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Towards a Stock-Flow Consistent Ecological Macroeconomics



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The overall aim of PASSAGE is to explore the relationship between prosperity and sustainability and to promote and develop research on the green economy.

The research aims of the fellowship are directed towards three principal tasks:

- 1) Foundations for sustainable living: to synthesise findings from a decade of research on sustainable consumption and sustainable living;
- 2) Ecological Macroeconomics: to develop a new programme of work around the macroeconomics of the transition to a green economy.
- 3) Transforming Finance; to work with a variety of partners to develop a financial system fit for purpose to deliver sustainable investment.

During the course of the fellowship, Prof Jackson and the team will engage closely with stakeholders across government, civil society, business, the media and academia in debates about the green economy.

PASSAGE also seeks to build capacity in new economic thinking by providing a new focus of attention on ecological macroeconomics for postgraduates and young research fellows.

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Abstract

Modern western economies (in the Eurozone and elsewhere) face a number of challenges over the coming decades. Achieving full employment, meeting climate change and other key environmental targets, and reducing inequality rank amongst the highest of these. The conventional route to achieving these goals has been to pursue economic growth. But this route has created two critical problems for modern economies. The first is that higher growth leads (*ceteris parabis*) to higher environmental impact. The second is that fragility in financial balances has accompanied relentless demand expansion.

The prevailing global response to the first problem has been to encourage a decoupling of output from impacts by investing in green technologies (green growth). But this response runs the risk of exacerbating problems associated with the over-leveraging of households, firms and governments and places undue confidence in unproven and imagined technologies. An alternative approach is to reduce the pace of growth and to restructure economies around green services (post-growth). But the potential dangers of declining growth rates lie in increased inequality and in rising unemployment. Some more fundamental arguments have also been made against the feasibility of interest-bearing debt within a post-growth economy.

The work described in this paper was motivated by the need to address these fundamental dilemmas and to inform the debate that has emerged in recent years about the relative merits of green growth and post-growth scenarios. In pursuit of this aim we have developed a suite of macroeconomic models based on the methodology of Post-Keynesian Stock Flow Consistent (SFC) system dynamics. Taken together these models represent the first steps in constructing a new macroeconomic synthesis capable of exploring the economic and financial dimensions of an economy confronting resource or environmental constraints. Such an ecological macroeconomics includes an account of basic macroeconomic variables such as the GDP, consumption, investment, saving, public spending, employment, and productivity. It also accounts for the performance of the economy in terms of financial balances, net lending positions, money supply, distributional equity and financial stability.

This report illustrates the utility of this new approach through a number of specific analyses and scenario explorations. These include an assessment of the Piketty hypothesis (that slow growth increases inequality), an analysis of the 'growth imperative' hypothesis (that interest bearing debt requires economic growth for stability), and an analysis of the financial and monetary implications of green investment policies. The work also assesses the scope for fiscal policy to improve social and environmental outcomes.

1 Introduction

The WWWforEurope project is a large-scale collaborative project with a common interest in the socio-economic transition to sustainability. The overall objective of Work Package 205 is to develop models to support a quantitative understanding of the socio-economic transition towards sustainability.

Milestone 38 (Jackson et al 2014) outlined the development of two separate strands of modelling work, one using a Dynamic Stochastic General Equilibrium (DSGE) approach and the other using a Stock-Flow Consistent (SFC) system dynamics approach. Milestone 39 (Kratena et al 2015) reports on the findings from the first approach. The aim of Milestone 40 is to report on the outcomes from the SFC modelling strand.

Section 2 of the report elaborates on the motivation for the modelling approach. It sets out the challenges associated with modelling the transition to sustainability and articulates the need for an 'ecological macroeconomics'.

Section 3 describes the broad principles of SFC modelling, drawing on the pioneering work of Wynne Godley and his collaborators. Though increasingly employed within the Post-Keynesian economic paradigm, SFC modelling is not particularly well-known beyond that field and has only recently begun to be used to model social or ecological aspects of the economy. This milestone aims to demonstrate the value of the approach in understanding the transition to a sustainable economy.

Sections 4 to 7 describe four distinct modelling exercises undertaken by the authors of this report using an SFC framework. The first of these explores the so-called 'Piketty hypothesis' that declining growth rates lead to rising inequality. The second examines the question whether or not the existence of interest-bearing debt necessarily creates a 'growth imperative'. The third model explores the financial and monetary implications of a large-scale green investment programme. The fourth model develops the combined challenge of substituting for fossil fuels in the context of social and economic goals.

Section 8 summarises the findings from the overall work programme and discusses the implications for debates about green growth and post-growth economies.

2 Motivating a Stock-Flow Consistent Ecological Macroeconomics

One of the clearest lessons from the financial crisis is that a narrow focus on real economy indicators and policies was insufficient to avert the potentially disastrous consequences triggered by weaknesses in the US housing market, the proliferation of financial derivatives, and the subsequent collapse of Lehman brothers in September 2008. The fragility instilled within the financial system as a result of over-heated asset markets, over-leveraged balance sheets, and over-complex financial instruments went largely unnoticed in a policy environment focused primarily on aggregate indicators such as the GDP, employment rates, inflation and consumer spending.

The failure of almost all mainstream economists to foresee the global financial crisis of 2008/9 represents a remarkable failure of financial governance (Bezemer 2010). Just a year before the onset of the great recession the then chairman of the U.S. Federal Reserve Ben Bernanke reported to the U.S. House of Representatives (Bernanke, 2007) that ‘the U.S. economy appears likely to expand at a moderate pace over the second half of 2007, with growth then strengthening a bit in 2008 to a rate close to the economy's underlying trend.’ Global financial institutions were also taken unawares. In August 2007, the IMF was able to argue that ‘notwithstanding recent financial market nervousness, the global economy remains on track for continued robust growth in 2007 and 2008, although at a somewhat more moderate pace than 2006. Moreover, downside risks to the economic outlook seem less threatening than at the time of the September 2006 World Economic Outlook.’ (IMF, 2007).

These oversights amount to a systematic failure to integrate a coherent description of the financial economy into models and policy prescriptions for the real economy (Keen 2011). The crisis revealed painfully that the apparent economic success of the ‘great moderation’ was largely built on a growing fragility in the balance sheets of firms, households and nation states (Barwell and Burrows 2011, Koo 2011). But these risks remained invisible to most economists and unpredicted by the majority of economic models. In the wake of the crisis, economists have therefore placed a renewed importance on the task of understanding the behaviour (and in particular the stability or instability) of the financial economy and integrating this understanding into the workings of the real economy. A host of new research initiatives and the re-emergence of some earlier schools of thought bears witness to this new turn in economics (Keen 2011, Minsky 1994, Turner 2013, Wray 2012).

Another notable shortcoming of traditional economic models is the failure to account properly for the stocks and flows of natural resources on which economic activity ultimately depends. The period of the great moderation also witnessed a progressive decline in environmental quality across the world: in particular, in relation to global climate change, biodiversity loss, the deforestation and desertification of semi-arid regions, the eutrophication of water supplies and the over-exploitation of mineral resources (MEA 2005, MGI 2013, Rockström et al 2009, Steffen et al 2015, TEEB 2010, IPCC 2014, Wiedmann et al 2013). These limitations are well-rehearsed in the literature from ecological economics (Daly 1972, Meadows et al 1972, Costanza 1989, Daly 1996, Costanza et al 1997). But attempts to redress them have been partial at best.

One of the reasons for this is a fundamental dilemma which haunts debates about a sustainable economy. Conventional formulations for achieving prosperity rely on a continual expansion of consumer demand. More is deemed better in the received wisdom, even when the wellbeing outcomes from increasingly material lives are tenuous. But expanding consumer demand increases the global throughput of materials and the consumption of fossil fuels and threatens the sustainability of the ecosystems on which prosperity depends. Continued growth of the kind seen hitherto is patently unsustainable.

On the other hand, slowing down, or reversing economic growth appears unpalatable too. Income growth is clearly still needed in the poorest countries at least, where it is highly correlated with real wellbeing outcomes. Even in the richest economies, growth in GDP is often regarded as the single most important policy indicator of progress. When growth falters, as it did in the crisis of 2008/9 incomes fall, high-street spending is reduced and production output falls. Businesses have less to invest, governments have lower tax revenues, social investment is withdrawn, people lose their jobs and the economy begins to fall into a spiral of recession. In short, growth may be unsustainable, but de-growth appears to be unstable.

Responding to the dilemma of remaining within the 'safe operating space' (Rockström 2009, Steffen et al 2015) of a finite planet in a growth-based economy has often been construed by economists primarily as a microeconomic task — one that governments can address with conventional fiscal instruments of tax and subsidy. The 'external' costs associated with economic activities should be 'internalized' in market prices, according to familiar axioms (Pigou 1920, Pearce et al 1989, Pearce and Turner 1990, Ekins 1992). Incorporating 'shadow prices' for environmental goods into market prices will send a clear signal to consumers and investors about the real costs of resource consumption and ecological damage, and incentivize investment in alternatives, according to this conventional wisdom.

But this prescription has been hard to implement over the last decades. Fears of damaging economic growth have led politicians to shy away from both ecological taxation and green investment. Recent attempts to overcome this fear have largely focused on arguing that the impacts of green investment will be either negligible or even positive in terms of stimulating growth (NCE 2014). But it remains an uncomfortable fact that fragile private and public sector balance sheets have slowed down investment in the real economy generally, let alone the additional (and less familiar) investment needed to make a transition to a sustainable economy. Conventional responses have focussed instead on cutting public spending (austerity) and stimulating consumption growth (consumer spending) as the basis for economic recovery. Unfortunately, these responses tend to ignore the structural problems of the conventional paradigm and delay further the investment needed to make the transition to a sustainable green economy.

This transition demands a quite specific investment portfolio which is quantitatively and qualitatively different from the investment portfolio that has characterised the prevailing economic system. Existing investment practices tend to be dominated by speculation on asset prices on the one hand and by the extraction and depletion of natural resources on the other. Easy returns in the first

category are gained at the cost of unstable asset prices and rising inequality (Credit Suisse 2014, nef 2015). Easy returns in the second are achieved only at the expense of resource depletion and environmental degradation (UNEP 2014). As these easy returns begin to dissipate, the dominance of extractive investments leads to portfolios weakened by stranded assets (HSBC 2012) with potentially destabilising effects on future financial markets.

By contrast, the investment portfolio for a sustainable economy consists in building long-term assets in low carbon technology and infrastructure, in resource-efficient manufacturing, in service provision, in health care, in education, in public spaces and social goods, and in the protection and restoration of habitats, forests, wetlands, soils and other natural assets. Some of these asset types may offer very conventional benefits with rates of return comparable to existing portfolios. Others however will impose considerable challenges on existing institutional structures and financial architectures because their very real environmental and social benefits are not reflected in market prices and financial returns.

The scale and nature of this dilemma suggest that the combined challenges of climate change, environmental pressure, and resource scarcity require macroeconomic as well as microeconomic responses. In fact, there is a need to develop a fully consistent ecological macroeconomics in which it is possible to maintain financial stability, ensure high levels of employment, improve the distribution of income and wealth and yet remain within the ecological constraints and resource limits of a finite planet.

In short, it is clear that an approach to macroeconomics configured only by 'real economy' aggregates such as output, productivity, employment, consumption and public spending, is insufficient to ensure economic sustainability, let alone social or environmental sustainability. Nor is it sufficient for monetary policy to consist largely in laissez faire regulation of financial markets combined with central bank interest rate policy aimed solely at 'inflation targeting'. These forms of monetary policy were plainly deficient in averting the crisis and insufficient to provide recovery from it. For two decades before the crisis, this same architecture signally failed to provide a financial landscape amenable to the investment needs of an environmentally sustainable and socially equitable economy. Building a more appropriate financial system needs to start from a clear understanding of the investment needs associated with the transition to sustainable economy.

Numerous questions emerge as a result of this analysis. These include questions: about the organisation and structure of asset portfolios; about the balance between public and private finance; about the balance between equity and debt; about the structure and distribution of asset ownership; about the impacts of elevated investments on prices, on wages and on consumer demand; and about the appropriate forms of horizontal and vertical money. Clearly, addressing these questions demands attention to both the real and the financial economy. Explicitly, it also requires a framework that integrates both of these aspects of the economy – in the context of ecological and resource constraints. The aim of this paper is describe several approaches to this over-arching problem, building on the theoretical framework of stock-flow consistent (SFC) macroeconomic modelling.

3 A Stock-Flow Consistent System Dynamics Framework

The intellectual foundation for the modelling work reported in this Milestone derive from a view of macroeconomics developed within post-Keynesian economic theory. We draw in particular from the Stock-Flow Consistent (SFC) approach to macro-economics, pioneered by Copeland (1949) and developed extensively by Wynne Godley and others over the last decades (Godley and Lavoie 2007, Lavoie and Godley 2001, Lavoie and Zezza 2012).²

The overall rationale of the SFC approach is to account consistently for all monetary flows between agents and sectors across the economy. This rationale can be captured in three broad axioms: first that each expenditure from a given actor (or sector) is also the income to another actor (or sector); second, that each sector's financial assets correspond to financial liabilities of at least one other sector, with the sum of all assets and liabilities across all sectors equalling zero; and finally, that changes in stocks of financial assets are consistently related to flows within and between economic sectors.

These simple understandings lead to a set of accounting principles with implications for actors in both the real and financial economy which can be used to test any economic model or scenario prediction for consistency as a possible solution in the real world. The approach has come to the fore in the wake of the financial crisis, precisely because of these consistent accounting principles and the transparency they bring to an understanding not just of conventional macroeconomic aggregates like the GDP but also of the underlying balance sheets. It is notable that Godley (1999) was one of the few economists who predicted the crisis before it happened.

The approach is broadly Keynesian in the sense that SFC models tend to be demand-driven, and the economy is articulated in terms of a number of inter-related financial sector accounts: households, firms, banks, government, central bank and the 'rest of the world' (or foreign sector). The accounts of firms and banks are usually further subdivided into current and capital accounts in line with national accounting practices. It is also sometimes useful to subdivide individual sectors further. For instance, the household sector can be subdivided into two sectors (see Section 4 below) in order to test the distributional aspects of changes in the real or financial economy.

Figure 1 illustrates a typical model structure for an SFC model with the familiar 'circular flow' of the economy visible (in red) towards the bottom left of the diagram. The rather more complex structure shown (partially) above and around the circular flow represents financial flows of the monetary economy in the banking, government and foreign sectors.

If the model is stock-flow consistent, the financial flows into and out of each financial sector consistently sum to zero at each point of time along the model run. So, for instance, the incomes of households (consisting of wages and profits) must be exactly equal to the outgoings of households (including taxes, net interest payments, consumption and investment spending, and net acquisitions of financial assets). Likewise, for each other sector in the model.

² For an overview of the literature on SFC macroeconomic modelling, see Caverzasi and Godin 2015.

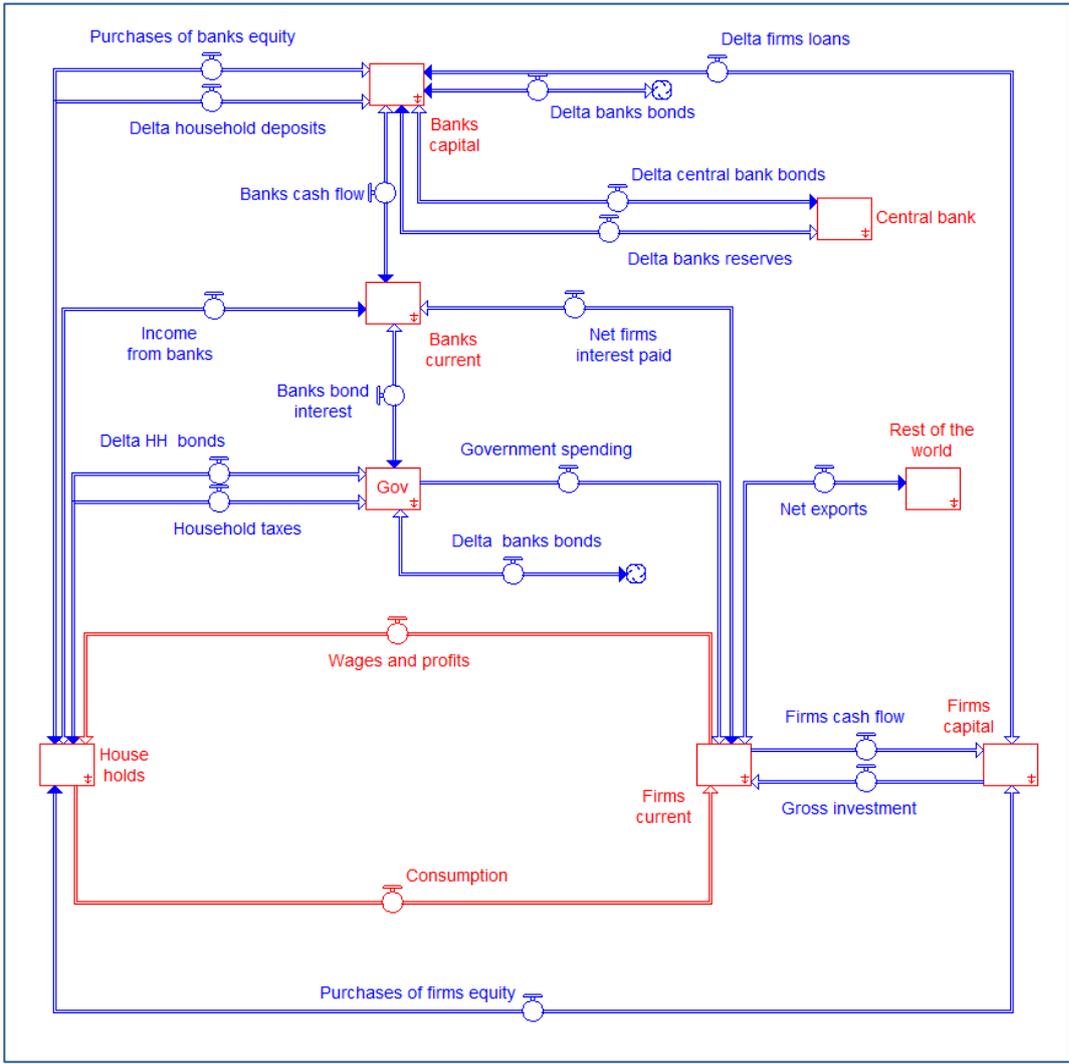


Figure 1: Illustrative Macroeconomic Structure for SFC Model³

The stock flow consistent approach to money flows within an economy can also be represented in tabular form, as illustrated in Tables 1 and 2. Table 1 shows an illustrative (and simplified) ‘transaction flows’ matrix for a closed economy.

The matrix creates a representation of all the transactions between different financial sectors in a given period (typically a year) of economic activity. It will be noticed that the production firms account is split into a current account, where revenue and costs are settled, and a capital account where the funds for investment reside. This split between current and capital account is also usually extended also to financial firms (banks), to the Central Bank, and to the foreign sector. For illustrative purposes we omit these accounts in Table 1.

³ This diagram is taken from the version of the FALSTAFF model reported in sections 5 and 6, which was developed using the interactive systems dynamics software STELLA at the University of Surrey in collaboration with York University Toronto (Jackson and Victor 2015).

	Households (h)	Firms (f)		Financial sector (b)		Central Bank (cb)	Gov (g)	RoW (r)	Σ
		Current	Capital	Current	Capital				
Consumption (C)	$-C$	C							0
Gov spending (G)		G					$-G$		0
Investment (I)	$-I^h$	$I^f + I^h$	$-I^f$						0
Exports (X) and imports (M)		$X - M$						$M - X$	0
Wages (W)	W	$-W$							0
Profits (F)	$+P_{fd} + P_b$	$-P_f$	$+P_{fr}$	$-P_b$					0
Taxes (T)	$-T_h$	$-T_f - T_p$					T		0
Interest on Loans (L)	$-r_l L_{-1}^h$	$-r_l L_{-1}$		$+r_l L_{-1}$					0
Interest on Deposits (D)	$+r_d D_{-1}^h$	$+r_d D_{-1}^f$		$-r_d D_{-1}$				$+r_d D_{-1}^r$	0
Interest on Bonds (B)	$+r_b B_{-1}^h$			$+r_b B_{-1}^b$		$+r_b B_{-1}^{cb}$	$-r_b B_{-1}$	$+r_b B_{-1}^r$	0
Change in Advances (A)					$+\Delta A$	$-\Delta A$			0
Change in Reserves (R)					$-\Delta R$	$+\Delta R$			0
Change in deposits (D)	$-\Delta D^h$				$+\Delta D$				0
Change in bonds (B)	$-\Delta B^h$				$-\Delta B^b$	$-\Delta B^{cb}$	$+\Delta B$	$-\Delta B^r$	0
Change in equities (E)	$-p_E \Delta E$		$+p_E \Delta E$						0
Change in loans (L)	$+\Delta L^h$		$+\Delta L^f$						0
Change in mortgages (M)	$+\Delta M$				$-\Delta M$				0
Change in pensions (N)	$-\Delta N$				$+\Delta N$				0
Σ	0	0	0	0	0	0	0	0	0

Table 1: Illustrative Transaction Matrix for SFC Modelling

The transaction matrix incorporates an account of the incomes and expenditures in the national economy, reflecting directly the structure of the system of national accounts. Thus the first ten rows in Table 1 illustrate the flow accounts of each sector. In terms of the household sector, for example, it can be seen that households receive money in the form of wages and distributed profits from production firms, while spending money on consumption and taxes.

It is to be observed that the first six rows of the Firms sector (column 3 in Table1) present a simplified form of the conventional GDP accounting identity:

$$C + G + I = GDP_e = GDP_i = W + P \quad 1)$$

where GDP_e represents the expenditure-based formulation of the Gross Domestic Product and GDP_i represents the income based GDP formulation.

The lower portion of Table 1 shows the changes in financial assets and liabilities between sectors. So for example the net lending of the households sector (the sum of rows 1 to 10 in column 2 of Table 1) is distributed amongst four different kinds of financial assets in this illustration: deposits, government bonds and equities. Note that this Table is for illustrative purposes only. Actual allocations in FALSTAFF include other options, including the taking of loans and mortgages by households.

A key feature of the transaction matrix, indeed the core principle at the heart of SFC modelling, is that each of the rows and each of the columns must always sum to zero. If the model is correctly constructed, these zero balances should not change over time as the simulation progress. The accounting identities shown in Table 1 therefore allow for a consistency check, to ensure that the simulations actually represent possible states of the monetary economy.

Associated with the transactions illustrated in the bottom five rows of Table 1 are changes in the capital accounts of each economic sector. For each transaction in financial assets between two sectors of the economy there is an associated change in the balance sheet of the same two sectors. For instance, a decision by the household sector to increase deposits at banks will increase the deposit assets of households while simultaneously increasing deposit liabilities at banks.

The balance sheet of an economy (Table 2 below) may be thought of as providing a record of all previous transactions upon which the transactions in the current period are added. Changes in the balance sheet from the end of period t-1 to the end of period t are therefore the result of transactions occurring in period t. Typically balance sheet data are collated and reported on an annual basis in the national accounts. One of the key financial axioms illustrated in Table 2 is that the

sum of all financial assets and liabilities in the economy is zero. The only net assets are non-financial, derived from fixed (and non-produced) capital.⁴

	Households	Firms	Banks	Gov't	Σ
Loans		$-L$	$+L$		0
Deposits (D)	$+D$		$-D$		0
Bonds (B)	$+B_h$		$+B_b$	$-B$	0
Equities (E)	$+e \cdot p_e$	$-e_f \cdot p_e$			0
Fixed capital (K)	$+K_h$	$+K_f$			$+K$
Net worth (NW)	NW_h	NW_f	NW_b	NW_g	K

Table 2: Illustrative Balance Sheet Matrix for a Closed Economy

As indicated in the introduction, this milestone reports on two distinct programmes of work which have contributed to the outputs from the WWWforEurope project. The first of these is the modelling approach pursued by Surrey which builds on an on-going project led by Prof Tim Jackson and Prof Peter Victor (York University, Toronto) to develop a stock-flow consistent (SFC) ecological macro-economics. The broad approach has several distinct features.

In the first place, it draws together three primary spheres of modelling interest and explores the interactions between them. These spheres are: 1) the ecological and resource constraints on economic activity; 2) a full account of production, consumption, employment and public finances in the 'real economy' at the level of the nation state; 3) a comprehensive account of the money economy, including the main interactions between financial agents, and the creation, flow and destruction of the money supply itself. Interactions within and between these spheres of interest are modelled, using a system dynamics framework.⁵

A further key feature of the Surrey approach is the focus of attention on the individual nation state. A premise of the work is that the 'dilemma of growth' has particular ramifications for national policy and is best explored at that level. The growth of GDP or national income in a particular country is not just a significant policy indicator in its own right, it is also a measure of production output and

⁴ These real assets are usually restricted to assets produced by the economy which have a market value eg housing, roads, schools. Other valuable assets such as the land base and mineral deposits are often excluded although efforts are underway to expand national balance sheets to include them. (e.g. United Nations et al 2003)

⁵ The primary modelling platform used by the research team is a system dynamics platform known as STELLA. Data collation organised in Excel and econometric calibration is carried out in Eviews.

consumption possibilities, as well as being related to a country's ability to provide citizens with work, finance its social investment, and compete in global markets. Admittedly, all of these questions could also be (and often are) asked at supra-national or sub-national level. Since the development of a unified System of National Accounts (UN 1993, 2008), however, the most comprehensive, reliable and consistent data sets tend to be available at country and national level.

The work led by Surrey has so far developed three related macro-economic models. The SIGMA model (Section 4) employs a somewhat simplified version of the broader modelling structure to explore the relationship between savings, inequality and growth in a macroeconomic framework. We address in particular the hypothesis advanced by Thomas Piketty that declining growth rates lead inevitably towards rising social inequality.

The FALSTAFF model (Sections 5 and 6) is a more extensive representation of the macro-economy incorporating a wider variety of financial assets and liabilities in a stock-flow consistent framework. We illustrate the use of FALSTAFF by exploring (Section 5) the so-called 'growth imperative' which is supposed (Binswanger 2009 eg) to arise from the creation of money alongside interest-bearing debt, and also (Section 6) the financial and monetary implications of large-scale green investment scenarios.

Finally, the GEMMA model (which is still under development – see Section 8) builds on the FALSTAFF framework to include greater inter-industry structure and more extended behavioural dynamics – including for instance an econometrically estimated portfolio allocation function for household assets and liabilities.

The second strand of work has been developed independently through the University of Vienna. The ECOGRO model (Section 7) is a stock-flow consistent model calibrated to the level of the EU as a whole. It incorporates two specific environmental extensions to the conventional stock-flow consistent framework. One of these expands the structure of nonfinancial firms to incorporate a separate energy sector. The other incorporates an environmental damage function which impacts on the capital stock.

The following sections of the paper provide an overview of the different approaches taken and report in the findings. Further details on each approach are to be found in the references.

4 Does slow growth lead to rising inequality?

The French economist, Thomas Piketty (2014), has received widespread acclaim for his book *Capital in the 21st Century*. Building on over 700 pages of painstaking statistical analysis, the central thesis of the book is nonetheless relatively straightforward to describe. Piketty argues that the increase in inequality witnessed in recent decades is a direct result of the slowing down of economic growth in modern capitalist economies. Under circumstances in which growth rates decline further, he suggests, this challenge would be exacerbated.

Piketty advances his argument through the formulation of two ‘fundamental laws’ of capitalism. The first of these (Piketty 2014: 52 et seq) relates the capital stock (more precisely the capital to income ratio β) to the share of income α flowing to the owners of capital. Specifically, the first fundamental law of capitalism says that:⁶

$$\alpha = r\beta, \tag{1}$$

where r is the rate of return on capital. Since β is defined as K/Y where K is capital and Y is income, it is easy to see that this ‘law’ is, as Piketty acknowledges, an *accounting identity*:

$$\alpha Y = rK. \tag{2}$$

Formally speaking, the income accruing to capital equals the total capital multiplied by the rate of return on that capital. Though this ‘law’ on its own does not force the economy in one direction or another, it provides the foundation from which to explore the evolution of historical relationships between capital, income and rates of return. In particular, it can be seen from this identity that for any given rate of return r the share of income accruing to the owners of capital rises as the capital to income ratio rises.⁷

It is the second of Piketty’s ‘fundamental laws of capitalism’ (op cit: 168 et seq; see also Piketty 2010) that generates particular concern in the context of declining growth rates. This law states that in the long run, the capital to income ratio β tends towards the ratio of the savings rate s to the growth rate g , ie:

⁶ In what follows, we suppress specific reference to time-dependency of variables except where absolutely necessary. Thus all variables should be read as time dependent unless specifically denominated with a subscripted suffix 0. Occasionally, we will have reason to use the subscripted suffix (-1) to denote the first lag of a time-dependent variable.

⁷ We will see later that the *ceteris paribus* clause relating to constant r here is important. In fact, the rate of return will typically change as the capital to income ratio rises; and to the extent that this ratio declines with increasing β , it can potentially mitigate the accumulation of the capital share of income.

$$\beta \rightarrow \frac{s}{g} \text{ as } t \rightarrow \infty. \quad (3)$$

This asymptotic law suggests that, as growth rates fall towards zero, the capital to income ratio will tend to rise dramatically – depending of course on what happens to savings rates. Taken together with the first law, equation (3) suggests that over the long term, capital’s share of income is governed by the following relationship:

$$\alpha \rightarrow r \frac{s}{g} \text{ as } t \rightarrow \infty. \quad (4)$$

In other words, as growth declines, the rising capital to income ratio β leads to an increasing share of income going to capital and a declining share of income going to labour. It is important to stress that the relationships (3) and (4) are long-term equilibria to which the economy evolves, provided that the savings rate s and the growth rate g stay constant. As Piketty points out, ‘the accumulation of wealth takes time: it will take several decades for the law $\beta = s/g$ to become true’ (op cit: 168). In any real economy, the growth rate g and the savings rate s are likely to be changing continually, so that at any point in time, the economy is striving towards, but may never in fact achieve, the asymptotic result.

Piketty’s hypothesis poses a particular challenge to those economists who have been critical of society’s ‘GDP fetish’ (Stiglitz et al 2009) and sought to establish alternative approaches (Daly 1996, Victor 2008, Jackson 2009, Rezai et al 2012, d’Alisa et al 2014) in which socio-economic goals are achieved without assuming continual throughput growth. Certainly, the prospects for ‘prosperity without growth’ (Jackson 2009) would appear slim at best if Piketty’s thesis were unconditionally true. The Piketty hypothesis is also problematic in the face of a potential ‘secular stagnation’ (Gordon 2012), in which declining growth rates are a feature of the national or global macro-economy.

In order to explore further the Piketty hypothesis, Jackson and Victor (2014, 2015) developed a closed, SFC, demand-driven model of Savings, Investment and Growth in a Macroeconomic framework (SIGMA). SIGMA was used to test for the implications of a slowdown of growth on a) capital’s share of income and b) the distribution of incomes in the economy. Policy options to reduce inequality were also examined.

SIGMA has four financial sectors: households, government, firms and banks. Firms’ and banks’ accounts are divided between current and capital accounts and the households sector is further subdivided into two subsectors (which we denominate as ‘workers’ and ‘capitalists’) in order to explore potential inequalities in the distribution of incomes and of wealth. By adding a government sector to the model, we are able to explore the potential to mitigate regressive impacts through a

progressive taxation system. The inclusion of a banking sector allows us to establish clear relationships between the real and the financial economy and discuss questions of household wealth. Before describing SIGMA in more detail, we first summarise Piketty's argument.

The model itself is built using the system dynamics software STELLA. This kind of software provides a useful platform for exploring economic systems for several reasons, not the least of which is the ease of undertaking collaborative, interactive work in a visual (iconographic) environment. Further advantages are the transparency with which one can model fully dynamic relationships and mirror the stock-flow consistency that underlies our approach to macroeconomic modelling.

Following much of the SFC literature, the model is broadly Keynesian in the sense that it is demand-driven. Our approach is to establish a level of overall demand through an exogenous growth rate, g , and to generate the level of investment through an exogenous savings rate, s . We then explore the impacts of changes in these variables over time on the income shares from capital and labour through an endogenous rate of return, r , on capital. To achieve this we employ a constant elasticity of substitution (CES) production function, not to drive output as in a conventional neoclassical model, but to derive the marginal productivity r_K of capital K and also to establish the labour employment associated with a given level of aggregate demand.⁸

To illustrate our arguments without unnecessary complications, we work with a simplified version of the more complex structure that we have developed elsewhere. First, as noted, the SIGMA economy is closed with respect to overseas trade. Next, we assume that government always balances the fiscal budget and holds no outstanding debt, so that government spending, G , is equal to taxes, T , levied only on households.

Finally, we employ a rather simple balance sheet structure, sufficient only to get a handle on changes in household wealth under different patterns of ownership of capital. Households assets are held either as deposits, D , in banks or as equities, E , in firms. The only other item on the balance sheet is loans, L , made by banks to non-financial firms. The banking sector plays a relatively straightforward role as a financial intermediary, providing deposit facilities for households and loans to firms.

Clearly none of these assumptions is accurate as a full description of a modern capitalist economy, but all of them can be relaxed in more sophisticated versions of our framework and none of them obstructs our purposes in this study.

⁸ We are aware of course of the limitations of using a broadly neoclassical production function (Cohen and Harcourt 2003, Robinson 1953). However, retaining this aspect of Piketty's analysis allows us to compare our findings more directly with his.

Household savings are distributed between new bank deposits, ΔD , and the purchase of equities, ΔE , from firms. It is assumed for simplicity that the demand for new equities by households is equal to the supply of new equities by firms and that these in their turn are determined via a desired debt to equity ratio in firms.⁹ The distribution of equity purchases between capitalist and worker households is deemed to be in the same proportion as the net savings of each sector. Changes in deposits are then calculated as a residual from net savings.

In order to model the evolution of the SIGMA economy over time, we follow Piketty by defining the evolution of the net national income NI according to an (exogenous) growth rate g such that:

$$NI = (1 + g) * NI_{(-1)} \quad (4)$$

where $NI_{(-1)}$ is the value in the previous period (ie the first lag) of the variable NI . In some scenarios g will take a fixed value g_0 throughout the period τ of the scenario,¹⁰ while in others g will decline uniformly from g_0 to zero over time t .

Testing Piketty's hypothesis requires that we establish the rate of return to capital, r , which in turn allows us to determine the split between wages and firms profits in the net national income. Along with Piketty (2014a: 213-214), we assume (for now) that the return to capital is given by the marginal productivity of capital, which we denote by r_K . This assumption only works under market conditions in which there are no structural features which might lead either capital or labour to extort more than their 'fair' share of the output from production.

In a sense, this assumption is a conservative one for us, to the extent that conclusions about inequality are stronger in imperfect market dynamics. Under conditions of duress, in which the owners of capital receive a rate of return r greater than the marginal productivity of capital r_K , our conclusions about any inequality which results from declining growth rates will be reinforced. Conversely, of course, we must beware of making too strong assumptions about the potential to mitigate inequality, in any situation in which the owners of capital have greater bargaining power than wage labour.

The results of our analysis are described in detail in Jackson and Victor (2015a) and summarised in Figures 2 and 3. The analysis confirms that, under certain conditions, it is indeed possible for both capital's share of income and income inequality to rise substantially as growth rates decline.

⁹ In contrast to our treatment elsewhere (Jackson and Victor 2015), this means that there is no speculative purchasing of equities that might lead to capital gains and losses.

¹⁰ In this paper we take $\tau = 100$, ie the scenarios run over 100 years.

However, we have also established that there is *absolutely no inevitability at all* that a declining growth rate leads to explosive (or even increasing) levels of inequality.

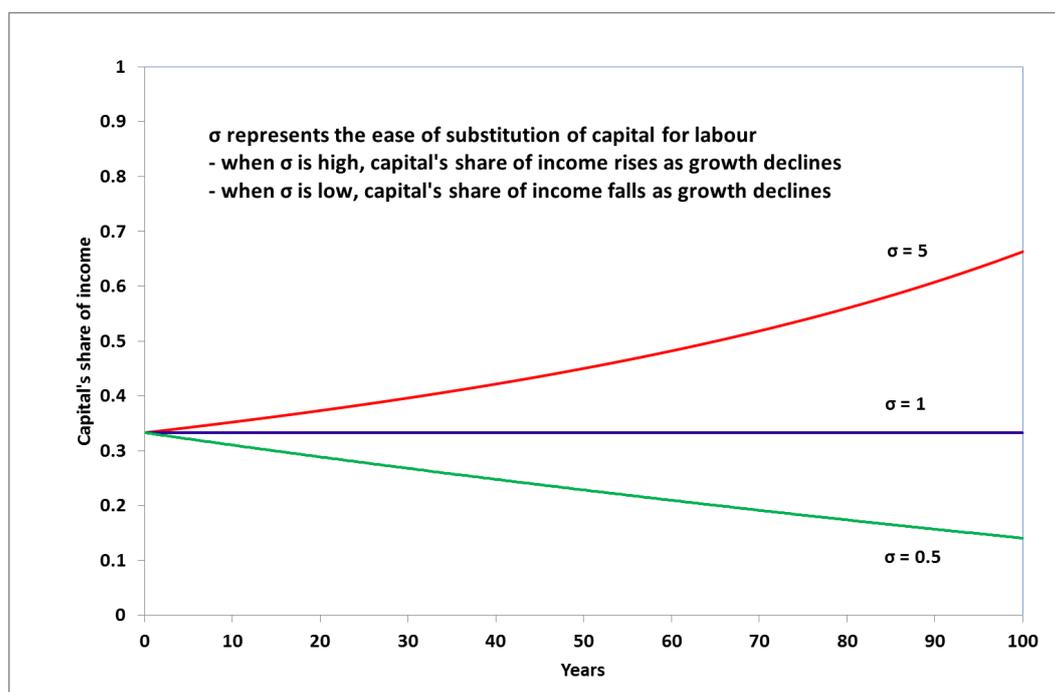


Figure 2: The variation of capital's share of income with elasticity of substitution of capital
Source: Jackson and Victor 2015a

Even under a highly-skewed initial distribution of ownership of productive assets, it is entirely possible to envisage scenarios in which incomes converge over the longer-term, with relatively modest intervention from progressive taxation policies. Specifically when the elasticity of substitution between capital and labour is low (0.5), with a differential tax rate of 40% on higher level incomes and a modest tax on capital assets (around 1.25%), it is possible to reduce the inequality between 'workers' and 'capitalists' entirely (Figure 3).

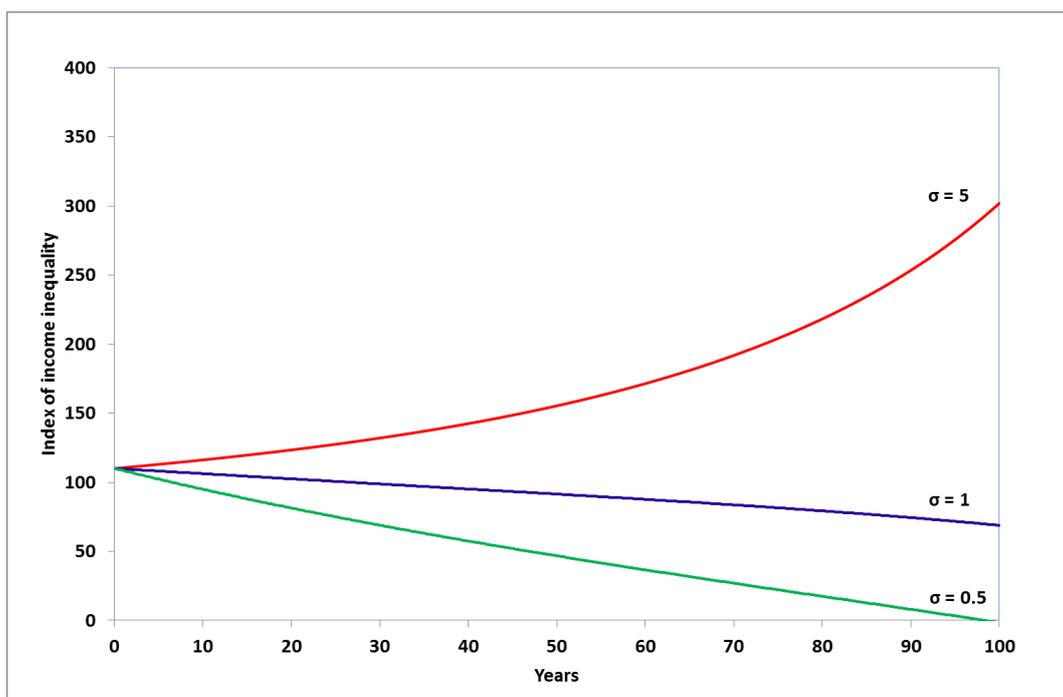


Figure 3: Variations in income inequality under a progressive tax regime

Source: Jackson and Victor 2015a

The most critical factor in this analysis is the elasticity of substitution, σ , between labour and capital. This parameter indicates the ease with which it is possible to substitute capital for labour in the economy as relative prices change. Higher levels of substitutability ($\sigma > 1$) do indeed exhibit the kind of rapid increases in inequality predicted by Piketty, as growth rates decline. In an economy with a lower elasticity of substitution ($0 < \sigma < 1$), the dangers are much less acute. The ease with which capital can be substituted for labour is thus an indicator of the propensity for low growth environments to lead to rising inequality. More rigid capital-labour divisions on the other hand appear to reinforce our ability to reduce societal inequality.

From a conventional economic viewpoint, this might appear to be cold comfort. Lower values of σ are often equated with lower levels of development. As Piketty points out (2014a: 222), low levels of elasticity characterised traditional agricultural societies. Other authors have suggested that the direction of modern development, in general, is associated with rising elasticities between labour and capital (Karagiannis et al 2005). Antony (2009a) and Palivos (2008) both argue that typical empirical values of σ are less than one for developing countries and above one for developed countries. The suggestion in the literature appears to be that progress comprises a continual shift towards higher levels of σ . But this contention embodies numerous ideological assumptions. In particular it seems to be consistent with a particular form of capitalism that has characterised the post-war period: a form of capitalism that has come under increasing scrutiny for its potent failures,

not the least of which is the extent to which it has presided over continuing inequality (Davidson 2013, Galbraith 2013).

The possibility of re-examining this assumption resonates strongly with suggestions in the literature for addressing the challenge of maintaining full employment under declining growth. In our own work, for example, we have responded to this challenge by highlighting the importance of labour-intensive services both in reducing material burdens across society and also in creating employment in the face of declining growth (Jackson 2009; Jackson and Victor 2011). The findings from the SIGMA model support this view. In fact, with constant labour productivity growth of 1.8% per annum, unemployment rises to over 70% in the SIGMA scenarios (Figure 4: scenario 1), a situation that would clearly be disastrous for any society.

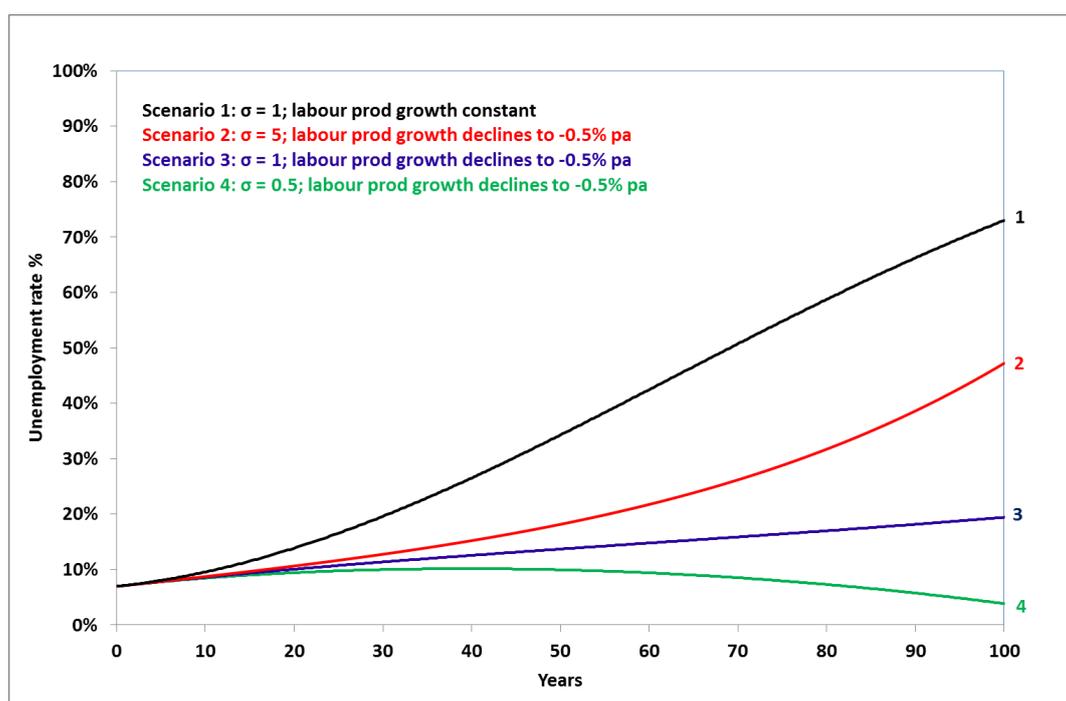


Figure 4: Unemployment scenarios under declining growth

Source: Jackson and Victor 2015a

Suppose, however, that labour productivity were not to grow continually. This could potentially lead to an important avenue of opportunity for structural change in pursuit of sustainability. Instead of a relentless pursuit of ever-increasing labour productivity, economic policy would aim to protect employment as a priority and recognise that the time spent in labour is a vital component of the value of many economic activities (Jackson 2011). Increased employment opportunities would be achieved through a structural transition to more labour intensive sectors of the economy (Jackson and Victor 2011). This would make particular sense for service-based activities – for instance in the care, craft and cultural sectors – where the value of the activities resides largely in the time people

devote to them. In policy terms, such a transition would involve protecting the quality and intensity of people's time in the workplace from the interests of aggressive capital. Such a proposal is not a million miles from Minsky's (1986) suggestion that government should act as 'employer of last resort' in stabilising an unstable economy.

Scenarios 2 to 4 in Figure 4 all describe a situation in which by the end of the run, labour productivity growth has declined to a point where it is slightly negative. By the end of the scenario, labour productivity itself is declining in the economy – production output is becoming more labour intensive. Figure 4 reveals that this decline in labour productivity growth is not in itself sufficient to ensure acceptable levels of unemployment. For higher values of σ , unemployment is still running dangerously high. But for lower values of σ it is possible not only to maintain but even to improve the level of employment in the economy, in spite of a decline in the growth rate to zero.

There is however a tantalising suggestion inherent in this analysis that changing the elasticity of substitution between labour and capital offers another potential avenue towards a more sustainable macro-economy, and in particular a way of mitigating the pernicious impacts of inequality and unemployment in a low growth economy. Exploring that suggestion fully is beyond the scope of this paper, but is certainly worth flagging here. We should also recall here our assumption that the rate of return to capital is equal to the marginal productivity of capital. As we remarked earlier, this assumption only holds in markets conditions where capital is unable to use its power to command a higher share of income. Clearly, in some of the scenarios we have envisaged, this assumption may no longer hold. Where political power accumulates alongside the accumulation of capital, the danger of rising inequality is particularly severe and is no longer offset simply by changes in the economic structure. This question also warrants further analysis.

In summary, the SIGMA model explores the relationship between growth, savings and income inequality, under a variety of assumptions about the nature and structure of the economy. Our principal finding is that rising inequality is by no means inevitable, even in the context of declining growth rates. A key policy conclusion concerns the need to protect wage labour against aggressive cost-reducing strategies to favour the interests of capital. This measure would have the additional benefit of maintaining high employment, even in a low- or degrowth economy.

5 FALSTAFF Part 1 – Credit creation and the ‘growth imperative’

It has been argued that capitalism has an inherent ‘growth imperative’: in other words, that there are certain features of capitalism which are inimical to a stationary state¹¹ of the real economy. This argument has its roots in the writings of Karl Marx (1848) and Rosa Luxemburg (1913) and there are good reasons to take it seriously. For instance, under certain conditions, the desire of entrepreneurs to maximise profits will lead to the pursuit of labour productivity gains in production. Unless the economy grows over time, aggregate labour demand will fall, leading to a ‘productivity trap’ (Jackson and Victor 2011) in which higher and higher levels of unemployment can only be offset by continued economic growth.

Our concern in this section is to address one particular aspect of the growth imperative: namely, the question of interest-bearing debt. A variety of authors have suggested that when money is created in parallel with interest-bearing debt it inevitably creates a growth imperative. To some, the charging of interest on debt is itself an underlying driver for economic growth. In the absence of growth, it is argued, it would be impossible to service interest payments and repay debts, which would therefore accumulate unsustainably. This claim was made, for instance, by Richard Douthwaite (1990, 2006). In *The Ecology of Money*, Douthwaite (2006) suggests that the ‘fundamental problem with the debt method of creating money is that, because interest has to be paid on almost all of it, the economy must grow continuously if it is not to collapse.’

This view has been influential amongst a range of economists critical of capitalism, and in particular those critical of the system of creation of money through interest-bearing debt. Eisenstein (2012) maintains that ‘our present money system can only function in a growing economy. Money is created as interest-bearing debt: it only comes into being when someone promises to pay back even more of it’. In similar vein, Farley et al (2013) claim that the ‘current interest-bearing, debt-based system of money creation stimulates the unsustainable growth economy’ (op cit: 2803). The same authors seek to identify policies that ‘would limit the growth imperative created by an interest-based credit creation system’ (op cit: 2823).

The popular understanding that debt-based money as a form of growth imperative is intuitively appealing, but has been subject to remarkably little in-depth economic scrutiny. A notable exception is a landmark paper by Mathias Binswanger (2009), who set out to provide an ‘explanation for a growth imperative in modern capitalist economies, which are also credit money economies’ (op cit:

¹¹ We use the term stationary state to describe zero growth in the Gross Domestic Product (GDP). We prefer here stationary to steady state, which is also widely used (Daly 2014 eg), for two reasons. First, the term steady state is employed in the post-Keynesian literature (Godley and Lavoie 2007) to describe a state of the economy in which flows are constant; but this may still entail growth. A stationary state is used to describe a state in which both flows and stocks are constant, in which case there is no growth. Second, this terminology harks back to early classical economists such as Mill (1848), emphasising the pedigree of the idea of a non-growth-based economy.

707). As a result of the ability of commercial banks to create money through the expansion of credit, he claims (op cit: 724), ‘a zero growth rate is not feasible in the long run’.

By his own admission, however, Binswanger’s paper ‘does not aim to give a full description of a modern capitalist economy’. In particular, he notes (op cit: 711) that his model ‘should be distinguished from some recent modeling attempts in the Post Keynesian tradition’ which set out to provide ‘comprehensive, fully articulated, theoretical models’ that could serve as a ‘blueprint for an empirical representation of a whole economic system’ (Godley 1999: 394). A recent symposium on the growth imperative has contributed several new perspectives on Binswanger’s original hypothesis, but these papers also fall short of providing a full analysis of this kind (Binswanger 2015, Rosenblum 2015). Our aim in this section is to address this limitation, in the context of a stock-flow consistent model, calibrated with empirically plausible data.

To this end, we have developed a macroeconomic model of Financial Assets and Liabilities in a Stock and Flow consistent Framework (FALSTAFF), calibrated at the level of the national economy (Jackson and Victor 2015b). As with the SIGMA model (Section 4), the approach is broadly post-Keynesian in the sense that the model is demand-driven and incorporates a consistent account of all monetary flows. The full FALSTAFF model is articulated in terms of six inter-related financial sector accounts: households, firms, banks, government, central bank and the ‘rest of the world’ (foreign sector). The accounts of firms and banks are further subdivided into current and capital accounts in line with national accounting practices. The household sector can be further subdivided into two sectors in order to test the distributional aspects of changes in the real or financial economy.¹² For the purposes of this analysis, we have simplified the FALSTAFF structure (denoted here as FALSTAFF⁵) in order to focus specifically on the question of interest-bearing money. For instance, we assume balanced trade and restrict the number of categories of assets and liabilities to include only loans, deposits, equities and government bonds.

The broad structure of the FALSTAFF⁵ model is as follows. Aggregate demand is composed of household spending, government spending, and the investment expenditure of firms.¹³ The allocation of gross income is split between the depreciation of fixed capital (which is assumed to be retained by firms), the return to labour (the wage bill) and the return to capital (profits, dividends and interest payments).

Households’ propensity to consume is dependent both on income and on financial wealth (Godley and Lavoie 2007). The model also incorporates the possibility of exploring two kinds of exogenous

¹² We have used this subdivision to explore the implications of Piketty’s (2014) hypothesis that inequality increases as the growth rate declines (Jackson and Victor 2015b).

¹³ For simplicity, we assume for the purposes of this paper a balanced trade position in which exports are equal to imports and net trade is zero.

‘shocks’ to household spending. In the first, a random adjustment is made to household spending throughout the run, within a range of plus or minus 2.5% from the predicted value. In the second, a one-off shock either reduces or increases spending by 5% over two consecutive periods early in the run. We use these exogenous shocks to test the stability of the stationary state under our default assumptions.

Household savings may in principle be distributed between government bonds, firms equities, banks equities, bank deposits and loans.¹⁴ Household demand for bonds is assumed here to be equal to the excess supply of bonds from government, once banks’ demands for bonds are met. Household demand for equities is assumed to be equal to the issuance of equities from firms and banks. Thus, households are the sole owners of equity in this model and the return on equities is limited to dividends received, since there are no capital gains in the model.¹⁵ The balance of household savings, once bond and equity purchases have been made, is allocated to paying down loans or building up deposits. If savings are negative, households may also borrow from banks to finance spending.

Firms are assumed to produce goods and services on demand for households, governments and to meet the demand for gross fixed capital investment. Investment decisions are based on a flexible accelerator function (Jorgenson 1963, Godley and Lavoie 2007) in which net investment is assumed to be a fixed proportion of the difference between capital stock in the previous period, and a target capital stock determined by expected demand and an assumed capital-to-output ratio. A proportion of gross profits equal to the depreciation of the capital stock over the previous period is assumed to be retained by firms for investment, with net (additional) investment financed through a mixture of new loans from banks and the issuance of equities to households, according to a desired debt-to-equity ratio.

Government receives income from taxation and purchases goods and services (for the benefit of the public) from the firms sector. Taxation is only levied on households in this version of the model, at a rate which provides for an initially balanced budget under the default values for aggregate demand.

Using these assumptions, Jackson and Victor (2015b) explore three government spending scenarios: one in which government spending remains constant throughout the run, one in which government spending plus bond interest is equal to tax receipts (ie a strict ‘austerity’ policy in which government balances the fiscal budget), and one in which government engages in a ‘countercyclical’ spending

¹⁴ In the full FALSTAFF framework, household savings are allocated between a range of financial assets (and liabilities) including bank deposits, equities, pension funds, government bonds (and mortgage and loans), using an econometrically-estimated portfolio allocation model based on the framework originally proposed by Brainard and Tobin (1968).

¹⁵ This assumption is relaxed in the full FALSTAFF model, in which both equity prices and housing vary according to supply and demand. These assets are therefore subject to capital gains in the full model.

policy, increasing spending when aggregate demand falls and decreasing it when aggregate demand rises. Government bonds are issued to cover deficit spending.

Banks accept deposits and provide loans to households and to firms, as demanded. Bank profits are generated from the interest rate spread between deposits and loans, plus interest paid on any government bonds they hold. Profits are distributed to households as dividends, except for any retained earnings that may be required to meet the capital account 'financing requirement'. This financing requirement is the difference between deposits (inflows into the capital account) and the sum of loans, bond purchases and increases in central bank reserves (outgoings from the capital account). The central bank plays a very simple role in the stationary state version of FALSTAFF, providing liquidity on demand (in the form of central bank reserves) to commercial banks in exchange for government bonds.

FALSTAFF⁵ provides for two regulatory policies that might reasonably be imposed on banks. First, the model can impose a 'capital adequacy' requirement in which banks are required to hold enough 'capital' to cover a given proportion of risky assets. Second, banks may be subject to a central bank 'reserve ratio' in which reserves are held at the central bank up to a given proportion of deposits held on account. Few developed countries retain formal reserve ratios these days, leaving it up to the banks themselves to decide what reserves to hold. However, we have included a default reserve ratio of 5% in order to test Binswanger's hypothesis that such requirements might lead to a growth imperative.

The capital adequacy requirement is supposed to provide resilience in the face of defaulting loans, as required for instance under the Basel III framework (BIS 2011). In fact, we adopt as our starting point the Basel III requirement that banks' 'capital' (the book value of equity in the banks' balance sheet) should be equal to 8% of risk-weighted assets (loans to households and firms). To meet this requirement, banks in FALSTAFF⁵ issue equities to households, which has the effect of shifting deposits to equity on the liability side of the balance sheet and increasing the ratio of capital to loans. To balance the balance sheet, banks purchase government bonds (conventionally deemed risk-free) which together with central bank reserves (also risk-free) provide for a certain proportion of 'safe' capital to balance against risky assets.

The principal aim of the analysis is to identify the potential for a stationary state economy, even in the presence of debt-based money. In fact, it may be noted that the FALSTAFF economy is almost entirely a credit money economy. No physical cash changes hands, and transactions are all deemed to be electronic transactions through the bank accounts of firms, household and government (and through the reserve account of the central bank). For the purposes of testing the role of credit creation in the growth imperative, this simplification is clearly robust. We have also incorporated

conditions on commercial banks appropriate for the testing of the overall hypothesis that interest-bearing debt leads to growth.

The results of the analysis are discussed in detail in Jackson and Victor (2015b) where the authors present a variety of scenarios, the first of these demonstrates clearly the potential for a stationary state: in such a scenario (which was tested under a range of values for the interest rate on deposits, loans and government bonds) there are no changes in any of the real economy aggregates, net lending is zero across all sectors and there are no changes in the stocks of assets and liabilities. Though not particularly representative of an economy in the real world, this solution does however refute the 'growth imperative' hypothesis.

Several sensitivity analyses were then carried out to test the robustness of this finding. First, the authors introduced a random variation in consumer demand to test whether the stationary state was stable. Figures 5 and 6 illustrate the results of this analysis. Although Figure 5 shows considerable variation in the short term growth rate (within a range of less than $\pm 1\%$) it is clear that the long-run growth rate is still around zero. Certainly there is no obvious systematic expansion of the economy, even though the net lending positions of the different sectors (Figure 6) vary considerably over the run. Again, variations in deposit, loan, and bond rates, and in the capital adequacy requirement and the reserve ratio make no appreciable difference to this long-term trend, or indeed to the amplitude of the variations around it.

We could describe the economy illustrated in Figures 5 and 6 as a quasi-stationary-state economy with a long-run average growth rate of zero. Notice that the sum of net lending, remains zero across the run, in spite of the variation in net lending in individual sectors. This is an indication that the model is working consistently, and reflecting correctly the accounting identities that must hold in any real economy. Though the pattern looks rather dramatic, notice that the amplitude of the variations in net lending is not high – less than 0.5% of the GDP in most cases.

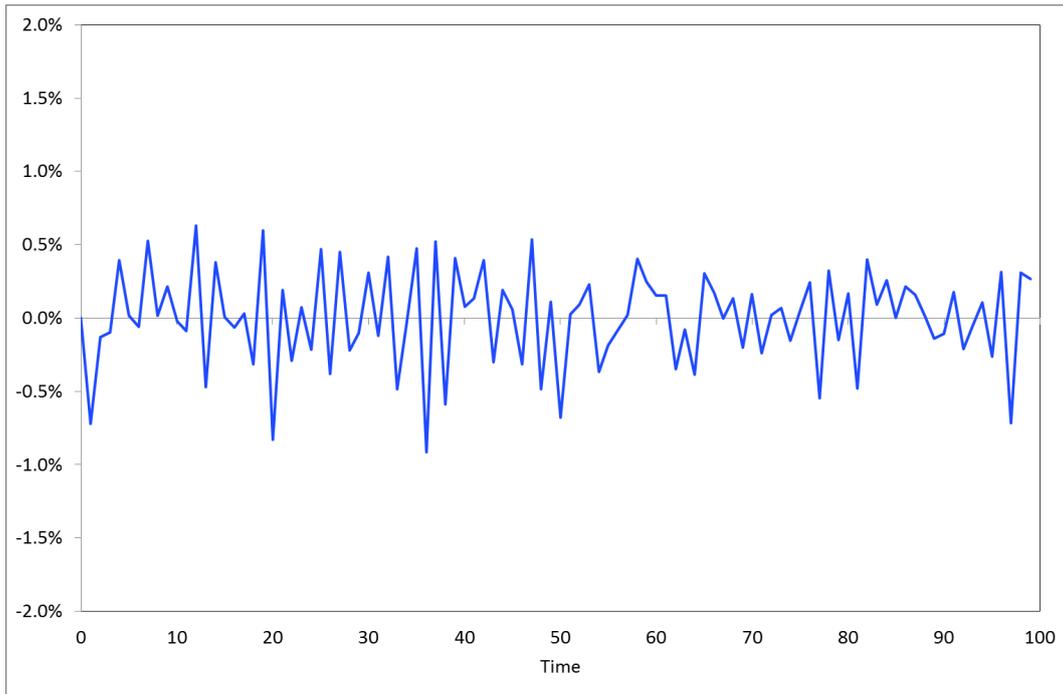


Figure 5: Growth rate under random fluctuations in consumer demand (Scenario 2)

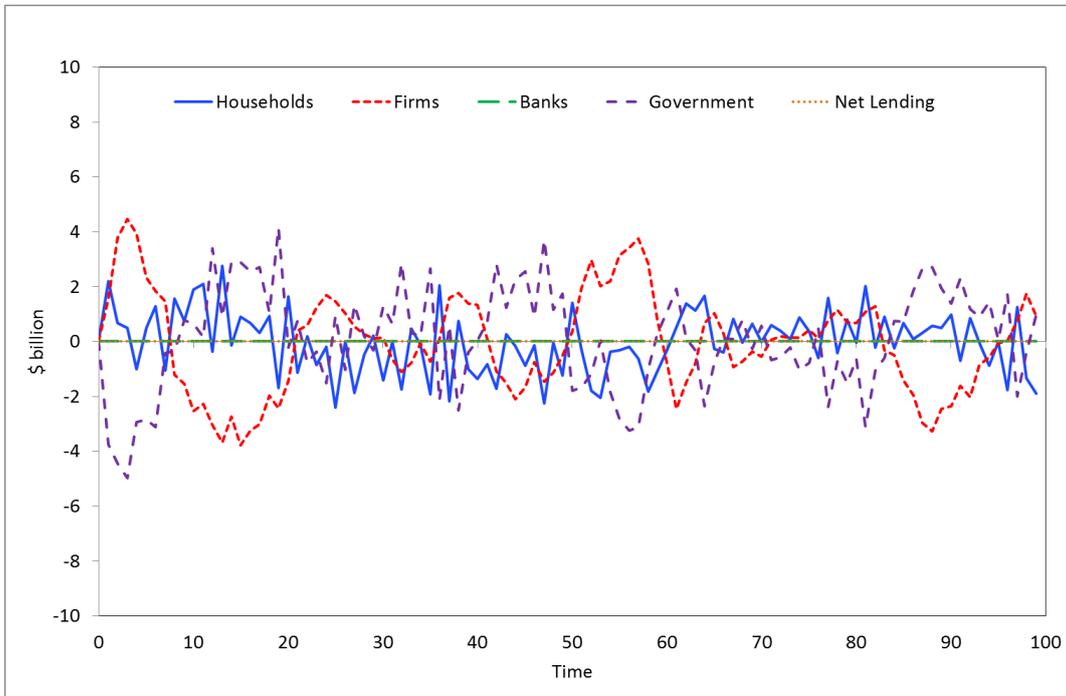


Figure 6: Net lending under random fluctuations in consumer demand (Scenario 2)

Next, the authors tested the stability of the economy following a larger one-off shock to consumer demand. Once again, (Figure 7, Scenario 3), the stationary state was stable, in the sense that the

growth rate returned to zero over the long term, despite initial fluctuations in demand. Jackson and Victor (2015b) also tested two potential kinds of responses in the face of such a consumption shock. The first was the response of government; the second was the response of investors (firms).

In the face of a decline in aggregate demand, governments tend to have lower tax receipts and potentially higher welfare costs, leading to a rising fiscal deficit with potentially higher borrowing costs in the future. It is therefore not unusual for governments to respond to lower aggregate demand by reducing government spending. Austerity policy (as it has come to be called) was one of the principal responses to the financial crisis of 2008/9 by western governments. Paradoxically however, this response can significantly slow down recovery and as Jackson and Victor (2015: Scenario 4) in the extreme case it can lead to a complete collapse in aggregate demand. Keynesians have long argued that the appropriate response of government in the face of declining aggregate demand is to increase government spending. FALSTAFF^S can be used to model the implications of this kind of 'counter-cyclical' spending.

A similar choice faces investors. When expected output falls, the tendency is to reduce investment, this reduction in investment depresses output further. However, it also acts to increase the rate of return on capital and hence to improve profitability. Conversely, when expected output rises, there is a tendency to overinvest and this reduces the return on capital and the profitability of firms. The outcome of these combined processes is a business cycle, in which investment (and output) typically follow a pattern of waves whose amplitude depends on the strength of the response (the animal spirits) of investors to expected changes in final demand. FALSTAFF^S can simulate a change in animal spirits – the strength of the investor response to changes in expected demand – and hence explore the implications of different behaviour responses to a one-off shock.

Figure 7 shows three scenarios taken from Jackson and Victor (2015b). Scenario 3 illustrates changes in the growth rate following a one-off shock with default government response (no change in spending) and default investor response (no amplification of the accelerator coefficient in the investment function). Scenario 5 shows how the amplitude of the after-shocks increases when there is an increase in animal spirits from investors. In fact, this scenario becomes unstable in the long run. Scenario 6 shows how these fluctuations can be tamed by a countercyclical spending strategy in which government spending is increased when demand growth falls below zero and decreases when demand growth rises above zero. Scenario 4 (not shown here) is the collapse scenario, in which government imposes strict austerity.

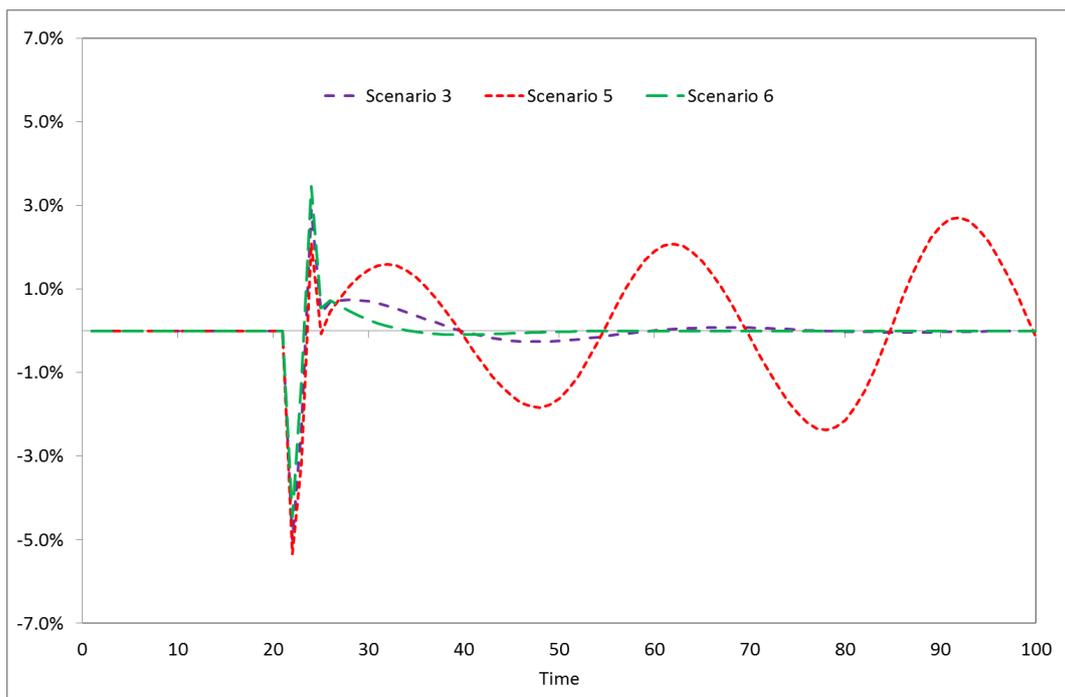


Figure 7: The stabilising influence of countercyclical spending after a demand shock with increased ‘animal spirits’

In summary, Jackson and Victor (2015b) had developed a variety of scenarios which exemplify quasi-stationary states of various kinds, and which offered resilience from instability in the face of random fluctuations, demand shocks, and exaggerated ‘animal spirits’. None of the scenarios were sensitive to modest changes in the values for interest rates on deposits, loans and government bonds.¹⁶

Perhaps most significantly, these conclusions are not changed by imposing demands on banks to maintain a given capital adequacy ratio or to hold a given ratio of central bank reserves to bank deposits. The only scenario in which instability led to economic collapse was the one in which we imposed a ‘strict’ austerity policy in response to a negative shock to consumer demand. In this case, it was the austerity policy, rather than the existence of debt, that crashed the model.

It is worth pointing out that, in spite of the findings here, there are a number of good arguments against private interest-bearing debt as the main means of creation (and destruction) of the money supply. As a wide variety of authors have pointed out,¹⁷ this form of money can lead to

¹⁶ A sensitivity analysis was conducted in FALSTAFF for values of the interest rate on loans between 0 and 15%, and on bonds and deposits between 0 and 10%. Slight increases in the amplitude of oscillations was observed at higher interest rates, under conditions of shock. But the conclusions observed in this paper still held.

¹⁷ Useful critiques of debt-based money can be found in Sigurjónsson 2015, Daly 2014, Wolf 2014, Farley et al 2013, Jackson and Dyson 2012, Huber and Robertson 2000, as well as the ground-breaking, early work from Douthwaite (1990). The idea of eliminating banks’ ability to create money can be traced to Frederick Soddy (1931); for a useful historical overview see Dittmer 2015.

unsustainable levels of public and private debt, increased price and fiscal instability, speculative behaviour in relation to environmental resources, greater inequality in incomes and in wealth, and a loss of sovereign control of the money system. We are therefore firmly of the opinion that monetary reform is an essential component of a sustainable economy. We regard the current study as an important way of distinguishing where effort should be placed in transforming this system. Specifically, the results in this paper suggest that it is not necessary to eliminate interest-bearing debt *per se*, if the goal is to achieve a resilient, stationary or quasi-stationary state of the economy.

It is also worth reiterating that, aside from the question of interest-bearing money, there exists a number of other incentives towards growth within the architecture of the capitalist economy. We have elucidated some of these incentives elsewhere (Jackson 2009, Victor 2008, Jackson and Victor 2011). They must be taken to include, for instance: profit maximisation (and in particular the pursuit of labour productivity growth) by firms, asset price speculation and consumer aspirations for increased income and wealth. Some of these mechanisms also lead to potential instabilities in the capitalist economy. Many of them are reliant on the existence of credit-based money systems. Minsky (1994), perhaps most famously, has shown how cycles of investment and speculation, built around debt-based money, can lead to endemic instability. But this logic does not entail that interest-bearing money, in and of itself, creates a growth imperative.

6 FALSTAFF Part 2: Green Investment and Portfolio Allocation

In addition to the work described in Section 5, the FALSTAFF framework has been used to illustrate the importance of assessing both real and financial aspects of the transition to a low-carbon economy. Illustrative results from an expanded version of the model were presented at a workshop convened by the UNEP Finance Initiative in Waterloo, Canada in December 2014 (Jackson and Victor 2015c). The Waterloo version of FALSTAFF – denoted here as FALSTAFF^W for ease of reference - included several additions and variations to the model described in the previous section. These comprised: an econometrically estimated investment function, an econometrically estimated portfolio allocation model to describe households savings behaviour, an additional sector to account for trade (and capital transactions) with the rest of the world, and an expanded balance sheet including debt, equity, bonds, housing, mortgages, loans and pension funds.

In this section we provide an overview of the structure of the expanded FALSTAFF^W model and present some of the illustrative results presented at the Waterloo meeting.

Households make three kinds of decisions in FALSTAFF^W. First they decide how much to spend and how much to save. Second, they decide how much to invest in fixed capital assets (housing). Finally they decide how to allocate savings/borrowing to different asset classes. In relation to the first decision, the model allows the user to choose between a simple savings ratio based on a proportion of disposable income, or a more sophisticated consumption function of the form favoured by post-Keynesian SFC theorists, in which household consumption C is given by a function of the form:

$$C = \alpha_1 Y_{disp} + \alpha_2 NW_h \quad 5)$$

where Y_{disp} is the disposable income of households and NW_h is their net worth. This form of consumption function thus incorporates both propensities to consume from disposable income and also propensities to consume from household wealth (as does the model in Section 5). In the long run this dependency of consumption on household wealth provides a link between behaviour in the real economy and the health of the financial economy (Godley and Lavoie, 2007), although it should be noted that these feedbacks are much slower than those provided via stock-market signals on consumer confidence, for instance. Values for α_1 and α_2 were estimated using quarterly national accounts data between 1991 and 2013, published by for Canada by Statistics Canada and for the UK by the Office for National Statistics.¹⁸

¹⁸ The StatCan database (<http://www5.statcan.gc.ca/cansim/>) is one of the most user-friendly national accounts databases of any country in the world and one of the reasons we decided to calibrate FALSTAFF first against Canadian data.

Housing investment in FALSTAFF^W is driven partly by population growth,¹⁹ and partly by an exogenously defined housing growth parameter to reflect changes in household size and composition. The price of housing is determined by the balance between supply of housing (investment) and the desire for housing, which flows from households savings decision. These savings decisions are a key element in the establishment of SFC monetary flows and are modelled in FALSTAFF^W using an econometrically estimated Portfolio Allocation Module based on a framework originally developed by Brainard and Tobin (1968) – part of the work for which Tobin later received a Nobel prize. The approach was later adopted (and adapted) by Godley and Lavoie (2007) as a key element within a post-Keynesian SFC approach.

The broad thrust of the approach is to suppose that the desired holdings of a particular asset depend both on the rate of return on that asset and also on the rates of return (or interest rates) on other assets (or liabilities). So for example, if the rate of return on equities rises (or is expected to rise), households tend to allocate more of their savings to equities than, say, government bonds. Conversely if the return on equity falls (or is expected to fall), households would tend to sell equities in favour of some other asset. There are several distinct ways of representing this kind of allocation process. For example, one can proceed (see Godley and Lavoie, 2007) by determining for each asset A_i a target proportion of household net worth, a_i^T , occupied by that asset, given by:

$$a_i^T = \lambda_{0i} + \sum_j \lambda_{ij} r_j + \lambda_{iY_d} \frac{Y_d}{NW} \quad 6)$$

where the r_j are the rates of return (or interest) on the various assets (or liabilities) and the λ_{ij} are constant coefficients, to be derived from a (constrained) econometric analysis of past trends.²⁰ In this version of FALSTAFF, we estimate these target proportions using data for seven distinct asset/liability classes: deposits, bonds, equities, housing wealth, mortgages, loans and pensions.

When we estimated these relationships using the econometric software Eviews and quarterly financial accounts data for Canada and the UK from 1991 to 2013, we found a high degree of dependency on $a_i^T(-1)$, the first lag of a_i^T . In other words, it seems as though households' portfolio allocations are relatively "sticky" on aggregate. To improve the estimation we made two changes to equation 6). The first was to use Y_d directly rather than the ratio Y_d/NW as a dependent variable on the right hand side of the equation. The second was to include the lagged variable $a_i(-1)$ – the actual value of asset A_i as a proportion of net worth in the previous period – as an additional

¹⁹ We assume an exogenously variable 0.5% annual growth rate for population.

²⁰ In order for this procedure to work correctly, it should be noted that liabilities (mortgages and loans) must be counted in a negative sense within the framework.

dependent variable on the right hand side of the equation.²¹ The econometric estimation of the target proportion for each asset and liability in FALSTAFF^W is therefore given by:

$$a_i^T = \lambda_{0i} + \sum_j \lambda_{ij} r_j + \lambda_{iY_d} Y_d + \lambda_{iA_i} a_i(-1) \quad 7)$$

The model in this form was reasonably successful in replicating historical trends in the holdings of different asset types. Figure 8 illustrates for example the estimated and actual holdings of equities by households in Canada between 1991 and 2013. In particular it is to be noted that the model successfully predicts both the impact of the financial crisis on equity holdings and also the subsequent recovery as well as the results of the earlier dot.com bubble and subsequent market fall. This is an important validation of the model’s ability to reflect financial stability and instability – a core goal of our approach.

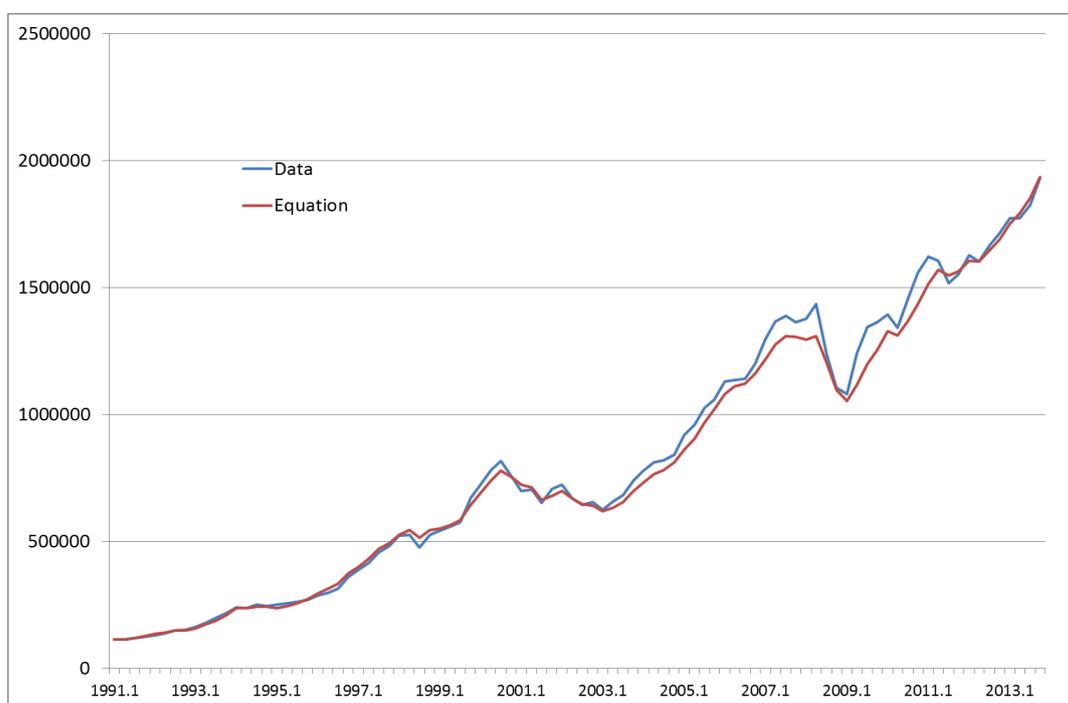


Figure 8: Estimated and actual holdings of equities by Canadian households, 1991-2013

Source: output from the Portfolio Allocation Module in FALSTAFF^W.

The *firms sector* in FALSTAFF^W simulates the production of all goods and services in the economy, including those accounted for by public spending.²² Nominal demand in the economy represents firms’ income. The labour employment *LE* required to meet this demand is calculated using a time-

²¹ This is similar but a little less constrained than estimating the differenced variable Δa_i^T on the left hand side of 6).

²² Though something of a simplification of the structure of a real economy, this is also the way in which public spending is accounted for in the national accounts.

varying labour productivity function LP which varies over time according to an econometrically estimated real labour productivity growth rate, lpg according to:

$$LP = LP_0(1 + lpg)^{t-2012} \quad 8a)$$

$$LE = \frac{GDP_{nom}}{p \cdot LP} \quad 8b)$$

where p is price and GDP_{nom} is the nominal demand. It should be clear that nominal demand cannot always be met by domestic production, particularly given that labour is constrained by the available labour force which therefore determines a supply constraint on the domestic economy.

Firms' costs include taxes on production and on products (determined in the government sector), interest payments on loans, and wages. The wage bill is calculated via a time-varying wage rate WR which also determines price in the model. Two factors are deemed to change the wage rate in the model. Initially we assume that labour productivity improvements are passed on to workers, so that the unadjusted wage rate WR is given by:

$$WR = WR_0(1 + lpg)^{t-2012} \quad 9)$$

An inflation adjusted wage rate WR' is then estimated by using a simplified Phillips curve that inflates the wage rate when unemployment is low and deflates it when unemployment is high.²³ The price of domestically produced goods in the model is determined by the ratio of the inflation adjusted wage rate WR' to the unadjusted wage rate WR .

Firms have to make three other kinds of decisions in FALSTAFF^W: how much of their net profits F to distribute as dividends; how much to invest in production; and how to finance this investment. The dividend distribution F_D can be decided either via an exogenously determined "retained earnings ratio" or else through an equation of the form:

$$F_D = F_D(-1) + \eta F(-1) \quad 10)$$

where $F(-1)$ denotes profits in the previous period (i.e. the first lag of profits) and η is an econometrically estimated coefficient.

The investment decision is determined in two parts. One of our intentions in the model is to be able to understand the implications of green investment on the performance of the economy. We therefore separate firms' investment into a conventional component, predicted econometrically in

²³ *Our Phillips curve is similar to the one used by Keen (2011) with a flat section around normal employment rates, a rising adjustment for low unemployment, a declining (but flatter) line for medium unemployment and a flat downwards adjustment of the wage for high unemployment.*

the model and a green component which is determined exogenously. For the conventional component, we use an investment function proposed by Lavoie and Godley (2001). Firms' investment I is estimated with a capital accumulation rate g which is deemed to be dependent on the rate of cash flow r_{cf} (calculated from the ratio of retained earnings to capital), the rate of interest r_{lf} on firms loans (moderated by a leverage ratio, l), Tobin's q ratio²⁴ and the rate r_{CU} of capacity utilisation:

$$g = \gamma_1 r_{cf} + \gamma_2 r_{lf} l + \gamma_3 q + \gamma_4 r_{CU} \quad 11)$$

Broadly speaking, this function means that conventional investment is expected to increase with increasing cash flow, to decline with increasing interest rates, to rise as Tobin's q rises (because the value of equity is high in relation to capital), and to increase with the capacity utilisation rate. This last factor reflects the impact of rising demand on investment. As demand rises, spare capacity diminishes, encouraging new investment. Conventional investment is then given by:

$$I = gK_f(-1) \quad 11)$$

Where $K_f(-1)$ is the lag of firms' productive capital stock K_f .

Although the investment in productive capital stock is endogenous in FALSTAFF^w, green investment is determined exogenously. It is assumed first that over the course of the run, a rising proportion of GDP (starting from zero) will be allocated to green investment. The user decides on the final target proportion and also selects the sectors in which this investment is made (firms, housing, government). The model then calculates the green investment in each sector over each year of the run assuming the same proportions of green investment in each sector as predicted for conventional investment. The impact on the economy of this green investment depends on two further parameters. The first is the extent to which it is deemed to be additional to or simply to substitute for predicted investment. The second is the extent to which both additional and nonadditional green investments are productive – in the sense that they add to the productive stock of the economy.²⁵ Both of these parameters can be selected by the user. The default position assumes that green investments will be non-additional, so that there will be a gradual shift away from “brown investment” towards green investment within the same investment architecture predicted by the model. It should be noted that productive additional investment adds to the productive capacity of the economy, whereas non-productive, non-additional investments subtract from the productive capacity of the economy. Non-productive, additional investments add to nominal demand in the

²⁴ *Tobin's q (first proposed by Nobel Laureate James Tobin) is a parameter that measures the ratio of the value of equity to the value of the capital stock.*

²⁵ *We use the term “productive” here in the rather conventional sense that an increase in the productive capital stock increases the immediate capacity of the economy to produce goods and services. Clearly, this does not always coincide with the long-term sustainability of that production, which might be better protected by the so-called “non-productive” investments designed to protect environmental resources.*

economy, but do not change the productive capital stock. The model accounts separately for non-productive capital stocks.

The financial and monetary importance of this distinction concerns the supply constraints on domestic production of goods and services. Just as supply is sometimes constrained by available labour, it may also be constrained by available capital. We assume here a constant capital output ratio (calibrated against historical data) to determine a further limit on maximum real (and hence nominal) demand supplied by the domestic economy. The overall limit on GDP is then the minimum of the maxima determined through labour and through capital constraints. Once supply constraints are reached, additional nominal demand created by the exogenous investment strategy can only be met in two ways: first by increasing imported final demand from the overseas sector; or in the absence of this possibility by an increase in prices. Both avenues would tend to depress real GDP growth.

The final decision to be made by firms is how to finance the overall investment needs (including both conventional and green investments). In FALSTAFF, firms investments can be funded through retained earnings (profits minus dividends), through issuing new equities and through taking out new bank loans. Once firms' retained earnings are exhausted we assume that additional financing needs are met through a mixture of loans and equities according to an exogenously variable debt to equity ratio, which is moderated to some (variable) degree by the rate of interest on firms' loans.²⁶

The *banks sector* in FALSTAFF is a simplified accounting sector with two main functions. Its profit and loss account simply collates the interest payments on loans (including household mortgages) and pays out the interest due on deposits. Gross profits are the difference between these two.²⁷ Banks pay taxes to the government on these earnings and net profits are divided between retained earnings and dividends. Banks' dividends are calculated as a residual. Retained earnings decisions depend on the financing requirements of banks, which are in their turn depend on what is happening in the capital account. This is the second function allocated to banks in FALSTAFF and relates to the provision of capital facilities (deposits and loans) for other sectors.

There are two main capital account decisions to be made by banks. The first is how much money to hold as reserves with the central bank. For the purposes of this version of the model, this is allocated through an exogenously variable reserve ratio, with a default value in which reserves constitute 1% of deposits held with the bank. The second decision involves banks capital adequacy requirements.

²⁶ *Currently this moderation of the debt to equity ratio is determined by a small exogenously set adjustment to the debt to equity preference. In future developments we will look for ways to endogenize the debt to equity ratio further to depend on market conditions.*

²⁷ *We do not, for instance, include banks wages in the banking sector. They are assumed to be accounted for via the firms sector.*

Basel III requires banks to hold a minimum of 8% of their risk-adjusted capital in the form of risk-free capital. We interpret this requirement to mean that the sum of banks reserves plus their holdings of sovereign bonds must be 8% of their total private sector lending.²⁸ This capital adequacy requirement then determines banks need for government bonds, and also (in conjunction with the changes in deposits and lending) determines their need for retained earnings. Specifically, the transaction matrix reveals that banks' undistributed profits FU_f are given by:

$$FU_f = \Delta D + \Delta P - \Delta L - \Delta M - \Delta R - \Delta B \quad 12)$$

Where D represents deposits, P is pensions, L is loans to households and firms, M is mortgages against property purchases, R is central bank reserves and B is government bonds. In the event that this funding requirement exceeds total net profits, banks can also meet their funding requirement by taking out loans (advances) from the central bank.

The *government sector* in FALSTAFF^W allows for a variety of government spending strategies and sets the tax rates on household income, firms' income and (indirectly) on products. Spending decisions by the government can be determined in three separate Modes in the model. In Mode 1, a simple exogenously varied growth rate is applied to both consumption spending and investment spending. The default value in the base run (described in more detail in the next section) is 2% per annum. In Mode 2, the government can operate a balanced budget policy in which spending is strictly constrained by tax receipts. Finally, in Mode 3, it can operate a counter-cyclical adjustment to the exogenous growth rate in which government spending rises (by up to 20%) if unemployment is high and falls (by up to the same amount) when unemployment is low. In each of these modes, it is also assumed that governments will tend to reduce deficits (or surpluses) through adjustments to both spending and the tax rates, when the debt to GDP ratio rises above (or falls below) certain levels.

Government borrowing is funded through the issuance of bonds which are conceptualised in FALSTAFF^W as simple loans with an endogenously varying interest rate. Three other sectors create an endogenous demand for loans. Households purchase bonds in response to their asset allocation preferences (equation 4) above). Banks hold bonds in order to meet their capital adequacy requirements. Central banks hold bonds (see below) in exchange for liquidity provided to commercial banks in the form of reserves. The gap between the supply of bonds (government borrowing) and the demand for bonds is assumed to be met by bond purchases/sales from the foreign sector.²⁹

²⁸ *Sovereign bonds are typically rated at zero risk. The historical data support a close to 8% capital adequacy ratio in Canada. This rate can be varied in the model.*

²⁹ *A more sophisticated endogenization of the price of bonds through capital gains/losses (ie changes in bond yields) is under development.*

The *central bank* sets interest rates in FALSTAFF^W, by lowering the base rate³⁰ when unemployment is high and raising it when unemployment is low. Rates on other assets or liabilities (deposits, household loans, mortgages on property, firms' loans, central bank advances and reserves) are set by historically calibrated interest rate spreads around the base rate.³¹ Aside from this monetary policy function, the central bank's only other interactions are with the commercial bank sector, providing additional liquidity for the commercial banks by exchanging government bonds for central bank reserves and providing a lender of last resort function through advances when required.

In contrast to the closed economies described in Sections 4 and 5, FALSTAFF^W introduces a foreign sector to account for the balance of trade between the domestic economy and the rest of the world. The import sector can be configured in two different ways. In the "balanced trade" mode the economy is assumed to aim in the short term for a balanced trade position in which imports are more or less equal to exports. In the second mode, the trade position can float, allowing the overseas sector to supply the balance between nominal domestic demand and the (capital and labour constrained) capacity of the domestic economy. This supply balance includes provision for a given target unemployment rate. Once unemployment in the domestic economy meets this target, it is assumed that additional supply capacity is provided by the overseas sector. This device is somewhat simplistic but serves for the moment both to maintain the supply demand balance in the model and also to stabilise the unemployment rate.

Aside from the nominal net import balance, the current account of the foreign sector includes only interest receipts (from bonds and deposits) and interest payments (for loans). The net lending of the overseas sector is then allocated in two separate ways, through bonds purchased from or sold back to the domestic economy government, and loans taken out from or deposits paid into domestic economy banks. Bond purchases are assumed to take up the slack between the domestic demand for bonds and the borrowing requirement of the domestic government. The remaining transactions (in either loans or deposits) are determined by the accounting requirement of the transaction flows matrix. In other words, any bond purchases must be paid for either from the net lending of the foreign current account sector or from loans taking out from domestic sector banks.

Finally, FALSTAFF^W incorporates an *environmental burden* sector which uses simple intensity coefficients and reduction targets to model the impact of exogenously determined investment strategies. Green investment (see above) acts to reduce the environmental burden index (EBI) which measures the overall environmental burden of the economy. The EBI was loosely calibrated to respond to the investment needs associated with meeting aggressive domestic greenhouse gas reduction targets.

³⁰ *The rate at which commercial banks can borrow from the central bank.*

³¹ *It is also possible to "turn off" the endogenously calculated interest rates in FALSTAFF. In this mode, the model simply uses the historical base year data.*

The broad aim of the FALSTAFF^W was to illustrate the need to integrate financial and monetary understanding into any exploration of the potential for green or sustainable investment. Financing the transition to a low carbon economy, for instance, cannot simply be a question of quantifying an investment need and then assuming that this quantum has no appreciable impact on financial or monetary stability. A core element within the work was therefore to demonstrate the capability of SFC modelling to inform questions about the structure (and long-term viability) of sustainable investment. Three, highly illustrative scenarios were discussed at the Waterloo meeting.

- A “Base Run” scenario assumed growth in government spending at a rate approximately equal to the desired growth rate, a liberal position in relation to overseas trade which did not seek to constrain the balance of payments, and investment driven only by the econometric investment function, with no specific role for green investment;
- A “Balanced Trade” scenario assumed the same parameters as the BAU usual scenario but sought in addition to achieve a position in which exports and imports were balanced;
- A “Green Transformation” scenario sought to explore the implications of very substantial increases in green investment over the lifetime of the scenario while allowing for a balanced trade position to be achieved; in support of these aims the Green Transformation scenario allowed for a policy of countercyclical spending by the government; and a shift to services, characterised as decline in labour productivity growth over the run.

Not surprisingly, since it is the only scenario with substantive green investment, only the Green Transformation showed a decline in the Environmental Burden Index (Figure 18 in Jackson and Victor 2015c). More interesting were a variety of indications in relation to monetary and financial aspects of the economy from the three scenarios. Amongst a number of tentative findings were the following:

- Although the Base Run achieved a consistent growth path over the scenario period, it did so at the expense of several undesirable features of the financial economy, including: a rising debt to GDP ratio; an increasing fragile position in relation to the household sector balance sheet, including the near collapse of pension provisions by the end of the run and an extended asset bubble in the housing market, with highly leveraged positions in the mortgage market; and a rising balance of payments deficit over the later years of the scenario (cf Figures 4-8 in Jackson and Victor 2015c);
- Under the Balanced Trade scenario several of these undesirable features were substantially improved: the balance of payments problem (not surprisingly) practically disappeared, the collapse in pensions was stabilised, and the housing bubble and overleveraging of the household sector was greatly reduced;

- Conversely, these gains were achieved at the cost of considerably lower growth, higher unemployment, and an increased debt to GDP ratio;
- The Green Transformation scenario was the only scenario which delivered a substantial reduction in the EBI (Figure 9); it also ultimately reduced unemployment below the levels in the Base Run; but these gains were achieved at the cost of rising inflation and a decline in the real growth rate to zero by the end of the run; though the debt to GDP ratio was also high in this scenario, the real debt servicing costs declined below the base run by the end of the scenario as a result of higher inflation;
- The flexibility of the government to engage in countercyclical spending plays an important role in stabilising the decline in the growth rate; attempts to impose 'austerity' when real growth declines lead to potential collapse states.

These findings are subject to a number of caveats and limitations, not the least of which is the beta status of the underlying model and the particular assumptions made about behaviour within different financial sectors. For instance, there is no 'realistic' model of dynamic market responses, such as the response of financial markets to the degree of leverage of the household sector. Consequently, the financial and political fragility of each scenario can only really be assessed by inspection of the underlying balance sheets. In reality, such fragility would likely create financial instability long before the model revealed problems in the macroeconomic aggregates.

Nonetheless, the work reported in Jackson and Victor 2015c has several important merits. First of all, it highlights the importance of incorporating financial and monetary analysis into a macroeconomic model of green investment. Secondly, it illustrates the feasibility of achieving a stock-flow consistent description of the macroeconomy, with a consistent set of transaction flow matrices and financial balances across each sector and the economy as a whole. Finally, it illustrates the kinds of trade-offs that might be anticipated, when a substantial proportion of national income is redirected towards a different form of investment. In the particular circumstances explored here, FALSTAFF^w has revealed potentially inflationary effects from a large-scale transition to green investment while still maintaining full employment.

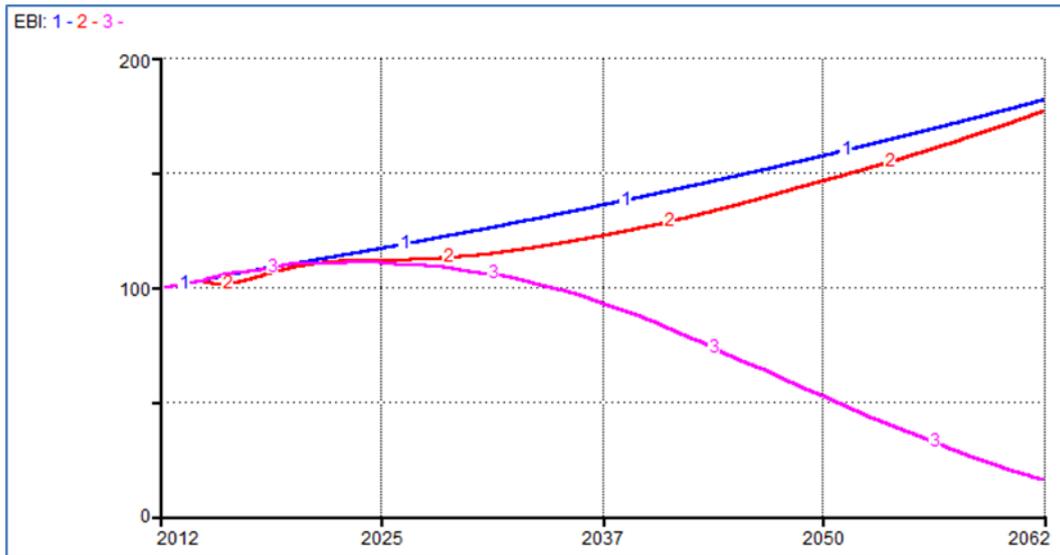


Figure 9: Illustrative trends in 'Environmental Burden Index'
1 = Base run; 2 = Balanced Trade; 3 = Green Transformation
 Source: Jackson and Victor 2015c (Fig 18)

7 ECOGRO: An integrated approach to growth, inequality and the environment

The previous sections have described three separate applications of SFC modelling carried out at the University of Surrey in collaboration with York University in Canada. A parallel development, broadly using the same post-Keynesian SFC framework, was carried out at the University of Vienna. The ECOGRO model is a multi-sector macro model in a stock-flow consistent (SFC) demand driven framework. There are a number of differences between the ECOGRO model and the SIGMA and FALSTAFF models developed in Surrey.

In the first place, SIGMA and FALSTAFF are both calibrated at the level of the national economy; ECOGRO is calibrated for the EU as a whole. Secondly, ECOGRO separates out the energy sector from within the firms sector in order to explore the implications of changing the energy mix. Thirdly, ECOGRO explores the impact of including an environmental damage function on the output of the economy. Finally, the financial structure of ECOGRO is somewhat simplified by comparison with SIGMA and FALSTAFF with a slightly less complex balance sheet and fewer specific representations of financial behaviour.³²

Figure 10 below summarises the overall structure of the ECOGRO model which consists of a five-sector real economy comprising households, firms, banks, central bank and government and an additional 'environment' sector which provides resource inputs and receives environmental emissions. This innovation allows ECOGRO to integrate supply side environmental constraints (Kroenenberg 2010; Fontana and Sawyer 2013) to deal with production led emissions in the EU.

The firms sector in ECOGRO is taken as a macro institution that produces both capital and consumption goods demanded within the economy. The production process requires three key inputs – labor, capital and energy. While labor is provided by households and capital stock formation is supported through loans from banks, energy is produced by the sector itself. Total energy supply is determined by total expected output which is given as a mix of non-renewable and renewable energy. This creates a vertical linkage across two producer types within a sector creating a supply-chain that allows for inter-sectoral feed backs through demand and price changes.

As indicated above, the household sector is divided between capitalists (who in ECOGRO are the sole owners of both production sector and banks) and workers (who supply labour to firms and earn wages from them). The household sector as a whole earns income either through firms' profits or through wages. Household income is used for consumption which in turn generates demand and

³² The work in this section is described in more detail in a WWWforEurope working paper available online: http://www.foreurope.eu/fileadmin/documents/pdf/PolicyPapers/WWWforEurope_Policy_Paper_018.pdf.

subsequently production decisions. This in turn determines employment levels of worker households.

The banking sector in ECOGRO is modeled as simple intermediary between the households and the firm sector. Banks hold household deposits and give out loans to firms. If deposits are insufficient to meet loan demand, the banks can take cash advances from the central bank. Profits earned by the banks are redistributed directly to capitalist households.

The government plays the role of maintaining public investment and supporting unemployed. In order to finance this expenditure, the government raises revenue through taxes on both the firms and the households. If expenditures exceed revenues, the government issues bonds which are purchased by the central bank.³³

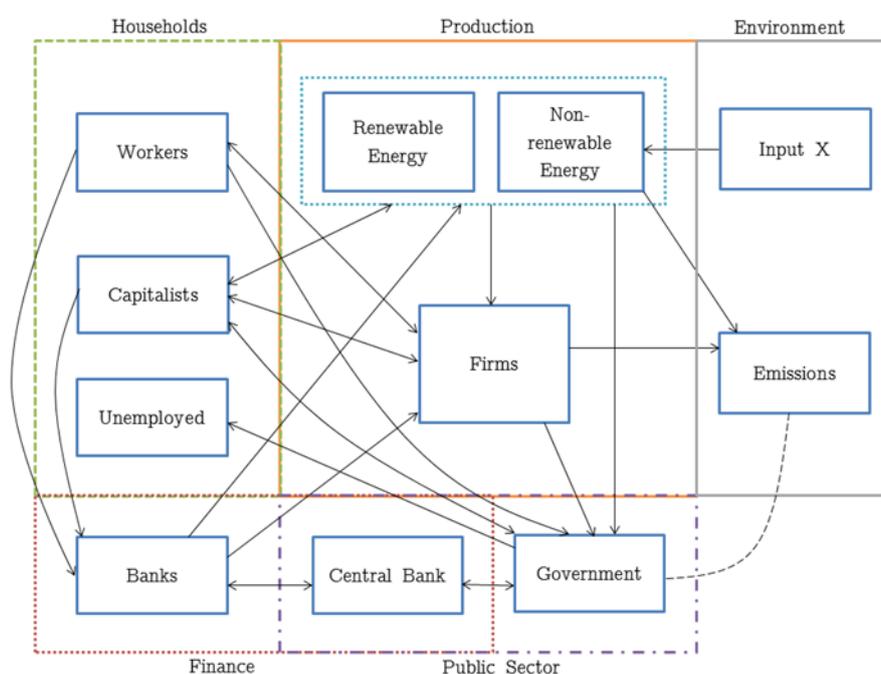


Figure 10: Overall structure of the ECOGRO model

Central Bank: The central bank functions as the financial arm of the government where it controls money supply and buys and sells government bonds as required. Like the Banks sector, the Central Bank is model as a passive agent which allows for monetary transfers between the private and the public sectors of the economy.

³³ This structural simplification is in fact prevented by the Maastricht Treaty which allows central banks only to hold bonds purchased on the secondary market. But for the purposes of the scenario exploration in ECOGRO this is not decisive.

These five sectors interact with each other to form the real side of the ECOGRO economy in a closed demand-driven framework. Table 3 shows the balance sheet of the economy in terms of assets and liabilities and subsequently the net worth of the economy.

	Households		Production		Financial		Govt.	Σ
	Workers	Capitalists	Firms	Energy	Banks	Central Bank		
Capital stock			+ K	+ K ^x				+ K
Inventories			+ IN	+ IN ^x				+ INV
Bank Deposits	+ D ^h	+ D ^k			- D ^b			0
Advances					+ A ^b	- A		0
Bills						+ B ^{CB}	- B	0
Loans			- L ^f	- L ^x	+ L			0
Σ	+ V ^h	+ V ^k	+ V ^f	+ V ^x	0	0	- V ^G	+ NV

Table 3: Ecogro Balance Sheet

Households' net worth is defined in terms of deposits while firms value is determined by capital stock and inventories minus loans. The government sector is assumed to have a negative net worth, while the banking sector and the central bank have a net worth of zero with perfectly balanced assets and liabilities.

To integrate the real economy with physical material flows, a sixth agent, the environment, is added to the model. The environment is modeled as an independent sector that interacts with the economy through two different channels. First, it provides a non-renewable raw material for energy production. Second, it accumulates Greenhouse Gasses (GHGs) through the production process. This interaction between the real and the environmental sector allows for studying issues of growth, distributions and climate change in a well-integrated single economic framework. For example, higher consumption levels result in a higher use of resources for output production. This in turn increases both demand for labor and energy which can have secondary multiplier impacts on the economy. Without fully understanding how these changes feedback and stabilize across the whole economic system, it is hard to justify the role of economic policy in the long-run. Another advantage of this framework lies in addressing the distributional impact of different policies especially on inter-household income and consumption distributions. While certain policies might not result in a change in aggregate demand, they might have a non-trivial impact the worker and capitalist income and consumption distributions.

Five policy scenarios have been evaluated so far in ECOGRO (Naqvi 2015);

- **LowCons:** Reduction in consumption levels to reduce emission levels following the „limits-to-growth“ hypothesis (Jackson 2009).
- **DmgFunc:** Damage to capital stock is proportional to the level of emissions and thus requires higher investment levels to maintain production capacity (Nordhaus 2011, Rezai and Taylor 2012, Taylor and Foley 2014). Capital stock depreciation rate is endogenized to the level of emissions.
- **HiRenew:** High share of more expensive renewable energy in the economy to reduce emissions (Tahvonen and Salo 2001). Renewable energy is assumed to be more capital intensive and more expensive than non-renewable energy. Thus in order to shift to a higher renewable energy sector, significant investment decisions need to be made to allow for a low carbon transition. This experiment looks at the indirect consequences of this transition process.
- **Carbon taxes (TaxF, TaxH):** Firms and households pay carbon taxes which are endogenously related to the level of emissions (Marron and Toder 2014). A carbon tax is usually proposed as an instrument to curb emissions. The debate is divided on whether it should be on firms (creator of jobs) or households (consumers of output). This experiment looks at the implications of both taxes across the economy.
- **Technological innovation; (InnoK, InnoE):** On the one hand, technological innovation has resulted in relative decoupling across high income countries (Jackson 2009). On the other hand, innovation implies low production costs, which can result in higher consumption levels. In order to assess the impact of this “rebound effect”, the model looks at two exogenous technological parameters; technological improvement in capital required per unit of output and energy required per unit of output (Herring and Roy 2007).

A number of model output variables are measured against a Business-as-Usual (BAU) benchmark across the seven scenarios defined above. These variables include: real output; unemployment; inequality (ratio of capitalist to worker incomes); and environmental sustainability (greenhouse gas emissions) and compared with a Business-as-Usual (BAU) benchmark scenario. Figures 11-14 show the simulation results for these four key indicators.

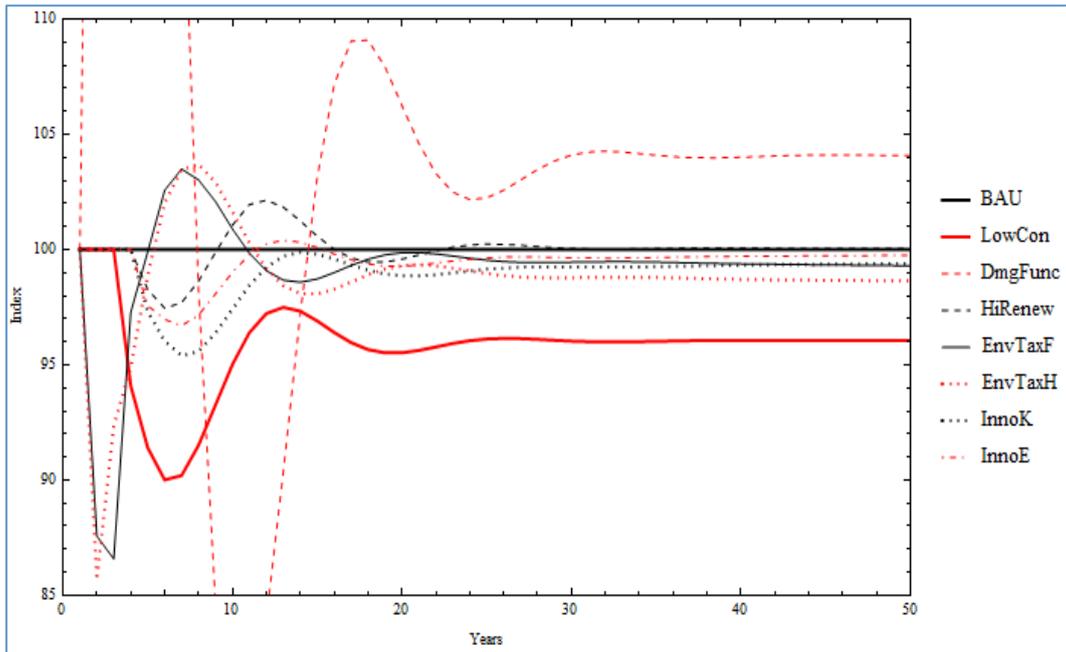


Figure 11: Real output relative to BAU Scenario

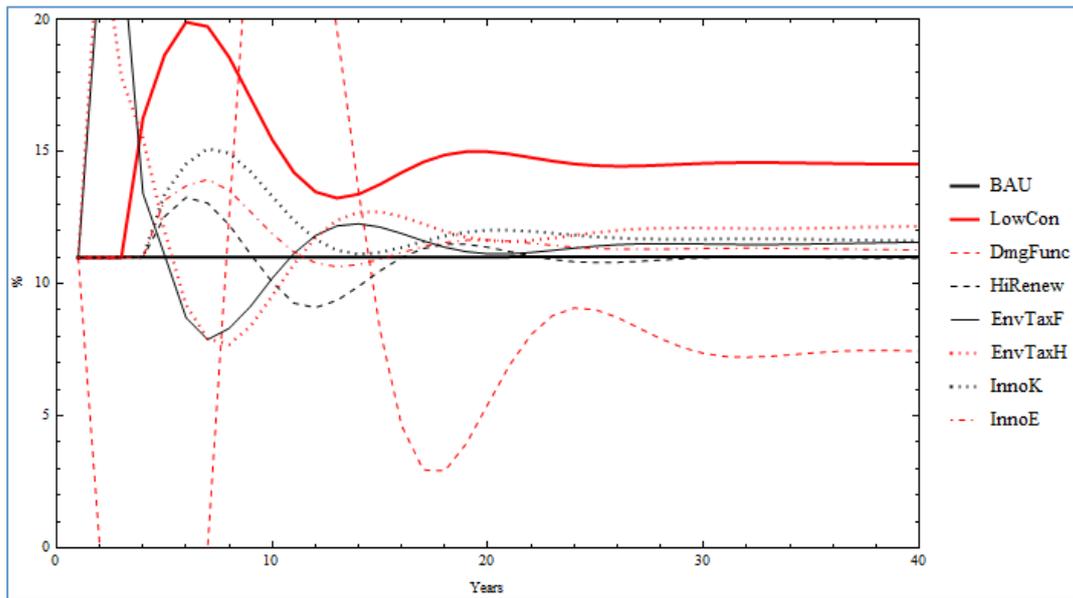


Figure 12: Unemployment in ECOGRO relative to BAU scenario

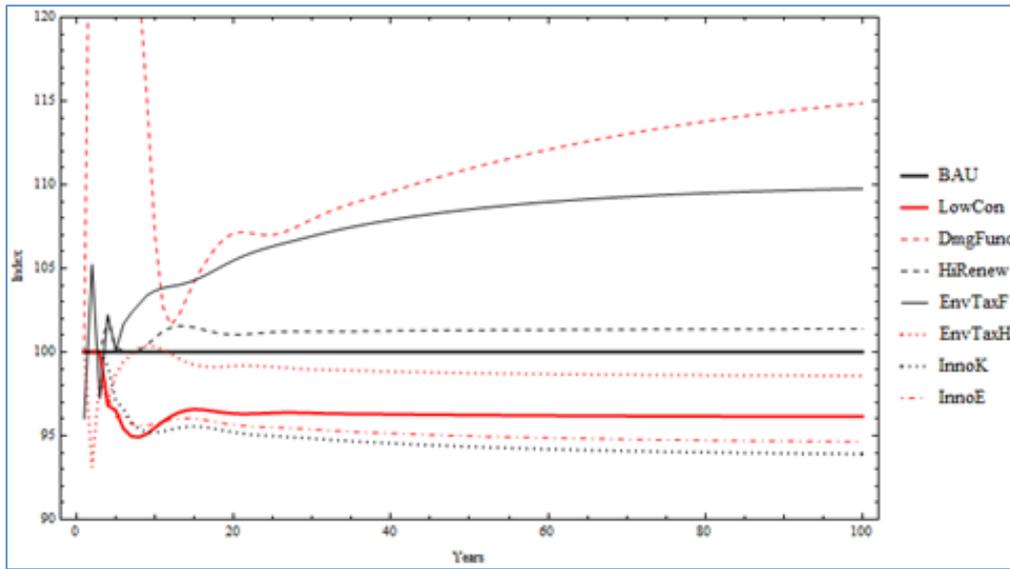


Figure 13: GHG emissions in ECOGRO relative to BAU scenario

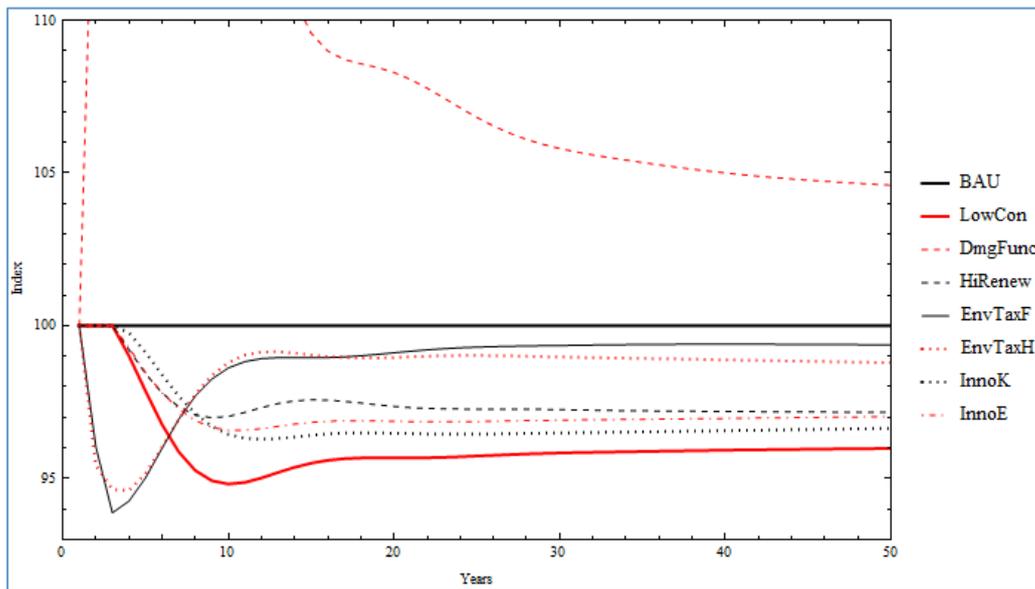


Figure 14: Income inequality in ECOGRO relative to BAU scenario

The results show that neither the link between output and income distribution, nor the link between output and the environment is predetermined. In particular, while the connection between output and unemployment conforms to the standard formulation of Okun's law, the income level and the functional income distribution are not as clear-cut. Similar macro level outcomes can be the result of very different underlying structural and distributional changes. Regarding environmental aspects, the absolute decoupling of energy use and emissions from output can be observed in this model in some cases.

Four policies show different trade-offs between growth, inequality and environment. The de-growth (*LowCons*) simulation shows that the lower output leads to higher unemployment while at the same time reducing inequality in the functional income distribution.³⁴ If emissions feed back into the depreciation of the capital stock as in the damage function experiment (*DmgFunc*), this has the opposite effect: unemployment falls but the functional income distribution worsens for workers. At the same time, this is the only policy which leads to higher emissions due to increased investment requirements. Environmental taxes on households (*TaxH*) or firms (*TaxF*) have mainly distributive effects while leaving output and emissions largely unchanged.

Three policies, however, appear to offer triple-win characteristics. Increasing the share of renewable energy (*HiRenew*) reduces emissions while leaving all other outcome variables virtually unchanged. Finally, innovations in capital (*InnoK*) or in energy (*InnoE*) productivity reduce both energy use and emissions, while at the same time raising real incomes and redistributing towards workers.

The model presented here can be extended to test for additional climate-related policies while keeping track of the feedback effects. These, for example, can include consumption based emissions through imports, endogenous growth, endogenous technical change, endogenous pro- (austerity) or counter-cyclical (stimulus) government spending. Other key areas include the inclusion of aspects of financialisation that indirectly feedback into the real economy and subsequently impact the environment.

³⁴ It should be noted that, in contrast to scenarios in Sections 4-6, no variations in labour productivity growth or working hours are explored in this section. Hence the relationship between output and employment is clearly coupled.

8 Discussion and Conclusions

Modern western economies (in the Eurozone and elsewhere) face a number of challenges over the coming decades. Achieving full employment, meeting climate change and other environmental targets and reducing inequality rank amongst the highest of these. The conventional route to achieving full employment and reducing inequality has been to pursue economic growth. But this route has created two critical problems for modern economies. The first of these is the coupling between output and environmental impact. The second is the fragility in financial balances that has accompanied relentless demand expansion.

The prevailing global response to the coupling between output and emissions has been to encourage decoupling through investing in green technologies (green growth). But this response runs the risk of exacerbating problems associated with the over-leveraging of households, firms and governments. An alternative approach is to reduce the pace of growth and to restructure economies around green services (post-growth).³⁵ But the potential dangers of declining growth rates lie in increased inequality and in rising unemployment. Some more fundamental arguments have also been made against the feasibility of interest-bearing debt within a post-growth economy.

The analyses in this paper have been motivated by the need to address these fundamental dilemmas and to inform the debate that has emerged in recent years about the relative merits of green growth and post-growth scenarios. In pursuit of this aim we have developed a suite of macroeconomic models based on the methodology of Post-Keynesian Stock Flow Consistent (SFC) system dynamics. Aggregate demand was calibrated at the level of the national economy (UK, Canada) in three of the models and at the level of the EU as a whole in the fourth. Applications of the modelling framework have included:

- Explorations of income inequality (SIGMA, ECOGRO)
- Understandings of the 'growth imperative' (FALSTAFF^S)
- Assessments of employment and unemployment (SIGMA, FALSTAFF^W, ECOGRO)
- Examinations of the effect of trade balances and imbalances (FALSTAFF^W)
- Elaboration of financial balances and imbalances (FALSTAFF^S, FALSTAFF^W)
- Illustration of green investment scenarios (FALSTAFF^W, ECOGRO)
- Exploration of trade-offs between policy goals (FALSTAFF^W, ECOGRO)

Our conclusions at this stage are necessarily preliminary, but it is possible to identify a number of important findings. We group these findings into several 'blocks' relating to the key challenges defined above:

³⁵ It is worth pointing out that western economies may find themselves confronted with declining growth rates perforce, irrespective of other goals, as a result of 'secular stagnation'.

The role of green investment

- substantial green investment is vital to both a green growth and a post-growth world;
- finding ways to finance green investment without destabilizing financial balance sheets or over-leveraging specific sectors is critical;
- a key (unresolved) question in the debate is the extent to which green investment does or does not contribute to the productive capacity of the economy as conventionally measured;
- depending on the answer to this question, substantial green investment faces potential complexities in terms of sector imbalances, balance sheet fragility and inflationary prices;
- macroeconomic policy that fails to incorporate such understandings is not capable of fully addressing the financial feasibility of green investment.

Addressing inequality

- rising inequality is a potential danger in both a post-growth and a green growth world; but combatting inequality is entirely possible within both strategies;
- key elements in the fight against inequality include:
 - increasing capital and energy productivity and slowing down the substitution of capital for labour;
 - protecting the rights of wage labour against excessive profit maximization by the owners of capital;
 - engaging in progressive taxation of income and introducing a low level of taxation on capital;
 - introducing mechanisms for redistributing the ownership of capital and slowing down asymmetric accumulation in capital assets.

Maintaining full employment

- productivity-driven growth creates an inherent challenge to full employment;
- the challenge of full employment in a post-growth economy arises primarily from the pursuit of labour productivity growth;
- achieving full employment with declining growth rates can be achieved through two strategies:
 - reducing the hours worked per employee
 - reducing the rate of growth of labour productivity in the economy
- expansion of service-based economic activities represents a double dividend in terms of reducing environmental burdens and increasing employment (Figure 15).

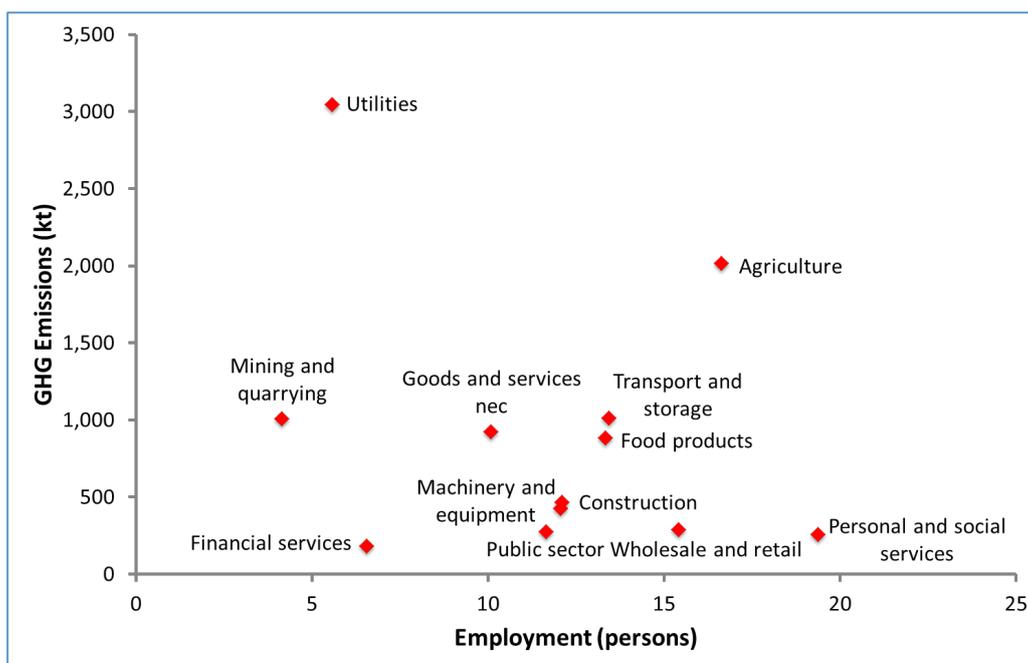


Figure 15: Direct and Indirect Employment and GHG Emissions per \$m in 2010 in Canada

Source: Jackson et al 2014 (Figure 2)³⁶

Achieving financial stability

- growth is not essential for the achievement of financial stability; but debt-fueled growth can lead to financial instability;
- austerity policy presents a significant risk of economic instability;
- countercyclical spending is a key element in the maintenance of financial stability;
- balanced trade policy can reduce financial imbalances and (in some circumstances) tame the creation of asset price bubbles.

Considerable uncertainties still attend the precise evolution of a convincing strategy for either green growth or for a post-growth economy. But the principal elements of any strategy for meeting the challenges which have motivated this work are already clear and must include: a robust strategy for green investment, employment policy that is not simply contingent on high-growth, distributive policies to address severe disparities in income and wealth, and rigorous institutional requirements

³⁶ The results shown in Figure 15 are taken from an expanded version of the FALSTAFF framework which will eventually include a multi-sector input output structure and is part of the ongoing development of the Surrey/York led work.

for financial stability. A particularly premium lies in strategies that offer multiple benefits or dividends in terms of the over-arching challenges articulated above.

So, for example, a structural shift towards service-based activities (Figure 15) has the potential to help meet carbon targets and at the same time to improve employment outcomes. Investment in energy productivity can reduce environmental impacts, improve trade balances and may in some circumstances contribute to redistribution towards wage labour (Figure 14). Countercyclical spending strategies by government can reduce financial instability and help maintain full employment.

Finally, it is to be noted that supposedly ‘fundamental’ objections to the feasibility of a post-growth economy are not supported by this research. There are in principle ways to achieve full employment, meet environmental targets, reduce income inequality and maintain financial stability even in the absence of exponential rates of growth. Encouragingly, our research also suggests that such a transition can be achieved without entirely dismantling the existing financial architecture of interest-bearing debt. Nonetheless, there are some significant advantages associated with financial and monetary reform – including the potential for sovereign money creation. Not the least of these advantages is the potential for post-growth governments to reduce the cost of social investment and engage more easily in countercyclical spending.

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