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THE ECONOMY AS A COMPLEX SYSTEM: THE BALANCE SHEET DIMENSION

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Given the economy's complex behavior and sudden transitions as evidenced in the 2007–2008 crisis, agent-based models are widely considered a promising alternative to current macroeconomic research dominated by DSGE models. Their failure is commonly interpreted as a failure to incorporate heterogeneous interacting agents. This paper explains that complex behavior and sudden transitions also arise from the economy's financial structure as reflected in its balance sheets, not just from heterogeneous interacting agents. It introduces "flow-of-funds" or "accounting" models, which were pre eminent in successful anticipations of the recent crisis. In illustration, a simple balance sheet model of the economy is developed to demonstrate that non-linear behavior and sudden transition may arise from the economy's balance sheet structure, even without any micro-foundations. The paper concludes by discussing one recent example of combining flow-of-funds and agent-based models. This appears a promising avenue for future research.

Keywords: Credit crisis; finance; complex systems; DSGE; agent-based models; stock-flow consistent models.

JEL codes: B52, E32, E37, E44, C63

1. Introduction

The 2007–2008 credit crisis and ensuing recession was a sudden transition of the economy from one state to another, similar to such transitions in physical and biological complex systems [42]. Unsurprisingly therefore, critics of mainstream macroeconomics have called for the application of complex system theory as the new leading paradigm in macroeconomics. In particular, agent-based models (ABMs for short) have become widely discussed. A search in the economic literature database *EconLit* by this author shows that the number of studies with the phrase "agent-based" in the summary was 165 in the four years 2003–2006 and 278 over 2007–2010 (Econlit 2011). The first ABM-style macroeconomic textbook appears in 2011 under the title *Macroeconomics from the Bottom-Up* [22], a phrase now adopted for some mainstream models as well [21]. *The Economist* (2010:22) singled out ABMs as better financial crises predictors than the currently dominant "Dynamic Stochastic General Equilibrium" (or DSGE) approach to modeling the macroeconomy. And a recent World Bank Working Paper titled "A flaw in the model that defines how the world works" argues that this model 'should be replaced by an approach using agent-based scenario analysis' [13].

The present paper contributes to this ongoing discussion by noting that ABMs constitute a method rather than a theory, so that their acceptance still leaves open the question of which new theoretical framework is an alternative to DSGE models. If the problem with DSGE models is that they neither helped anticipate financial instability nor provided insights and policy implications after the fact, one conclusion is that we should turn to those models which did. Prominent among them were so-called flow-of-fund models. This leads to four questions pertinent to the paradigmatic shift in modeling financial instability. How is financial instability modeled in current macroeconomics, and what are the problems? What is the nature of models that have been empirically helpful in anticipating the latest financial instability? Can such models in principle capture the behavior of complex systems — in particular, non-linearities and sudden transitions? And can these models be married to ABMs?

The failure of DSGE-style macroeconomics was a failure to meaningfully include finance in its models, not just a failure to model heterogeneous interacting agents. To augment the models with price rigidities [44] or heterogeneous interacting agents [21] is a solution to other problems of representative-agents equilibrium models, but not to the problem posed by the 2007–2008 financial crisis. The difference is very widely neglected. To start addressing it, this paper first discusses how the structure of mainstream economic models prevents a meaningful modelling of finance. Section 3 introduces other economic theory which locates the source of credit cycles and financial instability in the financial nature of capitalism: In its use of money rooted in debt, and the interaction between asset markets and the real sector that gives rise to balance sheet effects. It follows that the challenge is to explicitly model the economy's financial instability as residing in its financial structure, rather than in exogenous shocks in the real sector coupled with price rigidities (as DSGE models do) or only in the behavioral interactions of its agents (as in the behavioral finance approach). Both these approaches locate the source of instability ultimately (or exclusively, in the case of DSGEs) in individual behavior. But we know that causes of complex behavior (non-linearities and sudden transitions) need not be exclusively micro-founded — they may also be meso-founded, in the interaction of components of the system. After all, '[c]omplex systems are comprised of multiple interacting components, or agents, whose interaction gives rise to new system qualities' [1].

This is not to deny that exogenous shocks or behavioral interactions can also be sources of instability. But to confine the theoretical explanation to them would be to miss the structural tendency towards instability that is built into the financial relations found in every modern economy. The bulk of the paper is therefore devoted to addressing the third question above — can balance-sheet models capture non-linearities and sudden transitions? From Sec. 4, a deliberately simple model of a balance sheet economy without explicit microfoundations is developed. It is demonstrated in simulations that this gives rise to complex behavior. The concluding section discusses recent work that combines the balance sheet approach with agent-based modeling.

2. Equilibrium Models and the Problem of Financial Instability

The ruling paradigm of today's macroeconomics rests on two fundamental building blocks: Its behavioral underpinning and its system view. The behavioral underpinning of neoclassical economics is methodological individualism with optimization, which has also won currency in other social sciences, a development known as 'economics imperialism' [36]. One reason why ABMs enjoys growing popularity among economists may be that they safeguard methodological individualism. The notion of the economy as a system in multi-market or "general" equilibrium model goes back to Léon Walras in the 1870s.

Based on this, general-equilibrium models have become the workhorse models for modern macroeconomics since the demise of Keynesianism in the late 1970s. Their latest incarnation is the "Dynamic Stochastic General Equilibrium" (or DSGE) model, which allows for distributions of realizations (hence stochastic), and incorporating the future represented in agent's expectations as determinant of current behavior (hence dynamic). De Grauwe [21] is a good recent discussion of DGSE limitations and possible extensions. An and Schorfheide (2007:113)[3] note that they 'have become very popular in macroeconomics over the past 25 years. They are taught in virtually every Ph.D. program and represent a significant share of publications in macroeconomics.' DSGE models are also ubiquitous in policy analyses by international institutions and central banks — see, for instance, introductions to the DSGE model used by the IMF [14], the European Central Bank [44] and the Reserve Bank of New Zealand [37].

Given their predominance at the time of the crisis, DSGE models have come in for vocal criticism from within the profession [15, 45]. The defense [17] has typically been to point out that DSGE models are more sophisticated than their critics suppose, especially because they can incorporate frictional unemployment, financial market imperfections, and sticky prices and wages. However, such 'stable-with-friction models' [38] can mimic non-linear dynamics but not the financial causes of those non-linearities. This is because DSGE models are characterized by the "absence of an appropriate way of modeling financial markets" (Tovar 2008:29). The reason is that in DSGEs, the monetary side of the economy is fully determined in the real sphere. Therefore money must exist strictly in proportion to the sum value of all real-sector transactions — that is, to real-sector output. This determinateness is a problem when it comes to understanding financial instability, which can arise only if financial liquidity is created in excess of real output.

General-equilibrium modeling so denies the nature of finance, which is leverage: The creation of debt claims and credit instruments in excess of current output. Banks *create* money, they do not just pass it on from savers to investors (FRBC, 1992; FRBD, 2001). Where credit cycles are ostensibly treated in neoclassical macroeconomics, in as Kyotaki and Moore's (1997) *Credit Cycles*, what is really modeled are *external* (not financial) shocks. The equilibrium concept prevents the explicit modeling of financial variables (Godley and Shaikh, 2002).

In a model world where credit does not exist, a credit crisis cannot be anticipated. Alan Greenspan professed to "shocked disbelief" while watching his "whole intellectual edifice collapse in the summer of [2007]". Glenn Stevens, Governor of the Reserve Bank of Australia asserted in December 2008: "I do not know anyone who predicted this course of events." A quarter century ago, Bernanke (1983:258) already wrote that "only the older writers seemed to take the disruptive impact of financial breakdown for granted". This neglect was the intellectual background for the rise of DSGE models to prominence — a state of affairs which left mainstream economists impotent to anticipate the 2007 credit crisis.

3. Understanding Financial Instability: Flow of Fund Models

Outside of the neoclassical confines in which Chairman Greenspan and Governor Stevens moved, the crisis had been anticipated by (literally) scores of non-orthodox economists, often with remarkable precision regarding the timing and the mechanism of the collapse (AFEE, 2010). One example is the work by Godley and collaborators of the Levy Economics Institute of Bard College (NY). They consistently argued that the stability of the 1990s and 2000s was unsustainable, as it was driven by households' debt growth, in turn fuelled by capital gains in the real estate sector and its derivative products (Godley and Wray 2000; Godley and Zezza 2006). They correctly predicted recession in the US while official forecasters (e.g. the US Congressional Budget Office) were still optimistic — for details, see [5, 7, 10, 11].

Godley made his predictions based on a flow-of-funds framework, generically presented in [28], and developed in textbook format in [31] which built on an older strand of economic thinking outside the general-equilibrium orthodoxy. This includes the related strand of theorizing known as circuit theory, summarized in Graziani (2003). For recent theoretical contributions, see e.g. [23] and [46]. Skaggs (2003) and Bezemer (2010; 2011a)[11] identified this as the 'accounting approach' tradition in economics. Minsky (1986:34)[40], for instance, wrote that his analysis would be "based on accounting identities". Godley and Lavoie [31] introduced an "accounting framework" (p. 18) to macroeconomics by writing that the aspiration is to "describe the evolution of the whole economic system, with all financial transactions (including changes in the money supply) fully integrated" (p.xxxiv). "The fact that money stocks and flows must satisfy accounting equalities in individual budgets and in an economy as a whole provides a fundamental law of macroeconomics analogous to the principle of conservation of energy in physics." (Godley and Cripps 1983: 14)[29]. The accounting approach shows that every flow of payments comes from somewhere and goes somewhere [31], so that there are no financial "black holes" in the model. Flow-of-fund models, and the wider class of stock-flow consistent models (also including real variables) allow researchers to trace actually evolving patterns rather than imaginary equilibrium conditions. For instance, Kinsella *et al.* (2011) show how stock-flow consistent national accounts built from the local interactions of heterogeneous agents account for dynamics with respect to firm size and firm age, income distribution, skill set choice, returns to innovation and earnings.

In this paper, the application is to show that financial structure is one source for the economy's complex-system behavior. The next section develops a model that reflects this in the simplest possible manner. In particular, it explicates the economy's balance sheets but abstracts from specifying individual behavior, in order to bring out that instability is (partly) based in the economy's financial structure.

4. A Simplified Balance Sheet Approach

Schumpeter (1954:717)[43] advised to "look upon capitalist finance as a clearing system that cancels claims and debts and carries forward the differences — so that "money" payments come in only as a special case without any particularly fundamental importance". All financial transactions are credit/debit operations and the whole system is always subject to an overarching balance sheet identity of the type "credit = debt". In particular, as Schumpeter emphasizes, money is just one type of credit and interacts with other types; and since money creation is debt creation, the counterpart debt growth needs to be traced analytically so as to understand dynamics. These are the two organizing principles in explaining how finance induces instability: A balance sheet approach to the economic system, and distinction between money and other types of credit. To do this in a model as simple as possible (but not simpler), the economy is represented by the following balance sheet identity:

$$L + S = D + W \tag{1}$$

Where L denotes loans, S securities, D deposits and W wealth. With assets on the left hand side and liabilities on the right hand side, this is a balance sheet identity from the financial sector's point of view. Its assets are bank assets (loans to the non-financial sector L) and assets or instruments held by the non-bank financial sector, generically labeled 'securities' (S). Its liabilities are the non-financial non-bank (or 'real') sector's deposits (D) and its wealth (W). (In what follows, we will use "the real sector" and "the economy" interchangeably.) One way to derive this

Table 1. Consolidated balance sheets of the real sector.

Assets	Liabilities
Government	
Cash and deposits (D)	Public debt securities (S)
Tax accounts	
Firms	
Plant and equipment (W)	Taxes due
Inventories (W)	Long-term loans (L)
Deposits (D)	
Households	
Deposits (D)	Taxes due
Property (W)	Mortgage loans (L)
	Mortgage derivatives (S)
$D + W$	$L + S$

identity is by consolidating the real-sector's accounts, which produces the mirror image of Eq. (1). Table 1 illustrates.

"Wealth" is the aggregate of all non-deposit assets held by the non-financial sector (such as housing and plant and machinery) which are debt-financed by the financial sector. This representation implies a balance sheet aggregation choice, since other non-deposits assets cancel out against each other. Common stocks, issued by firm to households, or public debt, issued by the government, remain implicit in Wealth. Its distribution over firms, households and government is not specified, so that (for instance) common stock held as a household's asset and a firm's liability cancels out. Debt from non-financial firms to households do not appear on the financial sector's balance sheet. Also, we do not separate out a foreign sector.

It is important to distinguish between banks and the non-bank financial sector. The activities of the non-bank financial sector allow for an acceleration of lending and debt that is otherwise impossible. In this stylized model, banks are providers of finance to the real sector. They create deposits which are liabilities on themselves, and which are used by firms and households to conduct real-sector and wealth transactions. And banks receive repayment of loans with interest. Banks' balance sheets are so the financial reflection of the real-sector circular flow of goods and services. The non-bank financial sector also issues liabilities and holds claims (against both bank and the real sector), but its liabilities are not universally accepted as payment for goods and services, as bank money is.

The non-bank financial sector includes pension, leasing, asset management, consumer finance and non-bank mortgage institutions. Its role in this model is to act as an additional source of demand for bank liabilities, in addition to real-sector demand. Non-bank financial institutions generate this demand by obtaining assets from banks (e.g., buying loans) and issuing their own liabilities (e.g., a mortgage derivative or money market instrument). These are tradable and become part of the total stock of financial assets, held by e.g., pension funds on behalf of households.

In sum, the existence of a non-bank financial sector expands investment opportunities beyond real-sector investments, fuels asset price rises and increases demand for bank lending. At any given level of the economy (i.e., of real-sector activity), the non-bank financial sector so contributes to more debt and rising asset prices.

Identity 1 brings out the overarching accounting identity that whenever the economy's assets (deposit money and wealth) increase, its liabilities increase. In particular, the total sum of the money stock D and the value of transactions in wealth W, both held by the real sector, can grow in nominal value only if the financial sector creates the liquidity needed for these transactions by lending to real sector agents, accumulating debt claims against the real sector.[a] In the remainder of this section the identity is explained. It is convenient to do this in flow terms (denoted d). Figure 1 is a flow chart that presents the relations between L, S, D and W, with other symbols to be explained below.

When banks lend, the real sector receives the newly created liquidity on deposit and then uses it in transactions of goods and services or in wealth transactions [16, 47]. So far, that means $dL = dD + dW$. In words, fresh lending monetizes (i.e., provides the financial resources for) the additional transactions in goods and

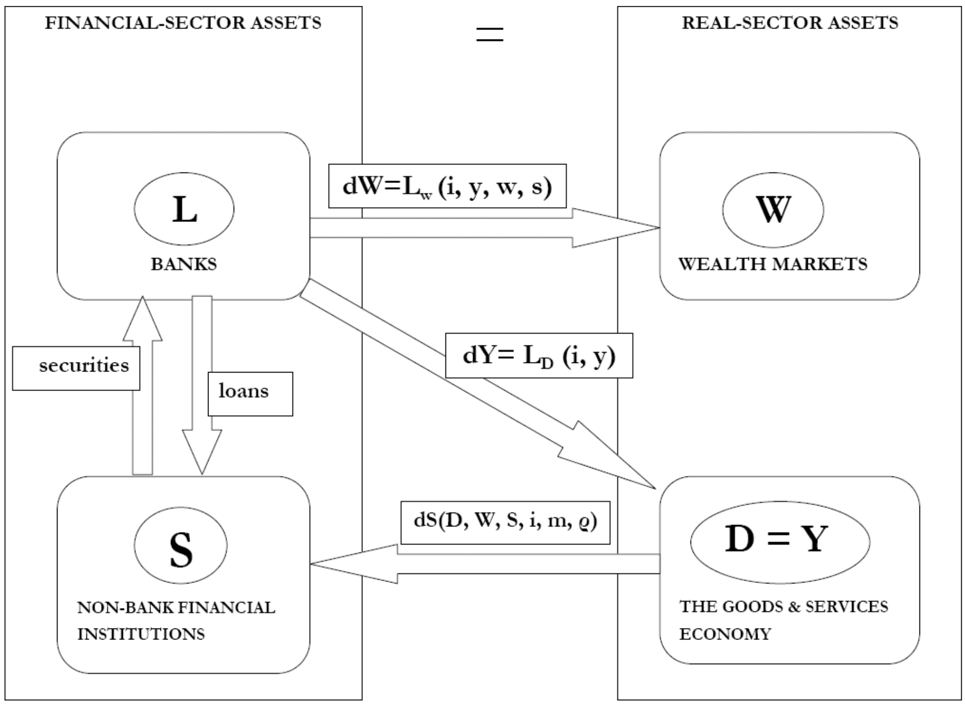


Fig. 1. Flow chart presentation of the model.

[a] Of course, the liquidity needed for wealth transactions is not equivalent to the capital gains made. Below we capture the difference in parameter q_W.

services that constitute economic (real-sector) growth dD as well as the additional transactions in wealth dW. But lending also induces return flows of interest and principal repayment. Repayment is from deposits and this reduces the levels of loans and of deposits in equal measure. These interest-driven repayment flows are key to debt deflation and finance-induced instability of the system, even though "it is standard practice... to ignore interest payments." (Godley, 1999:405)[28]. In this respect, stock-flow consistent models are complete where other models, referred to by Godley, are financially incomplete.

The economy's repayment of loans does not simply accumulate in the financial sector. They are capitalized into new loans or into investment instruments. We label this new asset class generically "securities", denotes S. For the financial sector to re-invest return payments means to lend it back into the real sector, replenishing dD to its initial level before repayment, and raising S accordingly. S epitomizes the non-bank financial sector. Including it means adding its assets to the left-hand side of the identity, resulting in $dL + dS = dD + dW$, or (in stock terms) the above identity $L + S = D + W$.

There are two types of securities S. Part of S is equity investment, allowing the non-bank financial sector to establish claims on output (i.e., to buy shares ands bonds). As a result, the real sector has increased in size (by dD) and in liabilities (by dS; it now has both loan and equity liabilities). Equity, by establishing new claims on output, changes the distribution of income between the real and the non-bank financial sector.

The other destination for repayment flows is securitization as we know it: The returns on loans are repackaged as new interest-bearing financial instruments. This has future repayment implications. Either way, repayment flows from the real to the financial sector are converted into claims held by the non-bank financial sector on the real sector.

5. Linking Finance and the Economy

In DSGE-type models, growth in deposit money dD is the only monetary variable that matters and asset markets (of size $S + W$) can be safely left out of the model. By assuming that money is just a unit of account, it is assumed that any growth of the economy that increases real-sector transactions by amount dY is always automatically accommodated by growth of money dD. There is no tracing of the debt implications of growth encapsulated in the lending that creates deposits (and which is part of dL; the other part being lending for wealth transactions). In DSGE models there is money (liquid liabilities held as assets by the financial sector), but not the credit creation process that produces money, and which implies liabilities (debt) held by the real sector. This violates accounting consistency: There are liabilities not balanced by assets. In sum, in standard macro models the (inconsistent) assumptions are that $dS = dW = 0$ and $dD = dY$. In this section we show that the second assumption has very strong credentials while the first precludes any meaningful analysis of credit cycles or financial instability.

Theoretically, any increase in the sum of all final goods-and-services transactions that make up the Gross Domestic Product (GDP, or Y) must be mirrored in bank credit creation supporting transactions of final goods and services.[b] This directly implies that the part of bank lending (L) that goes to the real economy and which creates deposits (D) should indeed be constant in proportion to the size of the economy, and so

$$D = Y \tag{2}$$

To equate growth in bank lending to the real sector to nominal economic growth is not a novel idea. Marx in *Capital* wrote of 'productive credit, whose volume grows with the growing volume of production', implying parity of credit for goods-and-services transactions with the volume of production of goods and services — true by definition. Werner [47] developed a modified equation of exchange approach to show this, and applied it to the case of Japan. He found that fluctuations in credit to the real sector and in GDP indeed have a correlation coefficient very close to one. Federal Reserve analysts also note for the US that "over long periods of time there has been a fairly close relationship between the growth of debt of the non-financial sectors and aggregate economic activity" (Board 2009:76). We may also show this long-term relation for the US from the 1950s to just before the 2007 crisis (Fig. 2). The growth of lending to the non-financial sector maps indeed virtually one-on-one onto growth of aggregate economic activity (GDP) since the beginning of the time series in 1952.

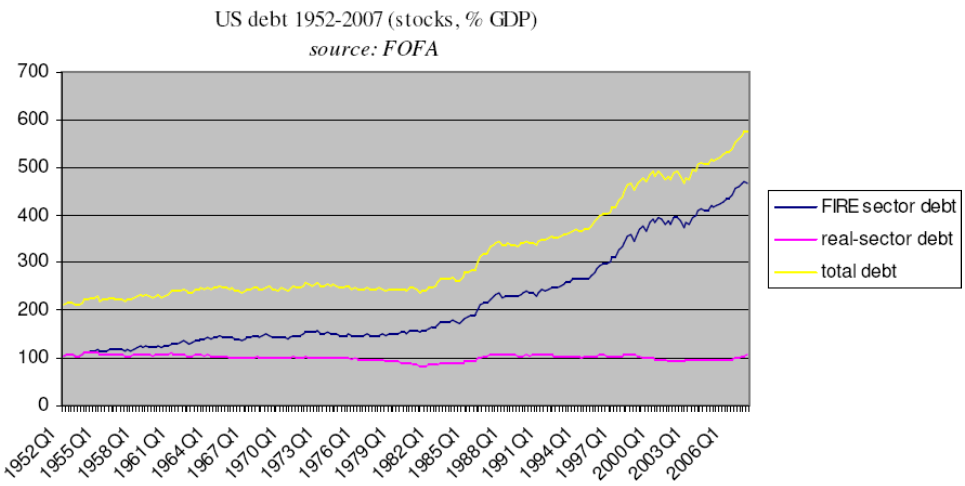


Fig. 2. Lending to the real sector equates to nominal economic growth.

[b] Effects on GDP of changes in inventory and inter-firm trade credit are abstracted from.

This is in contrast to the flows of other, "free" credit issued by US banks, defined in the US National Income and Product Accounts (NIPA) classification as the Finance, Insurance and Real Estate (or FIRE) sectors (see Bezemer, 2009 for details). They rose fivefold in proportion to the US economy since the 1950s. This, the bulk of the economy's debt flows, are left out of DSGE models. This credit other than used for goods-and-services transactions is by definition comprised of financial flows to the amount $(dL + dS - dD)$ (total lending minus growth in deposit money). It follows that the counterpart rise in debt must imply an increase in the economy's leverage, that is: in its debt-to-GDP ratio.[c]

In the model, we define the economy's leverage as $(L + S - Y)/Y$. We will use this to trace leverage, and the consequences of its absence in (DS)GE models, in the simulations below. Recall that the problem in these models is that finance is linked to the economy by assuming away "free" credit flows, as if money's role is only to circulate goods and services in the real sector. In model terms, this is to assume that $W = S = 0$ so that the model reduces to $L = D$: All lending is to increase deposit money, to be used in transactions of good and services. There is no leverage possible since there are no real-sector liabilities to the financial sector beyond the size of the economy. The real sector's liabilities are always and by definition equal to its size. Leverage can only exist to the extent that lending (whether L or S) is directed to boost the values of W and S itself. Analysts have indeed noted that each postwar US business cycle started at a higher level of leverage [34].

6. Dynamics

Dynamics are shaped by five parameters: nominal interest rate i, loan maturity m, securitization ρ, the economy's nominal growth rate y and the nominal wealth growth rate w. While the values for economic growth and wealth growth evolve endogenously in the simulations below, parameters for securitization, maturity and interest rate will be given constant values, so as to bring out that financial instability arises from the structure of financial capitalism, not from variations in its financial parameters. This is the key point made in Minsky's work: to have sophisticated financial markets (at the very least, asset markets distinguished from money) is to have financial fragility and instability. In particular, it bears emphasizing that instability dynamics do not exist because of interest rate movements. They exist because of the structure of leverage, the key element of capitalist finance. Geanakoplos (2009:9) [26] calls for an end to 'the obsession with interest rates' and asserts that 'regulating leverage, not interest, is the solution for a troubled

[c]The fact that wealth cannot grow unless debt grows is an *aggregate* accounting identity, not an individual-level assumption on how wealth is financed. Over the course of a credit boom, successive owners of an asset may sell the asset at a profit, but their buyers will have to shoulder proportionally more debt (or divert more of their real sector income) in order to acquire the asset, balanced (for the time being) by the asset's value. Asset trade may be individually profitable; it is a zero sum game for the economy (Bezemer 2009a, 2009b)[4, 5].

economy'. Endogenizing interest rates and making them variable does of course bring in additional dynamics which occur in reality. But Geneakoplos' point is that these may be secondary phenomena. The simulations below indeed show that credit cycles and financial instability exist also without changes in interest rates.

We now introduce growth rules. They are deliberately stylized and do not aim to realistically reflect the formation of agents' decisions regarding consumption, production and investment. As with endogenous interest rates, more realistic behavioral finance could be introduced into the model, no doubt adding to the complexity of the evolving dynamics. This is just what happens in the more sophisticated DSGE models. But doing that here might easily defy the paper's purpose to show that even *without* such realistic complications, non-linearities and sudden transitions already evolve. Figure 2 is a flow chart that depicts the variables and their relations.

The growth rules are the following. Per-period total lending dL is lending either to increase deposit money (L_D) or to increase wealth (L_W). Borrowing (L_D) to increase deposit money to be used in real-sector transactions of goods and services is determined by its cost (interest i) and its expected benefits, based on the GDP growth rate $y = dY/Y$ in the last period (backward-looking expectation formation). In the case of borrowing L_W for wealth investments (such as mortgages) the wealth formation preference is shaped by both past income growth y (more wealth titles are acquired when income is higher) and the wealth growth rate $w = dW/W$ in the last period (higher returns on wealth investments attract more wealth investment). In addition, dS is among the determinants of L_W since securities are interchangeable with (other) wealth investments W held by the non-financial sector (such as property and currency). It follows that the rate of increase of securities will be viewed as part of the rate of return on wealth investment. This is the way we capture the link between non-bank financial sector growth with investment decisions in the real sector. With scaling parameters q_D, q_W, simple growth rules capturing this are the following.[d]

$$dL = dL_D + dL_W \tag{G.1}$$

$$dL_D = q_D \cdot \frac{1}{i} \cdot (y)_{t-1} \tag{G.2}$$

$$dL_W = q_w \cdot \frac{1}{i} \cdot (y + w + s)_{t-1} \tag{G.3}$$

In each period, repayment of both types of loans (principal and interest) is from deposits, and repayment flows are channeled into equity investment or into loan

[d]The scaling parameters allow deviation from a one-on-one impact of the left hand side on growth in W and D. They change the levels but not the patterns of the simulations. For simplicity, Eq. (G.3) implies equal weights for past growth rates in wealth, securities and income in the determination of current lending for wealth. Different weights could be introduced by specifying three additional parameters.

securitization — jointly called "securities":

$$dD = dL_D - dS \tag{G.4}$$

$$dW = dL_W \tag{G.5}$$

Apart from repayment dS, we choose not to focus on explicating determinants of economic growth, and hence on the growth rate of deposit money dD. This evolves endogenously from a set starting value (of 3%).

Repayment flows dS are determined by the level of outstanding loans and by interest and maturity parameters i and m, and some scaling parameter qs. The level of outstanding loans comprises three elements: past lending into deposits (L_D), lending into wealth markets (L_W), and securities that were lent out in the past. Having dS depend on past values of S reflects the securitization feedback loop that makes growth of securitization self-propelled. With some constant parameter ρ ($0 < \rho < 1$) denoting the share of cumulative repayment that is loan securitized in each period, we have

$$dS = q_S \cdot \left(i + \frac{1}{m}\right) \cdot (D + W + \rho \cdot S)_{t-1} \tag{G.6}$$

with scaling parameter q_S. This concludes the model.[e] With four variables and five parameters/constants, it is perhaps the simplest model which still has the following five features:

(i) The economy is shaped by, not merely reflected in balance sheets;
(ii) The real sector's and the financial sector's flows are separate, because the real sector's money (deposits) and wealth are separate from the financial sector's assets (securities and loans). But they do interact (point 4 below).
(iii) Within the financial sector, the function of banks and non-banks is separated (loans making versus securities trading) — even though actual banks may mix them.
(iv) Securities trading affects the real-sector's wealth and increased lending elicits return flows of interest and financial fees. These are the key mechanisms of real-sector effect of finance.

Following Godley's dictum (e.g., Godley and Lavoie 2006: xii)[31], the model has so-called stock-flow consistency throughout. In model terms, this means that the identity $L+S = D+W$ is always satisfied because in flow terms, in each period $dL + dS = dD + dW$ holds. Everything is in nominal terms for, as e.g. Minsky [40] emphasized, its nominal values for assets and debt that are among the financial causes of

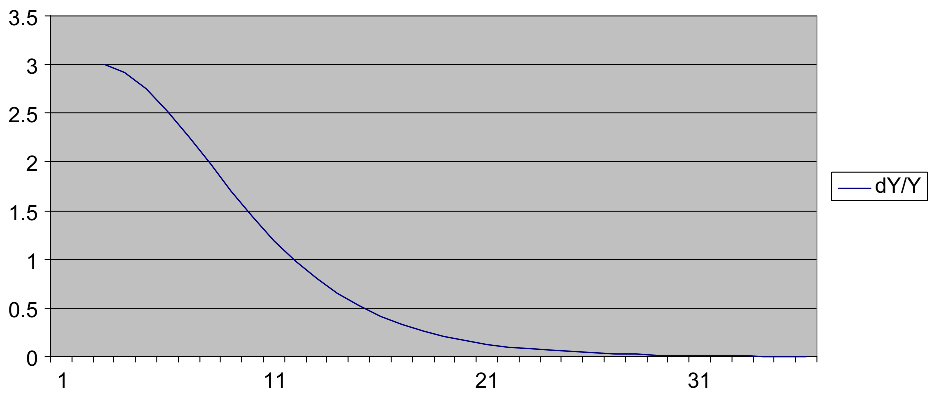
[e] As noted, we keep constant the financial parameters i and m in order to show that structure rather than parameter variation drives dynamics. In this setup, i and m reduce to constants and could be combined with q_D, q_W and q_D into one constant for each equation. But for didactic reasons we keep them separately in the model.

cycles and crisis. Model properties suffice to generate endogenous cycles and instability of cycles due to increasing leverage. But as we will see, the timing and severity of instability depend on the nature of securitization. We now turn to simulations.

7. Simulations

Without leverage, there are no finance-induced cycles. This is because finance *is* leverage. With $W = S = 0$ the model reduces to $L = D$, as in DSGE models: All credit creation is for the real sector, which grows auto-regressively. Loan repayment is not invested in securities, but just creates the financial room for new bank lending to the real sector. In the present specification, growth tapers off. For instance, with starting values $\{Y = D = 10{,}000, W = S = 0\}$ and parameters $\{i = 6\%, y_o = 3\%, m = 10 \text{ years}, q_D = 6\}$ income Y converges in 30 periods to a level that is stable to 2 decimal points percentage growth, with income growth rate y converging to zero (Fig. 3). Changes in parameter values change the pattern and the speed of convergence. For instance, with $i = 4\%$, growth first rises before falling, and the stable level is reached after 20 periods. This hypothetical simulation links in with the central role of finance for economic growth to occur at all in capitalists systems — or as Schumpeter, Keynes and Minsky emphasized, capitalism is inherently *financial* capitalism.

In the second simulation we introduce leverage without securitization by setting starting values $W_\text{o} = S_\text{o} = 10$ and $\rho = 0$ so that growth rules G.2 and G.3 come into play, and all else equal. Again, we normalize interest to 1% by setting $q_D = 1/i = 6$. Figure 4 below (top panel) shows three variables: income growth dY/Y, leverage $(L + -Y)/Y$ and net flows from finance to the economy, which is $(Dd + dW)/Y$, all multiplied by 100 to yield percentages of Y. The simulations over the short run (200



Starting values: $D = Y = 10{,}000$, $W = S = 0$, $y_\text{o} = 3\%$
Parameters: $i = 6\%$, $q_D = 6$, $m = 10$, $\rho = 0$

Fig. 3. Hypothetical capitalism without leverage stagnates.

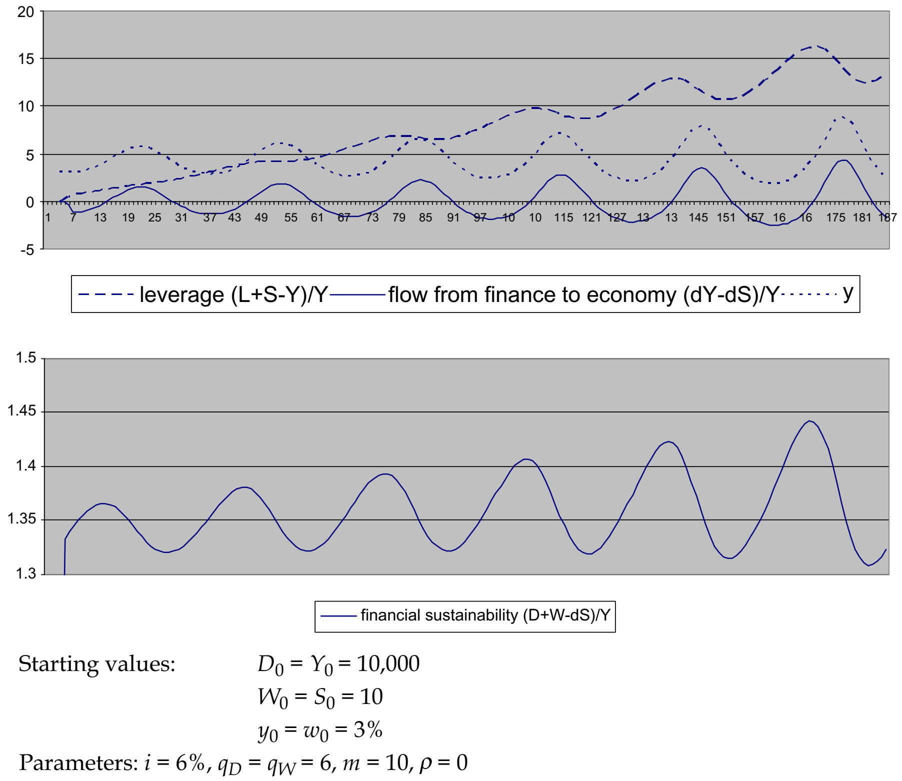


Fig. 4. The equity scenario in the short run: Financially sustainable credit cycles.

periods) show cyclicality of income and of financial flows, with increasing levels of leverage. As was the case with postwar US growth, each business cycle starts at a higher level of leverage. Leverage itself is also cyclical.

The bottom panel in Fig. 4 shows that the model is financially sustainable in the short run, in the sense that all financial obligations can be met. This is indicated by a "financial sustainability" measure which subtracts the flow of net payments from the real to the financial sector (dS) from the stock of financial means to service this payment ($D + W$), all scaled by Y. Since $D = Y$, this measure $(D + W - dS)/Y$ is equivalent to $(1 + (W - dS)/Y)$, or one plus the excess of wealth over repayment obligations, scaled by Y. Situations with $(W - dS) < 0$ are clearly financially unsustainable in this model.[f] However, in the equity scenario in the short run, financial sustainability is on an increasing trend, as Fig. 4(b) shows.

[f]This should be viewed as a minimum value for financial sustainability. In the real world, even dipping below some positive lower threshold value for $(W - dS)$ will be financially unsustainable. Financial market participants can foresee the $W < dS$ point approaching and the resulting fire sales of assets depress asset prices, so reducing W and hence repayment capacity. In other words, below a threshold financial sustainability will endogenously fall. This refinement is not included.

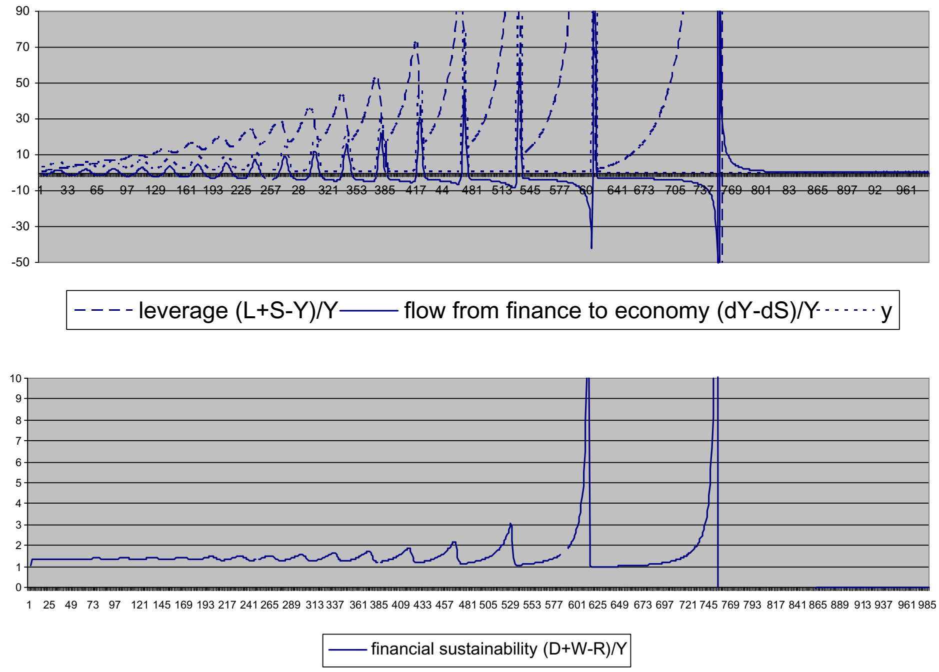


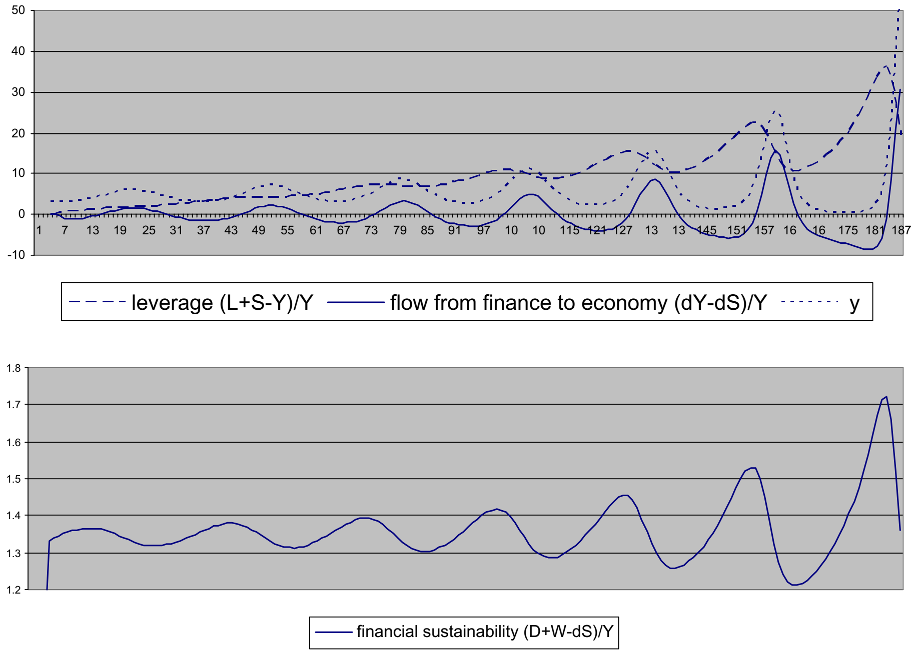
Fig. 5. The equity scenario in the medium run: Increasing cycles followed by breakdown.

That instability is nevertheless built into the fabric of financial capitalism, as Minsky [40] explained, becomes clear only in the medium run (1000 periods). Figure 5, bottom panel, shows for the same settings that the cyclical minimum value for financial sustainability peaks at $t = 612$, and sinks to just above value one where it hovers for 70 periods before skyrocketing, peaking and then crashing at $t = 755$. Value one for financial sustainability means that that period's repayment obligations can just be met out of total wealth W. However, since peak values for financial sustainability rise much more than trough values fall, average values continue to increase right until the crash. These peaks reflect the skyrocketing asset values typical of the last phase of a credit boom, aptly labeled the "winner's curse" phase by Harrison [33]. Leverage and financial flows to the economy also peak before they turn negative and the system collapses.

We now introduce securitization by setting $\rho = 0.1$ and everything else equal. Figure 6 shows the short-run 200-period scenario.

The differences with the equity regime are noteworthy (note the different scale):

(i) Securitization is good for growth, in the short run. The upward trend in income growth is now much stronger.
(ii) Securitization amplifies and intensifies the business cycle. The demeaned normalized standard deviation of growth increases. Within the first 200 periods,



Starting values: $D_0 = Y_0 = 10{,}000$, $W_0 = S_0 = 10$, $y_0 = w_0 = 3\%$
Parameters: $i = 6\%$, $q_D = q_w = 6$, $m = 10$, $\rho = 0.1$

Fig. 6. The securitization scenario in the short run higher growth but declining financial sustainability troughs.

securitized growth goes through seven cycles while equity-regime growth went through six cycles.

(iii) Leverage increases exponentially. After 100 periods it is at about the same level (peaking at about 10) as in the equity scenario but at $t = 200$ it peaks at over value 36, more than double the level attained in the equity regime. It also exhibits stronger increasing cyclicality.

(iv) Over time, booms become shorter and troughs longer than in the equity scenario.

(v) While the peak values for financial sustainability continue to increase, its trough values start declining already after $t = 58$.

Thus, already in the short run it is clear that securitization-led growth is financially unsustainable, although very profitable. A 400-period simulation shows that the system implodes at about $t = 260$ (Fig. 7). Stocks of loans and securities peak and then turn negative in a massive debt deflation. Net flows from finance to the economy as well as economic growth decline to zero.

Before we turn to the last simulation, it is helpful to briefly identify the conditions under which the system collapses at some point in time. Collapse comes

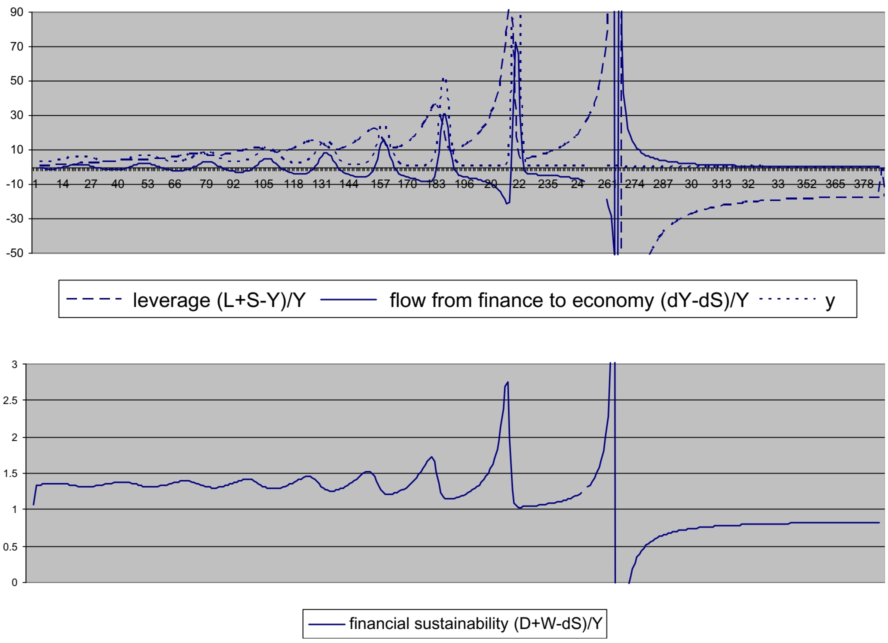
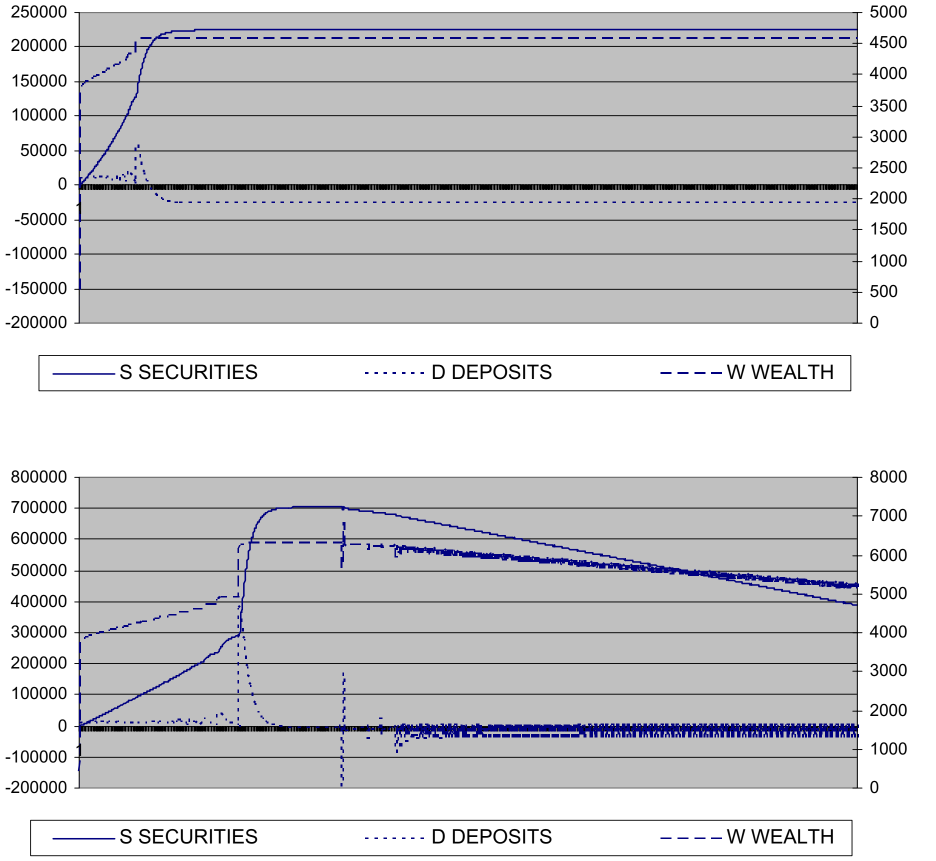


Fig. 7. The securitization scenario in the long run: Growth and volatility are higher and the end comes sooner.

sooner with higher levels of *securitization*: For values of ρ equal to (0.2, 0.4, 0.9) and all else equal to the Fig. 7 settings, the system collapses at times $t = 171$, $t = 114$ and $t = 72$, respectively. Second, collapse comes sooner with higher *interest rates* or (equivalently) shorter maturities and lower values for parameters q_D and q_w. For instance, if we increase interest rates form the 6% in Fig. 7 to 10%, 15% and 30%, then the system collapses at times $t = 181$, $t = 34$ and $t = 26$, respectively. Also, lower starting values for the whole system hasten collapse: dividing all starting values by 10 (so that $D = Y = 1000$) brings the collapse forward from $t = 251$ to $t = 78$. Increasing only the level of securities has no linear relation to the timing of the collapse, e.g., for values S at $t = 0$ of (10, 15, 20, 30, 50, 80, 100), the collapse comes at t values of (251, 390, 321, 342, 376, 402, 351). This is to be expected since S is determined non-linearly. Initial wealth levels do not matter much: Increasing W at $t = 0$ from $W = 10$ to $W = 1000$ pushes back the collapse only from $t = 251$ to $t = 235$.

We conclude with another noteworthy difference between the equity and securitization scenarios. Minsky (1978, 1986) [39, 40] in his early work analyzed that in post-war financial capitalism, financial fragility builds up in the good times and periodically morphs into financial instability. These crisis are then managed by massive government deficit spending and central bank lending, stabilizing the system at increasingly higher levels of leverage and setting the scene for the next boom. In later work, however, Minsky noted the increasing influence of securitization in



Note: Wealth is on the right-hand scale

Fig. 8. Securitization (top) and equity (bottom) scenarios, very long run: A system change is needed for revival.

achieving those higher levels of leverage (e.g., Minsky 2008 [1987])[41]. Minsky worried that what he called the "money manager capitalism" that he saw emerging in the 1980s and 1990s undermined capitalism's viability by redirecting investment to financial, not real investments and capital formation [48].

Figure 8 illustrates this difference in post-crisis viability of the two systems. It plots the stocks of securities, deposits and wealth. In the equity scenario, recurrent growth and instability characterizes the system also in the very long run (3000 periods). In the securitization scenario, the initial crash occurs at much higher levels of leverage and is final. Deposits (the financial measure for the size of the economy) turn permanently negative and so do growth in wealth and securities. Only a change in the system itself which reduces leverage (a change represented by lower ρ) could revive it. Geanakoplos (2009) likewise comments that "reduction of leverage, not interest is the solution for a troubled economy."

8. Summary, Reflections and Conclusions

This paper explored the methodological shift in macroeconomics towards agent-based models, widely considered to be a promising alternative to current macroeconomic practice dominated by DGSE models. It explains that complex behavior and sudden transitions also arise from the economy's financial structure as reflected in its balance sheets, not just from heterogeneous interacting agents. It introduces "flow-of-funds" or "accounting" models, which were pre eminent in successful anticipations of the recent crisis.

In illustration, a simple balance sheet model of the economy is developed to demonstrate that non-linear behavior and sudden transitions may arise from the economy's balance sheet structure, even without any micro-foundations. Finance implies leverage, which implies cycles of increasing amplitude in real and financial variables. Because financially sustainable growth requires minimum values for the means to meet financial obligations, increasing cycle amplitude with higher peaks and lower through leads to a situation of crisis, which implodes the system.

The paper explores two types of leverage, under the headings of "equity" and "securitization" scenarios. It is demonstrated that securitization leads to higher growth rates, more cycles, higher peaks for all variables but also longer trough periods and deeper troughs values. The model mimics post-war developments with increasing levels of leverage over business cycles and suggests that the system survives crises in the equity scenario but not in the securitization scenario.

It is not difficult to think of further analyses and extensions to this model, which the setup and scope of the present paper prohibit. Robustness should be evaluated more extensively by studying the effects of changes in starting and parameter values. Inflation could be included, studying real as well as nominal dynamics. Different classes of assets (bond, stocks and real estate) and players (central and commercial banks) could be introduced, as well as a trade and capital flows with a foreign sector and more detail in the real sector with regard to consumption patterns, savings behavior, production technologies, labor use, wages and prices, inventories, and industry disaggregation. It should be noted, however, that detailed flow of fund models (often with tens or hundreds of equations) exist, both theoretical and for specific economies. Even a "synthetic" model such as Treeck [46] has 27 equations and the 'Simplified, "Benchmark", Stock-Flow Consistent Post-Keynesian Growth Model' by Dos Santos and Zezza [23] has 66 equations. In a sense, extensions that make it more realistic would undermine the purpose of this stylized model, which was to demonstrate that complex behavior results from a complete but highly stylized balance sheet model of the economy, even without all those extensions. A more complex model could easily obscure that financial instability resides (in part, at least) in the economy's structure and not only in its policies or in the behavior of its agents. To demonstrate that was the aim of this paper.

In conclusion, we return to the motivation for this exercise, set out in the opening sections. This was to argue that the failure of DSGE-style macroeconomics was a failure to meaningfully include finance in its models. Apart from that, there also is a failure to model complex systems arising from heterogeneous interacting agents. The present model deliberately left out micro foundations in order to focus on structures rather than behavior within those structures. A next step would be to add micro foundations to a financially credible agent-based model. To the best of this author's knowledge, the only attempt to date at doing this is reported in [19]. Based on the EURACE simulator environment, they develop a model linking the balance sheets of firms by double entry accounting, and applying overarching accounting constraints. Cincotti *et al.* [19] simulate the effects of specific fiscal and monetary policies, depending on firm's dividend payout policies. This research demonstrates, among other things, how a financially realistic representation and, especially, accounting constraints, modify the outcomes. To combine agent-based modeling with the economy's core financial structure (its 'balance sheet dimension') is a promising avenue for future research.

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