The economic implications of the transition to a low-carbon energy system: a stock-flow consistent model

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Extended abstract

Introduction

The development and expansion of low-carbon economic activities is now widely accepted as a prerequisite to achieve an economic system sustainable in the long-term. The change in climate dynamics driven by anthropogenic emission of greenhouse gases, and its potentially catastrophic feedbacks on society, requires a determined steer towards forms of production that have a low impact on planet's resources (Stern, 2007; UNEP, 2011).

A crucial component of the transition to an environmentally sustainable economy is the transformation of the energy system. The production of energy, bound to increase dramatically in the next decades as demand expands (IEA, 2014), is currently based on fossil fuels such as oil, coal and gas. The combustion of fossil fuels is the main driver of greenhouse gases emissions, whose accumulation in the atmosphere is likely to create instability in climatic dynamics. For this reason the expansion of clean technologies of energy production is seen as one of the fundamental steps towards achieving a sustainable society.

Transitioning to low-carbon sources of energy in time to avoid an excessive increase in temperatures will require a large amount of dedicated investments. However, the exclusion of environmental goods from the pricing system - a major market failure - makes the returns on low-carbon investments too low to be really competitive. As a consequence, firms generally prefer to avoid investing in green sectors, and banks avoid lending credit to firms that do (Campiglio, 2015).

The highly aggregate nature of modern climate change economic modelling - Integrated Assessment Modelling in particular - doesn't allow investigating these problems appropriately. The usual economic framework in such models is a simple supply-side growth model drive by inter temporal maximization, where all input factors are fully utilized and there is no distinction between different economic agents - households, firms, government, banks - or productive sectors (Bowen, Campiglio, & Tavoni, 2014).

We thus present a demand-side model with the aim of grasping some of the economic features missing from the literature.

Literature

Our model relates to two strands of research. On one side, we share with environmental and ecological macroeconomics the objective of giving sound economic foundations to sustainability issues. On the other, we aim at contributing to the effort of properly introducing monetary and financial variables into macroeconomic modelling.

Although the two topics are usually seen as separate, the need for the elaboration of a systemic understanding of the macroeconomic system and the interactions between its main variables - so evidently lacking after the financial crisis - strongly calls for a better investigation of the links connecting the financial system with the ecological one.

In order to capture the interaction between real, financial and physical variables we build our model using Post-Keynesian Stock-Flow Consistent (PK-SFC) methodology, which makes extensive use of double entry accounting, depicting each sector as a set of interacting assets and liabilities (Godley & Lavoie, 2012). In this sense we position ourselves closer to the demand-side ecological macroeconomics literature (Godin, 2013; Jackson, 2009; Victor, 2008) rather than the supply-side Integrated Assessment Modelling.

The model

We consider a closed economy in discrete time. A single good is used for both consumption and investment purposes, and serves as a monetary asset. Six sectors populate the economy: households, firms, producers of ‘dirty’ energy, producers of ‘clean’ energy, private banks and the government.

The economy's single good is produced by firms in order to satisfy aggregate demand. Aggregate demand is the sum of consumption and investment, which are endogenously determined. Firms employ three input factors in production: labour, physical capital and a flow of energy services. Each input factor is employed in a way to satisfy aggregate demand Y and is therefore a function of its own productivity.

Energy services can be thought of as the electric power employed by firms to make the physical capital work. We assume that energy services can be produced in two different ways, using a ‘dirty’ or a ‘green’ production process. The dirty sector produces electric power combining fossil fuels (typically coal and gas), for which it has to pay an extracting license to the government, and some specific form of physical capital (a gas turbine, for instance). The green sector produces electricity combining a renewable source of energy (wind, sun, hydro-power) and a different type of capital (solar panels, wind turbines). We assume that both sectors are highly capital-intensive and employ no labour, and that the electricity produced in them is identical.

While the fossil-fuel sector has to pay to obtain the raw materials it needs to produce energy, the green sector obtains its primary energy for free. However, the fossil-fuel sector has a clear advantage in terms of capital costs. This is due to a variety of reasons, that include the more developed state of the technology based on fossil fuels, and the very high efficiency of fossil fuels in producing secondary energy.

The demand of energy is distributed among the two types of energy according to two factors. The first is represented by the prices of dirty and clean energy, which are assumed to be different and determined endogenously. The second factor is the set of preferences of the firms.

This is linked to a demand-driven macroeconomic module that follows some of the usual 'Post-Keynesian' modelling assumptions in the determination of prices, interest rates, investment and consumption. The use of stock-flow consistent methodology allows us to study the transition to green energy capacity in a systemic perspective, explicitly considering the dynamics of the balance sheets of different economic agents, and introducing the credit and banking sector into the picture.

Low-carbon policies and scenarios

The public actor can try to correct the environmental market failure in a variety of ways. In order to investigate the feasibility of implementing different options, and their effect on macroeconomic dynamics, we build and numerically simulate the following scenarios:

- *Business as Usual*. No public policy is implemented. The cost of green capital is assumed to stay higher than the cost of dirty capital in the long run. Price of energy remains stable.
- *Green (balanced) fiscal reform*. Both a tax on the consumption of dirty energy and a subsidy on the consumption of green energy are put in place. Public budget is balanced.
- *Green public R&D*. The revenues from the carbon tax are here used to invest in a stock of green knowledge that improves the productivity of clean capital. Public budget is balanced.
- *Green credit guidance*. No fiscal policy is implemented. The central bank implements a monetary policy that decreases the cost of credit to invest in green technology.
- *Unbalanced Budget*: carbon tax revenues are not enough to pay for public expenditure (either subsidies or R&D). Public debt accumulates. The interest rate on debt increases and stimulates a negative feedback.
- *Additional fiscal policies*. Taxation on labour and profits is introduced. The option of using carbon tax revenues to decrease taxation elsewhere is studied.

Conclusions

Preliminary and expected results show that a number of market failures prevent finance to flow naturally towards green investment. A successful transition to low-carbon forms of energy requires the implementation of strong policies by government and central banks. The socio-economic implications of each combination of policies are analysed and commented.

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