Analysis

Does credit create a 'growth imperative'? A quasi-stationary economy with interest-bearing debt

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ABSTRACT

This paper addresses the question of whether a capitalist economy can ever sustain a 'stationary' (or non-growing) state, or whether, as often claimed, capitalism has an inherent 'growth imperative' arising from the charging of interest on debt. We outline the development of a dedicated system dynamics macro-economic 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, credit creation by banks, and private equity. Contrary to claims in the literature, we find that neither credit creation nor the charging of interest on debt creates a 'growth imperative' in and of themselves. This finding remains true even when capital adequacy and liquidity requirements are imposed on banks. We test the robustness of our results in the face of random variations and one-off shocks. 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. Nonetheless, there remain several good reasons to support the reform of the monetary system. Our model also supports critiques of austerity and underlines the value of countercyclical spending by government.

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1. Introduction

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 state[1] of the real economy. This argument has its roots in the writings of Marx (1867) 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 paper 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 a 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 is a form of growth imperative is intuitively appealing, but has been subject to

[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 elsewhere to refer to a non-growing economy (Daly, 2014 eg), for several reasons. First, the term steady state is employed in the post-Keynesian literature to describe a state of the economy in which "the key variables remain in a constant relationship to each other" (Godley and Lavoie, 2007:71) 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, the terminology of the "stationary state" harks back to early classical economists such as Mill (1848), emphasising the pedigree behind the idea of a non-growth-based economy. Finally, as one of our reviewers pointed out, the term "steady state growth" was commonly found in the literature (Hahn and Matthews, 1964: 781; Solow, 1970: Ch 1) prior to Daly's concept of a steady state economy.

remarkably little in-depth economic scrutiny. A notable exception is a 2009 paper by Mathias Binswanger which 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 (2009) 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 his 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) seeks to ensure that banks have sufficient capital to cover the risk associated with certain kinds of assets (primarily loans). Binswanger maintains that this requirement is 'crucial for establishing the growth imperative' (op cit: 713). 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 modelling 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; Rosenbaum, 2015).

In the current paper, we seek to address this limitation. 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 the real and the financial economy and describe the calibration of this model with empirically plausible data. Our principal aim is to test the ability of the model to provide for a stationary state. We also explore the stability of the model under one-off shocks and random fluctuations in consumer demand, and under different responses from government and commercial firms. Finally, we test the potential for transitions from growth states of the economy into stationary states and discuss the implications of these findings for capitalism and for 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'. 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; and 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 these principles bring not just to an understanding of conventional macroeconomic aggregates like the GDP but also to the underlying financial flows and balance sheets. It is notable that Godley (1999) was one of the few economists who predicted the crisis 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 test the consistency of 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 all monetary flows. The full FALSTAFF model (Jackson et al 2015) 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 practises. 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 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. Fig. 1 illustrates the top-level structure of financial flows for the simplified version of FALSTAFF described in this paper.

The familiar 'circular flow' of the economy is visible (in red) towards the bottom of the diagram in Fig. 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. These balances provide a ready test of consistency in the model.
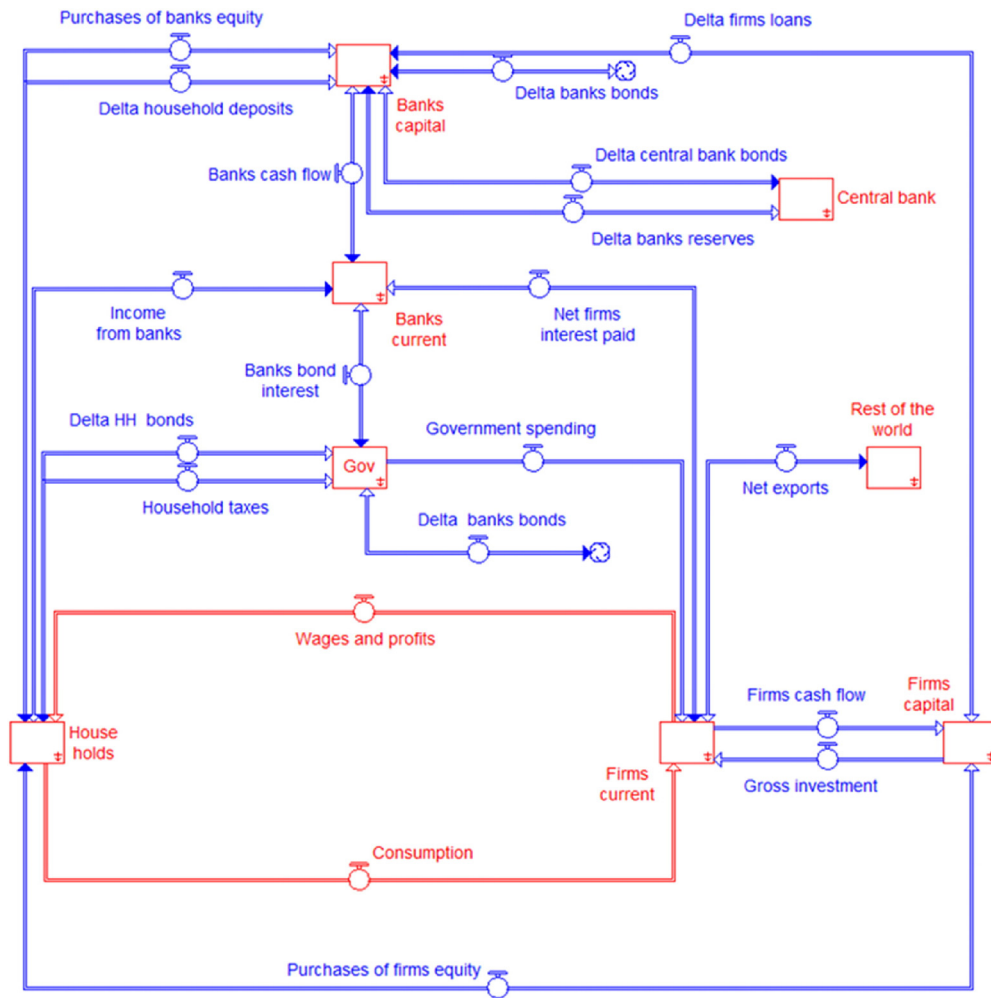

Fig. 1. An overview of the FALSTAFF 'stationary state' model.

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 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 saving may in principle be distributed between 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 saving, once bond and equity purchases have been made, is allocated to paying down loans or building up deposits. If saving is 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 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. For the purposes of this paper, we explore three

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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 saving is 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).

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[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.

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 (i.e., an 'austerity' policy in which government balances the fiscal budget), and one in 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 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.

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 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. Some developed countries (including the UK and Canada) no longer retain formal reserve ratios, 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 FALSTAFF issue equities to households. This 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.

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 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.

Though central to the real economy, and in particular the environmental impacts of production and consumption, we are less interested in this paper in the precise nature of 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 household saving. The second major input to production is labour. Employment in FALSTAFF is assumed to take place via the firms sector 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 investment. Firms' surpluses can either be used to pay down loans or to increase firms deposits D_f. 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.

The transaction flows matrix (eg Godley and Lavoie, 2007: 39) for FALSTAFF (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 ten 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 saving of the household sector. Note that the top rows of column 2 (firms' current account) represent a simplified form of the conventional GDP accounting identity:

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

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 10) 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.[9]

3. Analysis

The aim of this paper is to explore the hypothesis that the creation of money through interest-bearing debt necessarily 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:

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

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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.

[9] These identities are established in FALSTAFF via the accounting structure shown in Fig. Error! Reference source not found., in such a manner that the 'stock' associated with each monetary sector must always be empty. This structure therefore provides for a ready visual check on the consistency of the model.

Table 1
Financial balance sheet for the FALSTAFF stationary state economy.

	Households	Firms	Banks	Central bank	Government	Total
Net financial worth	$D^h + E + B^h - L^h$	$-L^f - E^f + D^f$	$L + R + B^b - D - E^b$	$B^{cb} - R$	$-B$	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

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). A numerical example of the financial balance sheet for FALSTAFF – representing the initial state of the model – is shown at Appendix 2.

where $i_{B^h} = r_B B^h_{-1}$ is the interest paid on the stock of bonds held by households, $i_{D^h} = r_D D^h_{-1}$ is the interest paid on households deposits and $i_{L^h} = r_L L^h_{-1}$ 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 saving S^h, we adopt a consumption function of the form (Godley and Lavoie, 2007 eg):

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

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:

$$Y^{hde} = Y^{hd}_{-1}\left(1 + \frac{\left(Y^{hd}_{-1} - Y^{hd}_{-2}\right)}{Y^{hd}_{-1}}\right). \tag{5}$$

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 saving is 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 FALSTAFF (Jackson et al., 2014, Jackson et al 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 the stationary state version of the model, however, we assume simply that households purchase all equities issued by firms and absorb the bonds not taken up by banks (and the central bank).

Table 2
Transaction flows matrix for the FALSTAFF stationary state economy.

	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)	$+P^{fd} + P^{bd}$	$-P^f$	$+P^{fr}$	$-P^b$	$+P^{br}$			0
Depreciation (δ)		-δ	+δ					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)	$-\Delta D^h$	$-\Delta D^f$			$+\Delta D$			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)	$+\Delta L^h$		$+\Delta L^f$		$-\Delta L^b$			0
Σ	0	0	0	0	0	0	0	0

The change in household deposits is then determined as a residual according to:

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

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 saving, 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:

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

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 Eq. (1) plus any interest $i_{D^f} = r_D D^f_{-1}$ received on deposits. From these revenues, firms must pay wages W, distribute dividends P^{fd}, and make interest payments $i_{L^f} = r_L L^f_{-1}$ on loans. Wages are calculated according to:

$$W = wLE, \tag{11}$$

where the labour employed LE is given by:

$$LE = \frac{GDP}{\eta} \tag{12}$$

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:

$$\eta = \eta_0 e^{g_\eta t}, \tag{13}$$

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

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

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:

$$w = w_0 e^{g_\eta t}, \tag{15}$$

and accordingly that wages W are given by:

$$W = \frac{w_0 e^{g_\eta t}}{\eta_0 e^{g_\eta t}} GDP. \tag{16}$$

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 in 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 Eq. (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:

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

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.

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

[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.

The *banks sector* in FALSTAFF is a simplified accounting sector whose main function is to provide loans ΔL^f to (and where necessary to take deposits ΔD^f from) firms and to take deposits ΔD^h from (and where necessary 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 under the long-term targets set out under the Basel III accord, banks are required to hold capital (equity) equivalent to a given proportion of risk-weighted assets. For the purposes of this paper we take the sum of risk-weighted assets to be equal to the sum of loans L^f and L^h to firms and households respectively. Banks' capital is defined by the book value of the banks sector equity E^b according to:

$$E^b = L + R + B^b - D \tag{28}$$

where B^b are government bonds held by the banks' sector, $D = D^f + D^h$, and $L = L^f + L^h$. The long-run Basel III requirement is then met by setting a target capital adequacy ratio φ^T, such that:

$$\varphi^T = \frac{E^b}{L} = 0.08. \tag{29}$$

Assuming initial conditions in which this requirement is met, then the capital adequacy ratio is maintained by the banks' sector, provided that:

$$\Delta E^b = \varphi^T L - E^b_{-1}. \tag{30}$$

In other words, banks' issue new equities (to the households sector) equivalent to the shortfall between the required capital adequacy proportion of loans and the equity value in the previous period.[12] It is worth emphasising here that loans and deposits are determined by demand (from the household and firms sectors), reserves are determined by the reserve requirement and equities are determined by the capital adequacy requirement. The final discretionary element on the banks' balance sheet is government bonds, which we assume that banks will hold in preference to reserves where they can – ie once the reserve requirement is met – because they bring income from interest. The target value of banks' bonds B^{bT} can be determined from Eq. (28) as:

$$B^{bT} = D - R - L + E^b. \tag{31}$$

Or equivalently, using the reserve requirement to determine R and the capital adequacy ratio to determine E^b, we can write:

$$B^{bT} = D(1 - \psi) - L(1 - \varphi). \tag{32}$$

Again assuming initial conditions meet this requirement, then banks target for holding government bonds is met, provided that:

$$\Delta B^b = B^{bT} - B^b_{-1} + \Delta B^{cb}, \tag{33}$$

where the last term is included to offset the purchase of banks bonds by the central banks to meet reserve requirements.

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.[13] Hence, banks' profits P^b are given by:

$$P^b = i_{L^f} + i_{L^h} + i_{B^b} - i_{D^h} - i_{D^f}. \tag{34}$$

Banks' saving is 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' saving 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 saving equal to this. Hence, we have:

$$NL^b = \Delta L^f + \Delta L^h + \Delta B^b_{cap\,ad} - \Delta D^h - \Delta D^f, \tag{35}$$

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

$$P^{bd} = P^b - S^b = P^b - NL^b. \tag{36}$$

with NL^b given by Eq. (35).

Finally, we describe the *government sector* accounts. The current account elements[14] in the Government's account are relatively simply expressed in terms of the equation:

$$NL^g = S^g = T - G - i_B, \tag{37}$$

where taxes, T, are given by:

$$T = \theta Y^h, \tag{38}$$

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

$$i_B = i_{B^h} + i_{B^b} = r_B\left(B^h_{-1} + B^b_{-1}\right). \tag{39}$$

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 aspect 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:

$$\Delta B = -NL^g. \tag{40}$$

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:

$$NL^h + NL^f + NL^b + NL^g = 0. \tag{41}$$

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[12] We assume in this version of FALSTAFF that households purchase all equities issued by the banks sector and that the market value of equities so issued is determined by the book value of equity.

[13] 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 banks. 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.

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

Or in other words, using Eqs. (7), (8), (22), (35) and (37) above, we should expect that:

$$Y^{hd} - C - I_{net} + P^b - P^{bd} + T - G - i_{B^h} - i_{B^b} = 0. \tag{42}$$

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

$$W + P^{fd} + i_{D^h} - i_{L^h} + P^b - i_{B^b} = C + G + I_{net}. \tag{43}$$

Since $P^{fd} = P^f$ and noting that P^b can be expanded (Eq. (34)) as a sum of interest receipts (and payments), we can show that Eq. (43) can be rewritten as:

$$W + P^f + i_{L^f} - i_{D^f} = C + G + I_{net} \tag{44}$$

or equivalently that:

$$W + P^f + i_f + \delta = C + G + I \tag{45}$$

which is precisely (see Eq. (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:

$$I_0 = \delta_0 = r_\delta K_0, \tag{46}$$

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:

$$G_0 + r_B B_0 = T_0, \tag{47}$$

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 Eqs. (46) and (47) it follows that:

$$NL_0^f = NL_0^g = 0, \tag{48}$$

and hence that:

$$NL^h + NL^b = 0, \tag{49}$$

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 either rise or fall, leading to rising or falling 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 Eq. (47) is satisfied. Since $T_0 = \theta_0 Y_0^h$, we can use Eq. (2) to deduce that:

$$\theta_0 = \frac{G_0 + r_B B_0}{W_0 + P_0^{fd} + P_0^{bd} + i_0^{Bh} + i_0^{Dh} - i_0^{Lh}}. \tag{50}$$

In short, conditions (46) to (50) 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.

4. Numerical Simulation

We select first a range of numerical values to initialise the variables in FALSTAFF as detailed in Appendix 1. Drawing from empirical data in Canada and the UK,[15] 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.[16] 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.[17]

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 Eq. (50) 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 imperative. 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 Appendix 1 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;
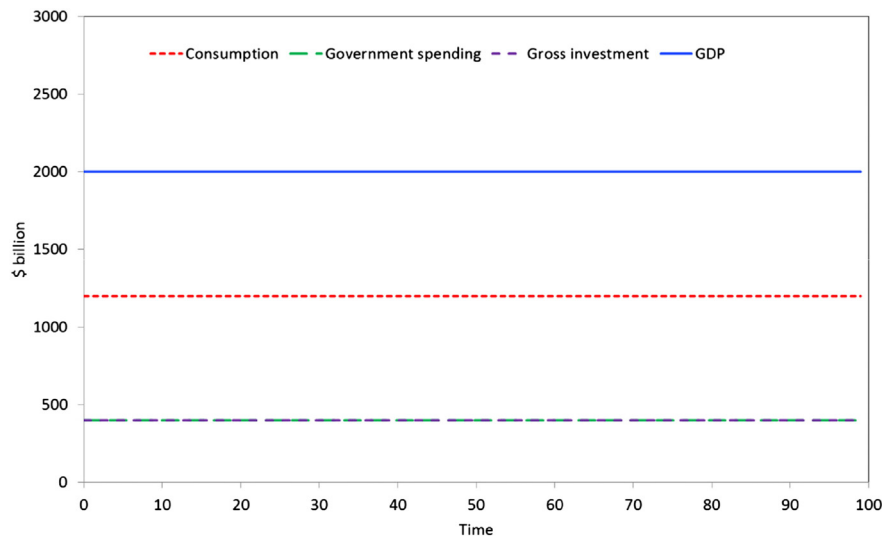- Scenario 5: firms respond to Scenario 3, with a version of Keynes'

Fig. 2. GDP on an expenditure basis (Scenario 1).

'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.

Finally, we explore a scenario in which the economy is initially growing and then moves towards a stationary state.

• 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.

The results of Scenario 1 are illustrated in Figs. 2 and 3. Fig. 2 shows the GDP on an expenditure basis. The graph itself is not particularly interesting other than that it confirms, 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 this result is 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.

Since net lending in the stationary state is equal to zero for all sectors, it is to be expected, and Fig. 3 confirms, that the net financial worth of each of the FALSTAFF sectors remains unchanged over the period of the run. Fig. 3 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.

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 Figs. 2 and 3 do not depend on specific values chosen for the interest rates on deposits, loans and bonds;[18] nor do they depend on the specific values chosen for capital adequacy or reserve ratio; although, not surprisingly, the steady state tax rate (Eq. (50)) changes when these parameters are altered. In short, the results of Scenario 1 appear to indicate that there is no categorical 'growth imperative' embedded in

the structure of a credit-based money system with interest-bearing debt in the capitalist economy.

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 ± 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 Figs. 4 and 5.

Although Fig. 4 shows considerable variation in the short term growth rate (within a range of less than ± 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 (Fig. 5) 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 Figs. 4 and 5 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.

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 Figs. 6 and 7. As might be expected, Fig. 6 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 (Fig. 7) 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. Fig. 7 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 Fig. 5, only the banking sector maintains a net lending position very close to zero. In spite of having the

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[18] 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.
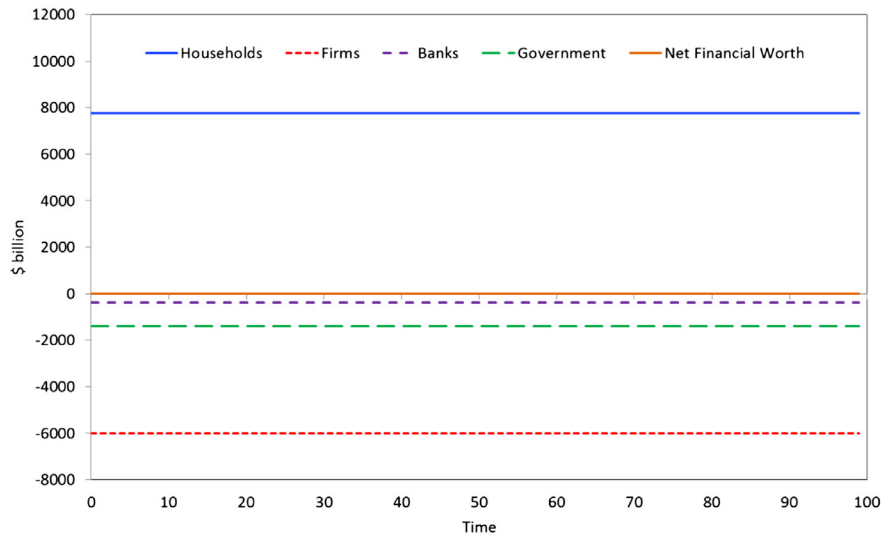
Fig. 3. Financial net worth of FALSTAFF sectors (Scenario 1).

flexibility to retain some proportion of profits in order to meet financing needs (Eq. (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.

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. Fig. 8 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.

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

Eq. (19) sets out a behavioural response by firms to changes in expected demand, depending on two factors:

$$I_{net} = \gamma(K^\tau - K_{-1}).\qquad(51)$$

The first factor (represented by the expression in brackets in Eq. (51)), 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 Eq. (51) 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
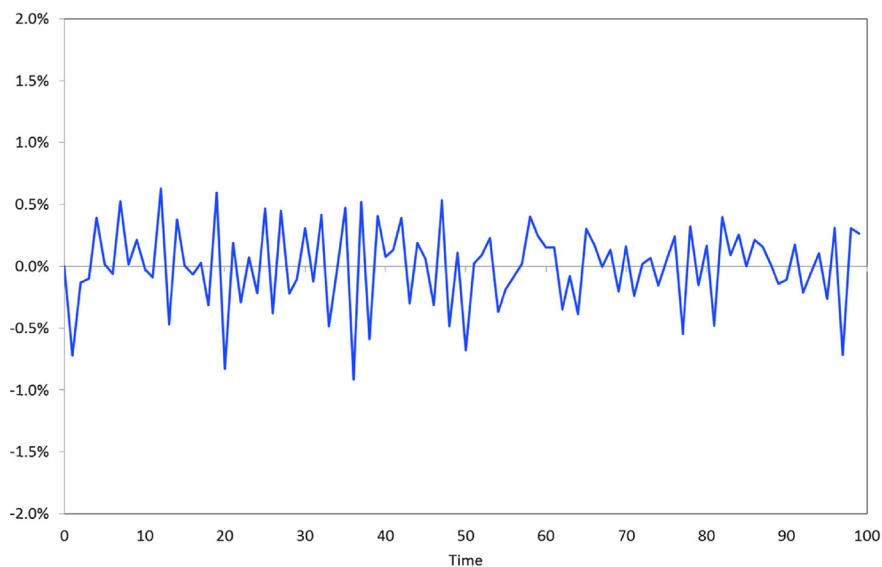

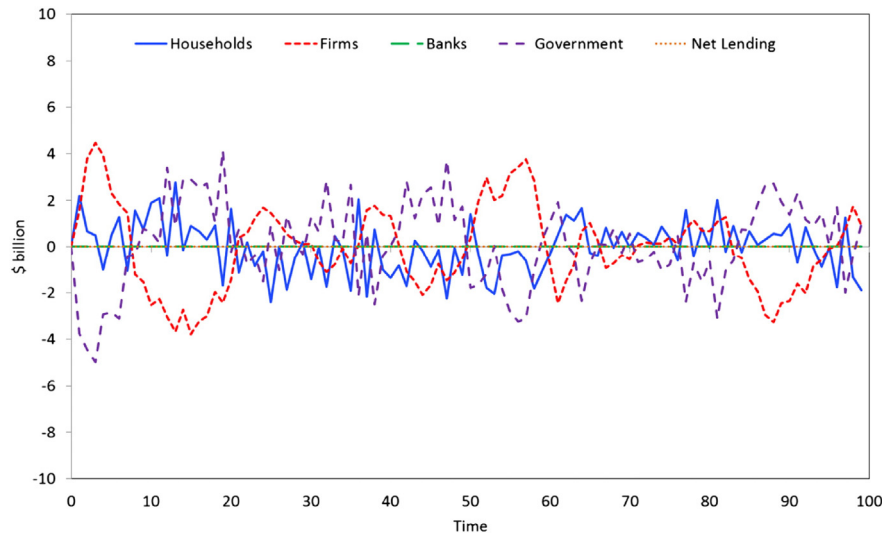Fig. 4. Growth rate under random fluctuations in consumer demand (Scenario 2).

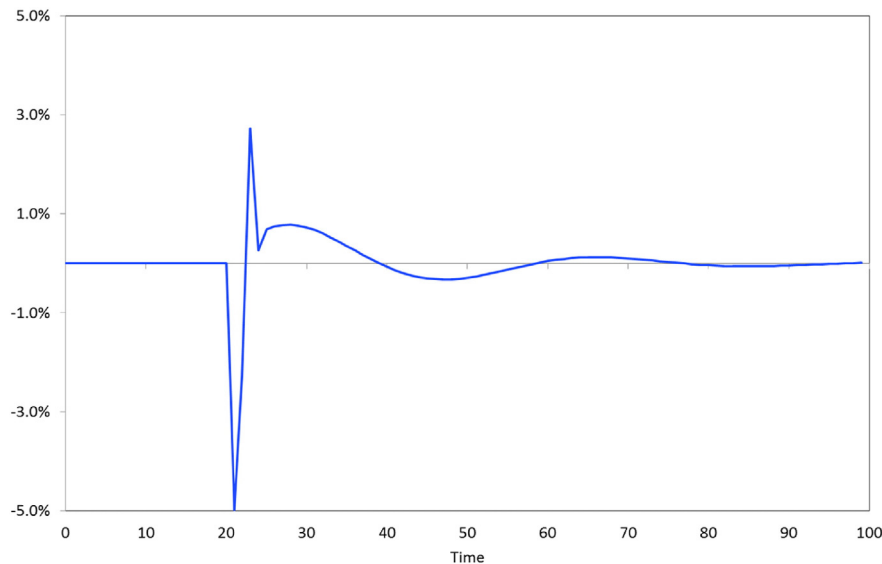**Fig. 5.** Net lending under random fluctuations in consumer demand (Scenario 2).

Fig. 6. Growth rate after a one-off negative consumption shock (Scenario 3).

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 Figs. 9 and 10.

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 Eq. (51)) 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.[19] In the real world such a dynamic would lead to numerous uncomfortable consequences,

including high unemployment, price instability, and widely fluctuating net lending positions (Fig. 10).

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 consequences on the growth rate are illustrated in Fig. 11, 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.

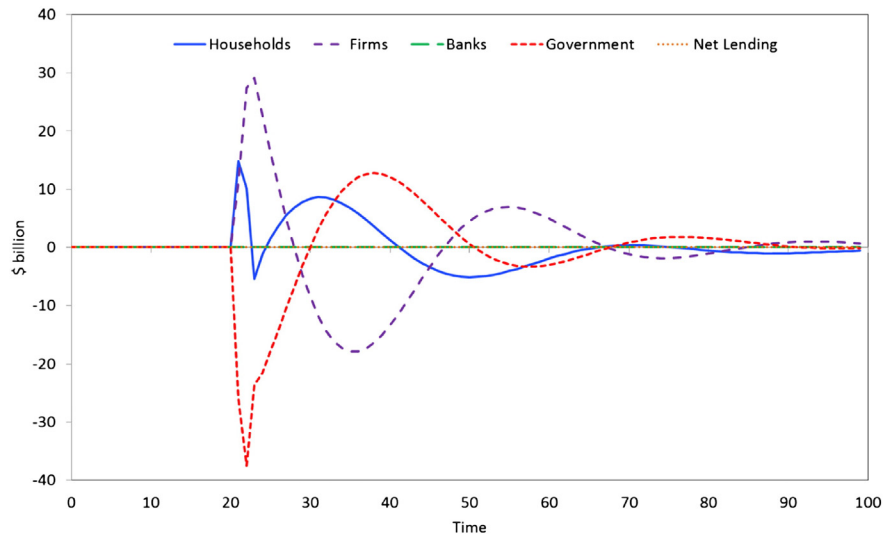[19] In fact, running the model to 200 periods reveals a collapse in stability.

Fig. 7. Net lending after a one-off negative consumption shock (Scenario 3).
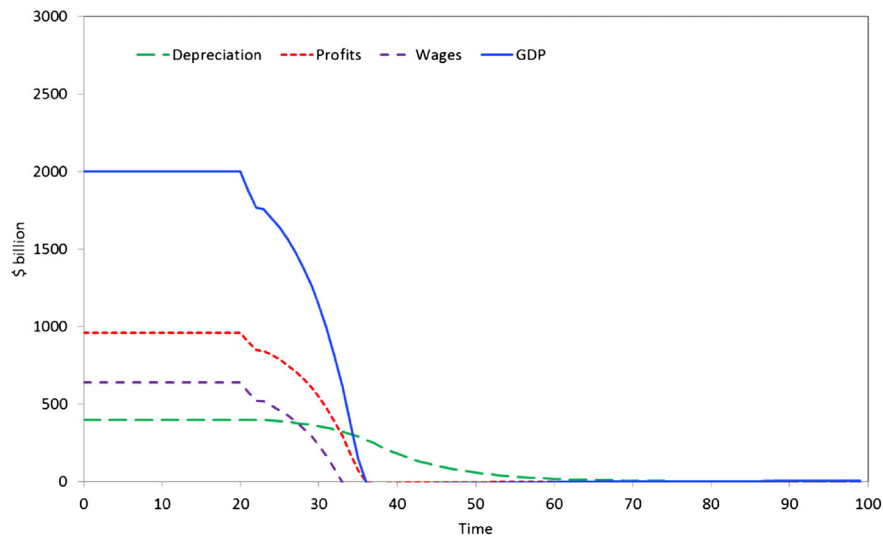
Fig. 8. Economic collapse from 'strict' austerity after a negative shock (Scenario 4).

Finally, we explore a scenario 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 growing, and accumulating debts or assets in different sectors? Is it still possible to move 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?

In Scenario 7 (Figs. 12 and 13), 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. Fig. 12 illustrates this transition in terms of the GDP for the FALSTAFF economy. It appears that the transition to a (quasi-) stationary state is indeed 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 (Fig. 13). Again it can be shown, that countercyclical spending by government dampens the oscillations associated with this transition.[20]

Fig. 12 also shows that the pattern of transition in the GDP is echoed in the money supply. It is interesting to note, however, that the oscillations in the money supply lag those in the GDP, suggesting that in the FALSTAFF economy at least, changes in the money supply are driven by what is happening in the real economy, rather than the other way around. Increased output demands increased loans from firms creating a higher level of deposits from households. Fig. 13 also shows the velocity of circulation of money which is calculated endogenously in

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[20] 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. See Scenario 8 in the online version of the model at: http://www.prosperitas.org.uk/falstaff_steadystate.
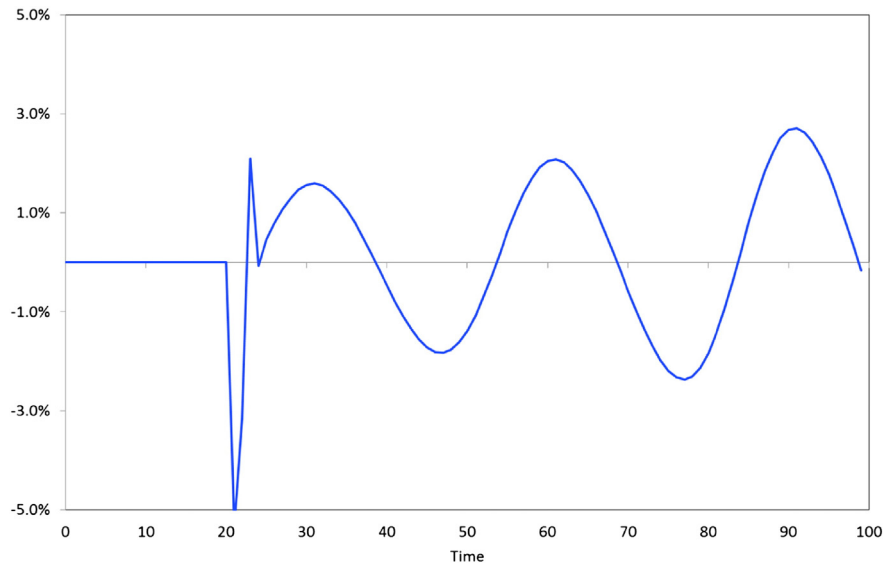
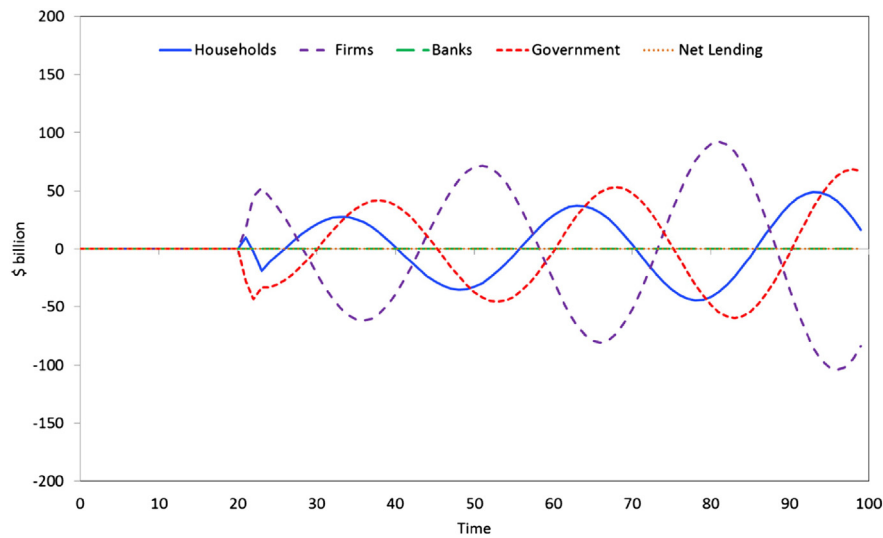**Fig. 9.** The growth rate after a demand shock with 'animal spirits' (Scenario 5).

Fig. 10. Net lending after a demand shock with 'animal spirits' (Scenario 5).

FALSTAFF through the ratio of *GDP* to the money supply.[21] Because money supply lags demand, the velocity of money increases initially in order to maintain aggregate demand.

5. Discussion

The aim of this paper was to explore the potential for a stationary (non-growing) economy in the presence of credit creation and interest-bearing debt. To this end, we presented a stock-flow consistent (SFC) system dynamics model (FALSTAFF) of a hypothetical closed economy with private ownership and credit-based money. Behavioural aspects of the model include the propensity to consume out of both income and wealth, a simple accelerator model of firms' investment, and

requirements on banks to maintain a minimum positive capital adequacy ratio and sufficient 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 on deposits, loans and government bonds.[22] Perhaps most significantly from our point of view, these conclusions are not changed by imposing demands on banks to maintain a given capital adequacy ratio or to hold a given

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[21] Since prices are not included in the model, conventional formula $Mv = pT$, where M is the money supply, v the velocity of money, p the price level and T the volume of transactions, reduces to $MV = GDP$. *GDP* is given by the model; M is taken as the sum of deposits and reserves and V can then be calculated as $V = GDP/M$.

[22] 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.
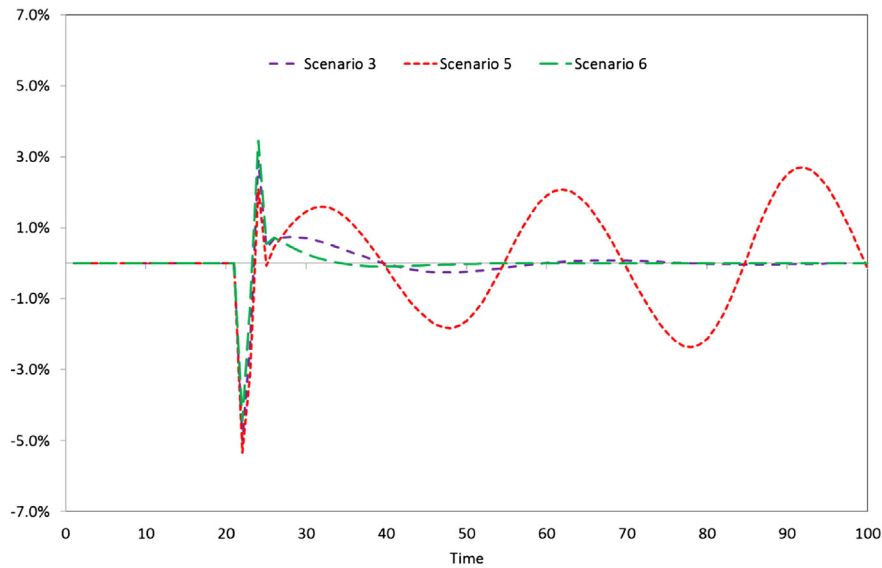
Fig. 11. Stabilising influence of countercyclical spending after a demand shock with 'animal spirits' (Scenario 6).

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.

The fact that the charging of interest on its own does not lead to a growth imperative could perhaps have been inferred from the realisation that the only interest payments which contribute directly to the GDP are the net interest payments of firms. All other interest payments turn out to be transfers between sectors and neither restrict nor enhance aggregate demand in themselves. Clearly net interest payments of firms will increase if firms' loan requirements expand; and this will happen if, for instance, firms decide to expand investment. But in this case, growth is driven directly by expansion in aggregate demand, not by the charging of interest in itself.

Slightly more surprising perhaps is that neither capital adequacy nor reserve ratio requirements change this conclusion. At the heart of the growth imperative hypothesis lies the claim that banks' capital is somehow money that is 'withheld' from the economy. Admati and Hellwig (2013:6) claim that this view arises from a misunderstanding of banks' capital as "cash that sits idly in the bank's tills without being put to work in the economy". In their view, this is a deliberate misrepresentation propagated by the banking lobby to "confuse regulatory debate" (Ibid). Irrespective of this point, our analysis confirms that these regulatory initiatives act neither to reduce the potential for debts to be serviced nor to expand aggregate demand.

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
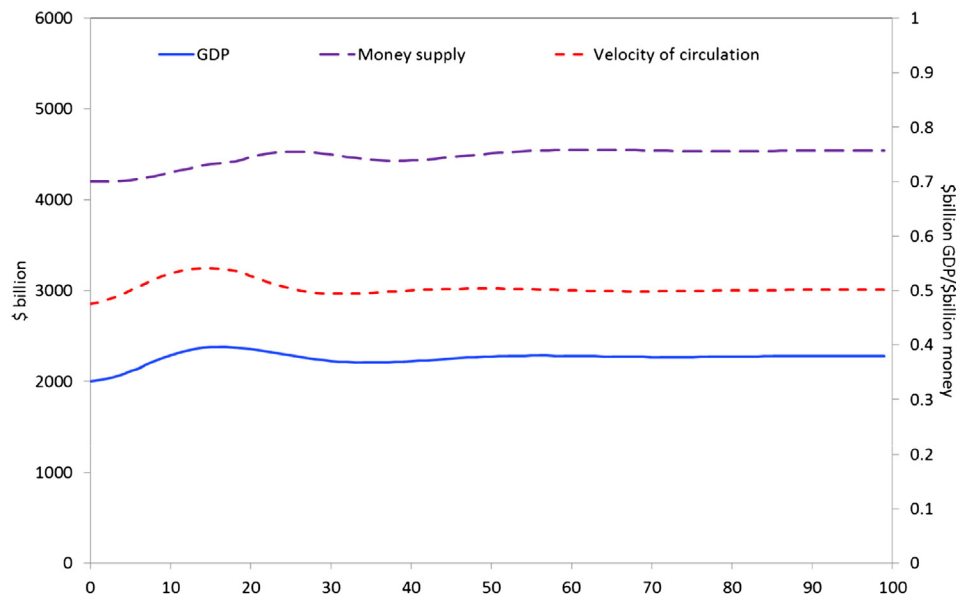

Fig. 12. GDP and the money supply during transition to a stationary state (Scenario 7).
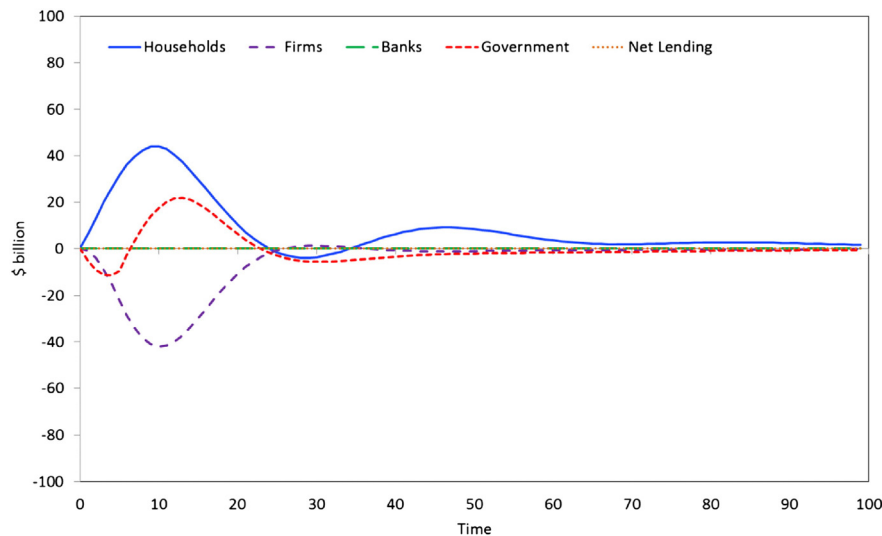
Fig. 13. Net lending positions during transition to stationary state (Scenario 7).

model, meaning that inflationary or destabilising price effects could not be explored. In Scenarios 1 to 6, we deliberately 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 initially 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 et al 2015).

It should be noted, in particular, that we have not included certain microeconomic behaviours which might be expected to lead to specifically both to a heightened monetary expansion and also to aggregate demand growth or perhaps instability. For instance, it is clear that competitive (positional) behaviour by firms through profit maximisation could expand investment (particularly when finance is cheap) in order to stimulate demand (Gordon and Rosenthal, 2003). Neither do we attempt here to model Minsky-like behaviour in which progressive over-confidence amongst lenders leads to an expansion of credit, over-leveraging and eventual financial instability (Minsky, 1994, Keen, 2011).

It is also 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,[23] 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 exist several 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.

Interestingly, the exercise in this paper has shown that, in spite of these incentives, a transition to a stationary economy from a growth-based 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.

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[23] 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.

Appendix 1
Initial values for FALSTAFF scenarios.
Sources for reference values: see note 16.

Variable	Values	Units	Remarks
Initial GDP	2000	$billion	UK GDP is currently around £1.6 trillion; Canada GDP is around CAN$1.9 trillion.
Initial consumer spending C	1200	$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	1600	$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)	6000	$billion	Based on the chosen estimate of capital to income ratio
Initial capital to income ratio	3		Ratio in Canada is a little under 3; in UK around 5.
Initial investment accelerator (γ)	0.1		Typical range for advanced economies: 0.08–0.15
Initial firms debt D_f	3000	$billion	Capitalisation split equally between debt and equity
Initial firms' loans L_f	1000	$billion	Included for completeness
Initial firms equity E_f	3000	$billion	Capitalisation split equally between debt and equity
Initial banks equity E_b	320	$billion	Calculated as the difference between banks' assets and liabilities other than equities
Initial household deposits D_h	3000	$billion	Consistent with the assumption that (broadly speaking) loans are equal to deposits
Initial household loans L_h	1000	$billion	Included for completeness
Initial household bond holdings B_h	1000	$billion	Leads to a debt-to-GDP ratio close to current levels
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	200	$billion	Chosen for consistency with reserve ratio
Initial central bank bonds B_{cb}	200	$billion	Chosen for consistency with capital adequacy ratio
Banks capital adequacy ratio	8%	%	Consistent with Basel III banking regulations
Initial banks bonds B_b	120	%	Consistent with chosen capital adequacy ratio, taking into account banks' reserve holdings.
Initial government debt B	1320	$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.

Appendix 2
Initial balance sheet for FALSTAFF scenarios.

	HH	Firms	Banks	CB	Gov	Totals
Net Financial Worth	6320	−5000	–	–	−1320	–
Assets	7320	1000	4320	200	–	12,840
Deposits	3000	1000	–	–	–	4000
Loans	–	–	4000	–	–	4000
Equities	3320	–	–	–	–	3320
Bonds	1000	–	120	200	–	1320
Reserves	–	–	200	–	–	200
Liabilities	1000	6000	4320	200	1320	12,840
Deposits	–	–	4000	–	–	4000
Loans	1000	3000	–	–	–	4000
Equities	–	3000	320	–	–	3320
Bonds	–	–	–	1320	–	1320
Reserves	–	–	–	200	–	200

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