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Modelling the dynamics of the financial-economic system: Understanding the current 'money as debt' crisis[1]

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Abstract

A system dynamics simulation model has been developed to describe the most important mechanisms governing the physical output of goods and services in the economy in interaction with the financial system. The model aims to reproduce the dynamic behaviour, in particular boom-bust cycles, of the current financial-economic system in which money is created as debt. The model is able to reproduce the basic system variables rather well, including the recession due to creation of credit for non-productive purposes, notably mortgages. The model thus confirms Werner's credit creation theory of banking and a modified form of Minsky's instability hypothesis of decentralized money creation by commercial banks causing boom-and-bust behaviour. The resulting uncertainty and volatility and the induced short-termism are obstacles for sustainable economic development pathways.

1. Introduction

Nine years after the 2007–8 financial crisis which 'no one saw coming' (Bezemer 2009), the measures to improve the financial system are limited to a marginal increase of capital ratios and strengthening of the supervisory network. Already in the 1980s, a fundamental analysis of economic instability as a consequence of credit provision to firms in the boom phase was given by the American economist Minsky, who considered it 'an inherent and inescapable flaw of capitalism' (Minsky 1986). Since the deregulation in the 1990's and in combination with ICT and globalization, the supply of credit in the form of money of debt has hugely increased and led to serious volatilities and instabilities in regional economies. In a country like The Netherlands, this manifested itself as a dramatic shift of money lending from productive investments by firms to non-

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productive mortgage lending to households (Bezemer 2015). Mainstream macro-economic models do not consider these issues adequately (e.g., Godley and Lavoie 2007, Werner 2012). Leading theories and models as well as influential textbooks in macro- and monetary economics do not feature money, causing Werner to call for "a concrete model linking banking and the economy via the reflection of a fundamental, yet usually neglected fact about banks [...]: banks create the money supply through the process of 'credit creation'" (Werner 2014).

The aforementioned instabilities have burdened many governments with large debts, partly as a result of rescuing the 'too-big-to-fail' banks that caused the crises. It leaves those governments with large interest payments and insufficient financial means to cope with the crisis and to support the necessary transformation to more sustainable economies (Daly 2011). Besides, there is evidence that the financialisation of the economy is an important cause of large and growing inequities in income and wealth; it spurs commodification and appropriation of common goods, such as in the acquisition of large amounts of arable land in low-income countries by foreign investors, the so-called land grabbing (Stiglitz 2012, Piketty 2014).

The objective of this paper is to present a dynamic simulation model in which private banks create the money supply by granting loans, rather than being just financial intermediaries that gather deposits to lend out. Such a model, along the lines Werner (2014) suggested, of interactions between the physical and the monetary economy is expected to provide a better understanding of the evolution and (in)stability of the existing financial system than current (equilibrium) models.

A neo-classical representation of the real economy is coupled to a macro bank balance, representing the financial system. The economic model is approximating real-world processes of production, consumption, investments, employment and wages. The financial model accounts for (three categories of) consumers, firms, banks and government. Using the data for the Dutch economy 1950–2010, the model is used to describe and simulate real-world economic and financial trends, in order to get a better and more widely shared insight into the credit creation theory on banking (Werner 2016) in which money is created as debt. Explorations of alternative money systems such as 'debt-free money' are presented in a subsequent paper.

The paper starts with a presentation of the basic model equations and their rationale in section 2. In section 3, we present historical data of the Dutch economy used for model calibration, and in section 4, we show the results for a default run of the Dutch economy for the period 1950–2050 in the context of money-as-debt and house price developments. In the last section, we discuss the model outcomes and present conclusions relevant for the broader sustainability debate.

2. Model description

Introduction

The Sustainable Finance (SF) model presented here is a system dynamics model that simulates the interaction between the economic and the financial system, as shown in Figure 1. The model is a compromise between the inherent complexity of the financial-economic system and model transparency.

Unlike in conventional general equilibrium models, the model consists of a number of difference equations that simulate non-equilibrium feedbacks and adjustments in general price level, investments, (un)employment, interest rates and house prices. Our approach is eclectic and builds on work done by Godley and Lavoie (2007), Hallegatte *et al.* (2008), Yamaguchi (2010, 2015), Jackson and Dyson (2012), Benes and Kumhof (2012), Van Dixhoorn (2013) and Meijers and Muysken (2016).

The *economic system* is modelled as a closed economy in which goods and services are produced using capital and labour as inputs. There are two production sectors (manufacturing and services) and three groups of consumers. Capital and labour inputs are based on marginal profitability considerations. The *financial system* is represented by a balance sheet of a hypothetical Aggregate Bank (AB). It has money from firms and consumers as deposits on the liability side. It can give loans to consumers, firms and the government. These loans enter as debts on the asset side and as deposits on the liability side. In the process, money is created as debt by (simultaneous) elongation of both the asset and the liability side of the bank balance. The *government* redistributes wealth by taxation and social payments and invests in and spends on societal functions (education, infrastructure etc.). The model simulates the interactions between producers (firms), consumers, banks and government in both physical and monetary terms, with an aggregate price as the conversion factor.

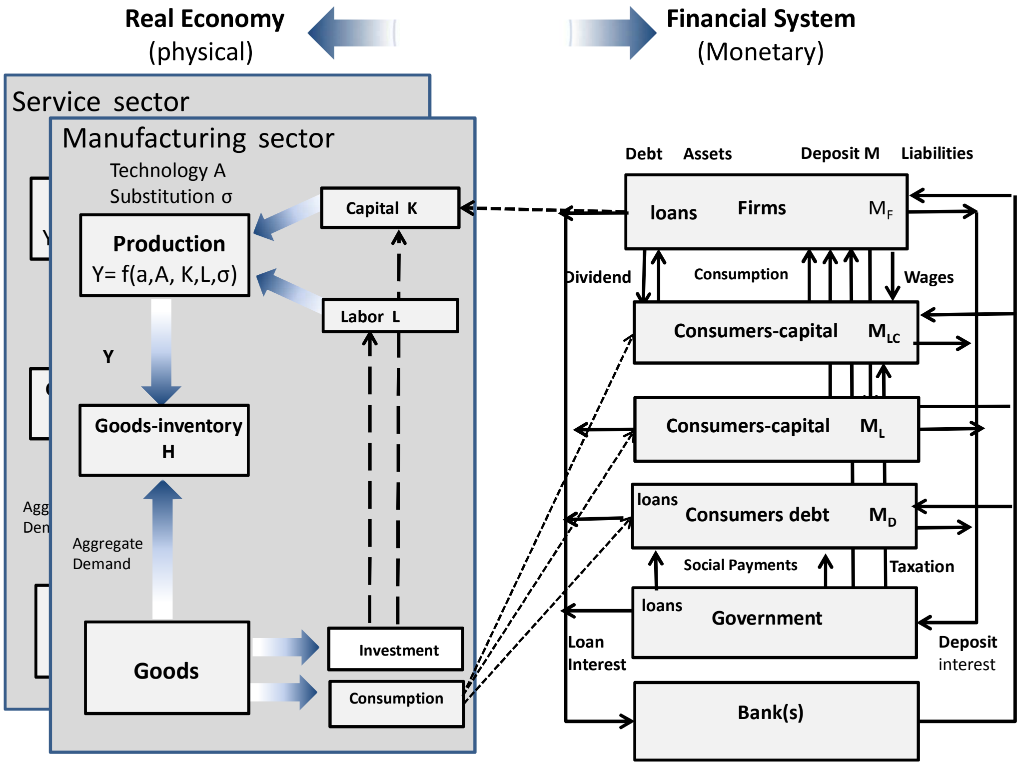

Figure 1. A schematic representation of the two parts of the Sustainable Finance model: the 'real', physical economy on the left hand side and the financial monetary system on the right hand side, and their interconnections for the manufacturing sector. The corresponding connections between the service sector and the financial system are not shown.

The Economic System

The mechanisms governing output in the real economy are summarized in Figure 2. Total output (or production) Y consists of (non-durable) consumption goods and services and (durable) investment goods such as machinery, equipment, buildings and infrastructure. The output of the manufacturing and service sectors, YM and YS respectively, is often simulated by means of a simple Cobb-Douglas (CD) production function with a declining marginal capital productivity upon substitution of capital for labour. There is empirical evidence, however, of an increasing share of capital in the production process and in the national income, one explanation being the subsequent waves of generic technologies such as ICT and robots (Piketty 2014, Jackson and Victor 2016). This suggests an increasing capital productivity for increasing capital-labour ratios. This can be accounted for by using a Constant Elasticity of Substitution (CES) production function (Arrow et al. 1961; Jackson and Victor 2014) with a value of the capital-labour substitution elasticity larger than 1:

$$Y(K, L, \sigma) = \left(a\times K^{\left(\frac{\sigma-1}{\sigma}\right)} + (1-a)(A\times L)^{\left(\frac{\sigma-1}{\sigma}\right)}\right)^{\left(\frac{\sigma}{\sigma-1}\right)} \qquad [G/yr]^{3} \qquad (1)$$

with the parameter which distributes production (initially) to capital *K* and labour *L* and *A* representing technology- and organization-driven increase in labour productivity. The latter is assumed to follow an exogenous exponential trend. For $\sigma = 1$, the CES production function is undefined but equivalent to the simpler CD production function:

$$Y = K^{\alpha}(A\times L)^{1-\alpha} \qquad [G/yr] \qquad (2)$$

The exponent α in Eq. 2 represents the (now fixed) output elasticity of capital and equals in this formulation the fraction of output that falls on the factor capital. In the results section, we will explore the difference between using a CES ($\sigma > 1$) production function and the simpler CD production function. In the simulations presented in this paper, the CES production function is applied.

The goods and services are exchanged on the market at the aggregate price of goods and services, p_M and p_S respectively, which links the *physical* economy of production and the *monetary* economy of income for employees and investors through the following identity:

$$pY = wL + \pi_{gross} = wL + (\rho + \delta + \varepsilon)p_k\times K \qquad [M/yr] \qquad (3)$$

with w the wage rate and wL the rewards for labour, π_{gross} the gross profits, ρ the interest rate at which firms can lend money (see below), δ the depreciation rate and ε a fraction that represents the extra capital costs for coping with environmental effects. The term $(\rho + \delta + \varepsilon)p_K\times K$ is the flow of interest and dividend paid to capital owners and reinvested profits. Positive values for ε account for the internalization of external costs, e.g., climate change damage and mitigation and adaptation costs as part of the energy transition. Because demand and supply will not match due to the difference between what producers expect to produce and consumers are willing to spend, we simulate an adjustment process via the sectoral price *p* which is discussed further on.

[3] Throughout the text, we indicate stocks and flows in the 'real' physical economic system with G[oods] and in the financial monetary system with M[oney] units.

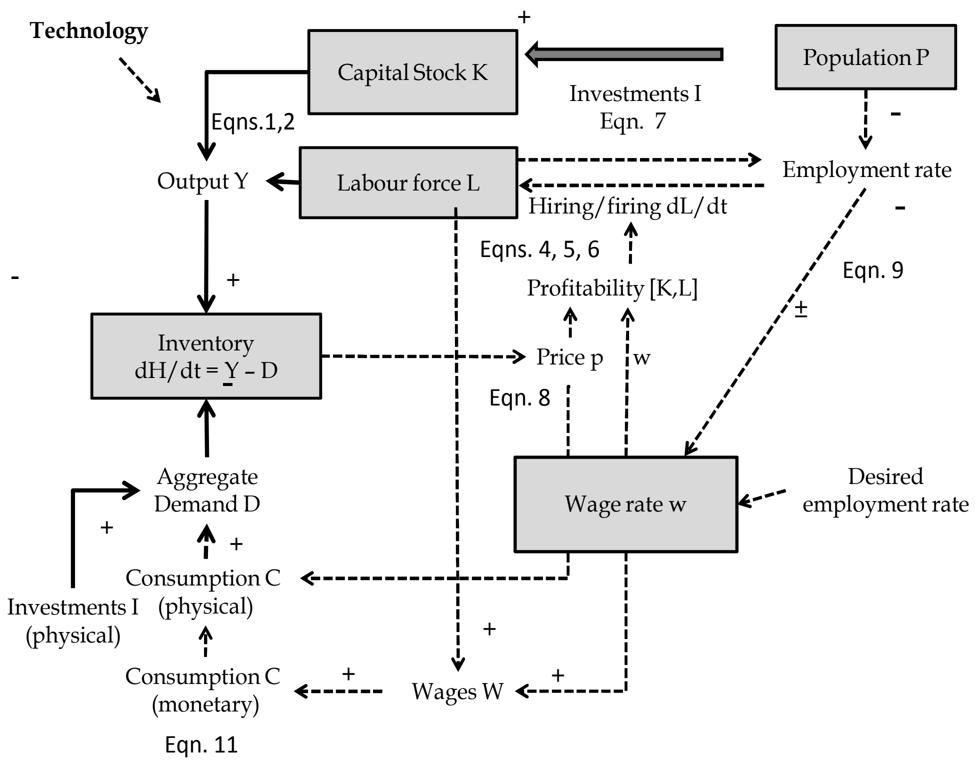

Figure 2. A Diagram of the real economy model. Grey boxes indicate stocks that are governed by differential equations. Solid arrows indicate physical flows; dashed arrows indicate informational flows. Corresponding equations in the text are indicated. The distinction between manufacturing and service sectors is not shown.

Growth of output is assumed to happen when investments are made in order to satisfy growth in demand. It is assumed that investment only takes place as long as the additional profits from higher output sales exceed the cost of the additional investment, i.e. as long as the net marginal capital productivity is positive, including environmental costs. Similarly, additional labour is hired until the marginal labour productivity exceeds net revenues. Thus, the desired levels of the capital and labour stocks are both driven by their respective marginal productivities. In this way the economy tends towards a steady-state in which production is efficient in the sense that it occurs on the production frontier given by the production function at employment level *L* and capital stock level *K* with an optimal, i.e. least over-all cost *K-L-ratio*. The following formulas simulate the dynamics.

Labour input: (un)employment

For an increase in the labour force *dL*, the marginal production in each sector will increase at a rate of $p \times dY$ in monetary terms. The cost of this additional labour equals $w \times dL$ with w the wage level in monetary units per hour. The marginal profit rate per additional labour unit expressed in wage units can thus be written as:

$$\pi_L = \frac{p.\,dY - w\,dL}{w\ \ dL} = \frac{p}{w}\frac{\partial Y}{\partial L} - 1 \qquad [-] \qquad (4)$$

Given the diminishing return character of the production function, additional labour input results in decreasing marginal labour productivity $\partial Y/\partial L$ and the marginal profit rate tends towards zero. The change in the labour force dL is some function of π_L (see, e.g., Keen 2013). In first instance the simplifying assumption is made that the relationship is linear. In equation form, one gets:

$$\frac{dL}{dt} = \frac{\pi_L}{\tau_L} L = \frac{1}{\tau_L}\left(\frac{p}{w}\frac{\partial Y}{\partial L} - 1\right) L \qquad \text{[hr/yr]} \qquad (5)$$

The parameter τ_L indicates the response parameter and represents labour market frictions and inertia.[4] The equation says that as long as an additional unit of labour yields an (expected) net gain, i.e. $p\, dY > w\, dL$ or $pY > wL/(1-\alpha)$, more labour will be hired, at a rate proportional to the marginal labour productivity expressed in wage units $p\,(\partial Y/\partial L)/w$. Using a CD function for which $\partial Y/\partial L = (1-\alpha)Y/L$, it is seen that $\pi_L = 0$ for $(1-\alpha)\, p\, Y = w\, L$ at which level the net profit rate from labour force expansion has fallen to zero. This is the equilibrium value to which our simulated economy tends to go.

Capital input: investment and depreciation

Similarly, investors increase the capital stock with an amount dK until the marginal profitability of an additional unit of capital becomes zero i.e. until the net profit in monetary units equals the additional output $p\, dY$ minus the cost of the additional capital. The additional costs of an increase dK is $p_K\, (\rho\, dK + \delta\, dK)$, with p_K the price of one unit of capital (see, e.g., Mankiw 2007). The variable ρ indicates the interest rate at which the firm can get a loan or some other form of capital on the capital market. It is set equal to the interest rate for loans ρ_l introduced in section 2.3. The marginal profit rate per additional capital expressed in capital cost units can now be expressed as:

$$\pi_K = \frac{p\, dY - p_K\,(\rho+\delta+\varepsilon)\, dK}{p_K(\rho+\delta+\varepsilon)dK} = \frac{p}{p_K}\frac{\partial Y}{\partial K}\frac{1}{(\rho+\delta+\varepsilon)} - 1 \qquad [-] \qquad (6)$$

Assuming that the price of capital p_K follows the general price level ($p/p_K \sim 1$), investments will only be made if the marginal capital productivity $\partial Y/\partial K$ exceeds $(\rho+\delta)$.

The change in the capital stock dK will, besides depreciation, be some function of the (expected) profit of investing additional capital which reflects the willingness of entrepreneurs to invest. Again assuming that the relationship is linear, the dynamic equation for capital K, and thus (intended) net investment I, becomes in physical units:

$$I_{net} = \frac{dK}{dt} = \frac{\pi_K}{\tau_K} K = \frac{1}{\tau_K}\left(\frac{\partial Y}{\partial K}\frac{1}{(\rho+\delta+\varepsilon)} - 1\right) K \qquad \text{[G/yr]} \qquad (7)$$

In which τ_K is again a response parameter, now representing the time period over which entrepreneurs respond to the (change in) return on investment. In the CD production function $\partial Y/\partial K = \alpha\, Y/K$, this equation states that firms will invest in new production opportunities as long as the (expected) profits are positive, that is, $dY > (\rho+\delta+\varepsilon)\, dK$ or $\alpha Y > (\rho+\delta+\varepsilon)\, K$.

Prices and wages

Demand as given by consumer spending and supply as given by the levels of capital and labour stocks – because we do use a utilization rate of one for simplicity – will not be equal in our model

[4] This parameter is also called relaxation time; a similar parameter is used in the other process descriptions. A small value means a rather fast adjustment. A high value implies a rather slow adjustment, which often leads to oscillations as the deviations are not fast enough corrected. In the present model simulations, they are assumed to be constant throughout the simulation period.

as will be explained later. Thus, an adjustment mechanism is needed that drives supply and demand towards equilibrium. Setting an initial value for p_M and p_S, we apply a change in the sectoral price p to regulate the demand-supply adjustment (Hallegatte *et al.* (2008).[5] If actual output ('supply') Y differs from the aggregate demand D – discussed further on –, there is a surplus (inventory) or a shortage (unmet demand), indicated by $dH/dt = Y – D$. For $Y > D$, the inventory H increases and as a result the price p will decline which permits consumers to purchase more goods and services at the same wages (and the same amount of money in circulation). For $D > Y$, the reverse will happen. This formulation guarantees a long-term 'conservation of mass' (Hallegatte et al. 2008). In equation form:

$$\frac{dp}{dt} = -\frac{p}{\tau_p}\left(\frac{H}{D}\right) \qquad \text{[M/G/yr]} \qquad (8)$$

With τ_p again the response parameter representing the inertia in the system. Note that the price p is constant if $H = 0$ and $dH/dt = 0$.

A similar adjustment mechanism is supposed to operate on the labour market. In a market economy, a shortage of labour will drive up wages whereas a surplus will do the reverse. The wage level w is thus assumed to be dependent on the employment level (Rose 1967; Hallegatte et al. 2008):

$$\frac{dw}{dt} = w\frac{(e - e_{des})}{\tau_w} \qquad \text{[M/hr/yr]} \qquad (9)$$

with e the employment level which equals L/L_{max} with L_{max} the maximum size of the labour force. The parameter τ_w is again a response parameter. The wage rate w is assumed to be constant when the actual employment level e equals a socially acceptable or desired employment level e_{des}, which is associated with full employment equilibrium. If e exceeds this desired level of employment e_{des}, in a tense labour market, the change in wage rate dw/dt is positive and w tends to rise. When e falls below the desired level e_{des}, dw/dt turns negative and wages will start to fall.

Money stock and interest rate

The stock of money M is supposed to influence the interest rate, although the relationship is rather unclear and controversial (Werner 2012). The controversy is at least partly due to whether one assumes the loans to come from loanable, existing funds on the deposits of firms and consumers or from the creation of new money through new bank loans with a corresponding increase in the total amount of money. Setting an initial value for the interest rate ρ, we hypothesize that the relative change in interest rate is proportional to the change in investments I, relative to the money stock M_{liqass} and the relative change in the liquid money stock M_{liqass}:

$$\frac{d\rho}{\rho} = \frac{1}{\tau_I}\frac{d\,I_{total}}{M_{liq\,ass}} - \frac{1}{\tau_M}\frac{d\,M_{liq\,ass}}{M_{liq\,ass}} \qquad [-] \qquad (10)$$

With τ_I and τ_M again response parameters. Investments I consist of investments by firms and consumers in the form of retained earnings, shares and bonds. The money stock M_{liqass} equals the 'liquid assets' (deposits) of consumers, firms and government. In this way, the interest rate will tend to increase whenever a larger fraction of the available money is invested – a rising demand effect – and/or the money stock shrinks – a money scarcity effect. The equations governing the money stock and deposits are discussed in the next paragraph.

[5] The setting of initial values for model variables such as price and interest rate is part of the calibration process. What matters for the relation with the empirical data is the change in the variables.

Demand: consumption and investments

The product of physical output Y and aggregate price p equals the monetary output which is the equivalent of the Gross Domestic Product (GDP): $pY = p_m Y_m + p_s Y_s \sim GDP$. This has to be paid for from the flow of wages, interest and dividend. A crucial issue in each economy is the set of mechanisms that determine which part of this flow F is used for consumer goods and services and which part for investments. In other words: what is determining effective aggregate demand D and savings S? Following Godley and Lavoie (2007), consumption in each consumer class j [= D, LB, LBC] is assumed to depend on both income and wealth level:

$$C = b_{ij} \times F_{net,j} + b_{wj} \times M_{liq\,ass,j} \quad \text{(M/yr)} \tag{11}$$

where C is consumption, F_{net} is the net income, M_{liqass} is the previously introduced net liquid assets and b the propensity to consume. The parameters b_i and b_w are taken to be constant ($b_{ij} = 0.73$ and $b_{wj} = 0.05$).[6] Net income consists of the wages, of interests on deposits and loans, of interest on bonds and of dividends (only for the LBC-consumers) minus taxation. So mutations of the deposits (from buying or selling bonds and/or shares) only affect the consumption function via the coefficient b_{wj} in the second term of Eq. 11.

All three consumer classes get income from labour in the form of wages and pay income taxes and VAT. Only the lowest income class consumers have debts: D-consumers, whereas the other consumers have a positive bank deposit and invest in bonds (LB-consumers) and equity in firms (LBC-consumers). As the D-consumers with the lowest income have debts, i.e. negative deposits, their net income equals wage income minus taxation, minus interest dependent costs of housing (repay and interest costs of mortgages) and we assume that this net income is entirely used for consumption ($b_{iD} = 1$, $b_{wD} = 0$).

Structural change

To reproduce the historical process known as structural change, consumption and labour shift dynamically between the manufacturing (M) to the services (S) sector. Consumption shifts from the M- to the S-sector proportional to the difference between the price levels p_S and p_M.. Labour, and thus employment shifts from the M- to the S-sector proportional to the difference in wage levels w_S and w_M.

The Financial System

The financial system is modelled as the balance sheet of an Aggregated Bank (AB) with two entries: assets and liabilities. The fundamental role of commercial banks, approximated here as the AB, is understood as *double entry bookkeeping*, in which money is created 'out of nothing' and disappears again later in the process when the created loan is repaid (Werner 2014, 2016). 'Money', in the form of bank deposits, always remains on the liability side of the AB (cf. Figure 1). These bank deposits are held by the three classes of consumers, by firms, by the government and by the (aggregated) bank itself as equity, and are discussed in this order further on. Each deposit has an inflow and an outflow; these are shown schematically in Figure 3. Total assets equal total liabilities and the stock of money equals the sum of all the liabilities. Only the ownership of money changes: there are continuous transactions of money between the various deposits, dictated by the processes which take place in the real economy. Unlike physical capital stocks

[6] We are aware of the simplification here. One might for instance wish to include the (perceived) difference between the market price of the house and the mortgage or include the change in buying instead of renting a house. For the present purpose, such refinements are not considered.

which turn into waste or are recycled and formally 'depreciated', the total amount of money involved in these transfers remains constant and in the bank deposits, unless money is created as debt or annihilated in debt repayment.

The model is stock-flow consistent. The transactions flow and the balance sheet matrices are presented in Tables 1 and 2. Via the balance sheet representation, the amount of money and debt in the system is continuously evaluated. Money only enters or leaves the system upon money creation on lending and money destruction on repayment of loans.

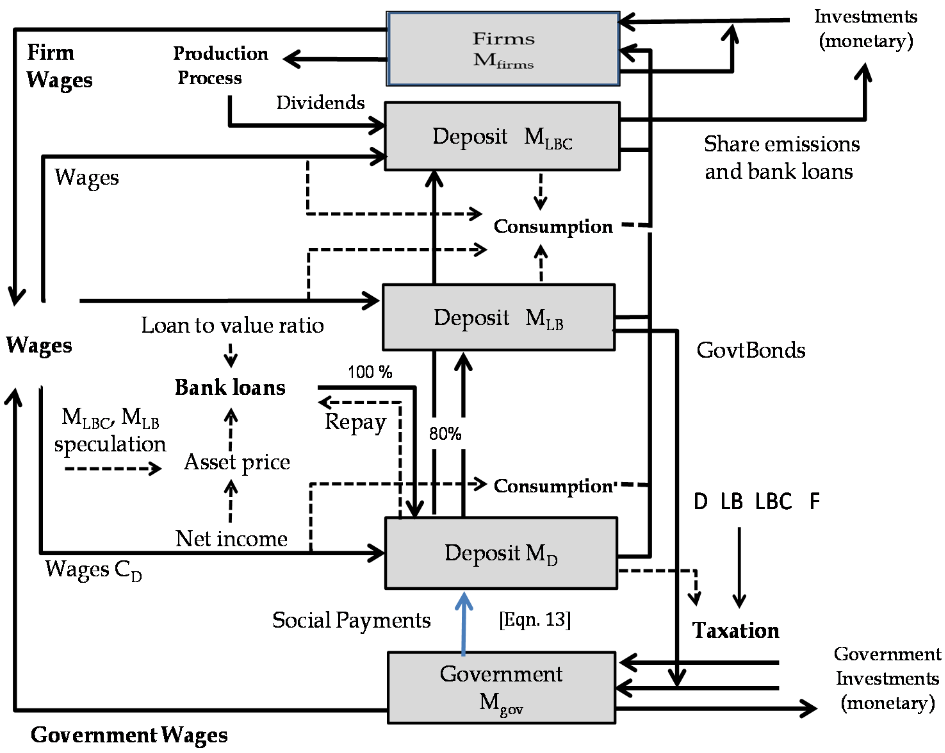

Figure 3. Diagram of the relationships in the financial system model. The financial system is modelled as the balance sheet of an aggregate bank (AB). Firms and government also may have loans at banks; these are not shown.

SFM transaction matrix							
		Consumers		**Firms**		**Government**	**Bank**
	in**Debt**ed D	**L**abour / **B**onds	**L**abour / **B**onds / **C**apita	**current**	**capital**		
	labour income	income LB	income LBC				
Consumption	$- C_D$	$- C_{LB}$	$- C_{LBC}$	$+ C$			
Government consumption				$+ C_{gov}$		$- C_{gov}$	
Investment				$+ I$	$- I$		
Change in Equities / shares				$- \Delta E$	$+ \Delta E$		
dividends			$+$ Div	$-$ Div			
Change in governm.bonds		$- \Delta B$				$+ \Delta B$	
Interest on bonds		$+ (\rho_d+0.01) \times B$	$+ (\rho_d+0.01) \times B$			$+ (\rho_d+0.01) \times B$	
Wages	$+ W_D$	$+ W_{LB}$	$+ W_{LBC}$	$- W_{firms}$		$- W_{gov}$	
Change in loans	$+ \Delta BL_D$ (mortgages)			$+ \Delta BL_{firms}$		$+ \Delta BL_{gov}$	$- \Delta BL$
Interest on loans	$- \rho_l \times BL_D$			$- \rho_l \times BL_{firms}$		$- \rho_l \times BL_{gov}$	$+ \rho_l \times BL$
Default on loans	$+ f \times BL_D$						$- f \times BL_D$
Recapitilization of banks						$- f \times BL_D$	$+ f \times BL_D$
Real asset transfers (houses)	$- \Delta BL_D$	$+ 0.5 \times \Delta BL_D$	$+ 0.5 \times \Delta BL_D$				
Interest on deposits	$+ \rho_d \times M_D$	$+ \rho_d \times M_{LB}$	$+ \rho_d \times M_{LBC}$	$+ \rho_d \times M_{firms}$		$+ \rho_d \times M_{gov}$	$- \rho_d \times M$
Social Payments	$+ SP$					$- SP$	
Taxation Income Profit / Wealth	$- T_D$	$- T_L$	$- T_C$	$- T_{firms}$		$+ T$	
Value Added Tax	$-$ taxrate $\times C_D$	$-$ taxrate $\times C_{LB}$	$-$ taxrate $\times C_{LBC}$			$+$ taxrate $\times C$	

Table 1. Transaction flow matrix; see text for meaning of variables.

SFM balance-sheet matrix									
		Consumers / households				**Firms**	**Government**	**Bank(s)**	
		in**Debt**ed D	**L**abour / **B**onds	**L**abour / **B**onds /**C**apital					
		labour income	income LB	income LBC					
									0
Loans		$- BL_D$ (mortgages)				$- BL_{firms}$	$- BL_{gov}$	$+ BL$	0
Deposits		$+ M$	$+ M_{LB}$	$+ M_{LBC}$		$+ M_{firms}$		$- M$	0
Equities /shares				$+ E$		$- E$			
Governm. bonds			$+ B_{LB}$	$+ B_{LBC}$			$- B$		0
Sum		NW_D	NW_{LB}	NW_{LBC}		NW_{firms}	NW_{gov}	NW_{banks}	K

Table 2. Balance sheet matrix.

Agents in the model

- *<u>InDebted consumers</u>.* As indicated above, there are three classes of consumers: D-, LB- and LBC-consumers. The first category of D-consumers receive only income from labour wages (W_D). This is entirely spent on consumption ($b_{iD} = 1$; $b_{wD} = 0$). They can take up a bank loan (BL_D), which is paid back over the loan period with interest payments. The loan is put on the M_D-deposit and transferred on an equal-per-household basis to the deposits of the LB-, and LBC-consumers, in exchange for ownership of real estate (houses). Besides, the D-consumers receive social payments (*SP*), depending on the employment rate and the available government budget which primarily comes from taxation.

- *<u>Labour and Bond income consumers.</u>* The second category of LB-consumers receive income from labour wages (W_L) and from interest on the money on their deposit which includes part of the loans taken up by the D-consumers. A fraction b_{iL} of this income is spent on consumption. They can buy *bonds* (*B*) from the Government, which are repaid later with an interest level 1 % above the current interest rate on deposits ρ_d. The fraction b_{wLB} of the wealth is spent on consumption.

- ***L**abour-and **C**apital income consumers.* The third category of LBC-consumers are similar to the LB-consumers but they buy besides government bonds also *equity* in firms (*E*). These shares give them additional income from dividend. The values of b_{iLC} and b_{wLC} are the same as for the LB-consumers and based on model experiments.

- *Firms.* Firms pay wages to labourers (W_{firms}) and receive money on their deposits (*Mfirm*) by selling products to consumers and the government. The profits, defined as sales revenues and interest income minus wage costs and interest and tax payments, are paid out as dividend. Firms also need to finance their expansion investments. It is assumed that this is done by loans from the AB and by offering LBC-consumers the option to buy shares on the stock market. In the model, it is checked whether the intended shareholders have enough money on their bank deposits:

$$pI_{net} = \mathrm{Min}\ (pI_{net}, M_{\text{liq ass LBC}}) \quad [\text{M/yr}] \qquad (12)$$

  Thus, the demand for financing is supplied from the deposits of the LBC-consumers in the form of shares, up to the available level $M_{LBC\ liq\ ass}$. The LBC-consumers receive dividend from equity. Firms also borrow money from the bank (BL_{firms}), pay interest at rate ρ_l and repay the resulting debt. Firms receive interest from the money on their deposit with the AB at an interest rate ρ_d and pay tax to the government over the net profit.

- *Government.* The inflows into the government deposit (M_{gov}) is made up of income from taxation of consumers and firms and from interest on the deposit. The taxes are raised on the basis of gross consumer/worker wages and of net profit of firms i.e. after dividend payments; besides, a Value Added Tax (VAT) is applied on the consumption flow. The deposit outflow are the expenditures in the form of wages to government employees (W_{gov}), of social payments to the D-consumers (*SP*) and of government consumption (C_{gov}) in the form of payments to firms for production of infrastructure. Social payments are assumed to be a function of both wages of D-consumers and the level of unemployment. As a consequence, social payments by the government increase when unemployment rises. Governments have financing needs too, when (expected) expenditures exceed revenues. This is done by selling government bonds (*B*) on the financial markets and/or borrow money from the bank (BL_{gov}). The bonds and bank loans of the government lead to cumulated debt. In accordance with present EU-rules, this is constrained to 60 % of annual output (GDP) by means of an automatic feedback: when debt exceeds this limit, taxes are increased and government expenditures are reduced.

- *Banks.* The bank AB is only involved in giving out loans (BL) to consumers, firms and the government. These are repaid over time. The banks' income or 'bank fee' is the difference between what is received as interest from the debtors at rate ρ_l and what is paid to the deposit holders at rate ρ_d, with $\rho_l - \rho_d$ the 'spread' and $\rho_l > \rho_d$. The scale on which banks can create loans is limited by the requirement that the 'capital ratio', i.e. the ratio between equity (own capital) and the sum of the outstanding loans of the bank, does exceed a certain minimum value. As shown by Werner (2016), this limitation can be circumvented in practice. However, in the model experiments the chosen capital ratio of 0.05 already allowed more than adequate lending to demonstrate the generation of boom-bust cycles.

The real estate driven credit cycle

As indicated above, the AB creates money ’out of nothing’ in order to satisfy the demand for financing consumer, firm and government needs. The process of credit creation for firms has been described by Minsky (1982). When the economy recovers after a crisis in terms of employment and growth, the fresh memory of the crisis keeps firms and banks conservative. They aim for low debt-to-equity and high profit-to-interest ratios. Gradually, confidence increase and managers and bankers start to finance riskier investment projects, which causes an increase in asset prices. This requires more external finance and the growth of credit accelerates. Rising interest rates and increasing debt-to-equity ratios make many projects speculative. Eventually, assets can no longer be traded at a profit, debts can no longer be serviced. There are only two forces that can bring asset prices and cash flows back into harmony: asset market deflation and goods inflation; after the boom, the bust (Minsky 1982, Keen 2013).

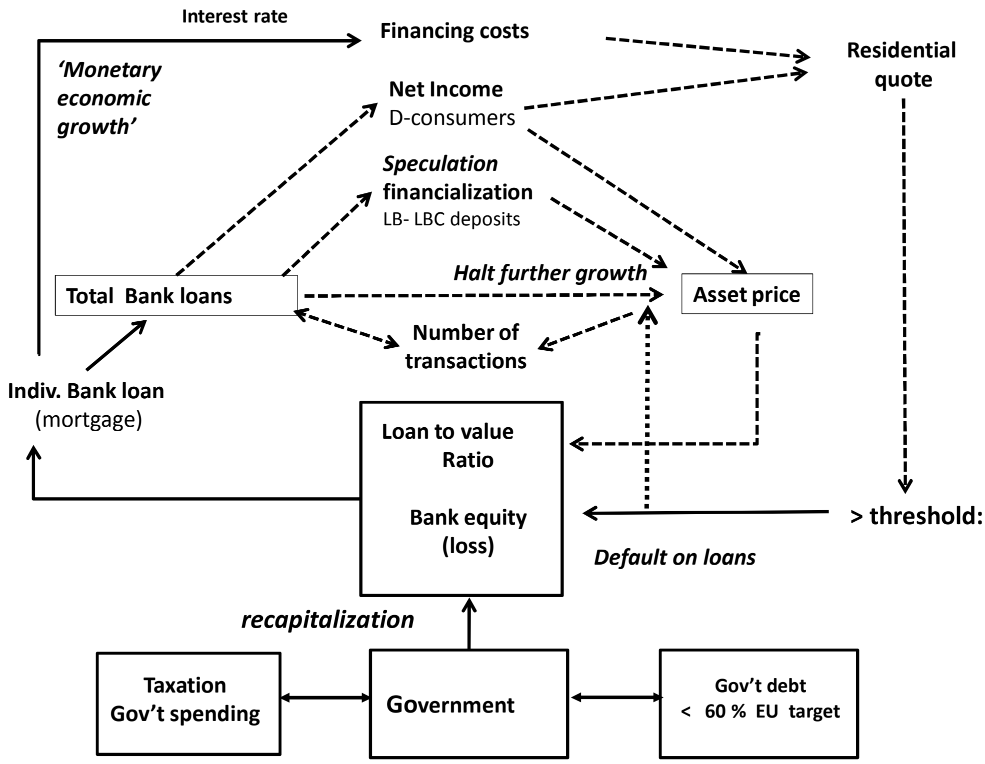

Figure 4. Diagram of the factors that play a role in the real estate-driven credit cycle. With rising income, house prices tend to rise in a positive feedback loop until defaulting occurs.

In the last decades, credit creation has increased enormously and used to an ever larger extent for non-productive uses, notably for house mortgages and financial market transactions. For instance, the fraction of outstanding debt for non-productive purposes, i.e. not for investments or consumption, in the Dutch economy is over two-thirds of total debt (Bezemer 2014). Therefore, we focus on the house price driven credit creation in relation to loans in the residential sector. The causal relationships in the SF-model are shown in Figure 4.[7] Bank loans, are given to D-consumers for

[7] There is evidence of a significant multidirectional link between house prices, private credit and the macro-economy (Goodhart and Hofmann 2008; Fitzpatrick and McQuinn 2007). We have attempted to represent some of the generic mechanisms in the SF-model.

purchase of real estate. This causes house prices to rise in combination with (expected) income growth and speculation. In the process, the ratio of the loan given by banks and the estimated house price (loan-to-value or *ltv*) increases and the deregulation of the financial sector allows banks to accept values above what previously had been considered safe.

This process of giving out loans to D-consumers for houses is modelled by making the relative change in the house price p_{ass} a function of the relative change in net income $F_{D\,net}$, in level of available bank loans BL_D and in the net liquid assets $M_{liq\,ass}$:

$$\frac{d\,p_{ass}}{p_{ass}} = \frac{1}{\tau_F}\frac{d\,F_{Dnet}}{F_{Dnet}} + \frac{1}{\tau_{B\,ass}} \cdot \frac{dBL_D}{BL_D} + \frac{1}{\tau_{spec}} \cdot \frac{dM_{liq}}{M_{liq}} \quad (-) \qquad (13)$$

The first term accounts for the expectation of rising income, the second for the willingness of the AB to create loans and the third term for real estate speculation. The loan given by the AB to a D-consumer-household equals p_{ass} times the *ltv*-ratio for each transaction. The *ltv*-ratio changes over time, given the changing risk perception of banks and policy makers. The *ltv*-ratio increased (in the Netherlands) to a level of 1.1 (110 %) in the year 2000. The dynamics of decreasing house prices differ from increasing ones, as they show a certain hysteresis. Under crisis conditions, prices remain relatively high at first, while the number of house transactions n_{trans} drops drastically. To account for this effect, negative changes in house price are modelled as $p_{ass}^{0.5}$.

The total loans BL_D given out by the *AB* equal the loan per D-consumer-household times the yearly number of transactions n_{trans} for existing housing and new housing:

$$BL_D = p_{ass} \cdot ltv \cdot n_{trans} \quad (€/y) \qquad (14)$$

The yearly number of transactions n_{trans} is assumed to be a fixed fraction of the number of D-consumer households plus the new houses added to the housing stock *HS*. Because the actual number of transactions will also depend on the house prices and the acceptable *ltv*-ratio, we hypothesize a positive correlation with increasing bank loans and a negative one with increasing house prices:

$$\frac{d\,n_{trans}}{n_{trans}} = \frac{1}{\tau_{Bf}}\frac{d\,BL}{BL} - \frac{1}{\tau_{p\,ass}}\frac{d\,p_{ass}}{p_{ass}} \quad (-) \qquad (15)$$

With τ_{Bf} and $\tau_{p\,ass}$ again response parameters.

Indeed, this mechanism is reproduced by the model. A key variable is the residential quote, defined as the ratio between debt servicing (interest plus repayment) and net income. If this ratio increases due to increasing debt and corresponding interest and repayment costs, the economy will collapse once the net income of D-consumers available for consumption declines below a certain value.

In the model runs the assumption is made that upon reaching a residential quote value of 0.5, significant default will occur, which reduces bank equity to levels lower than the capital requirement, halt bank loans and decrease asset prices according to Eq. 13.

Eq. 13−15 imply that the stabilization of new bank loans soon results in a decrease of house prices, which will be followed by a further decrease of new bank loans. This decline in credit creation causes a – moderate – decline in aggregate demand and hence in consumption, via both income and wealth (Eq. 11) (Biggs *et al.* 2010). This results in lower price levels (deflation; Eq. 8) and lower employment and investment levels as firms respond, with a delay, to lower consumption

(Eq. 5 and 7). The bonds acquired by the government to recapitalize the AB draws existing money from the M_{LB}- and M_{LBC}-deposits, with additional effect on demand and consumption. The combined effects cause, with some delay, a significant decline in demand cq. consumption. Physical output Y decreases as well, though less dramatic than the monetary production pY because of the presumably ongoing technological development and a corresponding deflationary price drop.

3. Model tuning and results

Historical data and parameter values

It goes without saying that the SF-model cannot reproduce the real-world complexity of, for instance, the open Dutch economy. Calibrating, let alone validating, system dynamic models is a notoriously difficult task (Sterman, 2000). Most model variables are aggregate mental constructs that are heterogeneous and not directly observable; often one can only rely on econometric relationships between a few variables. Besides, modern economies are open with multiple transactions with other economies. Instead, we intend to use it for 'model-based story-telling' and we have to this end tuned model initialization and parameters on the basis of a limited set of statistical time series of four key macro-economic indicators for the Dutch economy 1950–2010: notably GDP (~ pY), the consumer price index CPI, the money stock M3 and the house prices. Some of these are shown together with the simulation results.

In tuning the model, the time path of the four above-mentioned variables have been reconstructed for the period 1950–2010, with a forward simulation towards 2050. The initial and parameter values used in this reconstruction are given in the Appendix. A series of experiments with zero population growth and constant labour productivity have confirmed the development towards a steady-state solution. Additional perturbation experiments have indicated a great sensitivity for the value chosen for certain parameters, e.g., the propensity to consume b or the fraction of investments that is financed with loans $f_{firmloan}$.[8] This has not been explored any further in the present paper. Given empirical estimates of the average asset prices, one can estimate the various parameters.

Role of choice of production function

For the period 1950–2050, the trajectories of monetary output py ~ GDP, both for the CD-production function (σ = 1 in 1950 and 2050) and the CES-production function with two time-paths for σ (increasing to 1,4 and 1,7 in 2050) are given in Figure 5a. In the CES-functions with increasing values for σ, output pY is significantly below the CD-production equivalent to σ = 1. This is explained from the lower wage-level and subsequent lower levels of consumption and aggregate demand. At the same time, the net investment rate is higher when using a CES- than a CD function. For σ = 1,4 and 1,7, the fraction of revenues that falls on capital increases from 0.30 to 0.40 and 0.45 respectively for the manufacture sector (Figure 5b). In the service sector this fraction increases from 0.20 in 1950 to about 0,23 and 0,25 in 2050.The model simulates a shift in economic activity of about 10 % (2030) from the manufacture to the service sector by shifts in consumption and labour force. As indicated, the shift from the manufacture to the service sector is driven by the difference in price level between the M- and the S-sector and the shift in labour force is driven by the difference in wage-level.

[8] More detailed stability and sensitivity analyses for a somewhat simpler model, formulated in Mathematica, confirm these findings but also indicate the important role of some of the assumptions, for instance about savings behaviour of consumers and about how firms finance their expansion investments (Gomez 2015; cf. Eq. 11).

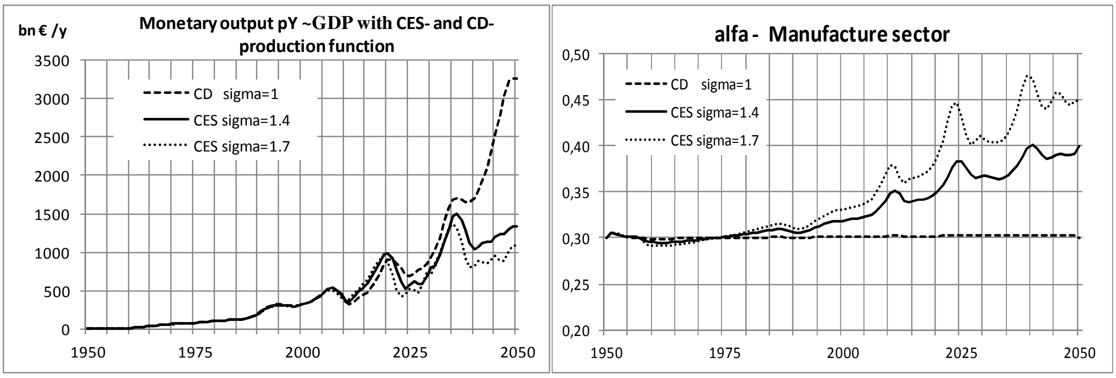

Figure 5. Simulated monetary output *pY ~ GDP* using the CES- (σ =1,4 and 1,7) and the CD-production function (σ =1,0) and the increasing share αM which falls on the factor capital.

Simulating the Dutch economy 1950-2050

The relevant time-series for the simulation of the financial-economic system over the period 1950–2050 are presented in Fig. 6-9. Within the total period, three episodes can be distinguished. The first one is 1950–2008, with strong output growth, tension on the labour market, price inflation and massive money creation and rising house prices, particularly after 1980. The second period is 2008–2018, during which too many mortgages cause a financial crisis, a fall in house prices and a government bail-out of the AB, resulting in a decline in GDP, deflation and larger unemployment and government debts. In the third period, 2018–2050, the model simulations suggest for the future recovery of economic growth and house prices, after which lending for mortgages with newly created money starts again. As the mechanisms are still the same, a new crisis occurs a few decades later, to a large extent based on the recovery of the housing market, increased lending and (thus) money creation contributing to price inflation. Notwithstanding a now lower, policy imposed and exogenous level of the loan to value-ratio, the unchanged mechanism of increasing house prices, subsequent mortgage lending and thus a new strong increase of the residential quote results in a new financial crisis later in the period after 2030. We proceed with a more detailed discussion of the model outcomes.

I. Historical period 1950–2008

The simulated *monetary output pY ~ GDP*, being a weighted function of pY_M and pY_S, reaches a level of about €600bn between 2005 and 2010, in line with the historical data, as Figure 6a shows. The simulated *aggregate price p* increases with a factor 10 between 1950 and 2008, somewhat higher than the empirical/historical level (Figure 6b). Consequently, *physical output Y* also increases but less than monetary output (Figure 6c). Behind this growth are capital-labour substitution and, more importantly, is the presumed ongoing, exogenous increase in labour productivity (A in Eq. 2). The latter slows down by the end of the 20th century, partly due to the shift to the service sector with lower labour productivity. The resulting deflationary pressure is counteracted by an increase in the money stock M3 (Figure 6d).

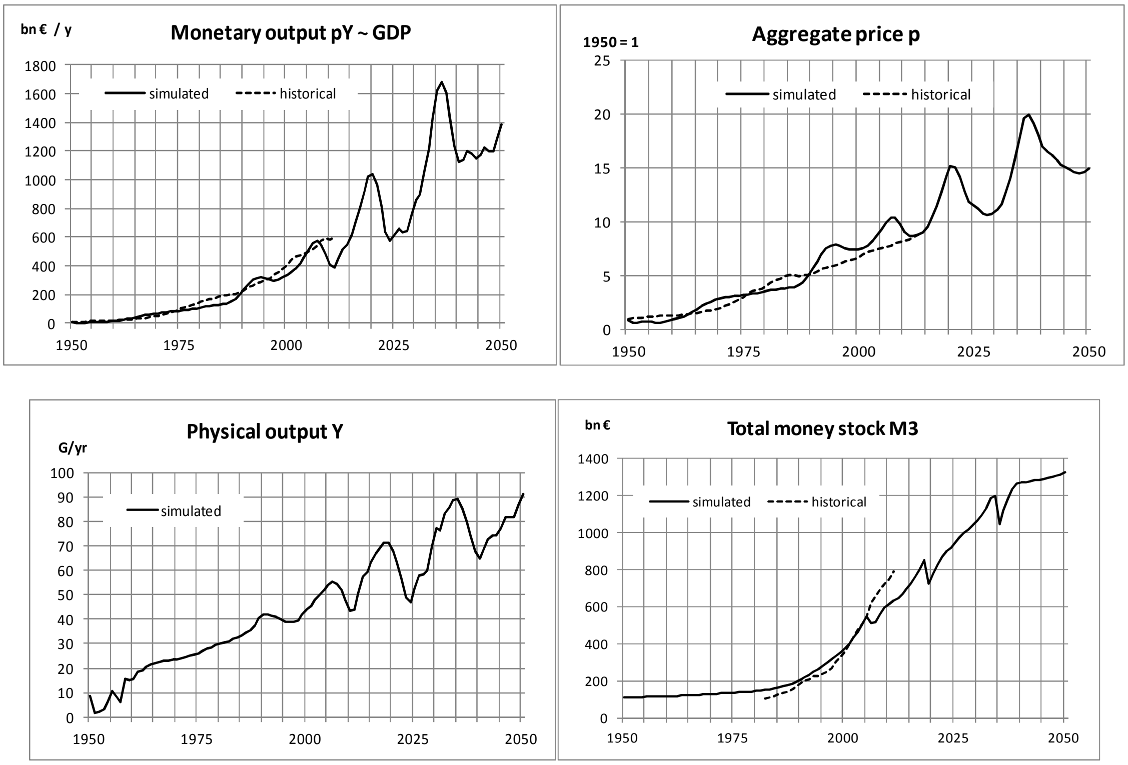

Figure 6. Simulated model results and historical data for the default money-as-debt scenario, tuned to represent the Dutch economy: monetary output, price, physical output and money stock.

Some other economic macro-indicators are shown in Figure 7a-d. Total employment is most of the time around 'full employment', sometimes even exceeding 1 (100 %) which can be interpreted as a labour market shortage (Figure 7a).[9] In line with the growing money stock, there has been in increase in the total wage sum (Figure 7b; *wL*). The simulated interest rate r remains in the range of 8–10 % for a long period, until it starts falling in the mid-1980s; our assumption on the interest rate dynamics is not able to reproduce the rapid increase in the historical data (Figure 7c; *r*). The consumption follows the trends in monetary output and total wage sum (Figure 7d; *C*). The simulated consumption – output ratio *C*/*pY* can be interpreted as one minus the savings rate and is around 0.75, slightly higher than the historical data around 0.8 suggest. Lastly, the simulated money stock M3 increases from an estimated €110bn in 1950 to about €600bn in 2010 (Figure 6d; *M*). Although this is somewhat lower than the historical data, the model reproduces the significant acceleration in the rate of money creation, from about 5 % of GDP per year before 1995 to values up to 10 % since then. This implies a modelled increase of more than €500bn in total liabilities in this period against an increase of €700bn when based on the historical data.

[9] The difference with historical data is partly due to an initialization effect, for the first decade, and partly to our assumption, for simplicity, of a constant participation rate of 40% (L = 0.4×Population).

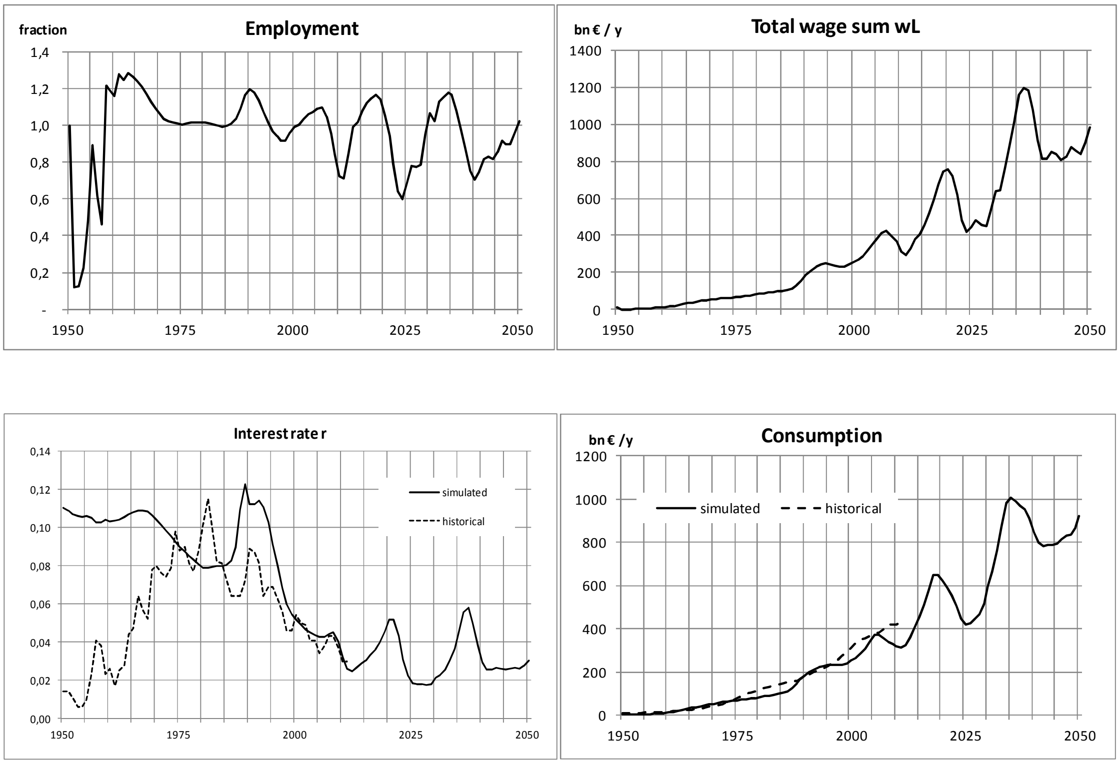

Figure 7. Simulated model results and historical data for the default money-as-debt scenario, tuned to represent the Dutch economy: employment rate, total wage sum, interest rate and consumption.

A remarkable feature of the simulated results is that the ratio between the money stock M3 and the price as indicated by the Consumer Price Index CPI – which does *not* include house prices – increases after 1990, corresponding with the limited historical data available. Money has been created that does not show up in the aggregate price. We therefore show four more variables in Figure 8. As it turns out, the simulated house price rises rapidly since the mid-1980s, in line with historical data although the model is unable to reproduce the earlier peak[10] (Figure 8a; p_{ass}). This is in good and understandable correspondence with the trends in the bank loans given out for mortgages (Figure 8b; *BL*), the residential quote (Figure 8c) and the bank equity (Figure 7d). The interpretation is that the acceleration in money-as-debt creation by the AB – in reality: commercial banks – for mortgages has led to rapid house price inflation. This money has not been available for productive use, as several analyses have confirmed (Bezemer 2014, 2016). The strong increase in both house prices and private credit, given their multidirectional link, is explained from relaxation of mortgage lending rules, market deregulation and financial innovations such as new forms of securitization (Bezemer, 2016). The 'break' between the periods before and after the mid-1980's is further promoted by policy preferences for increased home ownership allowing a gradual increase of the loan-to-value (*ltv*) ratio from 0,8 in 1970 to 1,1 around the year 2000.

[10] Probably, the exogenous oil price shocks play a role here; they are not part of the simulated mechanisms.

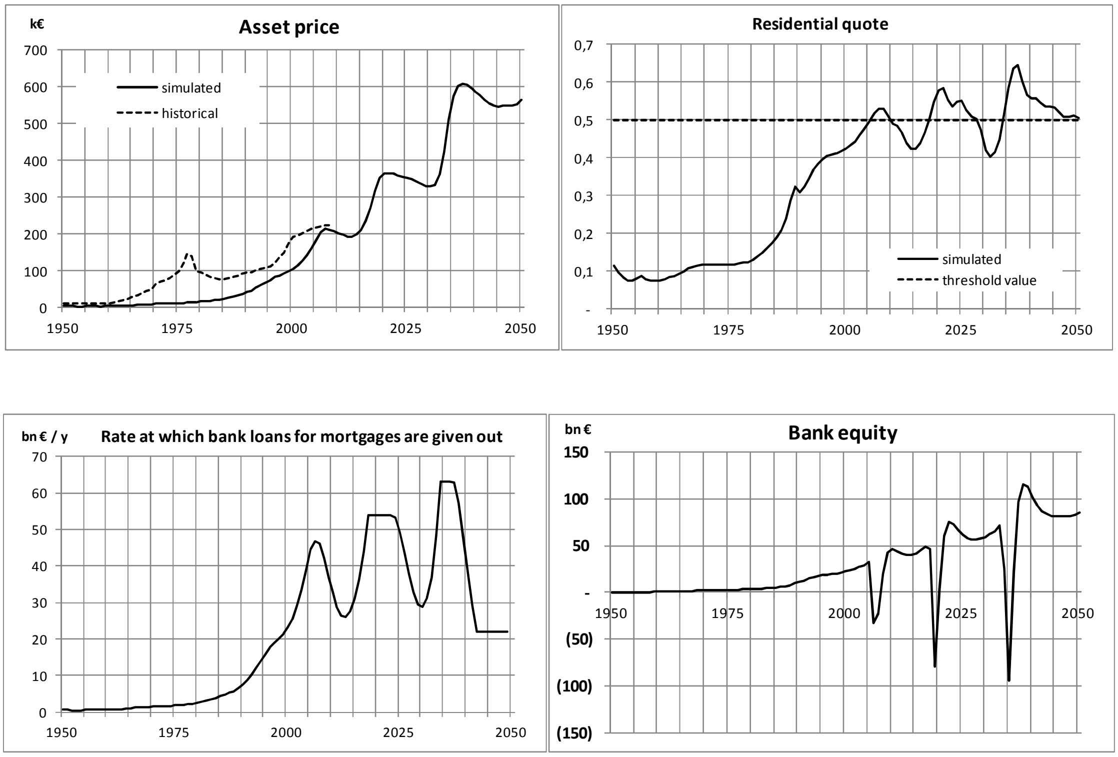

Figure 8. Simulated model results and historical data (asset price) for the default money-as-debt scenario, tuned to represent the Dutch economy: house price, residential quote, bank loans and bank equity.

The money created and lent into circulation ends up on the $M_{liq\ ass}$ deposits of the non-borrowing LB- and LBC-consumers, where it is partly used for consumption (Eq. 11). The newly created money is a major driving force behind the decline in interest rate (Figure 7c; *r*) and finds its way back through reinvestment in the house prices where it came from. These results are in reasonable conformity with the historical data. The major part of the increased lending since the early 1990's has been for mortgages – in the model assigned to the D-consumers – and can therefore be related to the price level of real estate. The modelled level of the house price falls somewhat below the statistical data (Figure 8a). The peak level between 1975 and 1980 was driven by the oil crisis and is beyond the scope of the model. Statistical data for the year 2005 indicate an average house price of 223.000 €, a total of 207.000 transactions and an average loan-to-value (*ltv*) ratio of 1,05 (CBS 2015). This corresponds to an estimated overall bank loan of €45bn per year (Eq. 14 and Figure 8c). With an estimated repay level of €10bn to €15bn per year, the annual net increase in the mortgage debt amounts to €30bn to €35bn per year. This is in line with empirical data on mortgage debt and the increase in the amount of M3-money between 1990 and 2008 (Figure 6d).

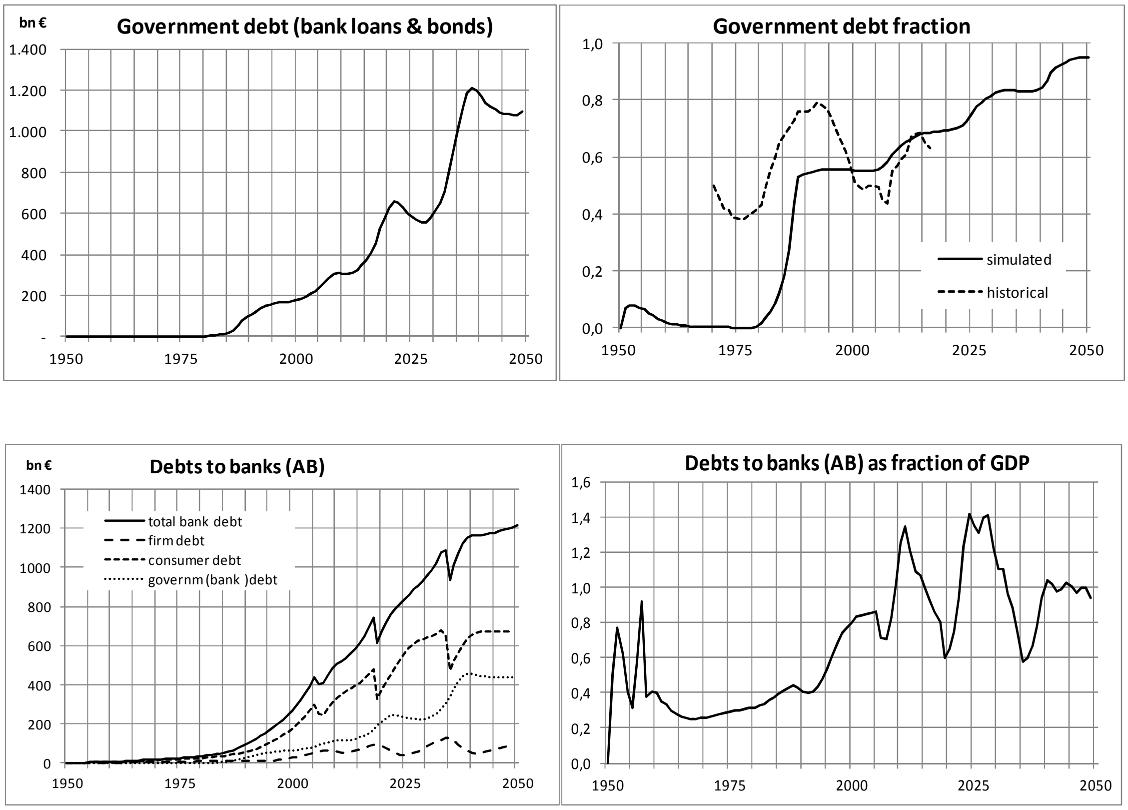

Figure 9. Simulated model results and historical data (9b) for the default money-as-debt scenario, tuned to represent the Dutch economy: government debt total (banks and bonds) and as fraction of pY ~ GDP, debt to banks total and as fraction of pY ~ GDP.

As shown in Figure 9c, the total consumer-debt for mortgages, increases steeply as more and more loans are given in line with the rising house price. As reflected in the total liabilities, the modelled net additional money creation as ‘consumer debt’ amounted to some €200bn around the year 2000, apart from an additional €100bn of loans of private banks to the government and an about €50bn to firms. These trends and numbers are in reasonable agreement with the statistical estimates. As shown in Figure 9d, the overall debt to banks as a fraction of GDP increases to about 0.8 times GDP in 2000. The increase indicates that more money is lent out (and created), then money is paid back. The total amount of overall debt to banks can be considered as ‘lent from the future’, as it will be destroyed after being paid back.

II. The financial crisis period 2008–2018

We now look in more detail into the simulated recession of the early 21st century, as illustrated in Figures 6-8. It unfolds along the following lines. The rising net income of D-consumers drive, in combination with higher acceptable *ltv*-ratio’s and speculation (Eq. 13), a positive feedback loop of increasing mortgage loans and house prices (Figure 8a-c). This continues until the residential quote of financing costs over net income increases to levels at which some D-consumers can no longer service their debts, notwithstanding the decrease in the interest rate resulting from the massive creation of money. In the simulation, defaults start to occur at residential quote levels over 0,5[11] (Figure 8b). The subsequent decline in house prices cause bank equity to fall below its capital requirement (Figure 8d). When this happens, the rate at which bank loans are given no longer increases and this causes a further decline in house prices and subsequent decrease in bank loans (Figure 8c).

The stabilization in the rate of new loans results in a reduction in the number of real-estate transactions (Eq. 15) which has in turn as a consequence that less money is brought into the financial system than is disappearing from it by repayment of due loans. The decreasing amount of money is manifested by deflation (Figure 6b). Given the slow response of wage levels, physical output decreases and monetary output decreases even more (Figure 6a–c), as are employment rate, wage sum and consumption (Figure 7a–d). The consumption of the D-consumers in particular decreases as their net income declines while the costs of financing their debts (repayment and interest) remain nearly unchanged. The moment at which trust in the economy, and in particular the real asset (housing) market is restored, is of psychological nature and thus hard to derive from model parameters alone.

The third act in the unfolding recession is the *bail-out of the AB by the government.* As the banks are 'too-big-to-fail', they are rescued by the government in the form of recapitalization. In the model, this is simulated as an immediate transfer of the sum of the default from the government deposit to the equity of the AB. This transfer is financed for 70 % by the emission of bonds on the capital market, i.e. from the deposits of the LB- and LBC-consumers, and for 30 % by additional loans from the AB. This 30 % needed to bail-out banks thus has to be lent by the government from other banks, which (partly) create this money out of nothing. The additional demand for government bonds (70 %) causes a slight increase in the interest rate (Figure 7c). However, this slight increase is followed by a strong drop of the interest rate as a consequence of the economic effects of the recapitalization of banks by the government.

The government debt has a momentary steep increase as a result of this recapitalization, in absolute terms and as fraction of GDP (Figure 9a–b). In the model it is assumed that the EU-target of 60 % is not strictly maintained. Nevertheless, the debt has to be limited as much as possible and thus has to be repaid by an 'austerity' policy of budget cuts and additional taxes. As a consequence, consumption and, with a delay, employment start falling, which sets in a downward wage–price spiral. The lower wages cause a further reduction in demand and an increase in the residential quote, causing more borrowers to default. During the following decades, the accumulated debt is to be paid back, with a depressing effect on consumption and thus on the economy at large. Finally, ongoing technological progress restores growth of the physical production, allowing the monetary economy finally to recover.

Forward simulation 2018–2050

One of the central objectives of the current paper is to quantitatively study the root causes of instability in the financial-economic system. To this end, a forward simulation towards 2050 is made, given the acceptable performance of the model in explaining the dynamic behaviour of the system in the preceding periods. The simulated model results fluctuate much stronger than the historical experience in the last decades. One reason is that we simulate the entire 100 year-period with a single set of model parameters used for the calibration of the 1950–2005 period. Secondly, there are large uncertainties in the behavioural dynamics before, during and after collapse. Apparently, the downward economic spiral has been less dramatic than the model suggests. This,

[11] The residential quote levels are marginal as they refer to the ratio between the financial costs and the net income of D-consumers over the most recent mortgages. They are gross in the sense that significant tax exemption on mortgage interest payments is not taken into account.

however, has the advantage of emphasizing the underlying mechanisms as part of the narrative we wish to expound.

The subsequent model experiment indicates ('predicts') two more future crises around 2020 and 2035. This results from the same dynamic which led to the 2008-crisis: income starts to grow again, house prices increase, and new loans are given which brings new money into the system. Notwithstanding the now effectuated policy of a gradually decreasing loan-to-value ratio, the residential quote again reaches the unsustainable level of 50 % of net income of D-consumers, after which level the first defaults start to happen. The rest unfolds in the same fashion as in the previous crisis, as exactly the same mechanisms are assumed to be operating.

4. Discussion and conclusion

The model experiments show that it is possible to reproduce some important macro-economic trends in the Dutch economy in the last half century. It confirms the credit creation theory of banking, in which massive creation of money as debt (MaD) by private banks provokes boom-and-bust cycles in the real asset (housing) market and in real economic activity. The underlying cause is the lack of coordination in the process of money creation. Private banks make their lending decisions on the basis of (local) company and financial market indicators and not on indicators of the system as a whole, e.g., stability. Lacking some sort of central coordination, (monetary) economic growth by decentralized money creation is a self-fulfilling prophecy which brings about the unjustified euphoric herd behaviour of the many private banks creating too much money, believing in the ongoing rise of house prices and monetary GDP-growth. The Central Bank's ability to determine the (lending) interest rate is not effective, in line with the growing insight that 'the interest rates appear as likely to follow economic activity as to lead it' (Werner 2012). Apparently the system is more controlled by the implicit policies of private banks than by the policy of the Central Bank.

The most outspoken unsustainable feature of the current MaD-system is the ever increasing overall debt level. In particular, a targeted (as desirable perceived) inflation rate (of say 2 %) implies a continuous further debt increase; monetary growth implies increasing debt. Due to the lack of coordination in private money creation, the overall inflation over the period 1950–2000 has been 4 %, which implies that too much money has been created.

The money as debt system, with private banks creating money, tends to jeopardize more sustainable development pathways; The pro-cyclic nature of the Money as Debt system makes prices more volatile and investment decisions more short-term oriented, both of which are detrimental for an effective long-term transition towards a more sustainable economy. During a financial-economic crisis, the government has to bail out the banks gone bust, thus increasing government debt and, more importantly, reducing the amount of money in the system by increasing taxation and decreasing government spending. Before the crisis, banks bring too much money into the system and after the crises too little. It goes without saying that such a pro-cyclic financial-economic system tends intrinsically to instability and is unsuitable for societies in transition towards a more sustainable condition. In a second paper we explore these issues in more detail, as we use the model to simulate an alternative to the money as debt system.

We are fully aware that our model is too simple to simulate correctly an open, advanced economy such as the Dutch one. However, standard macro-economic (equilibrium) models have not been of much use in explaining and anticipating the instabilities in modern financial capitalism and models like this challenge the participants in the debate about a more sustainable economy to formulate transparently the essential macro-economic mechanisms. If further improved, they also provide governments with better instruments to realize societal goals.

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Appendix: List of model parameters

Model variables and parameters, with their units and values in the standard run.

Variable name	Description	Unit	Value in base run
K	Capital stock [manufacturing, services]	10^9	
L	Labour force	10^6	40% of population
Pop	Population size	10^6	2.2 persons/household
LB and LBC	Consumer classes and size	10^6	28% and 22% resp. of number of households
e	Employment ratio (L/Pop)	-	
e_{des}	Desired employment ratio (L_{des}/Pop)	-	0,95
p	Average price of goods and services		1950= 1
w	Wage rate	'000 € / pp	1950= 3
ρ	Interest rate for investments	yr^{-1}	1950 = 0,11
ε	Environmental costs as fraction of investments	yr^{-1}	0,0 in baseline
δ	Depreciation rate (inverse of average lifetime of K)	yr^{-1}	0,1
τ_K	Time parameter investment adjustment		3
τ_L	Time parameter labour adjustment		0,09
τ_w	Time parameter wage adjustment		5
τ_p	Time parameter inventory-price adjustment		2,25
a	Distribution parameter (eqn. 1)	-	M 0,3, S 0,2
A	Technology and organization parameter (TFP; eqn. 1)	-	2-12, 3-13
σ	Capital-Labour substitution elasticity (eqn. 1)	-	1 (2000) to 1,4 (2050)
$b_{iL} = b_{iLC}$	Propensity to consume income of L- and LC-consumers (eqn. 11)	-	0,73
b_w	Propensity to consume wealth of L- and LC-consumers (eqn. 11)	-	0,05
$f_{firmloan}$	Fraction of financing for firms as loans	-	0,5
$f_{govloan}$	Fraction of financing for government as loans	-	0.3
ltv	[Ceiling in] loan-to-value ratio i.e. residential quote	-	0,5
HS	Number of houses	-	45 % of population
rq_{crit},	Residential quote value at which debt defaulting starts	-	0,5

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