A Post-Keynesian approach to modelling the economic effects of Covid-19 and possible recovery plans

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Contents

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A Post-Keynesian approach to modelling the economic effects of Covid-19 and possible recovery plans

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ABSTRACT

Only twelve years after the global financial crisis, in 2020 the world is again facing economic crisis. This time around the source of the crisis is the Covid-19 global pandemic, which is affecting the economy differently to the global financial crisis. However, conventional macroeconomic theory and models have once again been found wanting, and economists have again turned to the work of Keynes and more recent Post-Keynesian scholars.

This paper explores why the economics of the pandemic have been so difficult to model. It provides a simulation of the macroeconomic impacts of Covid-19 using the E3ME macro-econometric model. It then describes two potential recovery packages, one of which could be described as 'green'. The modelling shows that the green recovery package could support the global economy and national labour markets through the recovery period, outperforming an equivalent conventional stimulus package while simultaneously reducing global energy CO_2 emissions by 10%.

1. INTRODUCTION

As in 2008-09, economists have been caught out by a sudden downturn in economic fortunes. At least in 2020 the shock to economic activity originated externally from

[1] An older version of this paper was published on the Cambridge Econometrics website: https://www.camecon.com/wp-content/uploads/2020/06/The-economic-effects-of-COVID-19.pdf.

the pandemic, rather than activities in the financial system; no one this time is blaming the economists for 'not seeing it coming'. Nevertheless, economists have by and large found their tools to be inadequate for predicting short-term economic outcomes and, in some cases, ill-suited for policy analysis.

As soon as it became clear that it would be necessary to take extraordinary measures to contain the virus, there were demands for assessments of the economic effects. The UK economist Simon Wren-Lewis provided initial insights from previous work he had done exploring the potential economic effects of a pandemic[2]. Estimates of potential loss of GDP soon followed[3]. There have since been extensive discussions on the potential costs to government. In the environmental sphere, the oil price fell heavily, oil markets have shown considerable instability and projections of greenhouse gas emissions for 2020 remain highly uncertain (though many expect a large fall).

However, it could be argued that the effects at sectoral level are more important than the macro level outcomes. Unlike in 2008-09, the economic crisis we are currently facing in 2020 is rooted initially in reduced levels of consumer spending, rather than reduced levels of investment. There is a clear distinction between impacts on manufactured goods and impacts on service-oriented sectors. If firms are willing to bear the risk and cost of inventory, factories may keep producing and build up stocks in anticipation of 'pent-up demand' once lockdown periods end. Consumer-oriented services (e.g. restaurants) face a loss of income that will not be recovered.

In many developed countries, governments have offered levels of support that previously would have been considered outlandish. Governments have rapidly issued large amounts of new debt. There has been discussion of central banks monetising some of this debt, a topic previously restricted to Modern Monetary Theory (see e.g. Wray, 2016). Although economists offered advice, most of the government support measures were introduced with limited consultation or analysis; they were seen as urgent responses to a crisis situation.

This is all happening as the world is meant to be embarking on a transition to sustainability, including targets to reduce global greenhouse gas (GHG) emissions to net-zero, thereby keeping average surface temperature increase to 1.5°C. Any short-term impacts on emission levels are likely to be temporary but the nature of the economic recovery plans could have a longer-term bearing on the level and pathway of emissions.

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[2] https://mainlymacro.blogspot.com/2020/03/the-economic-effects-of-pandemic.html

[3] http://www.oecd.org/economy/global-economy-faces-gravest-threat-since-the-crisis-as-coronavirus-spreads.htm

This paper explores why economists and their models have struggled so much with Covid-19. It finds that current mainstream neoclassical and New Keynesian economics face shortcomings that limit their usefulness in the present situation. Similarly, Computable General Equilibrium (CGE) and Dynamic Stochastic General Equilibrium (DSGE) models are not well suited to modelling either the economic impacts of the crisis, or possible paths to recovery. However, we show that it is possible to obtain more useful insights from Post-Keynesian and complexity-based economic models – if they are applied in an appropriate manner.

The next section discusses the gap between what current modelling tools can offer and what is being demanded of them in the crisis. The following section describes our own attempt at forming economic projections using the E3ME Post-Keynesian macroeconomic model. We present the results of this exercise in Section 4, and offer brief conclusions in Section 5.

2. WHY COVID-19 IS DIFFICULT TO MODEL

2.1. Introduction

Understandably, economists have been asked to provide quantitative estimates of the impacts of Covid-19. To obtain these estimates, they usually turn to computer models. However, modellers face several important issues when attempting to understand the economic impacts a pandemic. In this section we discuss three of them:

- Combining analysis of public health with economic analysis
- Dealing with fundamental uncertainty
- Assessing a simultaneous shock to economic supply and demand

These are discussed in turn below.

2.2. Modelling health and economics together

At the start of the crisis, the key question being asked was what form the measures to prevent the spread of Covid-19 should take. The two main dimensions, which were expressed as a ‘trade-off’ by people on both the political left and right, were protecting human lives and protecting the economy.

Unfortunately, at the time there were no sophisticated models that could combine an assessment of the spread of disease and economics within a single framework, which meant that economists and epidemiologists were not always working on a consistent basis.

In order to model the spread of disease, a high degree of disaggregation (ideally to micro level) is required. The standard economic classifications (i.e. ISIC, NACE) offer some help here but the availability of detailed data is still limited. Post-Keynesian models, which operate at a macro or sectoral level, lack the necessary resolution. Neoclassical or New Keynesian models are based on 'micro-foundations', but reliance on the assumption of the representative agent makes them unsuitable for assessing disease propagation through a population.

The prospects for progress in this area falls to complexity-based approaches. Complexity already cuts across academic disciplines, having its roots in physics and biology. Complexity economics, first defined in Arthur (1999), assesses system-level outcomes from the interactions of individual components. Complexity-based models usually take the form of 'agent-based' models (see e.g. Miller and Page, 2007). These models may in fact be well suited to assessing the interactions between the propagation of disease and the economic system. Viruses spread through the same person-to-person interactions that are required for many economic transactions. Agent-based models focus on these interactions.

For example, the Sugarscape model described in Epstein and Axtell (1996) and Beinhocker (2007, Ch 4) develops a primitive economy through an agent-based model. While most of the analysis in Epstein and Axtell (1996) describes how the agents in the model interact with each other in economic terms (for example, leading to different income distributions), the final chapter of the book considers the propagation of diseases amongst the agents.

However, Sugarscape presents an extremely simplified representation of the economy, for example with only two commodities and agents that live mainly on subsistence. It is designed to demonstrate certain system properties rather than test real-world lockdown strategies.

More recent analysis in Pichler et al (2020) combines some of the insights from complexity with a more Keynesian approach, similar to the one applied in this paper. The authors apply infection rates to the various economic activities in the model and therefore link the spread of disease to different parts of the economy. While still subject to strong assumptions and limitations, this approach may point towards a way forward in future.

At this point in time, however, there is little prospect for combining health and economic effects within a single model that is detailed enough to support policy makers. The two areas of analysis will need to remain separated.

2.3. Fundamental uncertainty

One area where Post-Keynesian economics and complexity economics are aligned is in their commitment to the notion of fundamental uncertainty. Prior to writing his General Theory in 1936, Keynes published A Treatise on Probability (Keynes, 1921), which laid out the difference between 'risk' (quantitative unknowns) and 'uncertainty', which he later famously described as things 'we simply do not know' (Keynes, 1937). The economist Hyman Minsky, who is best known for predicting the 2008-09 financial crisis, noted that to understand Keynes' General Theory, one first had to read the Treatise on Probability. The entire Keynesian demand-led economic system is dependent on the likelihood of households saving to protect against uncertain future outcomes.

In complex systems, the uncertainty (and non-linearity) derives from the interactions of the agents in the system and the evolution of the agents' behaviour. We saw this in the pandemic, which had exponential growth in terms of new infections up to a certain level before tailing off. Clearly, the point at which the exponential growth ends is critical for determining the overall scale of the effects; but it is very uncertain when this will take place.

Attempts to predict aggregate GDP impacts are therefore reduced to little more than guesswork, whether a model is used or not. There is also a clear conflict with neoclassical and New Keynesian modelling approaches that leave no room for fundamental uncertainty in their underlying optimisation assumptions.

This raises the question of whether there is any benefit in attempting to model the economic effects of the pandemic at all. Indeed, those seeking a prediction of future GDP will be disappointed, which calls into question the use of New Keynesian Dynamic Stochastic General Equilibrium (DSGE) models that produce only aggregate outcomes. However, a scenario-based approach with a high level of disaggregation may still provide useful insights, for example on the types of sectors and jobs likely to be affected under certain lockdown conditions.

2.4. Modelling supply and demand shocks

There has been a rather esoteric debate amongst economists as to whether the pandemic is a demand or supply-side shock. The authors' view is that it is both: where businesses have been ordered to shut down, or where workers have to cut their hours to take care of children, there is a reduction in supply. But some products have suffered loss of demand even when they have not been the focus of government restrictions; the threat or actuality of lost incomes is making consumers cautious. The similarity in economic performance between Denmark and Sweden, one with strict lockdown conditions and one without, provides clear evidence that changes in supply and demand are both affecting economic outcomes.

Any attempt to model the economic effects of the pandemic, and potential recovery plans, must therefore account for both losses of demand and supply[4]. Unfortunately, this makes neoclassical CGE and New Keynesian DSGE models that incorporate a form of Say's Law (in which all supply finds a demand), unsuitable for assessing the crisis or any other situation in which there is a shortage of aggregate demand[5].

In contrast, two areas that Post-Keynesian economics focuses on (see King, 2015 Ch2) have come to the fore. The first is involuntary unemployment, reflecting both the demand and supply-side shocks to the economy. The second is the role of debts and finance in driving the economy (Pollitt and Mercure, 2018; Mercure et al, 2019), in this case particularly related to the financing of government support.

Given that Keynes developed his theories during the period of the Great Depression, it perhaps should not be surprising that they are of particular relevance at this time. Galbraith (1975; Ch16) discusses how Keynes got to the finding that public spending was required to bolster economic activity in the recovery from recession. The models that have been developed from these theories remain the most appropriate in such circumstances today.

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[4] Guan et al (2020) presents another, more accounting-based approach that is designed to show the immediate supply-chain effects of restrictions on global trade from Covid-19. The approach is based on a multi-regional input-output system, with manual interventions to represent trade limitations.

[5] CGE models that have incorporated more real-world features such as GEM-E3-FIT (see discussion in Mercure et al, 2019) may also be well placed if they do not enforce Say's Law or equilibrium in money and labour markets. It remains an open question whether these models could still be described as neoclassical.

2.5. Conclusions on the modelling of the economic impacts of Covid-19

It is ironic that the demand for model-based predictions is at its highest at the times when the limitations of models are most exposed. In this section we have presented some of these limitations, notably that tools which combine health-based and economic analysis are in their infancy. Our analysis suggests the usefulness of economic modelling is limited to cases where:

- The focus is on scenarios rather than forecasting
- The model is able to capture both demand and supply-driven impacts

The model does not assume that the economy adjusts quickly to full employment of resources and allows fundamental uncertainty to affect spending and saving behaviour

- There is a high level of disaggregation by sector / product in the analysis

From the present range of models, only those from the Post-Keynesian or complexity schools would be able to meet these conditions. In the following sections we present a first attempt at such an analysis using the post-Keynesian E3ME macroeconomic model.

3. HOW WE FORMED OUR PROJECTIONS

3.1. Introduction

This section describes the method that was applied to form the projections. First, we provide a brief introduction to the E3ME macroeconomic model. Then we describe the scenarios that were implemented in the model.

3.2. The E3ME model

E3ME is a macro-econometric model that is based on Post-Keynesian theory. The full model manual (Cambridge Econometrics, 2019) is available on the model website, www.e3me.com. A complete list of equations is provided in Mercure et al (2018).

E3ME breaks the world down to 61 regions, with 43 sectors in each region (69 sectors in European countries). Input-output tables link the sectors together and bilateral trade matrices link the regions. Figure 1 shows how the model integrates the energy system with the economy and incorporates bottom-up submodels of several key energy system sectors (Mercure, 2012).

The model's historical database covers the period 1970-2018 annually, drawing on data from Eurostat, the OECD, IEA and other national and international sources. These data are used to estimate the model's parameters using methods developed in Hendry et al (1984) and Engle and Granger (1987).

A previous version of E3ME was used to assess the 2008-09 financial crisis in Pollitt and Barker (2009) and a set of 'green' recovery packages in Cambridge Econometrics and Ecorys (2011).

The standard version of the model has been used here without further development; the challenge that is addressed in this paper is to build scenarios that reflect the key aspects of the pandemic, rather than develop the model further.

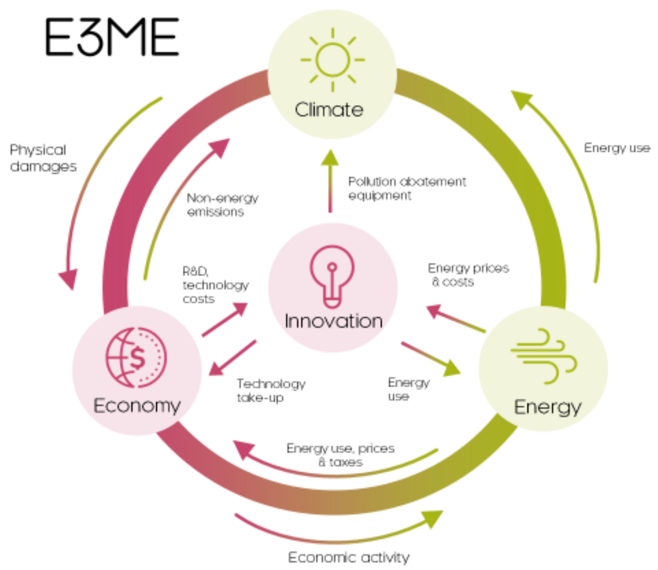

Figure 1: The E3ME model

3.3. Scenarios

In this paper we present the results from four different scenarios. They are:

- No-Covid-19 baseline – this is a 'business as usual' case in the absence of Covid-19. Both the economic and energy systems are calibrated to be consistent with the New Policies scenario in IEA (2019).
- Covid-19 scenario – described below.
- VAT recovery plan – in which a reduction in VAT rates is implemented to boost economic growth post-lockdown.
- Green recovery plan – in which environmental measures are implemented to boost economic growth post-lockdown.

The Covid-19 scenario makes assumptions for several different inputs that reflect different elements of the crisis. These inputs were formed in April 2020, based on data available at the time. These inputs were applied to all countries for the year 2020 (as the modelling is carried out on an annual basis, differences in timing during 2020 are ignored). All inputs are based on an assumed lockdown period of two months.

While, as discussed in Section 2, modelling of health outcomes should be separate from modelling of economic outcomes, direct health impacts were accounted for in the modelling based on estimates available. The first input is a small reduction in population to reflect the mortality rate in the pandemic. Initial estimates by experts put the potential range of the infection globally between 40-70%[6], with 60-70%[7,8], more likely in the case of an unconstrained outbreak. This rate of estimated overall infection was used to calculate mortality focusing on the elderly population: the 65+ population was reduced by just under 2% overall.

The second input is a loss of economic capacity across all sectors, representing the supply shock. This shock is assumed to be caused by two factors: (1) infections leading to health effects and self-quarantine, (2) stay-at-home policies aiming to reduce the extent of the pandemic. The health effects lead to reductions in labour supply (e.g. due to self-isolation) and productivity, leading to an overall 1.63% reduction[9] in the potential production capacity of the global economy.

The effect of stay-at-home policies is calculated based on del Rio-Chanona et al (2020) and Gottlieb et al (2020). The del Rio-Chanona et al (2020) paper considers two factors when producing sectoral supply shock estimates for the US: the possibility of working from home and jobs that are essential (therefore will be done regardless of

[6] https://www.theguardian.com/world/2020/feb/11/coronavirus-expert-warns-infection-could-reach-60-of-worlds-population

[7] https://twitter.com/mlipsitch/status/1228373884027592704

[8] https://foreignpolicy.com/2020/03/11/china-new-normal-coronavirus-pandemic-quarantine-ai-fen-propaganda/

[9] Calculated as 60% (assumed infection rate, see above) x 74.4% (symptomatic cases, based on Mizumoto et al, 2020) x 87.9% (cases with fever, based on WHO 2020) = 1.63% general loss of productivity.

policy) on the level of occupations. However, these estimates are derived from characteristics of industries and occupations in the US and, as Gottlieb et al (2020) highlights, there are major differences between economies (based on their level of development) in their ability to accommodate these changes. Therefore, sectoral supply shocks are adjusted based on what Gottlieb et al (2020) reports as differences between country groups of different stages of economy development. All impacts are annualised. This leads to sectoral supply shocks between ranging from -24% to -1.6%, with particularly large impacts in tourism, mining and forestry in the developing world and small impacts in sectors like utilities, postal services, telecommunications and computer services in the developed world.

Third, a demand shock is applied to relevant sectors. This is done through a reduction of consumer expenditure, with substantial differences between different products; data were gathered mainly from trade associations and international organisations (ICAO[10], OECD[11], European Parliament[12]). A 57-66% annual loss is assumed for sectors related to tourism, social consumption (e.g. entertainment), air transport and other modes of transport. ICAO results differ across continents; furthermore, for social consumption and transport effects the general impacts are adjusted at country level using activity reductions observed in Google's Mobility Reports[13]. For the range of effects see Table 1.

	Annual reduction (%)
Tourism (hotels, catering, etc.)	48-55
Air transport	57-66
Other transport modes	5-29
Social consumption (e.g. recreation, personal care, other services)	5-32

Table 1: Reduction of annual consumption in 2020 (% deviation from baseline)

10 https://www.icao.int/sustainability/Documents/COVID-19/ICAO_Coronavirus_Econ_Impact.pdf, downloaded April 27.

11 https://read.oecd-ilibrary.org/view/?ref=124_124984-7uf8nm95se&title=Covid-19_Tourism_Policy_Responses

12 https://www.europarl.europa.eu/RegData/etudes/ATAG/2020/649368/EPRS_ATA(2020)649368_EN.pdf

13 https://www.google.com/covid19/mobility/

The fourth input was an exogenous reduction in investment to reflect increased uncertainty in business conditions. It is assumed that this uncertainty continues into 2021, with 5% reductions in the growth rate for investment in both 2020 and 2021.

The fifth input covers the government responses. There is an increase in health-sector expenditure in all countries. Fiscal support schemes are also included, based on country-level information collected by Bruegel[14], complemented with data based on IMF's list of policy responses[15]. These interventions are modelled as an addition to government healthcare expenditures and as lump-sum transfers to individuals. Overall, the average magnitude of interventions is 2.4% (of the respective country's GDP), with effects largely felt in 2020, but continuing to 2021 and 2022.

Finally, the short-term shock to global oil prices was added to the model, assuming an overall 50% decrease for this year, gradually recovering back to baseline levels by 2025.

We consider two recovery packages in our modelling. These recovery packages should be considered as separate to the economic stabilisation measures described above, which are already included in the Covid-19 scenario. In order to simplify the interpretation of results, both the recovery packages do not start until 2021 in the modelling, even though the reality might see some measures implemented towards the end of 2020 (likely earlier in China).

The first recovery package includes a VAT (or sales tax) reduction of five percentage points in all countries. After the 2008-09 financial crisis, the UK used a VAT reduction to boost consumer spending. As the effects of Covid-19 are being felt primarily through consumption (rather than investment, as in 2008-09), VAT reductions are an appropriately targeted method to promote a return to 'normal'. The VAT increase is gradually phased out form 2024 onwards, and returns to baseline rates in 2028.

In the modelling, it is assumed that the VAT reduction is passed on to final consumers and so there is no direct change to company profit margins. In normal economic times this would be a standard assumption but it is much less clear how companies will respond in the aftermath of Covid-19. If companies choose not to reduce prices, the stimulus effects from VAT cuts will be much less.

The 'green' recovery plan costs national governments the same amount as the VAT reduction. A large part of the recovery plan remains VAT reductions, but some spending is diverted to five measures that are designed to reduce CO_2 emissions.

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[14] https://www.bruegel.org/publications/datasets/covid-national-dataset/, downloaded April 27.
[15] https://www.imf.org/en/Topics/imf-and-covid19/Policy-Responses-to-COVID-19

The first measure is a 67% subsidy for the capital costs in new wind (both onshore and offshore) and solar installations. Wind and solar power are becoming cost competitive even without subsidy in many parts of the world (IRENA, 2020) but this does not mean that they displace existing fossil fuel technology. In terms of technology diffusion, these technologies are now approaching the steep part of the S-shaped curve; an additional subsidy gives the impetus necessary to drive rapid uptake. A subsidy rate of less than 50% would still drive uptake, but at a lower rate; a rate of 67% means that most new installations are wind and solar (and so a higher subsidy rate does not increase take-up further). In addition to changing the generation mix, the subsidies lead to lower electricity generation costs and therefore prices, with potential benefits to all users including low income households.

The second measure also focuses on the electricity sector but specifically on national power grids. Governments pay for improvements to grids to accommodate additional wind, solar and other renewable power sources. The total spending on grid improvements is linked to new capacity and amounts to $25-35bn globally over 2021-2023.

The third measure is aimed at the transport sector. Car scrappage schemes were popular after the 2008-09 financial crisis and we include one in the green recovery package. This time, however, the scheme applies only to electric vehicles. We assume that the government subsidies 20% of cost and that this leads to 5% of the fleet turning over between 2021 and 2024. While initial vehicle purchases are assumed to lead to additional spending (i.e. from individuals unable to spend during lockdown), over time a larger share of expenditure on cars crowds out other household spending.

The fourth measure focuses on energy efficiency in buildings. Overall, a 6% reduction in household energy use is achieved over 2021-23, mainly through retrofitting measures, with the costs borne by national governments. In the IEA's Sustainable Development Scenario (IEA, 2019), energy consumption in buildings falls by 28% compared to baseline by 2040, i.e. around 1.6% pa starting in 2021. The scenario therefore represents a small acceleration of the average annual rate required to be consistent with the IEA scenario but not enough to hit capacity constraints. The cost estimates are derived from IEA (2017) and estimated per unit of energy saving ($1.1m/toe).

Finally, a tree planting programme is added to the green recovery package. Although a simple measure, there is relatively information available about the potential scale and cost of a tree planting programme. The scenario aims to be ambitious but realistic; an additional 2bn trees are planted, which is a substantial amount but would only make a small contribution to the trillion trees initiative[16]. Based on various online estimates, a rate of $8 per tree is used per tree[17]. Again, the cost of the programme is borne by national governments, with the payments being passed to the forestry sector in the model.

All public costs in the green recovery package are subtracted from the VAT reductions so that the two scenarios are comparable. While the exact figures vary by country, in most cases the green recovery package still includes a reduction in VAT of 4pp.

4. RESULTS FROM THE MODELLING

4.1. Economic projections

We start by presenting GDP impacts from the model simulations. It is important to note that the results from the Covid-19 scenario are not predictions; as described in Section 2 it is not possible to make predictions. For example, our results are contingent on the scenario assumption that the lockdown period in each country is two months.

Instead, the GDP results are intended to provide context for the more detailed sectoral analysis below, and the assessment of the recovery plans. Figure 2 shows the impacts at global level. In 2020, global GDP falls by 3.9% (based on market exchange rates); without Covid-19 GDP would have grown by 2.7%, so the net loss of production is 6.6%.

The modelling provides a neutral answer to the key question of what happens after 2020. There are both lagged effects pushing global GDP down further and rebound effects bringing back lost growth from 2020. Overall, these effects broadly cancel out, indicating a V-shaped recovery in growth terms, or an L-shaped pattern in levels terms. However, it must be stressed that these results assume no major 'second wave' of Covid-19, or abnormal lingering effects (e.g. from fear of being in crowds). No model can provide answers to these questions.

Where the model is more helpful is in assessing the merits of the recovery plans. These recovery plans are aimed at boosting employment rather than GDP, which we discuss

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[16] https://www.trilliontrees.org/

[17] e.g. https://treesisters.org/blog/much-cost-plant-tree#:~:text=It%20depends%20on%20the%20cost,tree%2C%20depending%20on%20the%20project

below, but they do also impact on production levels. The reductions in VAT are effective at increasing spending, with around a quarter of the loss of GDP recovered in 2021. As the VAT reductions are phased out, GDP remains higher than in the case with no government support.

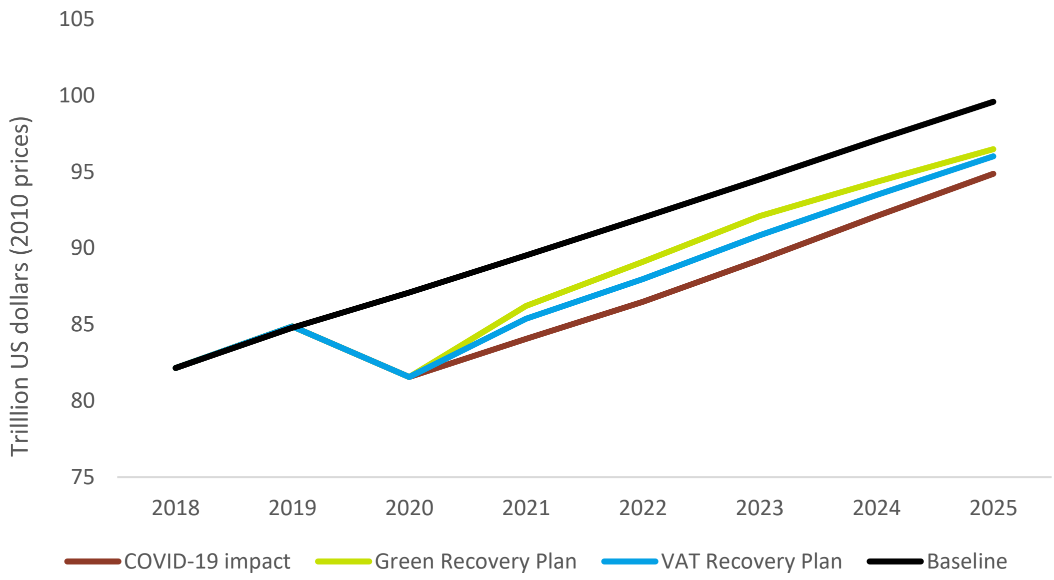

Figure 2: Global GDP in each scenario

The green recovery plan is more successful still in stimulating an economy that is well below capacity levels. The immediate boost in 2021 is higher than that from the VAT reductions and at its peak the measures replace more than half of the lost production. As shown below, this additional production is important in helping labour markets to recover.

The two recovery plans that we assess have the same cost to government (i.e. same amount of public expenditure) but the green plan is more effective in increasing GDP. The main reason for this outcome is that two of the measures in the green recovery plan leverage (or 'crowd in') private investment expenditure, leading to a larger stimulus effect for the overall economy. These measures are the renewables subsidies (one third financed privately) and the car scrappage schemes (80% privately financed). The latter effect is dependent on our assumption that an additional 5% of the vehicle fleet is replaced because of the measure but an extra 5% over three years does not seem excessive in a world where around 10% of the vehicle stock changes annually already. The additional private investment in renewables and vehicles more than offsets other reduced spending in the energy sector that results from the energy efficiency measures.

To summarise, the boosts to GDP in the VAT scenario comprise of the public stimulus from the VAT cuts, plus multiplier effects. In the green scenario, the boost to GDP comprises the public stimulus from VAT cuts plus green measures, the leveraged additional private investment minus reduced energy sector expenditure and multiplier effects. The difference between the two scenarios is thus the leveraged investment effects minus reduced energy sector expenditure.

Figure 3 shows the difference between the Green Recovery Plan and VAT scenario in selected economies. Of the major economies shown, India stands out as benefitting the most. The reason is that India still has relatively low penetration of renewables and relies on imported fuel for energy; the subsidies could encourage a rapid take-up of renewable energy and a reduction in India's fuel import bill. It is notable that the positive effects in India persist up to 2030. In other countries where renewables are already more established (e.g. EU, Japan and China), there are also benefits but they are more modest in size and reduce to around 1% of GDP by 2030.

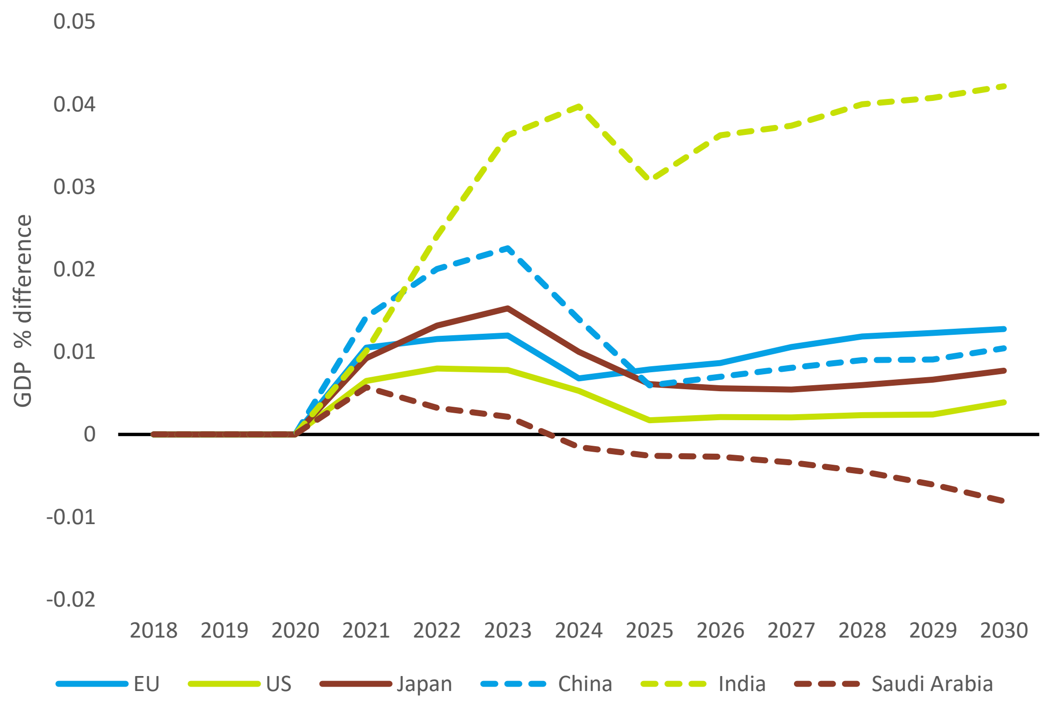

Figure 3: Benefits of the Green Recovery Plan, GDP % difference from VAT scenario

Energy exporters such as Saudi Arabia could lose out in the Green Recovery Plan scenario. The reason is not so much the domestic action taken by Saudi Arabia but that the rest of the world reduces oil demand because of increased electric vehicle penetration. This leads to a reduction in global oil prices and revenues from oil exports.

The effects in the US are broadly neutral because the positive effects of increased renewable and electric vehicle investment roughly balance the negative effects of reduced oil production.

One important difference from the 2008-09 financial crisis and subsequent great depression, is that the main impacts on economic activity have arisen through a loss of household expenditure (consumption) rather than investment by businesses. Household consumption is impacted through a combination of supply-side effects (consumers being unable to spend) and demand-side effects (loss of income leading to loss of spending). As shown in Table 2, in 2020 consumption falls by more than 9% globally (compared to baseline, and around 7% year-on-year).

Investment in 2020 falls by 6.3% in the simulation compared to the baseline. By assumption (relating to an uncertain business environment), there is a 5% fall. The remaining reduction is due to the effects of lower levels of consumption feeding into company profits.

The VAT recovery plan is designed to restore consumer spending, and the results for 2022 show it is successful in doing so, reducing the loss of consumption by more than half. The green recovery plan results in a smaller increase in consumption but is more successful in bringing back investment. This result is not surprising given that some of the measures in the green recovery plan involve a direct increase in investment.

	Investment		Consumption	
	2020	2022	2020	2022
Covid-19	-6.3	-11.2	-9.4	-6.3
VAT Recovery Plan	-6.3	-9.9	-9.4	-4.2
Green Recovery Plan	-6.3	-5.7	-9.4	-4.6

Table 2: Global investment and consumption, % difference from baseline in 2020 and 2022

The source of the loss of aggregate demand is reflected in the sectoral impacts of the pandemic (see Table 3). Consumer services are most affected, with a loss of output of

7.8% in 2020. Manufacturing sectors are affected by less initially, but continuing falls in investment mean that construction and manufacturing are much worse affected by 2022.

The year 2022 falls in the middle of the period in which the largest stimulus effect from the recovery plans occurs, and so offers a comparison between the different schemes. With its focus on consumer spending, the VAT recovery plan has the largest impact on consumer services, reducing the loss of production from 5.6% to 3.9% in 2022. In contrast, the biggest impacts in the green recovery plan are seen in construction and advanced manufacturing (which includes engineering), reflecting the focus on investment. In addition, it is notable that, due to indirect effects, the green recovery plan performs better than the VAT recovery plan even in consumer services.

However, part of the reason the green recovery plan benefits consumer spending is that household expenditure is diverted away from products that are not sold on the high street, i.e. energy. The energy and utilities sectors are relatively unaffected by Covid-19 in these scenarios but would be likely to lose out in any green recovery scenario.

	All scenarios 2020	Covid-19 2022	VAT RP 2022	Green RP 2022
Agriculture	-2.3	-2.0	-1.2	-1.0
Mining and extraction	-2.2	-2.1	-1.9	-2.8
Basic manufacturing	-4.4	-5.0	-4.1	-3.1
Advance manufacturing	-4.0	-7.7	-6.6	-3.7
Construction	-4.1	-6.9	-6.2	-2.3
Utilities	-1.8	-1.6	-0.8	-1.2
Consumer services	-7.8	-5.6	-3.9	-3.2
Business services	-3.7	-4.0	-2.7	-1.9
Public services	-0.7	-0.6	-0.1	0.0

Table 3: Output by sectors, % difference from baseline in 2020 and 2022

Turning to labour markets, the model results suggest that the impacts of Covid-19 on employment could be substantial. In 2020, employment falls by around 45m people (excluding temporary enforced job losses due to lockdown conditions) compared to the baseline (see Figure 4). Furthermore, the lagged nature of labour markets means that any recovery in employment may not start until 2025.

The rationale for the recovery plans now becomes clear and it is important to stress the need for recovery plans to ensure that government support leads to job creation rather than higher firm profitability (e.g. through automation). Given likely continued restrictions on social interaction (not included in the modelling), this issue seems particularly relevant to economic recovery from Covid-19.

The VAT recovery plan proves to be effective at preventing further job losses, but has little effect on reversing the trend for lower employment. In contrast, the green recovery plan is effective in bringing back some of the jobs lost in 2020. When the support peaks in 2023, the loss of jobs compared to baseline is less than half of that in the Covid-19 scenario.

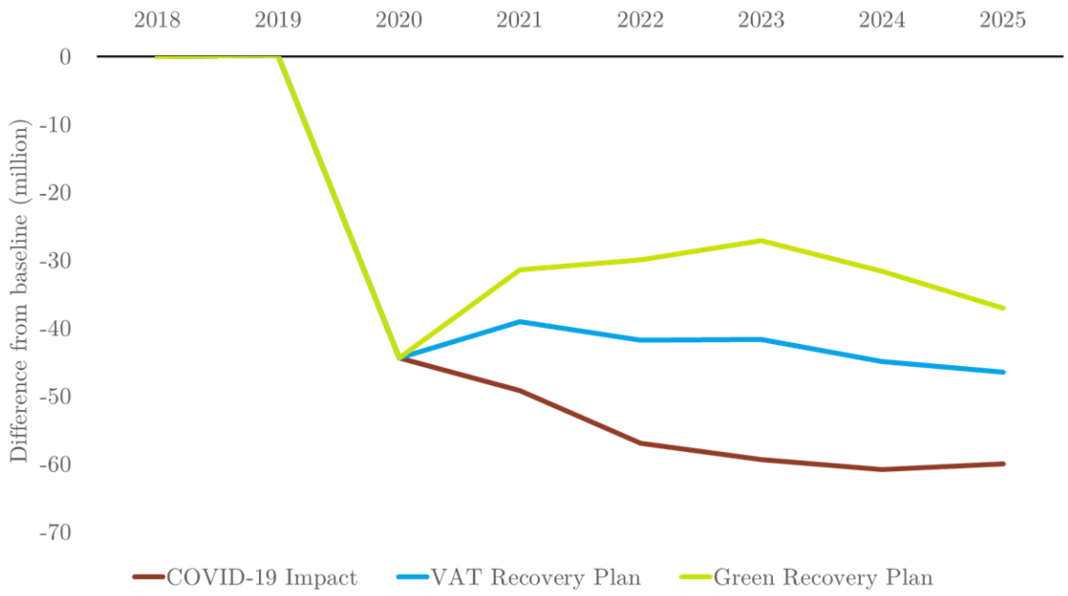

Figure 4: Employment effects in all the scenarios, difference from baseline

As always with employment impacts, it is important to consider whether the jobs being created match against the available skills base. The sectoral results above show that the green recovery plan includes a shift from energy sectors to construction and manufacturing, suggesting some assistance in transition might be required. Nevertheless, even in the green recovery plan scenario, global employment is still below baseline levels in every sector, suggesting that there is labour capacity. The issue is more likely to relate to specific training, for example in home retrofitting.

4.2. Projections of CO_2 emissions

While it should be stressed that the primary aim even of the green recovery package is to restore employment, the model results for CO_2 emissions are instructive. The crisis causes global energy CO_2 emissions to fall by 4% (see Figure 5). This estimate is based on restrictions being fully lifted after the two-month lockdown period and also does not include any additional environmental measures that were imposed during the crisis (e.g. bringing forward the closure of coal power plants). The final outcome for CO_2 emissions in 2020 could show a larger reduction.

However, the modelling reveals two important factors in projecting emissions. First, the concentration of the loss of production in services sectors limits the reduction in emissions. There may also be some loss of economies of scale; for example, factories that are not producing still use some energy. Second, the reduction in CO_2 emissions is unlikely to be substantial over time. The model results show that any reduction in emissions gradually declines. It is also worth noting that the only reason CO_2 emissions are lower in 2030 than in the baseline is that GDP never recovers to baseline levels.

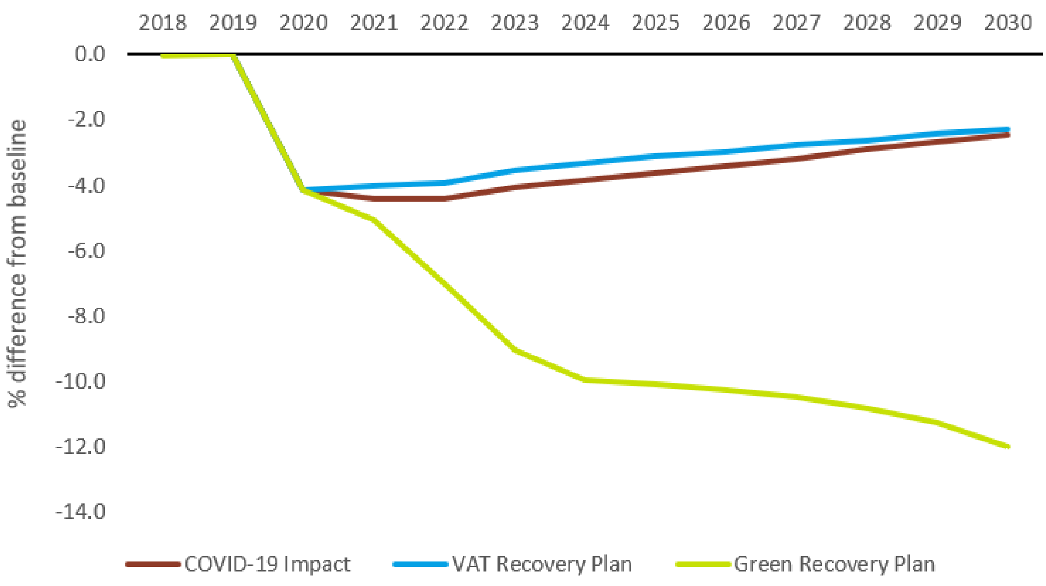

Figure 5: Energy CO_2 effects in all the scenarios, difference from baseline

The effects of the two recovery packages are markedly different. The reduction in VAT leads to a small increase in emissions because of higher production levels. However, the measures in the green recovery plan could lead to a reduction in emissions of around 10% compared to the Covid-19 scenario, and 12% compared to the baseline. The emission reductions result from a rapid movement towards wind and solar energy, electrification of transport and reduced energy consumption in buildings. There are further net emission reductions (not included in the figure) from the tree planting programme.

5. CONCLUSIONS

This paper has described the unique challenge that Covid-19 has presented to economists. It has shown that the models that economists use are not well suited to understanding the present crisis or pathways out of it, because these models do not incorporate both economic transactions and the spread of disease. Although there are complexity-based tools under development that may in future be able to combine public health and economics, these at present remain some way off.

The best that economists can do is therefore to take the results from epidemiologists' models and incorporate the same assumptions about government policy on lockdown and relevant regulatory areas. Even following this approach, we still find that there are shortcomings in most of the modelling tools that economists are using. For example, most models cannot adequately model a demand shock. Assumptions about the economy operating in equilibrium in CGE models rule out any meaningful analysis, while DSGE models do not offer a level of disaggregation capable of providing useful insight.

This leaves us with the Post-Keynesian models and models based on complexity. The theories of Keynes, developed during the Great Depression are particularly relevant to the present economic situation. However, it is important to note that even these models can only be used to test what-if scenarios and cannot be used for prediction. Fundamental uncertainty and the non-linear nature of the pandemic make prediction impossible.

The modelling presented in this paper, using the Post-Keynesian E3ME model, defines the crisis as a combination of demand and supply shocks. We show a path for GDP that is broadly consistent with other non-model-based estimates and describe a pattern of impacts across sectors consistent with a consumption shock. We then assess two possible recovery plans: one based on VAT (sales tax) reductions to boost consumption, and one that uses some of the money to reduce greenhouse gas emissions.

We show that both measures will help with global recovery but, even given their magnitude of around 2.5% of GDP, are not sufficient to counter all the negative effects of Covid-19. The green recovery plan is able to leverage in private finance on top of the additional public expenditure, and therefore outperforms the VAT cuts in terms of recovery growth rates (even if all the VAT cuts are passed on to final consumer prices).

We thus end with two main conclusions. The first is for economists, who need to improve their capability to model recessions in general and recessions due to pandemics in particular. This is likely to require a movement away from models that solve for equilibrium states of the economy or ignore the impact of uncertainty by making strong assumptions about stabilising, forward-looking behaviour. The second conclusion is for policy makers who are considering how to use money that is allocated to recovery plans. Numerous studies have shown that large amounts of investment are required to meet global climate targets. In this paper we have shown that a green recovery plan could contribute towards meeting the climate targets, while simultaneously boosting the economy by more than an equivalent reduction in VAT.

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