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Systems-dynamic analysis of employment and inequality impacts of low-carbon investments

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ABSTRACT

This paper provides a macroeconomic framework to evaluate the social and economic consequences generated by a shift of investment to low-carbon options. We introduce into a standard growth framework a modified Lotka–Volterra model for wage and employment determination to address both the long-run dynamics of the economic system in terms of carbon emission and GDP growth and the short-term macroeconomic fluctuations in terms of unemployment and inequality. We use this framework to compare the results of different combinations of three strategies for carbon emissions reductions: improvement in energy efficiency, expansion of the renewable energy sector, and the direct reduction in carbon emissions. We show that the shift to low-carbon investment required to achieve the targeted reductions increases employment and the labour share but slows down GDP growth and wages.

1. Introduction

The transition to sustainability has received attention in the economic literature since the late 1960s, when researchers such as Nicholas Georgescu-Roegen, Donella and Dennis Meadows and Herman Daly pointed out the negative consequences of increasing population and human activities on the ecosphere, including loss of biodiversity, air pollution and climate change. Against this background, a growing number of contributions have called for a fundamental change in several domains of human behaviour in order to sustain the delicate equilibrium that keeps ecological and socio-economic systems stable. More recently, the financial crisis has led to renewed interest of economists in its negative socioeconomic consequences, including increasing unemployment and amplified inequality. Therefore, any robust analysis of sustainablity needs to address both environmental and socio-economic challenges and need to discover an approach which guarantees a fine balance between the two.

Quite recently, some transdisciplinary fields have tried to assimilate the responses relating to the economic crisis and environmental impacts (Røpke, 2016). In this regard, one of the most promising field is ecological macroeconomics which not only attempts to integrate environmental, financial and macroeconomic aspects but also tries to evaluate the main consequences of such changes witnessed in these sectors at the socio-economic level. In particular, the debate aims to solve macroeconomic dilemmas such as "the balancing of consumption and investment while maintaining high employment as

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well as limits on material consumption [. . .]; and sufficient investment in the maintenance of critical natural capital systems including ecosystems and atmosphere." (Harris, 2009, p. 42).[1]

In this perspective, our contribution is twofold. We first propose a macroeconomic model to address the dynamics of the system in terms of economic growth, carbon emissions, unemployment and income distribution. Secondly, we apply this framework to evaluate the consequences that a shift to low-carbon investment produces in the economy.

We consider a standard growth model where energy is a complementary input in the final sector. Though the model is designed to address long-run growth, we highlight the short-run impacts of wage and employment changes on income distribution. Parker (1998) points out that cyclical downturns and unemployment have a regressive effect on income distribution. On the contrary, upturns have an equalizing effect. Moreover, Bilter and Hoynes (2015) confirmed the previous consideration, showing that recessions reduce earnings across the low-income population. Finally, according to Kumhof and Rancière (2010) and Piketty (2014), inequality increases when there is stagnation in the economy.

Accordingly, we built a modified Lokta-Volterra model in which wage and employment are endogenously determined and profit and labour share follow the dynamics previously described (Goodwin, 1967; Shaikh, 2004; Canry, 2005). Moreover, since total investment depends on functional distribution, the cyclical dynamics in the labour market induces cycles in investment and growth. Furthermore, the increase in low-carbon investments affects the level of employment in the energy sector which, in turn, affects the dynamics of the wage rate and hence employment in the final sector. In other words, this paper explores the consequences of a shift of investment towards the "green" sector in an economy where the wage rate and employment dynamics impact on income distribution, investment and growth.

In this perspective our paper is a contribution to the green growth discourse. This literature highlights two different arguments (Huberty et al., 2011; Jacobs, 2013). The first, the standard argument, states that the costs of emission reduction can have an imperceptible impact on economic growth (Jacobs, 1991; Ekins, 2000), and that, without tackling environmental damage, the cost to growth of climate change will be greater (Stern et al., 2007). According to the second, and stronger, argument, emission reduction and environmental protection are not only compatible with economic growth but they may even foster it. The last world economic crisis has stimulated the development of this new narrative, which aims to combine the capacity to tackle short-term macroeconomic fluctuations with attempts at long-term sustainability (Bowen and Fankhauser, 2011). In the Keynesian view, a green fiscal stimulus will enhance low-carbon investment by contributing to achieve two goals: output increase and emission reduction. By contrast, we highlight the emergence of a critical trade-off based on a different mechanism. An increase in low-carbon investment can induce a decrease in "traditional" investment. This slows down economic growth. However, low-carbon investment may create "green" jobs and foster the development of a sustainable energy sector, which can sustain a higher level of employment in an economy with a lower rate of growth. As a result, the cost of the transition to a low-carbon economy may be high in terms of GDP growth but low (or even negative) in terms of unemployment.

We investigate this issue, making use of system dynamics to identify and develop alternative scenarios. System dynamics is a suitable tool for the analysis of complex systems: it has a high degree of flexibility and a graphical structure which allows identification of feedback mechanisms (Costanza and Ruth, 1998; Costanza et al., 1993). However, there are few attempts to develop macroeconomic models through system dynamics. Of the few, a very interesting work is that developed by Yamaguchi (2011) which provides a model of an aggregate economy with a detailed representation of the main economic actors (consumers, producers, government, banks, the central bank).[2] More recently, Victor and Rosenbluth (2007) and Victor (2008, 2012) develop a macroeconomic model calibrated for Canada, where they discuss the consequence of low growth or negative growth on environmental, social and economic variables.[3] On the contrary, we analyse how the attainment of an established emission target affects employment and income distribution in the short run and the rate of growth of the system in the long run. In other words, the emerging rate of growth in the roadmap scenario is determined by the constraint on emissions and on the choice of the investment strategy. The rate of growth in this scenario is substantially lower than that of the business as usual scenario.[4] The dynamics of income distribution is the focus of Jackson and Victor (2016) in which they explore the Piketty hypothesis according to which slow growth increases inequality under a variety of assumptions. While they assume that growth and saving rates are exogenous, we determine those rates taking into consideration their feedback to unemployment and income distribution.

Finally this work is closely related to D'Alessandro et al. (2010). However, while they explore the trade-off between the positive effect of growth on the income available for R&D in renewable energy sources, and the negative effect of growth on the acceleration of the exhaustible resource depletion time, here we investigate the social and economic consequences of

[1] This framework refers to a strong sustainability perspective, where the complementary relationship between natural capital and manmade capital, and between flows and stocks of resources are preserved (Daly, 1996).

[2] Another example is the Macrolab model, developed by Wheat (2003), focusing on the US economy.

[3] Another work that deserves mention is the T21 project, developed by the Millennium Institute, the results being summarised in the report entitled "Towards a Green Economy" (UNEP, 2011). The dynamic simulation tool is designed for long-run planning of national development, being able to support the comparative analysis of different policy instruments and identify the set of policies aimed at achieving the desired objectives (Bassi, 2008; Bassi et al., 2010).

[4] Note that we are not focusing on the the need to downscale production to attain sustainability. For a discussion on *degrowth* and sustainability see for instance Spangenberg (2010), Hueting (2010), van den Bergh and Kallis (2012), Kalimeris et al. (2014).