**The contribution of post-Keynesian economics to climate policy and meeting global decarbonisation targets**

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**Abstract**

Climate change is now widely recognised as one of the major challenges facing policy makers in the 21st Century. The UN has set targets for limiting global average temperature change to well below 2°C. This paper describes how, historically, there has been limited engagement from post-Keynesian economists on climate change issues. The outcome has been a dominance of optimisation and CGE-based model analysis in assessing climate issues. Key aspects such as technology development, the role of the financial sector and the distribution of policy impacts have been excluded from the analysis. With 'climate emergencies' now being declared around the world, there is a need for rapid implementation of new environmental policies. This paper argues that there is a strong role for post-Keynesian economics and post-Keynesian models to contribute to the analysis of these policies. For example, without such inputs, it will be impossible to identify 'green growth' opportunities that are dismissed by assumption in standard neoclassical models. Similarly, potential adverse impacts on employment and vulnerable populations could be missed in neoclassical models. The paper concludes that more input from post-Keynesian economists is required to ensure a low-carbon transition that is both equitable and economically sustainable.

## 1 Introduction

Climate change is now widely recognised as one of the major challenges facing policy makers in the 21st Century. The Sustainable Development Goals recognise that the world should "take urgent action to combat climate change and its impacts". The global Paris Agreement (UN, 2015) set fixed targets for limiting global average temperature change to well below 2°C.

Although the representation of the environment in post-Keynesian economics has not been formally agreed (e.g. there is no discussion in Lavoie, 2015), intuitively there appears to be an important role for post-Keynesian economics in identifying suitable policy options to limit climate change and its impacts. For example, fundamental uncertainty runs throughout the climate system and there is a clear role for the state to coordinate efforts to meet societal goals. In an investment-driven transition, the role of finance will be crucial, and the development and diffusion of new technologies more generally must be properly understood. There is an increasing realisation that a 'just transition' is required and that climate policy cannot be seen to exacerbate income inequality (Markkanen and Anger-Kraavi, 2019). Furthermore, the sole policy option that is recommended by neoclassical/environmental economics, a global carbon price, is politically infeasible (Grubb et al, 2014).

However, so far the influence of post-Keynesian economics on climate change policy has been peripheral and none of the models used in the Inter-governmental Panel on Climate Change's (IPCC's) latest reports (IPCC, 2018; Clarke et al, 2014) are consistent with post-Keynesian principles.

In this paper we show that recent shifts in the policy environment suggest that post-Keynesian economics now has a crucial role to play in meeting climate targets. Without engagement there is a risk that misleading policy conclusions could be drawn from the application of simple analyses and models based on textbook neoclassical economics.

Sections 2 and 3 of this paper summarise how economists have historically addressed issues related to climate change. Section 4 describes the present situation and Sections 5 and 6 discuss how post-Keynesian economics and economic models fit in. Section 7 concludes.

## 2 The early days – trade-offs between the economy and the climate

In 2019, the Nobel Memorial Prize in Economic Sciences was awarded to William Nordhaus for his work in integrating the economy and the climate system into a single modelling framework. This framework was called the 'Dynamic Integrated model of Climate and the Economy', or DICE for short. A regionalised version, RICE, follows the same basic methodology.

As macroeconomic models go, DICE and RICE are relatively basic. All the equations in the original version of DICE are based on macro global-level relationships. Economic production leads to greenhouse gas emissions, which cause global warming and constraints on future production. The models determine an optimal 'social cost of carbon', which is the point at where the damage from an additional unit of greenhouse gas emissions is equal to the economic damage that measures to reduce emissions would incur.

One of the first published versions of DICE is in Nordhaus (1992), which was a discussion paper at the Cowles Foundation. However, Nordhaus's earlier work (e.g. Nordhaus, 1977) describes an approach that is similar to the model that was later published.

In many ways the DICE model was pioneering in its ambitions. Even today, very few models try to incorporate environmental feedbacks into their analysis (Stern, 2013a). The DICE model is fully transparent; not only is the model freely available for researchers to use and modify, the relative simplicity of the model makes its results easy to interpret. Two similar models, FUND (Tol, 1997) and PAGE (Hope, 1993) have since been developed; they are collectively referred to as 'Integrated Assessment Models' (often referred to as IAMs, in this paper small-scale IAMs) and are used in the US for policy-making purposes as part of cost-benefit analyses.

These IAMs incorporate an extreme form of neoclassical economics that is embodied more generally in cost-benefit analysis. Their aim is to essentially optimise the economic and natural systems simultaneously, with the optimal outcome being the highest level of GDP. Nordhaus' original work from 1977 highlights this aim very clearly (see Figure 1). The abstract from Nordhaus (1992) also makes this point clearly:

*The fundamental premise behind this study is that societies should undertake environmental policies only when their benefits, broadly construed, exceed their costs and that the level of environmental control should be at that point where the incremental benefits of additional controls no longer exceed the incremental costs… The work embodied in this study lays out one approach -- the use of dynamic economic optimization -- to the construction of an efficient control strategy.*

Nordhaus (1992)

Figure 1: Nordhaus' schematic for an optimising integrated energy-climate model

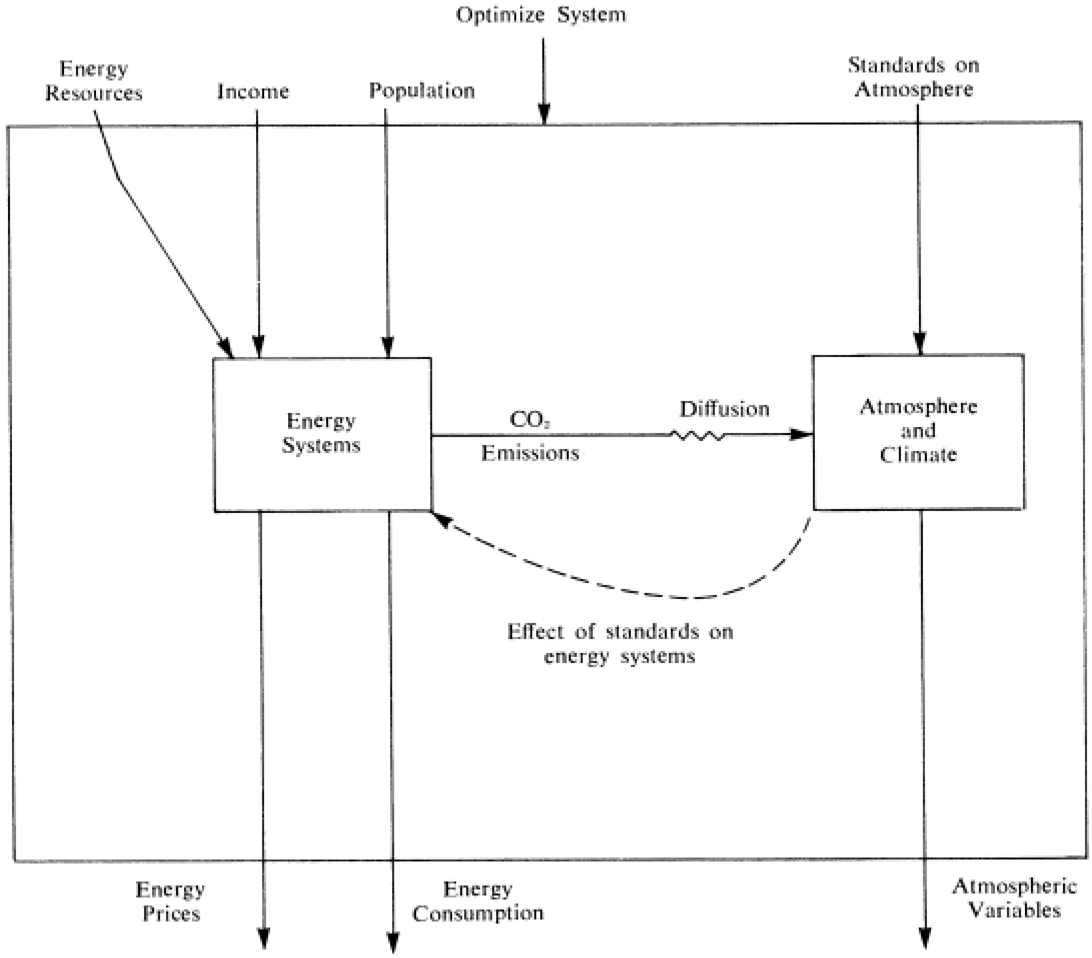


FIGURE 2. OVERVIEW OF MODEL OPTIMIZING THE ENERGY-ENVIRONMENT SYSTEM

DICE and the other IAMs have come in for substantial criticism, notably in Pindyck (2013) and Stern (2013b). Much of the criticism relates to the environmental feedbacks and arbitrary assumptions about discount rates. The latest conclusions from DICE (Nordhaus, 2017) that the optimal outcome for the planet would be to allow around 3.5°C of global warming, appears to be out of step with the scientific consensus that temperatures should not be allowed to increase by more than 2°C.

However, post-Keynesian economists immediately notice some other equally important short-comings of the model. Most obviously, it seems unlikely that Nordhaus has ever read Keynes' *Treatise on Probability* (Keynes, 1921) as there is little notion of uncertainty either within the model itself (i.e. the optimisation algorithm) or in the way the model has been applied to find 'optimal' solutions. As a result, the consensus position of natural scientists, that global average temperature change should be limited to 2°C because we do not understand the potential feedback effects beyond this point, is ignored in DICE, which instead puts the point estimates of its damage functions into its optimisation algorithm.

Weitzman (2009) laid out his 'dismal theorem', which suggested that fat-tailed distributions and a non-negligible risk of catastrophe meant that the simple cost-benefit calculations in DICE were not applicable to the issue of climate change. Four years later, Weitzman (2013) laid out formally what became known as the 'Precautionary Principle', that uncertainty should be an important component of the discussion of how much to limit temperature change by.

More generally, DICE and the other small-scale IAMs are essentially simple Computable General Equilibrium (CGE) models that are entirely supply-side driven. They are just about as far removed from post-Keynesian economics as is humanly possible.

Perhaps fortunately for the planet, the transparency of the small-scale IAMs was sufficient for non-economist observers to realise their limitations. After a much-contested debate, the scientific community opted to set absolute limits for temperature change, rather than follow economists' recommendations on estimating optimal values. After a failed attempt to establish these goals in 2009 at the UNFCCC's COP15 in Copenhagen, the 2°C target for limiting temperature change was formally adopted at COP21 in Paris in 2015 (UN, 2015).

With an agreed target for limiting temperature change, and therefore cumulative greenhouse gas emissions (sometimes referred to as the carbon budget), the raison d'être of small-scale IAMs has now long passed. The models are still used for academic experimentation but, outside the US, have little serious role in policy making, beyond interested parties attempting to justify a particular action. Over the past decade, the focus of the modelling community has instead been to test whether the specified climate targets in the Paris Agreement are feasible for a given set of technologies.

## 3 Recent estimates of the costs of limiting climate change

Despite the rejection of the optimal social cost of carbon, economists have continued to play an important role in the IPCC. A different set of models has provided analysis for 'Working Group III', which assesses options for mitigating climate change. Confusingly, these models are also called 'Integrated Assessment Models'; in this paper they are described as large-scale IAMs because they incorporate a much higher level of technological and sectoral detail than the models described in the previous section.

Large-scale IAMs often combine several specialised modelling tools. They usually have at their heart a representation of the energy system and a representation of land use. These are linked to a simplified model of the climate system, which gives estimates of global temperature change. The models thus integrate physical and economic processes. The most commonly used models include at most only a highly aggregated economic model; in most cases, the economic outputs of the models are a rather simple estimate of 'costs', similar to what is often fed into a cost-benefit analysis.

Examples of large-scale IAMs include the IMAGE model[1], the GCAM model[2] and the MESSAGE-GLOBIOM model[3].

These models are used to estimate ways of meeting the temperature targets and implied carbon budgets) that have been set by the UN. Although they are different to the small-scale IAMs discussed in the previous section, they also incorporate few insights from post-Keynesian economics. In most cases they are based on assumptions about optimisation and fully flexible prices, which in turn implies assumptions about perfect knowledge and, in some cases, perfect foresight.

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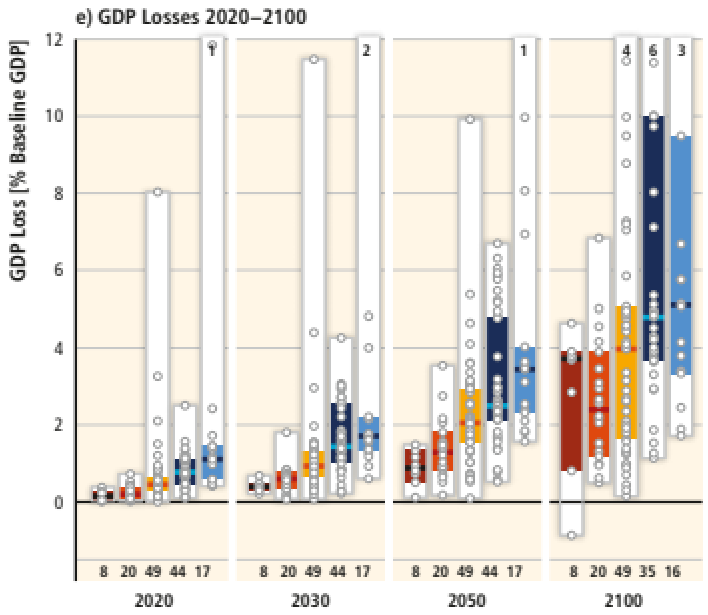
[1] See https://models.pbl.nl/image/index.php/Welcome_to_IMAGE_3.0_Documentation
[2] See http://jgcri.github.io/gcam-doc/
[3] See https://data.ene.iiasa.ac.at/message-globiom/

The scenarios in the models are treated as constrained optimisations. Reducing emissions is seen as adding a constraint to the optimisation of production and so almost always leads to an overall loss of output. Figure 2 shows the estimates of loss of GDP compared to a baseline case, as reported in the IPCC's Fifth Assessment Report (Clarke et al, 2014). Sometimes the estimated loss of GDP is considerable.

Figure 2: Impacts of meeting global temperature targets on GDP




Source: Clarke et al (2014), p450.

The large-scale IAMs receive criticism on several fronts. Unlike the small-scale IAMs, they do not include economic feedbacks from a changing climate. They also often rely on an unrealistic amount of biomass (linked to carbon capture and storage) to meet specified targets (Anderson and Peters, 2016) and can implicitly assume that physical transformations are reversible in the same way that economic transactions usually are.

Technology is often treated as exogenous to policy inputs, which the recent solar revolution (led by policy implemented in Germany) has shown to be a crucial weakness. Basic cost-optimisation algorithms mean that the uptake of new technologies can be unrealistically fast, once technologies become cost-competitive. Inter-temporal optimisation (based on discount rates) can push the models to favour long-run technologies that are still under development and may never work (including 'negative emissions' technologies). These features combined suggest that delaying action to reduce climate action may be preferred.

More generally, from an economic perspective, assumptions of optimal allocation of resources and a fixed money supply miss out on important dynamics relating to investment and debt stimulus. Regarding employment effects, Clarke et al (2014) notes that:

*The net effect is typically addressed in general equilibrium literature. Although many integrated models used to develop long-term scenarios are general equilibrium models, they usually assume full* *employment and are therefore not well-suited to addressing gross versus net employment related questions*

Clarke et al (2014), p476.

The impact that most policy makers see as most important is therefore not covered.

The final point to note is that these models have little in the way of policy detail. The scenarios to meet carbon targets are usually designed by setting a global carbon price and adjusting it until the specified target for greenhouse gas emissions is met. Given that the possibility of a global carbon price remains remote (Grubb et al, 2014), this is of limited used to policy makers.

The aim of these models is thus to test whether climate targets are theoretically possible and to give a rough indication of costs to the agents involved. They do not provide commentary on specific policies.

## 4 The move from agenda setting to policy making

This brings us to the present day, in which we have:

- a set of agreed global temperature change targets, that can be translated to global emissions levels
- a set of Nationally Determined Contributions (NDCs, i.e. national targets for emissions) that are unlikely to be sufficient in ambition to meet the global targets
- current implemented policies, which are in most cases not sufficient in ambition to meet the NDC national targets (den Elzen et al, 2019)

The questions that policy makers face are how to reach the targets that they have set, and whether they should commit to increasing the level of ambition in their targets (i.e. reducing emissions by more or at a faster rate). There is no further policy requirement to assess global emissions targets or 'optimal' amounts of emission reduction, even though such exercises are still being carried out in academia (e.g. Nordhaus, 2017).

Crucially, policy makers need analysis that can be used in the formulation of real-world policy. The single global carbon price that many models adopt is of little use. Even at national level, there are relatively few carbon pricing instruments (either taxes or trading schemes) currently in operation (World Bank and Ecofys, 2018). Global coordination seems as remote as ever.

Following the framework laid out in Grubb et al (2014), climate policy can be categorised into three groups:

- short-term 'easy-win' policies, that are usually best-addressed through regulatory instruments
- medium-term policies, with a focus on improving production to use current best available technologies
- longer-term policies to develop new technologies

There are examples of all three types of policies in use around the world and important interactions between the three groups. However, national choices tend to reflect a range of different factors, including historical precedent, economic characteristics and the outcomes of lobbying activities.

The answers that policy makers require are also changing over time. Impacts on GDP still play a role but there is now much more interest in a 'just transition' that considers distributional impacts (Markkanen and Anger-Kraavi, 2019). Above all, impacts on jobs remain of paramount importance to elected officials.

The key steps in the policy-making process in the EU are summarised in Figure 3. Although the exact methods may differ in other countries, the general principles are the same.

The answers to the first three steps are now non-negotiable so there is a role for economists in first designing potential policies and then assessing them. It should be stressed that the role for economists in Step 4 is to work alongside political scientists, legal experts and other groups that feed into policy design.

Figure 3: Key steps in the policy making process

| The questions an impact assessment should answer | |
|---|---|
| ***1.*** | ***What is the problem and why is it a problem?*** |
| ***2.*** | ***Why should the EU act?*** |
| ***3.*** | ***What should be achieved?*** |
| ***4.*** | ***What are the various options to achieve the objectives?*** |
| ***5.*** | ***What are their economic, social and environmental impacts and who will be affected?*** |
| ***6.*** | ***How do the different options compare (effectiveness, efficiency and coherence)?*** |
| ***7.*** | ***How will monitoring and subsequent retrospective evaluation be organised?*** |

Source: European Commission, 2017

The types of question being asked in Steps 5 and 6 are well suited to a simulation-based assessment approach. It should be noted that there is no mention of optimal outcomes in the questions; policy makers require an estimate of what *will* happen if a chosen policy is implemented, not what *should* happen if economic agents behave optimally. The aim of the exercise is to find policies that work rather than policies that are in some way optimal (Probst and Bassi, 2014).

In summary, for policy analysts and economic modellers alike, the questions being asked have become much more complex in nature. Where previously a single input (carbon price) and single output (GDP) were required, there is now a multitude of different policy options and output indicators to consider. The boundaries of neoclassical and environmental economics have become at best severely tested. The requirement for post-Keynesian analysis has grown.

## 5 A need for real-world economic analysis

Of the three short, medium and long-term policy categories outlined above, neoclassical economics is only useful for assessing the one that considers the medium term; and only then for price-based policies. However, all three of the policy areas outlined above play in some way to the relative strengths of post-Keynesian economics.

The first, short-term policy area relates strongly to human behaviour. Many of the lowest-cost ways of reducing greenhouse gas emissions are through efficiency measures. These efficiency measures are often cost-effective but in the current market are not taken up. The reasons for a lack of take-up are regarded by mainstream economics as market failures (and ignored altogether in CGE models). Examples include information gaps (e.g. most householders do not know how to improve the efficiency of their homes). Some groups may lack the necessary access to finance and there are also principal agent problems relating to rented homes. In contrast to the results from current neoclassical models, it seems pretty clear that leaving things to the market will not produce the best outcomes.

The second, medium-term policy area is more relevant to the decisions taken by firms. Pricing instruments may help to guide these decisions but there are other factors too. For example, institutional structure is important. The degree of competition in a particular sector can impact on outcomes. Policy makers usually wish to know where the costs of decarbonisation will be borne; assumptions about perfect competition and the full pass-through of economic costs do not provide useful information on this topic.

Finally, technology development will be critical to any successful decarbonisation strategy. Assessments that do not include endogenous representations of technology development will provide a biased estimate of the outcomes for implementing climate policy.

The issue of finance cuts across all three policy areas. A transition to a low-carbon economy will require substantial amounts of investment (see e.g. IEA, 2018) and the global economy is likely to become more capital-intensive and less energy-intensive. Without an understanding of how the financial system works, it is not possible to provide a realistic assessment of the main decarbonisation policies (Pollitt and Mercure, 2018). In particular, the ‘crowding out’ effects of investment in neoclassical models (in which a fixed money supply dictates that higher energy-sector investment leads to lower investment or consumption elsewhere) is one of the main drivers of negative outcomes in their results, but also at odds with the observed reality.

The indicators that policy makers require are in general similar to those that Keynes originally set out to address. First and foremost, elected officials and civil servants both focus primarily on the number of jobs created and lost. After that they need a range of socio-economic indicators that show both the absolute levels and distributions of wealth within society.

Nevertheless, despite all the advantages that post-Keynesian economics has to offer, it remains the case that the majority of policy analysis carried out is based on CGE models and other optimisation-based approaches. This can sometimes lead to rather dubious policy conclusions. For example, analyses conducted by global institutions often use CGE analysis to show that carbon taxes provide the ‘optimal’ way in which to reduce emissions. However, this analysis is doing little more than reproducing the neoclassical assumptions on which the model was founded.

In addition, the set-up of CGE-based analyses typically rule out the possibility of green-growth and environmental double dividends by assumption. Every policy that is entered into the model (usually a carbon or fuel pricing measure) acts as an additional constraint on the model's optimisation, meaning that results can only get worse. This has led to a popular conception that climate policy can only have negative economic impacts, and the role for policy makers is to minimise the costs. In reality, there is little evidence from anywhere in the world that climate policy has led to substantial reductions in GDP and household incomes.

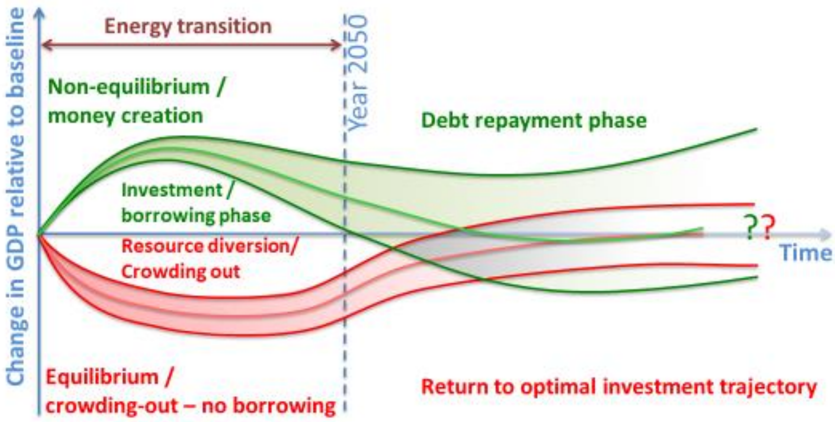
**6 Current post-Keynesian tools in operation**

There are some ongoing efforts to apply post-Keynesian models to address climate policy questions. The current models used for analysing climate policy fall into two groups. The first of these are extensions of the Stock-Flow-Consistent (SFC) modelling approach. The field is narrow but notable examples include the DEFINE model (Dafermos et al, 2016) and the model presented in Bovari et al (2018). Both these examples are unusual in that they include feedbacks from the climate system to the economy. As would be expected from an SFC model, they present a lot of detail on the financial sector, which, as noted above, will inevitably play a key role in a low-carbon transition.

The other class of models available is structural, macro-econometric models. Again, there are relatively few examples; the two global models in operation are E3ME (Cambridge Econometrics, 2014) and GINFORS (Lutz et al, 2010). These models go into much less detail about the financial sector but can provide a much more disaggregated sectoral (and regional) analysis, which is often important for policy makers. There have been several exercises where the results from one of these models has been compared to results from CGE models (e.g. Cambridge Econometrics et al, 2015: Ch6).

To many people, the stand-out feature of the results from the post-Keynesian models is that they may find that climate policy has positive impacts on GDP and employment (e.g. NCE, 2018). However, although this message is a simple and effective one to direct at policy makers, underlying it is a much more complicated picture of dynamics relating to the financial system and the development of new technologies. Many of the benefits of climate policy occur in the short term when there is additional borrowing to fund investment in new equipment. In the longer term, unless the technology trajectory is substantially shifted, there may be costs as these debts are repaid (see Figure 4).

Figure 4: Impacts on GDP in low-carbon scenarios in post-Keynesian models (green line) and equilibrium models (red line)



Source: Mercure et al (2019).

To date, the main specific direct (quantitative) policy applications of post-Keynesian models have been through the consultancy work carried out by Cambridge Econometrics using the E3ME model. Much of this has been at European level, for example providing inputs to the current EU 'long-term strategy' for climate policy (European Commission, 2018). European regulations state that all substantial policy announcements must be assessed quantitatively if possible (European Commission, 2017) so the model-based analysis feeds directly into the policy-making process. The results from the modelling exercise are often compared to a similar exercise carried out with a CGE model.

Outside of the policy community, there is also growing interest; in particular there has been recent interest from the financial sector (which is also highly relevant to SFC models). Insurance companies and other firms that must take a long-term perspective are becoming increasingly interested in climate change and climate policy. These companies face several challenges, for example accounting for potential climate damages (e.g. from extreme weather events, see Burke et al, 2015; 2018) or the potential for being stuck with worthless fossil fuel assets (Mercure et al, 2018).

Like the policy community, companies in the financial sector are more likely to favour an empirical approach over theoretic rigidity. They require an analysis that includes a proper representation of the financial sector, which the mainstream neoclassical models cannot provide. Given the role that the financial sector is expected to play in funding the necessary investment for a low-carbon transition, engagement with post-Keynesian economists could be important.

## 7 Conclusions

This paper has summarised three distinct phases of economic modelling in the area of climate change and climate policy. In the first two phases there has been a limited role for post-Keynesian macroeconomics and, indeed, most post-Keynesian economists would probably disagree with the basic premise of extreme optimisation approaches applied to estimate social costs of carbon. However, as the amount of media attention devoted to climate change increases, policy makers require ever-more detailed assessment of real-world policies for reducing emissions. Here there is a much clearer potential role for post-Keynesian analysis.

These trends look likely to continue in the foreseeable future, as the world aims for a trajectory in which greenhouse gas emissions are gradually reduced to zero over the next 30-50 years. While each country chooses its own ways to reduce emissions, the path will be decidedly uncertain and events along the way send policy through a constant phase of evaluation and re-evaluation.

There are several aspects of policies to enable a low-carbon transition that post-Keynesian economics and its modelling tools should be particularly strong in assessing. First and foremost, post-Keynesian economics has the capacity to address a much wider range of policy options than the current mainstream, including ones that address information gaps or non-rational behaviour.

Second, the transition to a low-carbon economy will be undoubtedly technology driven. An accurate depiction of technology development and diffusion is required if the economic analysis is to be in any way realistic. Third, the low-carbon transition will require large amounts of investment and therefore a realistic representation of the financial sector is an absolute requirement. Finally, as recent events have shown, the political economy and concerns over a 'just transition' and the distributional impacts of climate change policy (including impacts on employment and unemployment) cannot be ignored.

Keynes was strongly influenced by the global events that occurred during his lifetime. He developed his economic theories as a response to meet the biggest socio-economic challenges of the time. Today we may face different challenges but these theories remain as relevant as ever. The fundamental workings of the economy have not changed and the key issues that policy makers face have not changed either.

As a final point, it could be argued that there is not just an *opportunity* for post-Keynesian economists to focus research on issues relating to climate change policy, but that there is a *requirement* to do so. The global financial crisis demonstrated what can happen if neoclassical theory is given a free run at designing the system. We cannot afford to go through a similar collapse in our natural planetary systems.

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