0.2 per cent) and Russia (three per cent).
K Wiebe, et al, 2019, *Global Circular Economy Scenario in a Multiregional Input–Output Framework*	Input-output	Global, 2030	Circular economy scenario leads to ten per cent less material extraction globally, slight increases in employment across most world regions and no significant impact on value added, other than redistribution between industries.
H Schandl, et al 2016, *Decoupling global environmental pressure and economic growth: scenarios for energy use, materials use and carbon emissions*	Integrated assessment model including a computable general equilibrium (CGE) model, material flow model and multi-regional input-out model	Global, 2050	A high carbon price and doubling annual material efficiency improvements sees a 1.6 per cent reduction in GDP by 2050, without taking into account the impact of climate change itself. Doubling material efficiency leads to a 52 per cent decrease in global material extraction compared to the reference scenario in 2050. However, this is still an increase of 20 per cent compared to 2015. This is largely due to increases in material consumption in countries such as China. The material footprint of the US, Japan and EU roughly halves by 2050.
J Beasley and R Georgeson, 2014, *Advancing resource efficiency in Europe: indicators and waste policy scenarios to deliver a resource efficient and sustainable Europe*	Bottom-up assessment (jobs per tonne of material, jobs multipliers)	Europe, 2030	Ambitious recycling and reuse scenario could lead to 867,003 additional (gross) jobs by 2030.
P Mitchell and M Doherty, 2015, *Job creation in the circular economy: increasing resource efficiency in Northern Ireland*	Bottom up assessment	Northern Ireland, 2030	In a transformative scenario, 13,000 jobs could be created by 2030 in Northern Ireland. The number of circular economy jobs more than doubles by 2030.

Green Alliance and WRAP, 2015, *opportunities to tackle Britain's labour market challenges through growth in the circular economy*	Bottom up assessment	Britain, 2030	In a transformative scenario, 470,000 jobs could be created by 2030 in Britain. 88,000-115,000 of these are expected to be net jobs.
SUEZ and Eunomia, 2016 *A resourceful future: expanding the UK Economy*	Bottom up assessment	UK, 2030	Transition to a more circular industrial strategy results in a GVA net gain of £9.1 billion in 2030 compared to the reference scenario.
WRAP, 2021, *Levelling up through a more circular economy*	Bottom up assessment, building on Morgan and Mitchell, 2015	UK, 2030	Transformative scenario, including 50 per cent increase in remanufacturing activities, 37 per cent in recycling and 25 per cent increase in reuse increases UK GVA by £82 billion and creates 550,000 jobs by 2030. 98,794 of those are net job creation.
Green Alliance, 2021, *Levelling up through circular economy jobs*	Bottom up assessment, building on Green Alliance and WRAP's report from 2015	UK, 2035	Transformative scenario, including a 50 per cent increase in remanufacturing activities, 85 per cent increase in recycling, 25 per cent increase in reuse and 100 per cent increase in rental and leasing, lead to 472,000 new jobs by 2035. These jobs would be distributed across the UK in regions where unemployment is forecasted to grow.
G Hernandez, et al, 2020, *Macroeconomic, social and environmental impacts of circular economy up to 2050: a meta analysis*	Meta-analysis of 27 papers, 300 model scenarios	Global, 2050	For GDP, ambitious scenarios lead to a median increase of three per cent in 2050. Projections range from one per cent to ten per cent increase. For job creation, median increase of 4.1 per cent in 2050.
OECD, 2020, *Labour market consequences of a transition to a circular economy*	Review of 15 modelling studies	Global, 2030 and 2050	Most studies find employment increases by 0-2 per cent, with one study predicting employment gains up to seven per cent. Only three scenarios find slightly negative impacts on employment. Results are mostly driven by stylised policy scenarios with material taxes. Scenarios with revenue recycling increased employment by a further two per cent.

Methodology for part three: 'Consumers and the circular economy'

This product level analysis calculates the cost savings of switching to circular business models for a consumer. The analysis covers three commonly used product categories: mobile phones, domestic appliances and clothing. The three business models covered are repair, resale (reuse), and renting.

Mobile phones

Repair

Retail prices of the latest models of mobile phones, as at 30 May 2023, for commonly used brands (Apple, Samsung, Google were obtained from the brands' respective websites. [33,34,35]

Two common types of phone repairs, screen replacement and battery replacement, were used to calculate cost savings. We assumed that repair was undertaken through the manufacturer rather than a third party provider. Costs of repair (including VAT) were then gathered from the brands' respective websites, and prices varied depending on the type of replacement and model.

Resale

Resale prices of mobile phones were obtained from BackMarket, a leading online marketplace for refurbished electronic devices.[36] All listings (as of 30 May 2023) for the chosen models were extracted and the mean was calculated to find the average resale price of each model.

Rent

Two rental platforms, musicMagpie and Oodles, were used to obtain the prices of renting a mobile phone for the chosen models.[37,38] For the purpose of this analysis, it was assumed that mobile phones would be rented for a period of 12 months. Google phones were omitted in this scenario as no providers on the market currently rent them.

Domestic appliances

Repair

Three types of commonly used domestic appliances were selected: washer dryers, fridge freezers, and dishwashers. Five of the most popular and cheapest options were selected, by using the 'sort by price low to high' and 'sort by most popular' functions on the AO website.[39] The average of the top five most popular models was calculated to determine the baseline price for each appliance. We also calculated the average of the five cheapest models, to compare if it would be more cost efficient to repair an appliance or purchase a new cheaper alternative instead.

A cost guide for domestic appliance repairs compiled by Which? was used to determine the cost of repair. [40]

Resale

Resale prices of domestic appliances, based on the appliances identified as the most popular models, were obtained through listings on eBay on 31 July 2023.

Clothing

Repair

Average prices of different types of garments as of 3 May 2023 were obtained using the Office for National Statistics (ONS) Shopping Comparison Tool.[41] The shopping basket tool included variations of each type of garment (eg casual and formal), disaggregated by gender. Based on the available data, the types of garments were grouped into five categories: tops and shirts, trousers, jeans, dresses, and jackets and blazers. To find the 'cheapest market option', we selected the cheapest item (as of 27 July 2023) in those same categories from three fast fashion producers: Boohoo, Primark and ASOS.[42] We then calculated an average of the cheap items which we could use as a comparative price point.

Costs of repair were gathered from City Tailors and AirTasker.[43,44] As there are some nuances in between the definitions of 'repair' and 'alteration', tailors were contacted by telephone and we requested if the costs of repair varied from that of alternations but were informed that there were no major differences in price.

Resale

The second hand or 'pre-loved' clothing market is rapidly growing, with prices varying significantly based on brand, quality and rarity. For this analysis, we wanted to investigate the scale of potential savings from buying second hand, and whether that varied by price point. Therefore, we used three websites to source data: two included listings on the low to middle end of the price band, Vinted and Depop; and one had higher end designer items, Reselfridges.[45,46,47] On Vinted and Depop, the cheapest ten items were selected across: tops and t-shirts, trousers and dresses to demonstrate the potential scale of possible savings. Retail prices of the respective items were sourced using the Google Reverse Image Search tool which was able to detect matches on retail sites. Higher end second hand items in each category were sourced from Reselfridges. This was to reflect the broad range in quality of the second hand market and investigate whether savings remain proportional: for instance, fast fashion items for resale can be very cheap (as little as £1.20), as their original price was low, but more expensive items are resold at a higher price.

Rent

Similar to the resale clothing scenario, we used product specific comparisons between retail and renting prices. It was assumed that a garment would be rented for three days, accounting for buffer time around the day that the garment would be worn. Data was sourced from two leading shared wardrobe platforms, ByRotation and Hurr Collective.[48,49] The four categories of garments we included in the analysis were: tops, trousers, dresses and coats.

ByRotation did not have a feature to sort the garments by price, so we selected the first ten items that appeared when the filter was applied for each garment type on 28 June 2023. Hurr Collective did have a 'sort by' feature, so we used data from the cheapest ten items and the most expensive ten items to represent a broader sample. We compared these to the retail prices of each garment new, which were listed on the respective brand websites.

Toddler clothing is increasingly being rented, as babies outgrow seven sizes of clothing in two years.[50] Hence, we included data from two sources in our analysis: TheLittleLoop and bundle.[51,52] We assumed that bundles of toddler clothing are rented every three months, and calculated cost savings using the same method outlined above.

Endnotes

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