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Analysis

An integrated approach to climate change, income distribution, employment, and economic growth☆

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ABSTRACT

A demand-driven growth model involving capital accumulation and the dynamics of greenhouse gas (GHG) concentration is set up to examine macroeconomic issues raised by global warming, e.g. effects on output and employment of rising levels of GHG; offsets by mitigation; relationships among energy use and labor productivity, income distribution, and growth; the economic significance of the Jevons and other paradoxes; sustainable consumption and possible reductions in employment; and sources of instability and cyclicality implicit in the two-dimensional dynamical system. The emphasis is on the combination of biophysical limits and Post-Keynesian growth theory and the qualitative patterns of system adjustment and the dynamics that emerge.

1. Introduction

This paper presents a demand-driven model of interactions between greenhouse gas (GHG) accumulation, global warming, and economic growth. The goal is to avoid weaknesses of supply-side models usually deployed to address these issues.

Mainstream economists follow the neoclassical tradition and analyze the impacts of global warming on macroeconomic growth from a supply-side perspective. All resources, especially labor, are supposed to be fully employed, so that total spending on investment and climate mitigation is determined by available saving. Following Keynes (1936) this set of assumptions is often called "*Say's Law*." The most widely discussed climate change models such as Nordhaus (2010) further assume that decisions about investment and mitigation are taken by a "representative agent" which maximizes a mono-metric, discounted utility from consumption over a time horizon spanning centuries. The Nordhaus model has severe technical drawbacks (Rezai et al., 2012) but more fundamentally its key assumptions are not convincing. Will labor be fully employed if global warming significantly reduces the level of output? Does the optimizing agent make any institutional sense? There is good reason to think that the answer to both questions is No, especially in a world of countries with conflicting interests.

Economists following the tradition of Ecological Economics, such as Victor (2008) and Jackson (2009), view global warming from another angle. They advocate "sustainable consumption." Sustainability in this sense implies that the growth rate of consumption per capita should be low or negative (to be complemented by restructuring the consumption basket in favor of less energy-intensive goods). This transition away from consumerism should enable a stabilization of the overall size of the economy (and its carbon emissions) at sustainable levels. But on the macroeconomic level, one has to ask if spending on investment or mitigation will rise enough to absorb an increase in the saving share of income? This response occurs automatically in neoclassical growth models. In Post-Keynesian models, output is not determined by the full employment of all factors, including labor and "environmental capital" and if higher savings are not met by an increase in investment, output levels will adjust downward to restore the saving-investment equilibrium (this mechanism is often referred to as "*Paradox of Thrift*"

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whereby a higher saving rate leads to a lower level of output). Lower (or even negative) levels of economic growth, however, attenuate the distributional conflict and lead to unemployment if productivity growth continues.

There are also problems with a high saving rate in the "long run." A widely accepted convention in economic growth theory is that a model should be set up to force the variables in a macro system toward a stable attractor or balanced growth path in which they all increase (or decrease) at the same growth rate (perhaps zero or negative).[1] Ratios of variables such as output/capital or employment/population become constant. In model simulations the trajectories that variables follow toward the same growth rate are strongly influenced by the nature of the steady state (the stable attractor) itself. At a steady state, the presence of global warming implies that to avoid an ever-increasing concentration of GHG there should be zero or negative population growth and a stable level of per capita consumption.[2] The implication is that eventually a *low* saving rate will be required. Saving would only be needed to pay for mitigation to offset emissions from ongoing production and to maintain a constant level of the capital stock per capita by financing investment to make good the loss of productive capacity due to depreciation. In Sections 2 to 4 we show that proposals for "sustainable consumption" bare direct consequences for investment, output, and distribution.

Finally, Schor (2010) and others suggest that the adverse effects in the labor market due to lower consumption could be supported by a reduction in employed labor time (through either open unemployment or fewer working hours per year). This idea raises complications involving output determination, shifts in productivity, and patterns of energy use which are discussed below. The difficulties are related to a Keynesian "lump-of-labor" paradox (usually called a "fallacy" by mainstream economists) whereby total employment is a direct function of output as determined by aggregate demand. This paradox means that labor cannot be "applied" directly to mitigate climate change, a common neoclassical prescription. The application can occur only if demand for labor is increased by, for example, higher spending on GHG mitigation. The determinants and dynamics of labor productivity are taken up in Section 5. Zwickl et al. (2016-in this issue) discuss the history of working time reductions and their potential in mitigating distributional conflict in a stagnant economy.

Our main aim is to present a model that combines biophysical limits in the form of atmospheric greenhouse gas concentration and Post-Keynesian growth theory. The model is set up in terms of two "state" or "slow" variables that evolve over time — the capital/population ratio and the level of GHG concentration, which capture the underlying conflict between capital accumulation and climate change. Following another convention in growth theory, in the model's "short run" of about a decade both are treated as constant. This allows us to determine the effect of capital accumulation and GHG concentration on the rapidly adjusting or "fast" variables of economic interest such as the income, distribution, employment, and the level of labor productivity. Our model stays within economic growth theory which implies that we neither address societal problems associated with a low-carbon transition as explored in Roepke (2016-in this issue) nor question the importance of economic growth for social welfare despite the recent empirical evidence (Howarth and Kennedy, 2016-in this issue).

We show that under "appropriate" assumptions and under "appropriate" climate policy the two slow variables converge over time to a quasi-steady state in which the ratio of capital to population is constant, and GHG concentration is stable or falling. In contrast to most growth models there is no particular reason for such convergence to be monotonic; there are several ways in which oscillations around a unique steady state could arise. Moreover, destabilizing positive feedbacks in the system may simply make it diverge. Climate policy has the potential to lower the carbon intensity of output but also to increase energy efficiency. Both policy instruments have stabilizing effects. Our analysis extends the verbal analysis of Rezai et al. (2013) and presents a consistent modeling framework for the questions outlined above. We abstract from monetary issues as discussed in Fontana and Sawyer (2016-in this issue) and their implications for climate change as discussed in Campiglio (2016-in this issue). Section 2 introduces the essential elements of a demand-driven growth model which incorporates energy use and greenhouse gas emission. Section 3 discusses the short run determination of output. Section 4 introduces income distribution to the model. Sections 5 and 6 turn to the growth of labor productivity and the dynamics of output and capital stock. Section 7 brings in energy use and the dynamics of greenhouse gas accumulation. Section 8 presents the analysis of the interaction of greenhouse gas accumulation and economic growth and Section 9 concludes.

2. Demand-driven Growth

Any theory of economic growth must incorporate a narrative about how the economy evolves in what Joan Robinson (1974) called a model's "logical" (certainly not observable *chrono*logical) time. It makes sense to sketch out the model verbally before jumping into the mathematics.

Over the past 25 years a lot of effort has been devoted to working out demand-driven growth models that incorporate shifts in the income distribution.[3] Taylor (2010) presents a moderately accessible, nontechnical survey. In the present model's short run, saving and investment respond positively to a rise in the profit rate. In general, a higher profit rate is accompanied by a shift of income away from workers with high consumption propensities to households owning capital who empirically spend a lower share of their income on consumption (since their income is usually much higher than that of workers). The effects of an increase in the profit rate on output and capital accumulation can depend on several factors.

First, if higher profitability induces a sufficiently strong increase in investment demand, aggregate demand can overcome initial reduction in consumption, due to the redistribution away from workers and the paradox of thrift, so that output, employment, and the growth rate of the capital stock go up. Such a "profit-led" adjustment to a shift in the income distribution seems to be characteristic of (at least) high income economies although this is still an ongoing controversy. Higher output increases GHG emissions, given a certain emission intensity.

Second, higher atmospheric GHG concentration can reduce profitability and investment demand. On the other hand an increase in expenditure on mitigation will boost output and thereby GHG emission, in a macroeconomic version of the "Jevons paradox" or "rebound effect" recently emphasized by ecological economists. Whether the induced increase in emission will overwhelm the reduction due to greater mitigation is ultimately an empirical question in simulation of Eq. (11) below.

Third, higher output leads to increases in employment. There is a line of thought dating back to Marx that a tighter labor market (as signaled by an increase in the employment/population ratio) will tend to reduce the profit share. This negative feedback means that any initial profit surge and increased economic activity will be at least partly offset by an induced "profit squeeze."[4]

[1] In other words, chaotic behavior or unbalanced structural change are not permitted and ignored.

[2] Strictly speaking, if there were positive population growth at constant per capita income, then GHG emission could be held stable by devoting an ever-increasing share of output to mitigation, but with increasing costs of mitigation (as assumed below) that strategy would ultimately fail.

[3] We do not consider the distribution of wealth. Jackson and Victor explore the effects of low growth on wealth distribution in another paper of this special section.

[4] There is an alternative to this "profit-led/profit squeeze" model. Demand may be "wage-led" (rising when the profit share falls) and there may be a "wage squeeze" when output rises. It would be natural to assume in this formulation that higher GHG concentration cuts into the wage (instead of the profit) share. Such a specification is beyond the scope of this paper.