PASSAGE

Prosperity and Sustainability in the Green Economy

Tim Jackson and Peter A. Victor

Credit creation and the 'growth imperative'
a quasi-stationary economy with debt-based money

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Prosperity and Sustainability in the Green Economy (PASSAGE) is a Professorial Fellowship held by Prof Tim Jackson at the University of Surrey and funded by the Economic and Social Research Council (Grant no: ES/J023329/1).

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.

Publication

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Abstract

This paper addresses the question of whether a capitalist economy with interest-bearing money can ever sustain a 'stationary' (or non-growing) state, or whether, as often claimed, capitalism has an inherent 'growth imperative' which arises from the creation of money as interest-bearing debt. We outline the development of a dedicated system dynamics model for describing Financial Assets and Liabilities in a Stock-Flow consistent Framework (FALSTAFF) and use this model to explore the potential for stationary state outcomes in an economy with balanced trade, debt-based money, and private equity. Contrary to claims in the literature, we find that neither credit creation nor the charging of interest on debt create a 'growth imperative' in and of themselves. We show further that it is possible to move from a growth path towards a stationary state without either crashing the economy or dismantling the system. Our model supports critiques of austerity and underlines the value of countercyclical spending by government. Nonetheless, there remain several good reasons to support the reform of the monetary system.

1. Introduction

It has been argued extensively that capitalism has an inherent 'growth imperative': in other words, that there are certain features of capitalism which are inimical to a stationary state[1] 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.

Another argument concerns the question of interest-bearing debt. A variety of authors have argued that interest-bearing money (the basis for credit and debt in capitalist economies) in itself creates a demand for 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) argues explicitly 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) suggests 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) and seek to identify policies that 'would limit the growth imperative created by an interest-based credit creation system' (op cit: 2823).

This popular understanding of 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 published in the *Post-Keynesian Journal of Economics* by Matthias Binswanger (2009), who sets out to provide an 'explanation for a growth imperative in modern capitalist economies, which are also credit money economies' (op cit: 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'.

Binswanger finds that much depends on the destination of interest payments in the economy. If banks distribute all their profits (the difference between interest received and interest paid out) to households, then the 'positive threshold level' for growth can fall to zero. This condition is ruled out in Binswanger's analysis, however, by the demands of 'capital adequacy' – the need to ensure a certain buffer against risky assets on the balance sheet of commercial banks. This requirement, underlined by many in the wake of the financial crisis (BIS 2011), leads banks to seek to place a certain proportion of their profits in less risky assets, withdrawing money from circulation and

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[1] 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.

reducing the flow of funds available for households or firms to service their debts. 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). In the current paper, we seek to address this limitation of Binswanger's analysis.

Specifically, we aim to analyse the hypothesis that debt-based money creates a 'growth imperative' within a Stock-Flow Consistent (SFC) representation of the macro-economy. In the following section, we provide a brief overview of a systems dynamic model of the macro-economy, including both real and financial economy. We then describe the calibration of this model and illustrate its ability to provide for a stationary state. Next we explore the stability of this result under one-off shocks and random fluctuations in consumer demand, and under different responses from government and commercial firms. We also test the potential for transitions from growth states of the economy into stationary states. Finally we discuss the implications of these findings for capitalism and the 'growth imperative'.

2. Overview of the FALSTAFF Model

The analysis in this paper is based on our development (over the last four years) of a consistent approach to 'ecological macroeconomics' (Jackson et al 2014, Jackson and Victor 2015a). Our broad approach draws together three primary spheres of modelling interest and explores the interactions between them. These spheres are: 1) the environmental 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 financial 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.

An important intellectual foundation for our work comes from the insights of post-Keynesian economics, and in particular from an approach known as Stock-Flow Consistent (SFC) macro-economics, pioneered by Copeland (1949) and developed extensively by the late Wynne Godley and his colleagues.[2] SFC modelling has come to the fore in the wake of the financial crisis, because of the consistency of its 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 well before it happened.

The overall rationale of the SFC approach is to account consistently for all monetary flows between different 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 asset corresponds to some financial liability for 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 ground truth economic models and scenario predictions.

Building on these foundations 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. The approach is broadly post-Keynesian in the sense that the model is demand-driven and incorporates a consistent account of 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.[3]

The FALSTAFF model 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. STELLA also allows for an online user-interface (NETSIM) through which the interested reader can follow the

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[2]   See for instance: Godley 1999, Godley and Lavoie 2007, Lavoie and Godley 2001. For an overview of the literature on SFC macroeconomic modelling, see Caverzasi and Godin 2015.

[3]   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).

scenarios presented in this paper and explore their own.[4] Data collation and reporting are carried out in Excel.

For the purposes of this paper, we have simplified the FALSTAFF structure in order to focus specifically on the question of interest-bearing money. For instance, we assume balanced trade in this version of FALSTAFF and restrict the number of categories of assets and liabilities to include only loans, deposits, equities and government bonds. Further simplifications are noted at the relevant places in our full model description below. Figure 1 illustrates the overall model structure for the simplified version of FALSTAFF described in this paper.
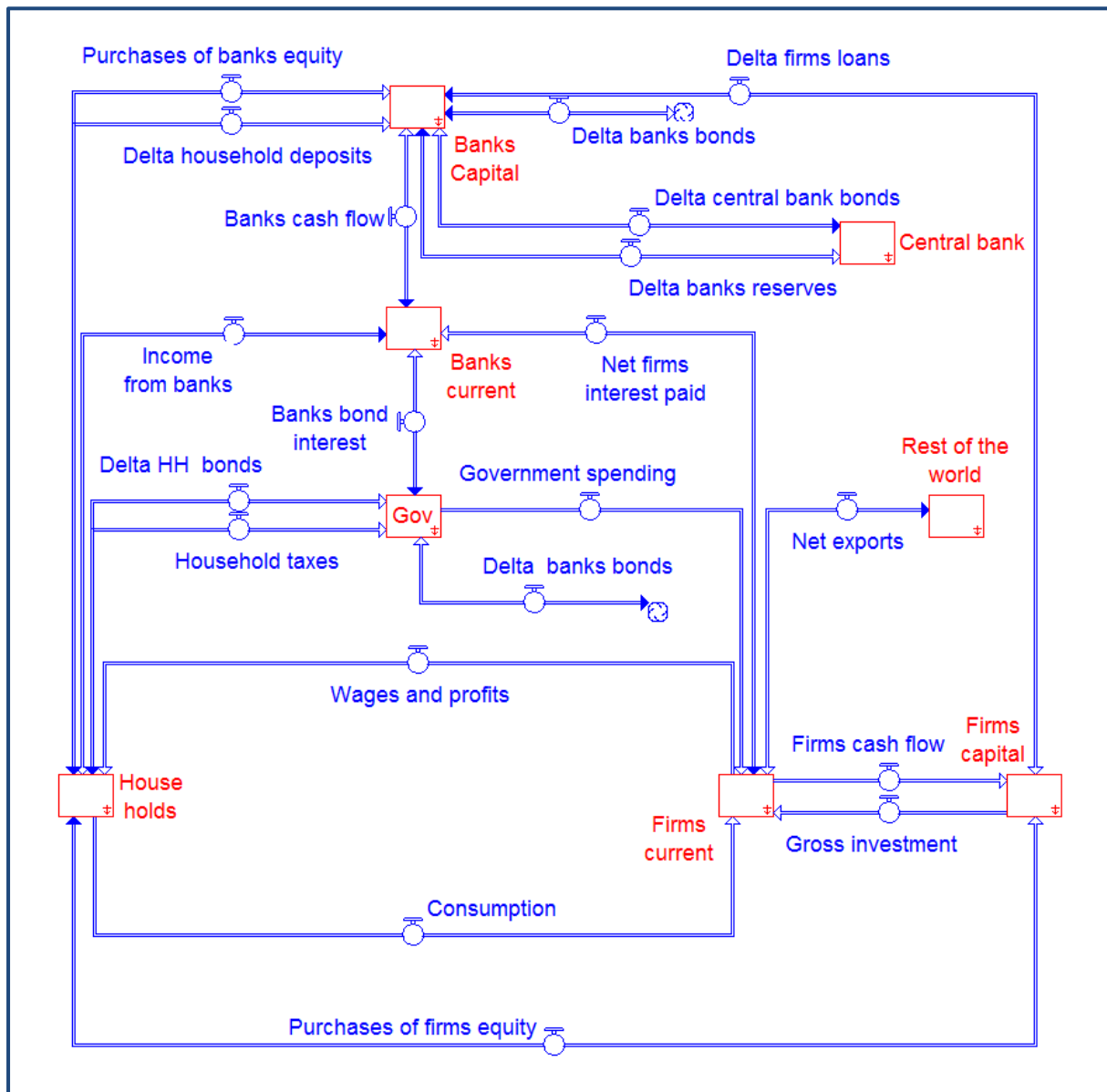
Figure 1: An overview of the FALSTAFF 'steady state' model

The familiar 'circular flow' of the economy is visible towards the bottom of the diagram in Figure 1. The rather more complex surrounding structure 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 throughout the model run. So,

for instance, the incomes of households (consisting of wages, dividends and interest receipts) must be exactly equal to the outgoings of households (including consumption, taxes, interest payments and net acquisitions of financial assets). Likewise, for each other sector in the model.

The broad structure of the FALSTAFF model is as follows. Aggregate demand is composed of household spending, government spending, and the investment expenditure of firms.[5] 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 '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 a single period 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 to government bonds, firms equities, banks equities, bank deposits and loans.[6] 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.[7] 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 increase the level of loans.

Firms are assumed to produce goods and services on demand for households, governments and gross fixed capital investment. Investment decisions are based on a simple 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 buys goods and services 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. For the purposes of this paper, we 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 an 'austerity' policy in which government balances the fiscal budget), and one in

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[5] 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.

[6] 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).

[7] 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.

which government engages in a 'countercyclical' spending 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 household 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 steady state version of FALSTAFF, providing liquidity (in the form of reserves) on demand to commercial banks in exchange for bonds.

FALSTAFF 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 'safe' assets (either reserves or government bonds) up to a given proportion of 'risky' assets (household and firms loans). 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. The first of these requirements 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 use the Basel III capital adequacy requirement of 8% as our default assumption for the purposes of this model. As for the reserve requirement, few developed countries formally retain such requirements 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 a requirement might lead to a growth imperative.

As noted above, our principal aim in this paper 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 our 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 growth imperative, this simplification is perfectly robust. We have also incorporated conditions on commercial banks appropriate for the testing of the overall hypothesis that interest-based money leads to growth.

We are less interested in this paper in the production process itself. Clearly, however, some aspects are important for our task. For instance, we need to establish the capital investment needs for production, since these are a core component of aggregate demand and determine both the level of financing for firms and the destination of savings for households. The second major input to production is labour. Employment is assumed to take place via the firms sector in FALSTAFF and labour demand is calculated through a simple labour productivity equation. Labour productivity growth can be set exogenously in the model. The wage rate is assumed to follow any increase in labour productivity.[8]

Table 1 shows the financial balance sheet for the FALSTAFF 'steady state' model. As mentioned above, we have employed a rather simple asset and liability structure for the purposes of this exercise in order to allow us to focus our attention on the question of interest-bearing debt. Households own firm equities E_f and purchase government bonds B_h. Balances are held either as deposits D_h or as loans L_h. Firms take out loans L_f or issue equities E_f in order to finance

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[8]   The full version of FALSTAFF includes a model of wage bargaining and therefore allows us to consider the question of prices and inflation.

investment. In addition to the loans they provide to firms and households, commercial banks also hold government bonds B_b for capital adequacy reasons and central bank reserves R for liquidity reasons. The central bank balances its reserve liabilities with government bonds B_{cb} purchased from banks on the secondary market. Governments hold only liabilities in the form of bonds B.

	Households	Firms	Banks	Central bank	Government	Total
Net financial worth	$D^h + E + B^h - L^h$	$-L^f - E^f + D^f$	$L + R - D - E^b$	$B^{cb} - R$	$-B$	0
Financial Assets	$D^h + E + B^h$	D^f	$L + R$	B^{cb}	0	$R + D + L + B + E$
Reserves			R			R
Deposits	D^h	D^f				D
Loans			L			L
Bonds	B^h		B^b	B^{cb}		B
Equities	E					E
Financial Liabilities	L^h	$L^f + E^f$	$D + E^b$	R	B	$R + D + L + B + E$
Reserves				R		R
Deposits			D			D
Loans	L^h	L^f				L
Bonds					B	B
Equities		E^f	E^b			E

Table 1: Financial balance sheet for the FALSTAFF 'steady-state' economy[9]

The transaction flows matrix (Table 2) 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 six rows in Table 2 illustrate the flow accounts of each sector. For instance, the household sector receives money in the form of wages and dividends from production firms and dividends and (net) interest from banks. Households spend money on consumption and on taxes. The balance between income and spending represents the savings of the household sector. Note that the first nine rows of column 2 (firms' current account) represent a simplified form of the conventional GDP accounting identity:

$$C \ + \ G \ + \ I \ = \ GDP_e \ = \ GDP_i \ = \ W \ + \ P + i_f + \delta \qquad (1)$$

where GDP_e represents the expenditure-based formulation of the GDP, GDP_i represents the income based formulation, and i_f represents the net interest paid out by firms.

The bottom five rows of the table represent the transactions in financial assets and liabilities between sectors. So, for example, the net lending of the households sector (the sum of rows 1 to 9) is distributed amongst five different kinds of financial assets in this illustration: deposits, loans, government bonds, equities and central bank reserves. 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 2 therefore allow for a consistency check, to ensure that the simulations actually represent possible states of the monetary economy.

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[9] Our presentation of the financial balance sheet in Table 1 follows the format established in the National Accounts (http://stats.oecd.org/Index.aspx?DataSetCode=SNA_TABLE720 eg) rather than the presentation favoured by SFC theory (Godley and Lavoie 2007: 32 eg).

	Households (h)	Firms (f)		Banks (b)		Central Bank (cb)	Gov (g)	Σ
		Current	Capital	Current	Capital			
Consumption (C)	$-C$	C						0
Gov spending (G)		G					$-G$	0
Investment (I)		I	$-I$					0
Wages (W)	W	$-W$						0
Profits (P)	$+P^{fd} + P^{br}$	$-P^f$	$+P^{fr}$	$-P^b$	$+P^{br}$			0
Depreciation (δ)		$-\delta$	$+\delta$					0
Taxes (T)	$-T$						T	0
Interest on Loans (L)	$-r_l L^h_{-1}$	$-r_l L^f_{-1}$		$+r_l L_{-1}$				0
Interest on Deposits (D)	$+r_d D^h_{-1}$	$+r_d D^f_{-1}$		$-r_d D_{-1}$				0
Interest on Bonds (B)	$+r_b B^h_{-1}$			$+r_b B^b_{-1}$		$+r_b B^{cb}_{-1}$	$-r_b B_{-1}$	0
Change in Reserves (R)					$-\Delta R$	$+\Delta R$		0
Change in Deposits (D)	$-\Delta D^h$				$+\Delta D$			0
Change in Bonds (B)	$-\Delta B^h$				$-\Delta B^b$	$-\Delta B^{cb}$	$+\Delta B$	0
Change in Equities (E)	$-\Delta E$		$+\Delta E^f$		$+\Delta E^b$			0
Change in Loans (L)	$+\Delta L^h$		$+\Delta L^f$					0
Σ	0	0	0	0	0	0	0	0

Table 2: Transaction Matrix for the FALSTAFF 'steady state' Economy

3. Analysis

The aim of this paper is to explore the hypothesis that interest-based money creates a 'growth imperative'. The existence of one reasonable stationary state solution, based on reasonable and consistent values for the various parameters would disprove the hypothesis. In pursuit of such a solution, we first run through the algebraic structure of the model.

Starting with the *household sector*, we can define the income Y^h, of households (in accordance with Table 2) as:

$$Y^h = W + P^{fd} + P^{bd} + i_{B^h} + i_{D^h} - i_{L^h} \tag{2}$$

where $i_{B^h} = r_B B_{-1}^h$ is the interest paid on the stock of bonds held by households, $i_{D^h} = r_D D_{-1}^h$ is the interest paid on households deposits and $i_{L^h} = r_L L_{-1}^h$ the interest paid by households on loans. Disposable income, Y^{hd}, is given by:

$$Y^{hd} = (1 - \theta)Y^h \tag{3}$$

where θ is the rate of income tax on households, determined (below) by government's initial financing requirement. In allocating household income between consumption spending, C and savings S^h, we adopt a consumption function of the form (Godley and Lavoie 2007 eg):

$$C = \alpha_1 Y^{hde} + \alpha_2 NW_{-1}^h \tag{4}$$

where α_1 and α_2 are respectively the propensity to consume from disposable income and the propensity to consume from wealth (both assumed constant for the reference scenario) and households' expected disposable income Y^{hde} is given by a simple extrapolation of the trend over the previous period:

$$Y^{hde} = Y_{-1}^{hd}(1 + \frac{(Y_{-1}^{hd} - Y_{-2}^{hd})}{Y_{-1}^{hd}}) \tag{5}$$

Remembering that households are the only owners of equity in this model, the household net worth NW^h is equal (see Table 1) to:

$$NW^h = D^h + B^h + E - L^h. \tag{6}$$

Household savings are then given by:

$$S^h = Y^{hd} - C. \tag{7}$$

In this version of FALSTAFF we do not have households making fixed capital investments, and so the net lending NL^h of households is given simply by:

$$NL^h = S^h. \tag{8}$$

The next step in the model is to determine the allocation of net lending between different assets and liabilities. In the full version of our FALSTAFF model (Jackson et al 2014, Jackson and Victor 2015) we adopt a portfolio allocation function of the form originally proposed by Brainard and Tobin (1968) and adapted by Godley and Lavoie (2007) to fulfil this task. For this simplified version of the model, however, we assume simply that households purchase all equities issued by firms and absorb

the bonds not taken up banks (and the central bank). The change in household deposits is then determined as a residual according to:

$$\Delta D^h = \max\{\left(NL^h - \Delta E^f - \left(\Delta B - \Delta B^b - \Delta B^{cb}\right)\right), -D^h_{-1}\} \qquad (9)$$

So long as $NL^h - \Delta E^f - \left(\Delta B - \Delta B^b - \Delta B^{cb}\right) \geq -D^h_{-1}$, households do not need to take out loans. In the case where the supply of equities and the residual supply of bonds exceeds savings, households draw down deposits in order to purchase these assets. Where there are insufficient deposits, ie where $NL^h - \Delta E^f - \left(\Delta B - \Delta B^b - \Delta B^{cb}\right) < -D^h_{-1}$, then households will take out loans ΔL^h according to:

$$\Delta L^h = \Delta E^f + \left(\Delta B - \Delta B^b - \Delta B^{cb}\right) - NL^h - D^h_{-1}. \qquad (10)$$

Coming next to the *firms sector*, we assume that this sector supplies all the goods and services included in the GDP, so that firms' revenues are given by the left hand side of equation (1) plus any interest $i_{Df} = r_D D^f_{-1}$ received on deposits. From these revenues, firms must pay wages W, distribute dividends P^{fd}, and make interest payments $i_{Lf} = r_L L^f_{-1}$ on loans. Wages are calculated according to:

$$W = wLE, \qquad (11)$$

where the labour employed LE is given by:

$$LE = \frac{GDP}{\eta}. \qquad (12)$$

and η is the labour productivity of the economy at time t. Typically, in a capitalist economy, the labour productivity is deemed to grow over time. If g_η is the growth rate in labour productivity, then we can write:

$$\eta = \eta_0 e^{g_\eta t}, \qquad (13)$$

where η_0 is the initial labour productivity, and it follows that:

$$W = \frac{w}{\eta_0 e^{g_\eta t}} GDP. \qquad (14)$$

We further assume that the wage rate w increases over time at the same rate as labour productivity. In other words, we suppose that workers are paid the marginal product of their labour.[10] Wage rates are not suppressed by the power of capital (as might happen for instance when unemployment is high); nor do workers exert any upward pressure on wages (as might happen when unemployment is very low). In this case it follows that:

$$w = w_0 e^{g_\eta t}, \qquad (15)$$

and accordingly that wages W are given by:

$$W = \frac{w_0 e^{g_\eta t}}{\eta_0 e^{g_\eta t}} GDP, \qquad (16)$$

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[10]   This assumption is relaxed in the full version of FALSTAFF.

In other words it follows that wages W are a constant proportion $\frac{w_0}{\eta_0}$ of the GDP. Firms profits P^f (net of depreciation) are then given by:

$$P^f = \left(1 - \frac{w_0}{\eta_0}\right) GDP - i_{L^f} + i_{D^f} - \delta, \tag{17}$$

where the depreciation, δ, of firms' capital stock K is defined by:

$$\delta = r_\delta K_{-1} \tag{18}$$

for some rate of depreciation r_δ (assumed constant).

One of the critical decisions that firms must make is how much to invest each year. We assume here a simple 'accelerator' model (Godley and Lavoie 2007: 227 eg) in which net investment I_{net} is decided according to the difference between the actual capital stock at the end of the previous period K_{-1} and a 'target' capital stock K^τ sufficient to meet the expected demand for output, with a fixed capital to output ratio κ. Hence we have:

$$I_{net} = \gamma(K^\tau - K_{-1}) \tag{19}$$

for some 'accelerator coefficient' γ, with $0 \leq \gamma \leq 1$, and target capital stock K^τ given by:

$$K^\tau = \kappa GDP^e, \tag{20}$$

where GDP^e, the expected GDP, is determined (as for disposable income) via a simple trend function of the same form as shown in equation (5). Gross investment I is then given by:

$$I = I_{net} + \delta. \tag{21}$$

We assume a funding model for firms in which firms cash flow or retained earnings is equal to the depreciation δ, so that profits, P^{fd}, distributed as dividends, are equal to profits P^f net of depreciation.[11] In this case, the net lending of firms NL^f is given by:

$$NL^f = -I_{net}. \tag{22}$$

Net borrowing (negative net lending) of firms is funded by a mixture of loans ΔL^f from banks and equity ΔE^f sold to households. The exact split between debt and equity is determined by a desired debt to equity ratio ε, such that:

$$L^f = \varepsilon E^f. \tag{23}$$

Assuming that historical debt and equity more or less satisfy this ratio, then firms would be expected to take out net loans ΔL^f and issue new equities ΔE^f in the same proportions so that:

$$\Delta L^f = \varepsilon \Delta E^f, \tag{24}$$

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[11]   It is in principle possible to relax this assumption, but it would immediately lead to positive net investment and accumulation of the capital stock. Since these provide conditions for growth in the real economy, they would detract from our desire to eliminate such conditions from the model, in order to test that aspect of the growth imperative that derives from interest-bearing money.

from which it is straight forward to show that:

$$\Delta L^f = -\frac{1}{\left(1+\frac{1}{\varepsilon}\right)} NL^f \tag{25}$$

while:

$$\Delta E^f = -\frac{1}{(1+\varepsilon)} NL^f. \tag{26}$$

In the event that net investment is negative, ie when firms are inclined to disinvest in fixed capital, then firms' net lending is positive. We assume first that firms use this cash to pay off loans. In the event that there are no more loans to pay off, firms save excess cash as deposits with banks.

The *banks sector* in FALSTAFF is a simplified accounting sector whose main function is to provide loans ΔL^f to (and occasionally to take deposits ΔD^f from) firms and to take deposits ΔD^h from (and occasionally provide loans ΔL^h to) households. In order to meet liquidity needs, commercial banks keep a certain level of reserves R with the *central bank*, depending on the level of deposits held on their balance sheet. The additional reserve requirement ΔR in any year is given by:

$$\Delta R = \psi\left(D^h_{-1} + D^f_{-1}\right) - R_{-1}, \tag{27}$$

where ψ is the desired (or required) reserve ratio. Banks 'pay for' these reserves by 'selling' an equivalent value in government bonds to the central bank, thus depleting their stock of bonds by an amount ΔB^{cb} equal to ΔR, and increasing the stock of government bonds held by the central bank by the same amount.

To comply with capital adequacy requirements, banks are required to hold a certain amount of risk free assets (bonds B or reserves R) as a proportion of risky assets (loans L^f and L^h). Accordingly, in each year, we have commercial banks purchase a certain quantity of bonds $\Delta B^b_{cap\ ad}$ from the government according to:

$$\Delta B^b_{cap\ ad} = \varphi\left(L^h_{-1} + L^f_{-1}\right) - \left(B^b_{-1} + R\right) \tag{28}$$

where φ is the capital adequacy ratio. Thus the overall change ΔB^b in banks bonds is given by:

$$\Delta B^b = \Delta B^b_{cap\ ad} - \Delta B^{cb} = \varphi\left(L^h_{-1} + L^f_{-1}\right) - \left(B^b_{-1} + R_{-1}\right) - \Delta R. \tag{29}$$

Or in other words:

$$\Delta B^b = \varphi\left(L^h_{-1} + L^f_{-1}\right) - B^b_{-1} - \psi\left(D^h_{-1} + D^f_{-1}\right), \tag{30}$$

Whereas for firms, capital account positions are determined by the needs of the current account, in the case of banks, we derive the current account balances from the capital account positions, specifically we determine banks retained earnings (undistributed profits) from their financing needs. Banks income consists in the difference between interest received on loans and government bonds and the interest paid out on deposits.[12] Hence, banks' profits P^b are given by:

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[12]   We omit here for simplicity interest paid on reserves. In the event that this was included in the model, it would simply represent a transfer from the central bank (essentially from government) to firms. We note here also that the banks sector does not pay wages in FALSTAFF. These are deemed to be paid via the firms sector as are public sector wages.

$$P^b = i_{L^f} + i_{L^h} + i_{B^b} - i_{D^h} - i_{D^f}. \tag{31}$$

Banks savings are equal to the difference between total profits P^b and the profits P^{bd} distributed to households as dividends. Rather than specifying a fixed dividend ratio to determine P^{bd} and calculating banks savings S^b from this, we determine instead a desired net lending NL^b for banks, according to the financing requirements of banks' capital account and set the savings equal to this. Hence, we have:

$$NL^b = \Delta L^f + \Delta L^h + \Delta B^b_{cap\ ad} - \Delta D^h - \Delta D^f, \tag{32}$$

And we can then determine banks' dividends, P^{bd}, according to:

$$P^{bd} = P^b - S^b = P^b - NL^b. \tag{33}$$

with NL^b given by equation (32).

Finally, we describe the *government sector* accounts. The current account elements[13] in the Government's account are relatively simply expressed in terms of the equation:

$$NL^g = S^g = T - G - i_B, \tag{34}$$

where taxes, T, are given by:

$$T = \theta Y^h, \tag{35}$$

and the interest, i_B, paid on government bonds is given by:

$$i_B = i_{B^h} + i_{B^b} = r_B(B^h_{-1} + B^b_{-1}). \tag{36}$$

Note that no interest is included for government bonds owned by the central bank, as profits from the central bank are assumed to be returned directly to the government. The capital aspects of the government account is simply a matter of establishing the level of government debt, through the change in the stock of outstanding government bonds, B, according to:

$$\Delta B = -NL^g. \tag{37}$$

When the government runs a fiscal deficit, the net lending, NL^g, is negative leading to an increase in the stock of outstanding bonds. In the event that government runs a fiscal surplus, NL^g is positive and the stock of outstanding bonds declines.

A key feature of stock-flow consistent models is that they explicitly satisfy a key condition that prevails in the macroeconomy, namely that sum of net lending across all sectors is equal to zero. In other words:

$$NL^h + NL^f + NL^b + NL^g = 0. \tag{38}$$

Or in other words, using equations (7), (8), (22), (32) and (34) above, we should expect that:

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[13] In keeping with National Account conventions, the current and capital elements of the government sector are not shown in separate accounts in Table 2.

$$Y^{hd} - C - I_{net} + P^b - P^{bd} + T - G - i_{B^h} - i_{B^b} = 0 \qquad (39)$$

Noting that $Y^{hd} + T = Y^h$ and using equation (2), it follows that:

$$W + P^{fd} + i_{D^h} - i_{L^h} + P^b - i_{B^b} = C + G + I_{net} \qquad (40)$$

Since $P^{fd} = P^f$ and noting that P^b can be expanded (equation 31) as a sum of interest receipts (and payments), we can show that equation (40) can be rewritten as:

$$W + P^f + i_{Lf} - i_{Df} = C + G + I_{net} \qquad (41)$$

or equivalently that:

$$W + P^f + i_f + \delta = C + G + I \qquad (42)$$

which is precisely (see equation 1) where we started from. The net lending condition is therefore a useful consistency check for the validity of the model as a whole and will be one of the aspects tested across different scenarios in the numerical simulations.

Having established the accounting identities and behavioural relationships of the FALSTAFF model, we next need to determine some initial values consistent with stationary (or quasi-stationary) solution. For the purposes of this exercise, this means that there should be no long-term drivers of growth in the 'real economy'. So, for instance, we would expect no net accumulation of the productive capital stock K. Specifically this means setting the initial gross investment, I_0, in productive capital equal to the initial depreciation δ_0:

$$I_0 = \delta_0 = r_\delta K_0, \qquad (43)$$

where r_δ is the depreciation rate and K_0 denotes the value of the capital stock at time t = 0. In addition, government spending is assumed not to grow over time and government debt does not accumulate over time. This means setting initial government expenditure G_0 and the initial household income tax rate T_0 so that government achieves a fiscal balance:

$$G_0 + r_B B_0 = T_0, \qquad (44)$$

where r_B is the rate of interest on government bonds (assumed constant) and B_0 is the stock of outstanding bonds at time t = 0. From equations (43) and (44) it follows that:

$$NL_0^f = NL_0^g = 0, \qquad (45)$$

and hence that:

$$NL^h + NL^b = 0, \qquad (46)$$

For stationary state solution, as Godley and Lavoie (2007: 73) point out, the net lending NL_0^h of the household sector must also be equal to zero. Otherwise, it is clear to that NW^h would rise, leading to rising consumption. This means that the initial value C_0 of household consumption must be equal to the initial disposable income Y_0^{hd}. This can be satisfied by choosing a tax rate θ_0 at which equation (44) is satisfied. Since $T_0 = \theta_0 Y_0^h$, we can use equation (2) to deduce that:

$$\theta_0 = \frac{G_0 + r_B B_0}{W_0 + P_0^{fd} + P_0^{bd} + i_0^{Bh} + i_0^{Dh} - i_0^{Lh}}.$$ (47)

In short, conditions (43) to (47) define an initial state consistent with a stationary solution to the model. In the following section, we illustrate this stationary state solution with specific numerical values, check its evolution over time, and explore what happens when the system is pushed away from equilibrium.

Table 3: Initial Values for FALSTAFF Scenarios
Sources for reference values: see note 14.

Variable	Values	Units	Remarks
Initial GDP	2,000	$billion	UK GDP is currently around £1.6 trillion; Canada GDP is around CAN$1.9 trillion.
Initial consumer spending C	1,200	$billion	Assumes consumer spending is approximately 60% of GDP, typical for advanced western economies.
Propensity to consume from wealth (α_2)	0.034		We assume a small propensity to consume from wealth equivalent to $200 billion, consistent with empirical data.
Propensity to consume from income (α_1)	0.83		Calculated as the ratio of non-wealth consumption ($1 trillion) to initial disposable income.
Initial government spending G	400	$billion	Assumes government spending of 20% of GDP.
Initial gross investment I	400	$billion	Assumes investment of 20% of GDP.
Initial depreciation	400	$billion	Assumes that gross investment equals depreciation.
Initial depreciation rate	6.67%	%	Chosen so that depreciation is equal to gross investment. Typical rates in advanced economies are around 6-8%.
Initial National Income	1,600	$billion	Calculated by subtracting depreciation from GDP.
Initial wages (W)	960	$billion	Assumes labour's share of income is around 60% of the national income, typical in both Canada and the UK.
Initial profits (P)	640	$billion	Calculated by subtracting labour's share of income from the National income.
Initial capital stock (K)	6,000	$billion	Based on the estimate of capital to income ratio chosen below.
Initial capital to income ratio	3		Capital to national income ratio in Canada is a little under 3; in UK it is higher at around 5.
Initial investment accelerator (γ)	0.1		Typical range for advanced economies: $0.08 - 0.15$.
Initial firms debt D_f	3,000	$billion	Initial capitalisation of firms is assumed split equally between debt and equity.
Initial firms equity E_f	3,000	$billion	Initial capitalisation of firms is assumed split equally between debt and equity.
Initial banks equity E_b	887	$billion	Calculated so that the initial return to equity in banks (from banks' dividends) is equal to the initial return to equity for firms.
Initial household deposits D_h	3000	$billion	Consistent with the assumption that (broadly speaking) loans are equal to deposits.
Initial household bond holdings B_h	1000	$billion	Leads to a debt-to-equity ratio which is close to current levels in UK and Canada.
Interest rate on deposits	1%	%	Typical of current values
Interest rate on government bonds	2%	%	Typical of current values
Interest rate on loans	5%	%	Typical of current values
Initial reserve ratio	5%	%	High by pre-crisis standards; low by post-crisis standards.
Initial banks reserves R	50	$billion	Consistent with chosen reserve ratio.
Initial central bank bond holdings B_{cb}	50	$billion	Consistent with initial reserve holdings.
Initial banks capital adequacy requirement	8%	%	Consistent with Basel III banking regulations.
Initial banks bonds B_b	240	%	Consistent with chosen capital adequacy ratio, taking into account banks' reserve holdings.
Initial government debt B	1290	$billion	Equal to the total of household, bank and central bank bond holdings.
Initial household tax rate	26%	%	Calculated from initial household income at a level that will lead to a zero fiscal balance for government.
Initial unemployment rate	7%	%	Typical of both Canada and the UK over the last few years.
Initial workforce	21.5	Million	Workforce is typically 45% - 55% of population.
Initial labour productivity	1	$m GDP/emp	Consistent with initial GDP delivered by the initial workforce at the given unemployment rate.

4. Numerical simulation

We select first a range of numerical values to initialise the variables in FALSTAFF as shown in Table 3. Drawing from empirical data in Canada and the UK,[14] we select values that could reasonably be taken to describe an advanced western economy. The initial GDP of $2 trillion is broken down between consumption (60% of GDP), government expenditure (20%) and gross investment (20%). We assume an initial capital stock value of $6 trillion suggesting a capital-to-output ratio of 3. For the economy not to be growing in real terms, this means that the depreciation rate is approximately 7%, so that gross investment just covers the depreciation of capital. The national income (GDP minus depreciation) is assumed to be split initially between wages (returns to labour) and profits (return to capital) in the ratio 60:40.

Firms' productive capital stock is assumed to be capitalised equally between debt ($3 trillion in loans from banks) and equity ($3 trillion in shares held by households). The accelerator constant γ in the investment function is taken initially as 0.1.[15] A smaller amount of equity ($887 billion) is invested in banks, sufficient to provide an initial rate of return on equity (banks dividends divided by the equity) equal to the rate of return on firms equity. In addition to equity holdings, households are also deemed initially to hold $1 trillion in deposits and an equal amount in government bonds. Interest rates of 1% (on deposits), 2% (on bonds) and 5% (on loans) are set exogenously.[16]

A capital adequacy ratio for banks is set at 8% and the desired reserve ratio for banks holdings of central banks reserves is set at 5%. These parameters in their turn determine the level of bond holdings by the banks, reserve holdings by banks and bond holdings by the central bank (equal to the reserve holdings of banks). The sum of bond holdings by households, banks and the central bank is taken as the initial stock of government debt. Using the exogenous bond interest rate, it is then possible to calculate the initial interest burden on government which, together with the exogenous initial government expenditure, must be met by taxation. Using households' total income, this enables us to calculate (see equation (47) above) a tax rate on households sufficient to ensure a balanced fiscal budget equal to the initial target government spending plus the interest rate on bonds held by households and by banks. For the parameters given above this turns out to be approximately 26%.

Finally, we assume a level of the workforce required to produce the output in the FALSTAFF economy with an initial unemployment rate of 7%, typical of advanced economies. From these initial values, we construct eight separate scenarios to test the hypothesis that positive interest rates lead to a growth hypothesis. The first six of these scenarios are initialised using parameters consistent with a stationary state and are defined as follows:

- Scenario 1: the model is run using the values established in Table 3 with no adjustments;
- Scenario 2: the model is run with a small (max ±2.5%) random variation to consumer demand in each year;
- Scenario 3: the model is run using a small (5%) one-off shock (reduction) in consumer demand in year 20;
- Scenario 4: government responds to Scenario 3 with a 'strict' austerity policy in which the initial fiscal balance is maintained, no matter what;

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[14]   Data for the Canadian economy may be found in the Cansim online database: http://www5.statcan.gc.ca/cansim/home-accueil?lang=eng; and for the UK economy on the Office for National Statistics online database: http://www.ons.gov.uk/ons/taxonomy/index.html?nscl=Economy#tab-data-tables

[15]   See for example Tutulmaz and Victor 2013.

[16]   As with most of the variables in the model, these values can be selected by the user.

- Scenario 5: firms respond to Scenario 3, with a version of Keynes' 'animal spirits', in which more is invested when things are going well (ie when expected output rises) and less when they are going worse (ie when expected output falls);
- Scenario 6: governments respond to the conditions in Scenario 5, by engaging in counter-cyclical spending.

The final two scenarios are deliberately initialised as growth scenarios:

- Scenario 7: government expenditure is assumed to grow at 2% per annum for the first three periods of the run; this growth rate the declines to zero over the subsequent decade and remains at zero for the rest of the run;
- Scenario 8: as in Scenario 6, government modifies expenditure counter-cyclically according to what is happening to the overall growth rate.

The results of Scenario 1 are illustrated in Figures 2 and 3. Figure 2 shows the GDP on an expenditure basis; Figure 3 shows the same output broken down on an income basis. The graphs themselves are not particularly interesting, other than that they confirm, as expected, that with a suitable choice of initial values, a stationary state economy is possible. More interesting for our purposes in this paper is that these results are obtained from an economic model with interest-bearing debt, and in spite of the fact that banks are subject to both a capital adequacy requirement and a reserve ratio requirement. It is not possible in the space of this paper to illustrate, although the reader can verify for themselves in our online model, that the results in Figure 2 and 3 do not depend on specific values chosen for the interest rates on deposits, loans and bonds;[17] nor do they depend on the specific values chosen for capital adequacy or reserve ratio; although, not surprisingly, the steady state tax rate (equation 47) changes when these parameters are altered.
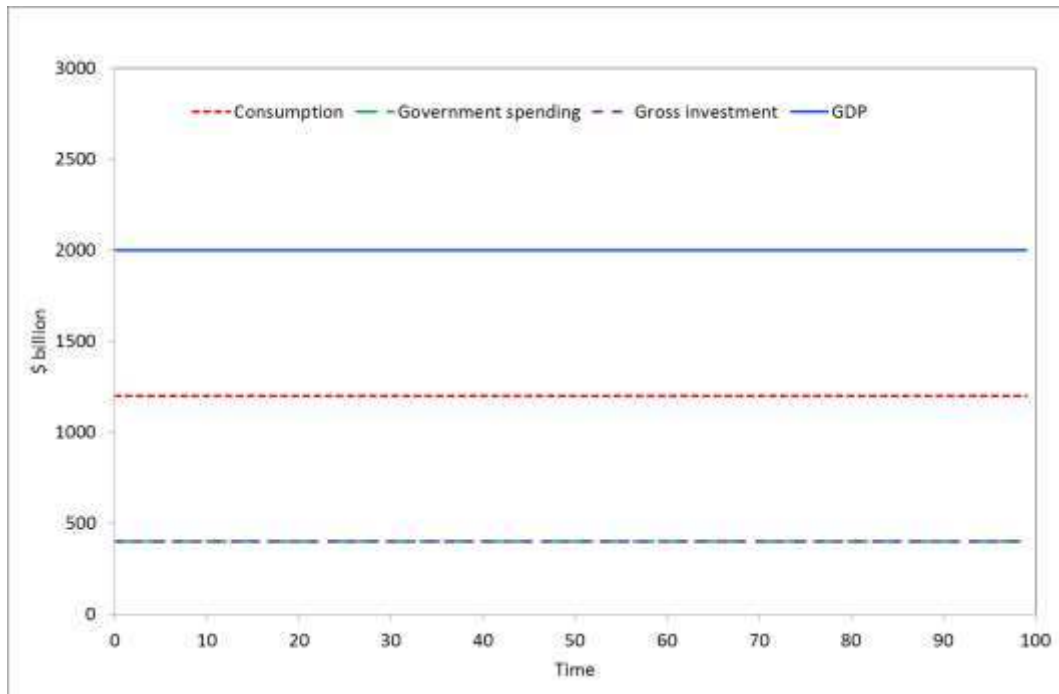

Figure 2: GDP on an expenditure basis (Scenario 1)

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[17] Explicitly, these results were tested for deposit rates between 0 and 10% and for loan rates between 0 and 15% (with an interest rate spread between 0% and 10%). The interested reader may check for themselves using our online model at: www.prosperitas.org.uk/FALSTAFF_steadystate.

Figure 3: GDP on an income basis (Scenario 1)

Since net lending in the stationary state is equal to zero for all sectors, it is to be expected, and Figure 4 confirms, that the net financial worth of each of the FALSTAFF sectors remains unchanged over the period of the run. Figure 4 also illustrates one of the fundamental accounting identities of the stock-flow consistent model, namely that the sum of all financial assets and liabilities across all sectors, ie the net financial worth of the economy as a whole, is zero. In short, the results of Scenario 1 appear to indicate that there is no categorical 'growth imperative' embedded in the structure of a debt-based money with interest-bearing debt in the capitalist economy.
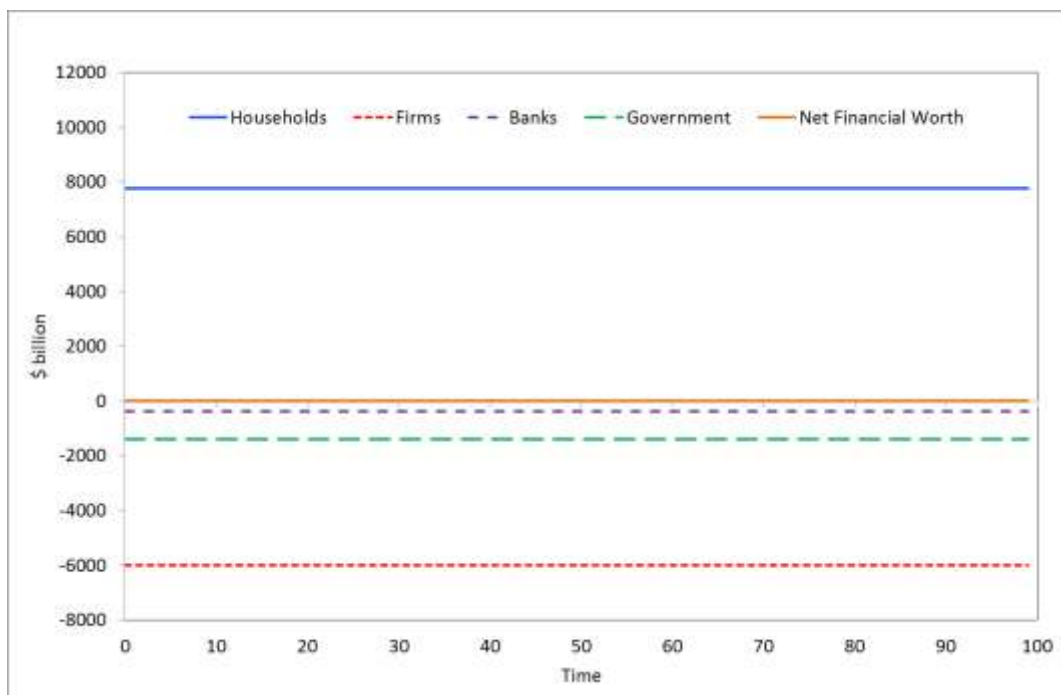
Figure 4: Financial net worth of FALSTAFF sectors (Scenario 1)

Our next aim is to test the robustness of this finding, once values depart from the equilibrium values defined at t = 0. Scenario 2 subjects consumer demand to a small random variation within a range of $\pm 2.5\%$ of the initial value, C_0, of consumer demand. In other words, within each period consumer spending is assigned a random value in the range $[0.975C_0, 1.025C_0]$. All other initial values for both stocks and flows are the same as in Scenario 1. The impact on the growth rate from this variation is shown in Figures 5 and 6.
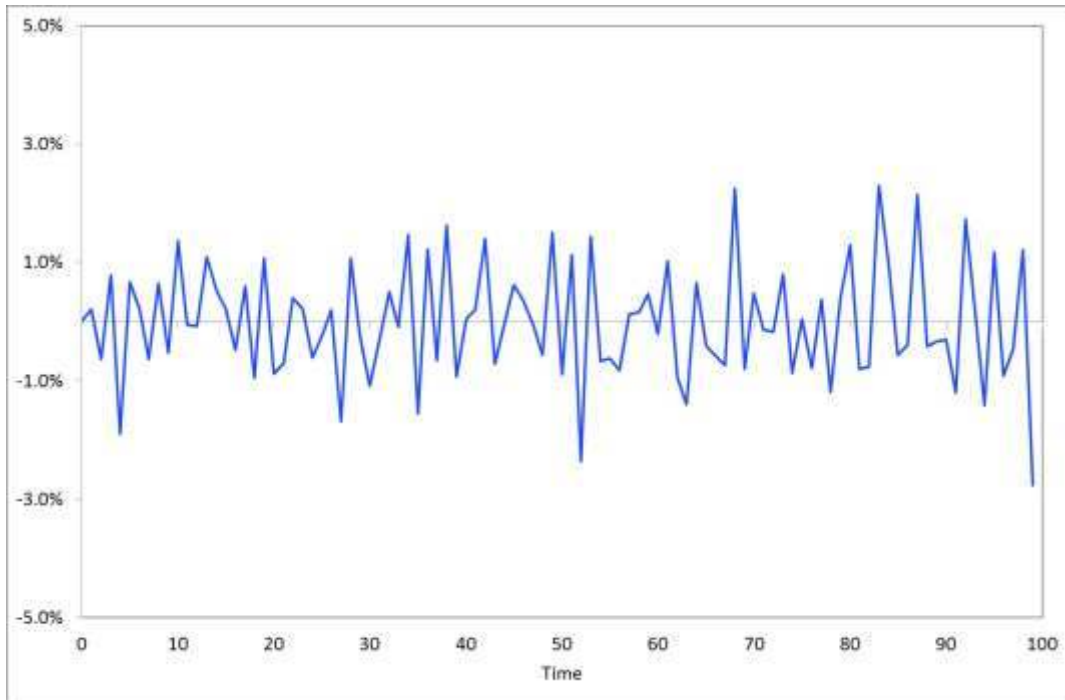
Figure 5: Growth rate under random fluctuations in consumer demand (Scenario 2)
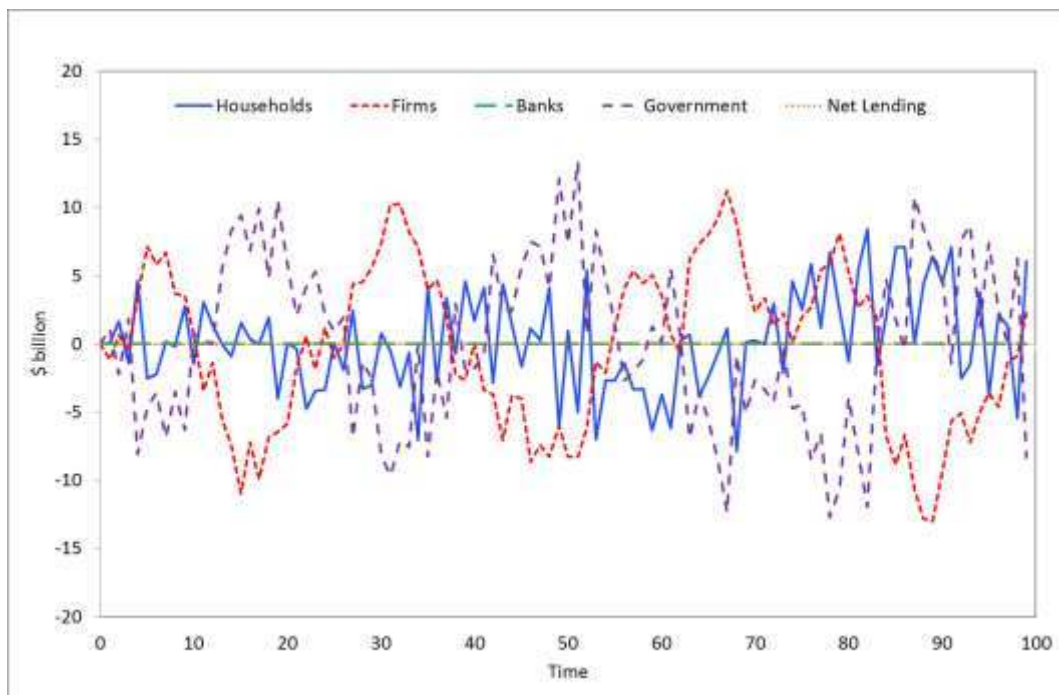
Figure 6: Net lending under random fluctuations in consumer demand (Scenario 2)

Although Figure 5 shows considerable variation in the short term growth rate (within a range slightly greater than $\pm 2.5\%$) 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 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.
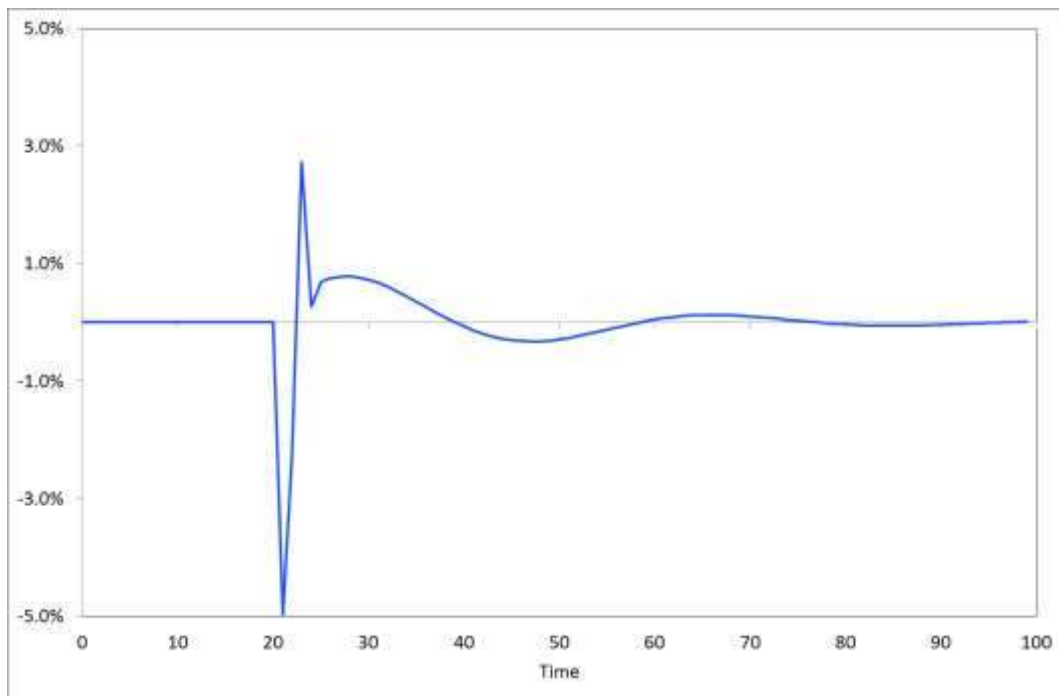
Figure 7: Growth rate after a one-off negative consumption shock (Scenario 3)

Scenario 3 tests the resilience of the stationary state solution under a single consumption shock. Consumer demand is depressed by 5% in periods 20 and 21 of the scenario, and thereafter returns to the initial value. All other values are unchanged. The results of this scenario are illustrated in Figures 7 and 8. As might be expected, Figure 7 shows a sharp downward spike in the growth rate, followed by a sharp upward spike (above the long-run zero growth rate) as 'normal' consumption behaviour resumes in period 22. Thereafter, the growth rate rather quickly returns to something close to zero, but tends to oscillate around zero for some time, approaching zero asymptotically as the economy 'settles down' again.

The net lending behaviours of different sectors (Figure 8) show a similar pattern, with rather high initial movements away from the equilibrium position, which tend to attenuate over time as the growth rate flattens towards zero. Figure 8 reveals that some individual sectors switch from being net lenders to net borrowers and back again several times during this process of readjustment. As in Figure 6, only the banking sector maintains a net lending position very close to zero. In spite of having the flexibility to retain some proportion of profits in order to meet financing needs (equation 32), this turns out not to be necessary most of the time, with the outlay on new loans, bonds and reserve requirements more or less matching the inflow of new deposits. The sector most negatively affected in the early years following the shock is the government sector which experiences a dramatic increase in the deficit.
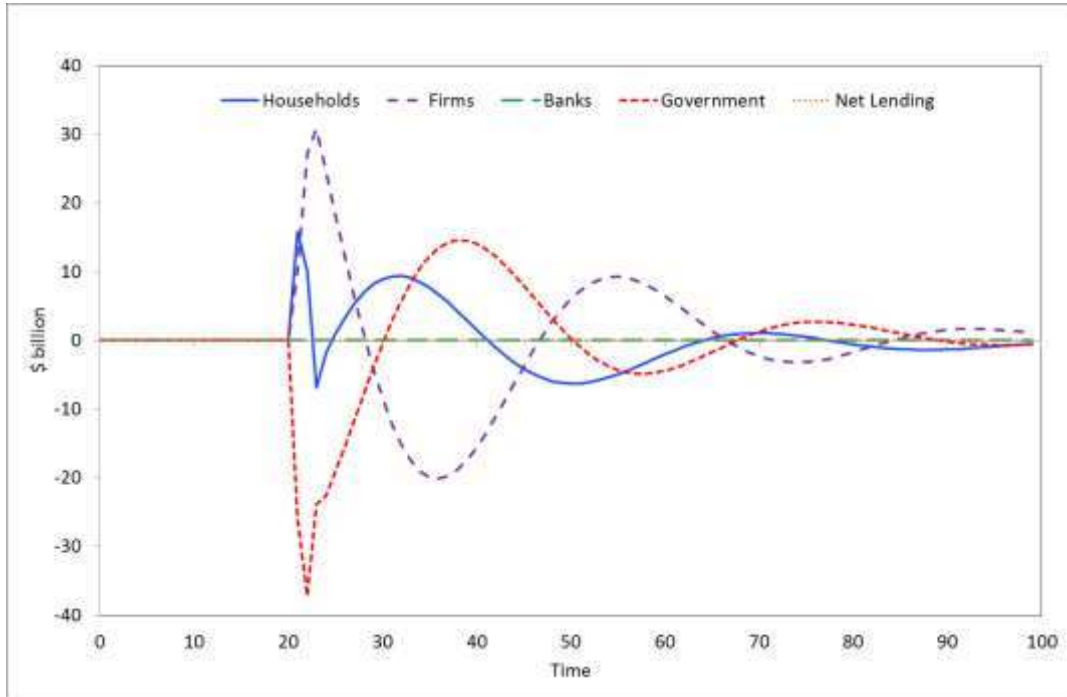
Figure 8: Net lending after a one-off negative consumption shock (Scenario 3)

At this point, the government is faced with some critical choices about how to respond. Instinctively, of course it may want to respond to the increased deficit either by increasing taxation or by reducing spending. In Scenario 4, we test the outcome of strict 'austerity' policy on the shock introduced in Scenario 3. Figure 9 provides a graphic illustration of how things can go wrong if governments cut back spending too fast in order to reduce a fiscal deficit. In this (admittedly extreme) case, the government insists on trying to return the fiscal deficit to zero, resulting in a spectacular collapse of the FALSTAFF economy.
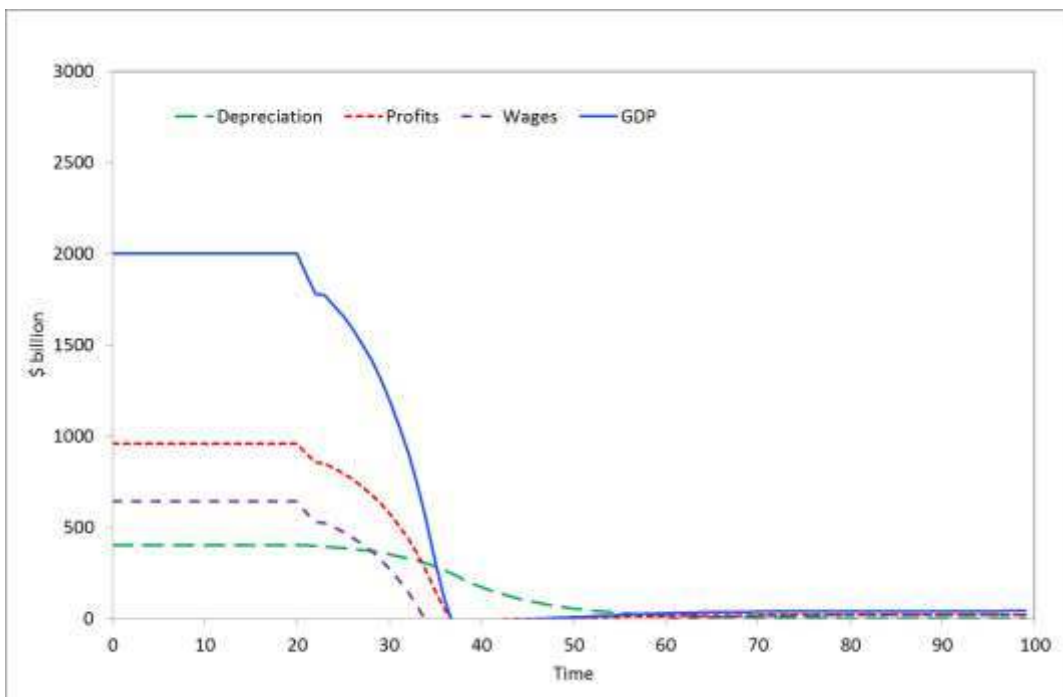
Figure 9: Economic collapse from 'strict' austerity after a negative shock (Scenario 4)

It is also useful to think a little about the potential responses of firms to the sudden change in circumstances represented by the one-off consumption shock established in Scenario 3, in particular in relation to their investment behaviour. The investment function introduced in equation (19) sets out a behavioural response by firms to changes in expected demand, depending on two factors:

$$I_{net} = \gamma(K^\tau - K_{-1}). \tag{48}$$

The first factor (represented by the expression in brackets in equation (48)), is the perceived shortfall or surplus in capital stock, determined on the basis of a target capital stock required to meet the expected demand. If expected demand rises, the target capital will be higher than the capital in the previous year, and so the expression in brackets will be positive and firms will seek to undertake net investment. In this case, gross investment is greater than the depreciation of the capital stock. If expected demand falls, the expression in brackets will be negative and firms will seek to disinvest. In this case the gross investment is less than the depreciation of the capital stock.

The second key element in equation (48) is the 'accelerator coefficient', γ, which is a measure of the desired 'speed of adjustment' undertaken by firms in response to changes in demand. Higher values of γ will increase the responsiveness of firms to a change in demand, lower values of γ will decrease the responsiveness. A higher value for γ can be thought of as capturing a high degree of what Keynes (1936) called 'animal spirits'; that is: a greater willingness amongst entrepreneurs to invest when times are good, and a lower willingness to invest when things are not going so well. To test the impact of animal spirits on the FALSTAFF economy, in the wake of a consumption shock, we looked at the impact of increasing the γ coefficient (from 0.1 to 0.15) throughout Scenario 5. The result is illustrated in Figures 10 and 11.
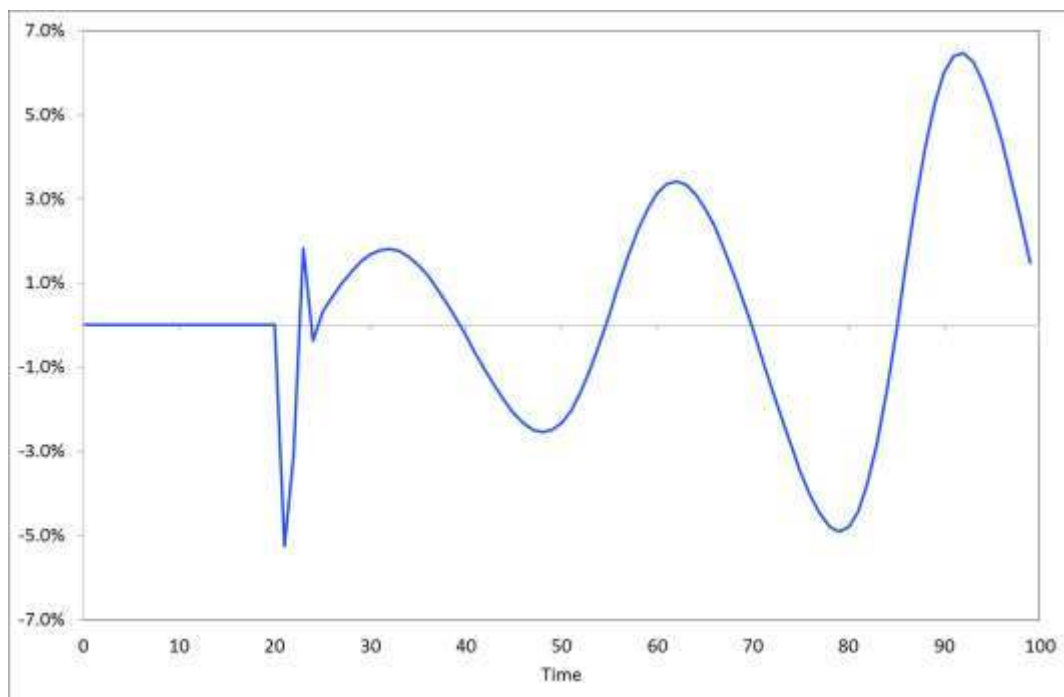

Figure 10: The growth rate after a demand shock with 'animal spirits' (Scenario 5)
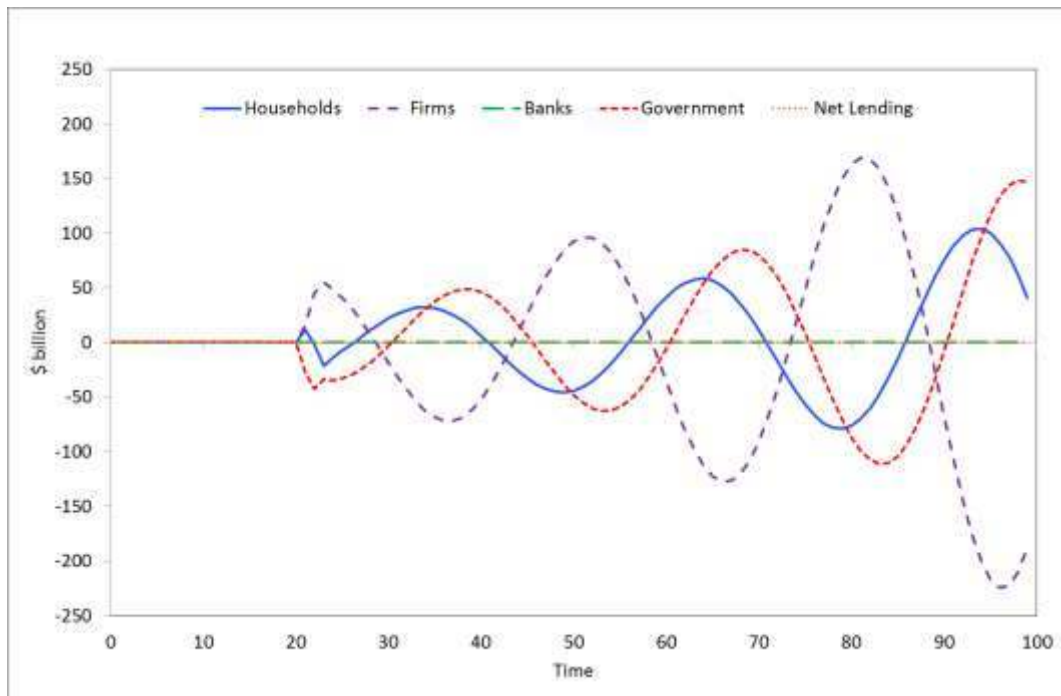
Figure 11: Net lending after a demand shock with 'animal spirits' (Scenario 5)

We assume in this exercise that animal spirits are a long-term feature of the economy and do not change over time. So the new value of γ is applied from the beginning. Interestingly, this has no impact while the economy is in a stationary state. This is because the capital shortfall (the expression in brackets in equation (48)) is zero during this time. Consequently the value of the accelerator coefficient is irrelevant. Once the economy is shocked out of its stationary state however, things are different: the higher coefficient immediately sets in motion a cyclical pattern of increasing amplitude, with every sign of becoming unstable.[18] In the real world such a dynamic would lead to numerous uncomfortable consequences, including high unemployment, price instability, and widely fluctuating net lending positions (Figure 11).

A core concept in Keynesian and post-Keynesian economics is the idea of countercyclical spending; that is: the idea that governments can play a useful stabilising role in an unstable economy by increasing spending when output is falling and reducing spending when output is rising. In Scenario 6, we explore the impact of countercyclical spending as a possible policy response to the situation in Scenario 5. Following the consumption shock (as in Scenario 3) in an economy with high animal spirits (as in Scenario 5), the government in the FALSTAFF economy responds by increasing spending at the same rate as the expected aggregate demand is falling when the economy is in recession and reducing spending at the same rate as expected aggregate demand is rising when the economy is growing. The results of this scenario on the growth rate are illustrated in Figure 12, where we also show for comparison the growth rates for scenarios 3 and 5. Remarkably, a countercyclical spending response more than compensates for the destabilising influence of animal spirits following the demand shock. The FALSTAFF economy is returned more quickly to a quasi-stationary state than in scenario 3, with only slight long-run deviations from zero growth and no net accumulation.

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[18]   In fact, running the model to 200 periods reveals a collapse in stability.
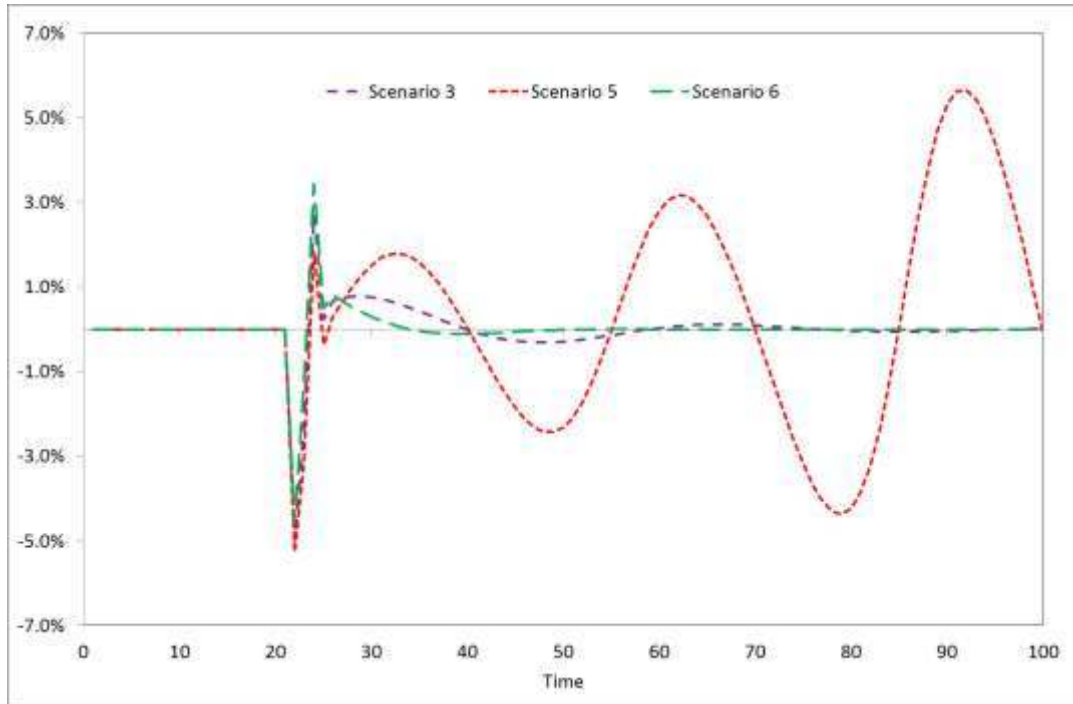
*Figure 12: Stabilising influence of countercyclical spending
after a demand shock with 'animal spirits' (Scenario 6)*

Finally, we explore two scenarios in which the economy is initially growing, in other words where the economy starts away from the stationary equilibrium. We are interested to find out if the ability to achieve a stationary state depends on a particular starting position, in which the sectors are all in balance, with no net lending and zero growth. What would happen if the economy was already growth, and accumulating debts or assets in different sectors? Is it still possible to more towards a stationary or quasi-stationary state from these conditions with positive interest rates? Or is such an economy destined to either grow for ever or become unstable?
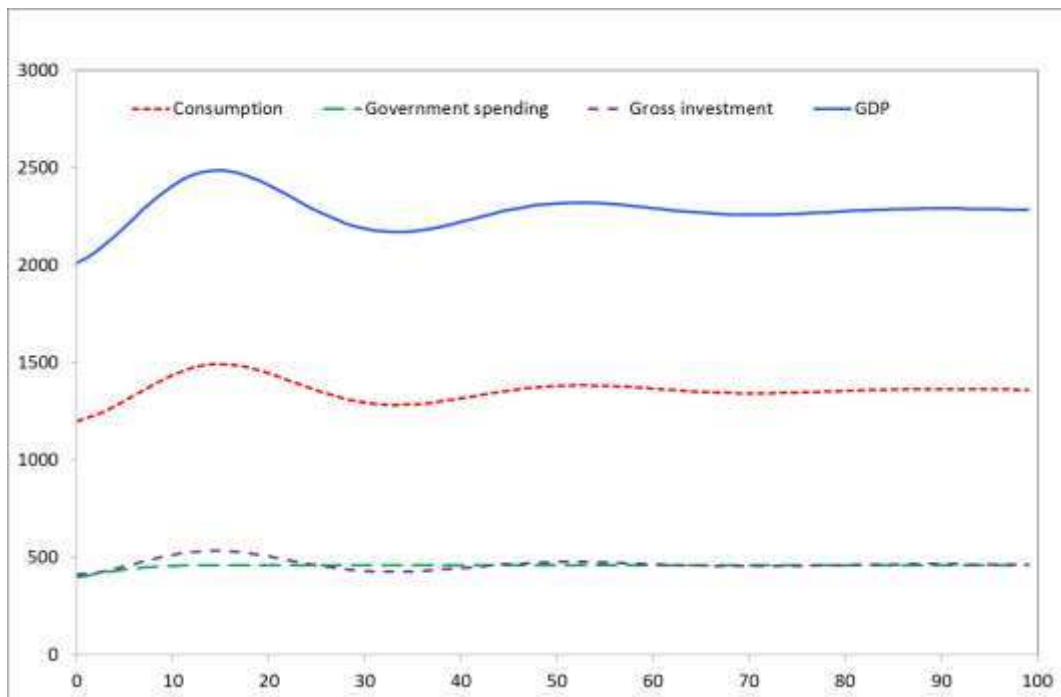

Figure 13: Rise and fall in GDP during transition from growth to stationary state (Scenario 7)

In Scenario 7 (Figures 13 and 14), we suppose that the initial growth rate in government spending is 2% per annum, and that the initial expected growth in output, disposable income and household wealth is also 2% per annum. We assume that these conditions pertain for the first three periods of the scenario, but that after this point, government begins slowly to reduce the growth rate in spending until by period 13 of the run, it has declined to zero. Figure 13 reveals that the transition to a stationary state is in fact possible; but it takes some time before the perturbations induced by 'animal spirit' responses die down. These oscillations are also visible in the net lending positions (Figure 14).
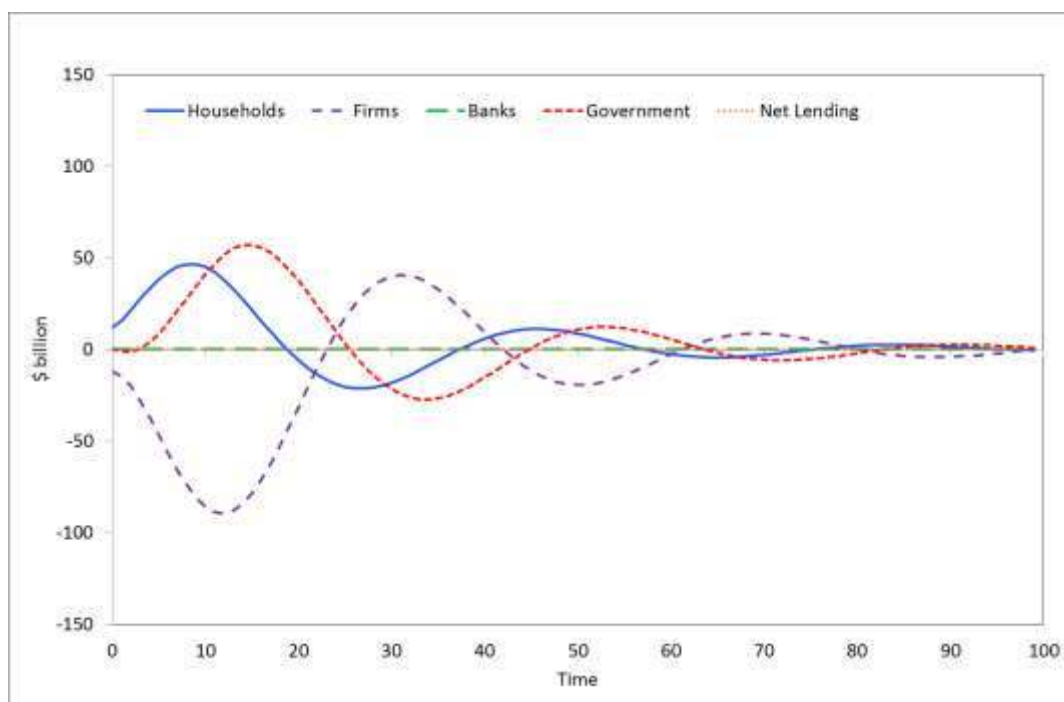

Figure 14: Net lending during transition from growth to stationary state (Scenario 7)

In Scenario 8 therefore, we adopt a similar strategy to the one illustrated in Scenario 6, in which government offsets the negative impacts of investment in uncertain times by a pattern of countercyclical spending. The decline in the growth of government spending is moderated by whatever is happening to the overall growth rate of the economy. If growth in the economy is declining faster than the desired growth rate, government spending is increased above the target rate. If it is declining slower than the desired rate, spending growth is reduced faster than the target rate. The outcome of this scenario is shown in Figure 15. The initial perturbations are significantly reduced, and the transition to a stationary state is swifter than before and relatively smooth.

These results are certainly encouraging. They appear to indicate that the ability to reach a stationary or quasi-stationary state of the FALSTAFF economy is not simply a result of judiciously chosen values in which the stationary state already pertains. For any real-world economy, it would be necessary to map the initial conditions carefully and to identify strategies by which any pernicious dynamics from the process of convergence could be mitigated, either through fiscal policy (as in the countercyclical strategy tested here) or through other measures designed to 'calm' animal spirits, maintain employment or otherwise reduce potential instabilities that may arise. In principle however, the results described in this section suggest that the existence of debt-based money is not inimical to a stationary or quasi-stationary state of the economy.
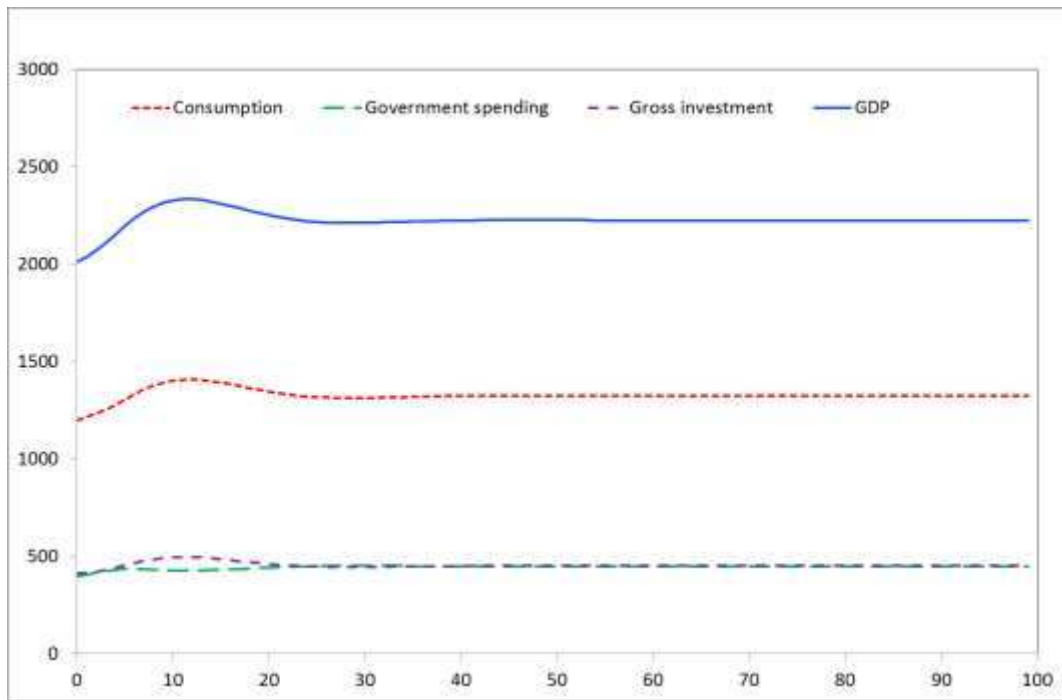
Figure 15: Transition to stationary economy with countercyclical spending (Scenario 8)

5. Discussion

The aim of this paper was to explore the potential for a stationary (non-growing) economy with debt-based money. To this end, we presented a stock-flow consistent (SFC) system dynamics model (FALSTAFF) of a hypothetical closed economy with private ownership and interest-bearing debt. Behavioural aspects of the model included the propensity to consume out of both income and wealth, a simple accelerator model of firms' investment, and positive requirements on banks for capital adequacy and central bank reserves. Contrary to claims in the literature, we found no evidence of a growth imperative arising from the existence of a debt-based money system per se.

In fact, we presented a variety of scenarios which exemplified quasi-stationary states of various kinds, and which offered resilience from instability in the face of random fluctuations, demand shocks, and exaggerated 'animal spirits'. We also simulated a transition from a growth-based economy towards such a state. None of the scenarios were sensitive to modest changes in the values for interest rates, capital adequacy requirements or reserve ratios. 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. In this case, it was the austerity policy, rather than the existence of debt, that crashed the model.

The exercise in this paper is subject to a number of caveats and limitations. In the first place, we assumed a 'closed' economy, in which net trade was zero throughout. In addition, prices were excluded from the model, meaning that inflationary or destabilising price effects could not be explored. In Scenarios 1 to 6, we chose values for key variables such that real economy aggregates were not introducing expansionary effects. For instance, the model assumes no demographic changes which might require a rise in government expenditure even for a non-expanding population. Taxation is set so that government debt does not accumulate. Firms financing behaviour is determined in such a way as not to accumulate capital assets beyond those deemed necessary to satisfy expected demand. There is no attempt to model housing investment and house price inflation, both of which may well introduce expansionary dynamics into the economy. Some of these assumptions can be relaxed by the user in the online version of the model. Others are the subject of ongoing exploration (Jackson and Victor 2015).

It is worth pointing out that, in spite of the findings in this paper, 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,[19] this form of money can lead to 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

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[19] Useful critiques of debt-based money can be found in Sigurjónsson 2015, Daly 2014, Wolf 2014, Farley et al 2013, Jackson and Dyson 2012, Wray 2012, Keen 2011, Huber and Robinson 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 (1930); for a historical overview see Dittmer 2015.

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.

Interestingly, the exercise in this paper has shown that, in spite of these incentives, a transition to a stationary economy is theoretically possible. We have illustrated in particular the role of countercyclical spending by government in smoothing that transition. Encouragingly, we have shown that it is possible to get from a growth-based economy to a quasi-stationary state without either destabilising the economy or dismantling the concept of interest-bearing debt.

References

BIS 2011. Basel III: A global regulatory framework for more resilient banks and banking systems. Basel Committee on Banking Supervision, Bank for International Settlements, Basel.

Brainard, W and J Tobin 1968. Pitfalls in financial model building. *The American Economic Review* 58(2): 99-122.

Caverzasi, E and A Godin 2015. Post-Keynesian stock-flow-consistent modelling: a survey. *Cambridge Journal of Economics* 39(1): 157-187.

Copeland, M.A 1949. Social accounting for money flows. *The Accounting Review* 24(3): 254-264.

Daly, H 2014. *From Uneconomic Growth to a Steady-State Economy*. Cheltenham: Edward Elgar

Dittmer, K 2015. 100 per cent reserve banking: a critical review of green perspectives. *Ecological Economics* 109: 9–16.

Douthwaite, R 1990. *The Growth Illusion. How Economic Growth Enriched the Few, Impoverished the Many and Endangered the Planet*. Cambridge: Green Books.

Douthwaite, R 2006. *The Ecology of Money*. Cambridge: Green Books. Online at: http://www.feasta.org/documents/moneyecology/pdfs/chapter_one.pdf.

Eisenstein, C 2012. We can't grow ourselves out of debt, no matter what the Federal Reserve does. Guardian, 13th Sept: http://www.theguardian.com/commentisfree/2012/sep/03/debt-federal-reserve-fixation-on-growth.

Farley, J, M Burke, G Flomenhoft, B Kelly, D Forrest Murray, S Posner, M Putnam, A Scanlan and A Witham 2013. Monetary and Fiscal Policies for a Finite Planet. *Sustainability* 5: 2802-2826.

Godley, W 1999. Seven Unsustainable Processes: medium term prospects for the US and for the world. NY: Levy Economics Institute. Online at: http://www.levyinstitute.org/pubs/sevenproc.pdf.

Godley, W and Lavoie, M 2007. *Monetary Economics – An Integrated Approach to Credit, Money, Income, Production and Wealth* London: Palgrave Macmillan.

Huber, J and J Robertson 2000. *Future Money*. London: New Economics Foundation.

Jackson, A and B Dyson 2012. *Modernising Money: why our monetary system is broken and how it can be fixed.* London: Positive Money.

Jackson, T 2009. *Prosperity without Growth – economics for a finite planet*. London: Routledge.

Jackson, T and P Victor. 2011. Productivity and work in the new economy: some theoretical reflections and empirical tests. *Environmental Innovation and Societal Transitions* 1(1): 101-108.

Jackson, T and P Victor 2015a. Towards a stock-flow consistent ecological macroeconomics. PASSAGE working paper 15/02. Guildford: University of Surrey.

Jackson, T and P Victor 2015b. Does low growth increase inequality? Some theoretical reflections and numerical simulations. *Ecol Econ*. http://dx.doi.org/10.1016/j.ecolecon.2015.03.019.

Jorgenson, Dale W. 1963. Capital Theory and Investment Behavior". *American Economic Review* **53** (2): 247–259.

Keen, S 2011. *Debunking Economics – revised and expanded edition*. London and New York: Zed Books.

Lavoie, M and W Godley 2001. Kaleckian models of growth in a coherent stock-flow monetary framework: a Kaldorian view. *Journal of Post Keynesian Economics* 24(2): 277-311.

Mill, J S 1848. Of the Stationary State. In *Principles of Political Economy*. Online at: http://panarchy.org/mill/stationary.1848.html.

Minsky, H 1994. Financial Instability and the Decline (?) of Banking: Public Policy Implications. *Hyman P. Minsky Archive.* Paper 88. http://digitalcommons.bard.edu/hm_archive/88.

Piketty, T 2014. *Capital in the 21st Century*. Harvard: Harvard University Press.

Sigurjónsson, F 2015. Monetary Reform: a better monetary system for Iceland. A report commissioned by the Prime Minister of Iceland. Online at: http://www.forsaetisraduneyti.is/media/Skyrslur/monetary-reform.pdf.

Tutulmaz, O and P Victor 2013. Labor Oriented Stock Adjustment Model Estimations of Total Investment for Canadian Industries, International Proceedings of Economics Development and Research, Volume 69, pp. 18-24.

UN 1993. UN System of National Accounts 1993. New York: United Nations.

UN 2008. UN System of National Accounts 2008. New York: United Nations.

Van den Belt, M 2004. *Mediated Modelling: A System Dynamics Approach to Environmental Consensus Building.* Washington DC: Island Press.

Victor, P 2008. *Managing without growth - slower by design, not by disaster*. Cheltenham: Edward Elgar.

Wolf, M 2014. Strip private banks of their power to create money. *Financial Times*, April 25th 2014.

Wray, R 2012. *Modern Money Theory: a primer on macroeconomics for sovereign monetary systems*. New York and London: Palgrave Macmillan.