Modeling Financial Instability

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1. Introduction

Literally no-one disputes that the financial sector was the cause of the post-2007 economic crisis: disputation instead centers on the causal mechanisms. I follow Fisher (Fisher 1933) and Minsky (Minsky 1980) in assigning key roles to the growth and contraction of aggregate private debt (Keen 1995; Keen 2000), but this perspective is rejected by New Keynesian economists on the *a priori* basis that private debts are "pure redistributions" that "should have no significant macro-economic effects" (Bernanke 2000p. 24), and as a corollary to the oft-repeated truism that "one person's debt is another person's asset" (Krugman 2012c, p. 43).

My analysis also follows the Post Keynesian tradition of endogenous money (Moore 1979; Moore 1983) in seeing the banking sector as an essential component of the macroeconomy, yet this is also dismissed by New Keynesian economists on the grounds that banks are merely a specialized form of financial intermediary (Krugman 2012a; Krugman 2012b; Krugman 2013a; Sumner 2013; Tobin 1963), all of which can be safely ignored in macroeconomic models. When banks are introduced in New Keynesian models, they function not as loan originators but effectively as brokers between savers and borrowers (Eggertsson and Krugman 2012b, pp. 21-22).

In response, authors in the Post Keynesian and Endogenous Money traditions express exasperation that New Keynesian authors ignore credit creation and the accounting mechanics of bank lending (Fullwiler 2012; Roche 2013), as laid out in numerous Central Bank publications (Carpenter and Demiralp 2010; ECB 2012; Holmes 1969; Keister and McAndrews 2009).

Given the key public policy role of economics, and the acknowledged failure of Neoclassical models in general to anticipate the financial crisis (Bezemer 2009; Blanchard 2009; Blanchard, et al. 2010; OECD 2007), the existence within academic economics of two diametrically opposed perspectives which fail to communicate is a disservice to the public.

In this paper I attempt to conclusively determine whether aggregate private debt and banks matter in macroeconomics by putting the two rival models of lending—Loanable Funds and Endogenous Money—on a common footing. Using the dynamic Open Source monetary modeling program ***Minsky***,[1] I firstly put the New Keynesian model of banking in Eggertsson & Krugman 2012b into a strictly monetary model and I show that, if the structure of lending in this model accurately characterizes actual lending, then the Neoclassical perspective that aggregate debt is unimportant,[2] and that banks can safely be ignored in macroeconomics, is correct. I then modify this model to match the Post Keynesian perspective on the structure of lending, and show that in this structure,

[1] ***Minsky*** (and the system dynamics tradition from which it emanates) is described more fully in Section 5 of the Appendix.

[2] Except during a Liquidity Trap.

changes in the aggregate level of private debt have a direct impact upon aggregate demand, and banks therefore play a crucial role in macroeconomics.

2. Loanable Funds vs Endogenous Money

The Neoclassical model of "Loanable Funds" and the Post Keynesian concept of "Endogenous Money" constitute the polar opposites on the nature and significance of banks, debt and money in macroeconomics. Both models portray the money supply as variable, and hence in one sense endogenous, though by very different mechanisms and to very different degrees (Palley 2013, p. 411). In the Loanable Funds tradition, banks function as "mere intermediaries" (Graziani 1989, p. 8) between savers and borrowers, private debts are "pure redistributions" that "should have no significant macro-economic effects" (Bernanke 2000, p. 24), and banks, debt and money can be and are ignored in canonical macroeconomic models (Smets and Wouters 2007; Woodford 2009). In the Endogenous Money tradition, banks are crucial to macroeconomics because they create money by creating debt (Holmes 1969; Moore 1979), but no consensus has yet emerged on how to represent this phenomenon in Post Keynesian macroeconomic models (Palley 1991; Palley 2002).

There is little communication between the two approaches, with authors in the Loanable Funds tradition frequently deriding those in the Endogenous Money camp (Krugman 2012a; Krugman 2012b; Krugman 2012e; Krugman 2012f), and dismissing the proposition that banks must be included in macroeconomics (Krugman 2012a; Krugman 2012b; Krugman 2012d; but see Rowe 2013; Sumner 2013).[3]

This dispute can be resolved by an appeal to the Occam's Razor principle that unless a more complex model makes different and better predictions than a less complex one, the simpler should be preferred. Therefore, unless bank lending *necessarily* affects vital macroeconomic aggregates in a significant manner, then even though the "loans create deposits" accounting perspective of Endogenous Money is technically correct (Carney 2012; ECB 2012; Holmes 1969)—as even Paul Krugman has conceded (Krugman 2013a)[4]— the Loanable Funds approach is justified, and banks should be excluded from macroeconomics. Conversely, if bank lending necessarily affects macroeconomic aggregates, then banks, debt and the endogeneity of the money supply are integral to macroeconomics, and models that exclude them are not models of a capitalist economy.

[3] A typical instance is the following from Krugman in a post entitled "Banking Mysticism": "For in the end, banks don't change the basic notion of interest rates as determined by liquidity preference and loanable funds — yes, both, because the message of IS-LM is that both views, properly understood, are correct. Banks don't create demand out of thin air any more than anyone does by choosing to spend more; and banks are just one channel linking lenders to borrowers. I know I'll get the usual barrage of claims that I don't understand banking; actually, I think I do, and it's the mystics who have it wrong." (Krugman 2012a)

[4] "All the points I've been trying to make about the non-specialness of banks are there. In particular, the discussion on pp. 412-413 of why the mechanics of lending don't matter — *yes, commercial banks, unlike other financial intermediaries, can make a loan simply by crediting the borrower with new deposits*, but there's no guarantee that the funds stay there — refutes, in one fell swoop, a lot of the nonsense one hears about how said mechanics of bank lending change everything about the role banks play in the economy.
Banks are just another kind of financial intermediary, and the size of the banking sector — and hence the quantity of outside money — is determined by the same kinds of considerations that determine the size of, say, the mutual fund industry." (Krugman 2013, "Commercial Banks as Creators of "Money"; emphasis added)

3. A monetary model of Loanable Funds

Eggertsson and Krugman note that the vast majority of mainstream economic models ignore debt:

> If there is a single word that appears most frequently in discussions of the economic problems now afflicting both the United States and Europe, that word is surely *debt*… one might have expected debt to be at the heart of most mainstream macroeconomic models—especially the analysis of monetary and fiscal policy. Perhaps somewhat surprisingly, however, it is quite common to abstract altogether from this feature of the economy. Even economists trying to analyze the problems of monetary and fiscal policy at the zero lower bound—and yes, that includes the present authors (see Krugman 1998, Eggertsson and Woodford 2003)—have often adopted representative agent models in which everyone is alike and the shock that pushes the economy into a situation in which even a zero interest rate is not low enough takes the form of a shift in everyone's preferences. (Eggertsson and Krugman 2012a, pp. 1469-71)

In order to introduce debt into a New Keynesian two-period model, Eggertsson and Krugman divided agents into two groups who "differ only in their rates of time preference": "patient agents" and "impatient agents" where the latter have a higher rate of time preference than the former, so that "In that case, ''impatient'' individuals will borrow from ''patient'' individuals." (Eggertsson and Krugman 2012ap. 1474). Debt was explicitly modeled throughout this paper,[5] and banking was introduced in the Appendix (Eggertsson and Krugman 2012b) as an intermediating function between depositors and borrowers, where borrowing by impatient agents was strictly for investment.[6]

The authors describe their model as a "just the standard New Keynesian model", with one twist, in that the natural rate of interest, which is normally an exogenous parameter in the *IS* equation, is instead endogenous with borrowers' debt being one of its parameters. Therefore the level of private debt plays a macroeconomic role:

> we need to figure out the evolution of debt of the "borrowers" to figure out the natural rate of interest. In particular we see that if … the economy is "overleveraged" … it is easy to get endogenously negative natural rate of interest. (Eggertsson and Krugman 2012b, p. 24)

The New Keynesian and "Liquidity Trap" aspects of this model (on which see Solow 2003; Solow 2008) are tangential to the topic of this paper, which is a strictly structural one: does bank lending—as opposed to lending by non-bank agents to each other—significantly alter the macrodynamics of

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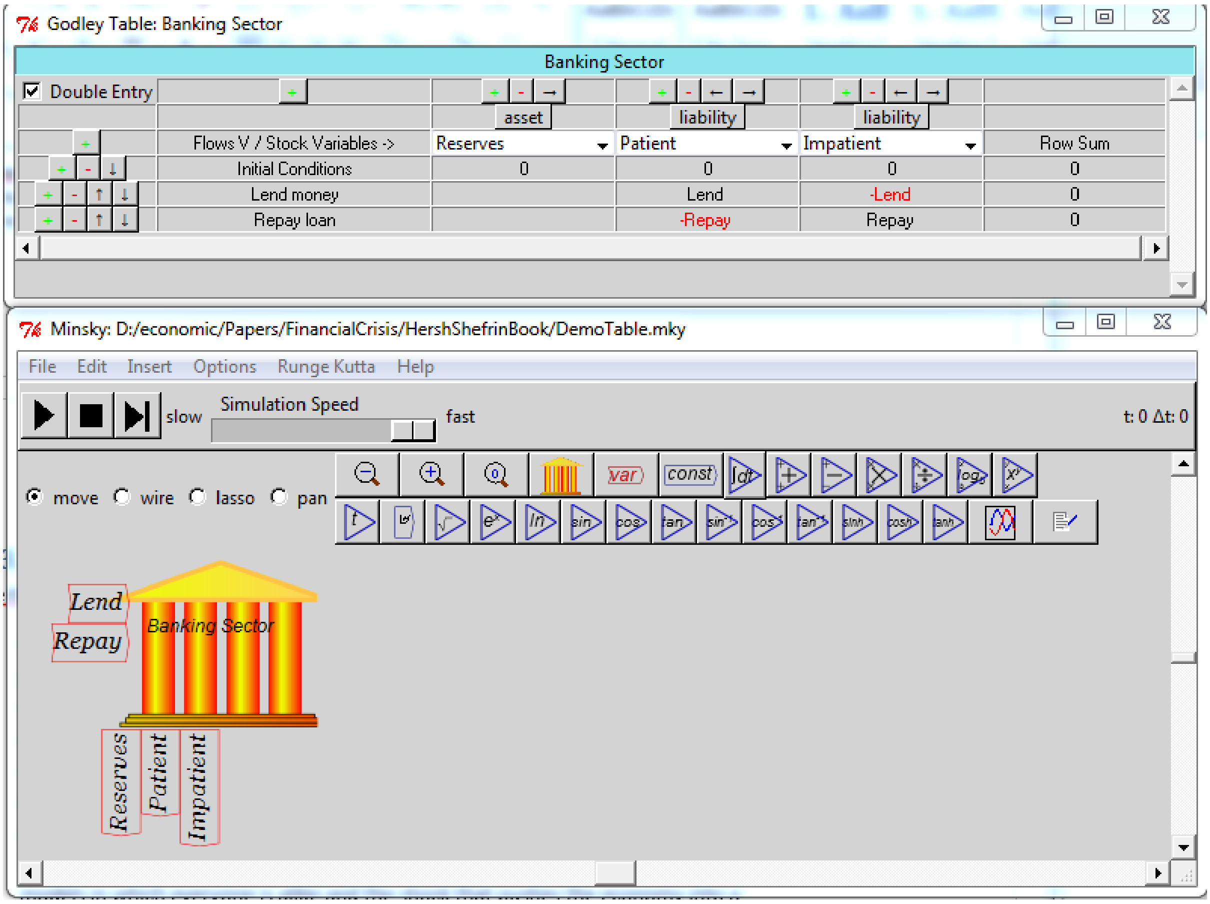
[5] Though not banks or money: initially "borrowing and lending take the form of risk-free bonds denominated in the consumption good" (p. 1474).

[6] "To motivate borrowing and lending we assume that one of the household types (the borrowers) can investment [sic] in capital, while the other type (the saver) can only invest in a one period risk-free bond. In order to have borrowing and lending in steady state we need to ensure that the borrowers cannot self-finance in the long run… A mathematical [sic] equivalent way to accomplishing [sic] this is to simply assume the borrower is more "impatient", a short-cut we use here for a better comparison with the other variations of the model in the paper… The only difference with the model in the main text, then, is that there is a capital income that accrues to the borrower that does not show up in the model without capital." See http://qje.oxfordjournals.org.ezproxy.uws.edu.au/content/127/3/1469/suppl/DC1.

the economy? To consider this question, I render the Loanable Funds aspects of Eggertsson and Krugman 2012b in a strictly monetary form in a ***Minsky*** model.

Minsky is a system dynamics program which generates dynamic models of financial flows from double-entry bookkeeping tables (called "Godley Tables" in the program), in which the columns represent bank accounts and the rows are transactions between accounts. The sample model shown in Figure 1 generates the dynamic equations shown in Equation (0.1) (more details on ***Minsky*** are given in the Appendix).

Figure 1: Sample Godley Table and banking icon in *Minsky*



$$\frac{d\text{Reserves}}{dt} = 0$$

$$\frac{d\text{Patient}}{dt} = \text{Repay} - \text{Lend} \qquad (0.1)$$

$$\frac{d\text{Impatient}}{dt} = \text{Lend} - \text{Repay}$$

The Loanable Funds features of Eggertsson and Krugman (2012b) are:

- that deposits by the "patient agents" enable loans to "impatient agents"; and
- that banks intermediate between saver and borrower and profit by an intermediation fee, but otherwise play no role in lending.

The ***Minsky*** model shown in Figure 2 replicates these features using the bank accounts of four separate entities: the consumption goods sector (with deposit account Dep_{Cons}) which is the lender in (Eggertsson and Krugman 2012b); the investment goods sector (with account Dep_{Inv}) which is the borrower; Workers (with account *Workers*) who are employed by both the Consumption Sector and the Investment Sector;[7] and the Banking sector (with the Asset account *Reserves* and equity account $Bankers_{NW}$) which intermediates the loans from the Consumption Sector to the Investment Sector, and charges a fee for doing so. Each sector maintains a financial table showing the flows into and out of its accounts, and calculates its net worth as a result as the difference between the value of its assets and liabilities (account $Bankers_{NW}$ for the banking sector).

Figure 2: Loanable Funds model—a 4 account view of Loanable Funds generated in *Minsky*

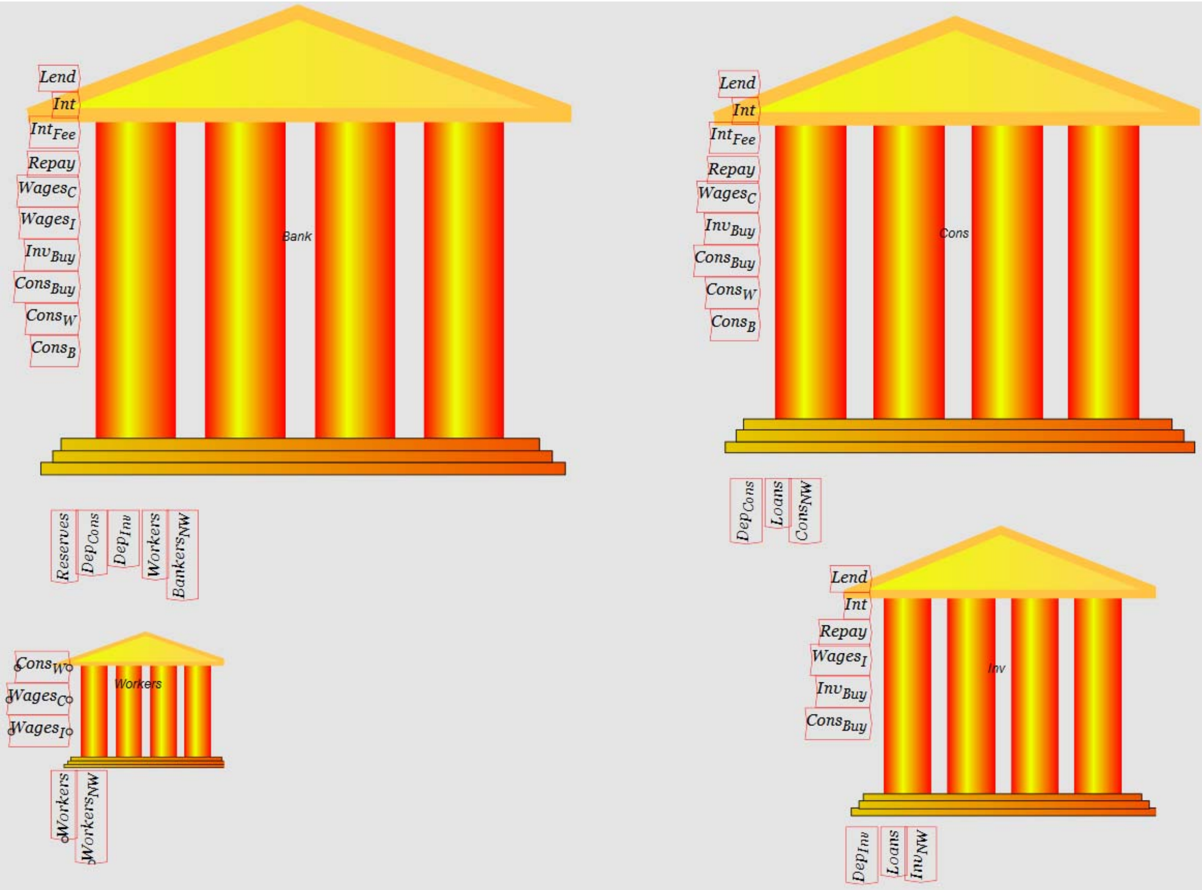


Table 1 shows this financial system from the banking sector's perspective, and Table 2 shows it from the perspective of the lender, the Consumption Sector. Following the conventions in ***Minsky***, assets are shown as positive amounts, and liabilities and equity are shown as negatives, while the source of any financial transaction is shown as a positive and its destination as a negative.[8] All entries in the table represent flows, and ***Minsky*** automatically generates the resulting system of differential equations in LaTeX. The ten flows that define the model are all shown in the banking sector's table, and are respectively:

[7] Employment by the banking sector is ignored since it is inconsequential to the purpose of the paper.
[8] ***Minsky*** can also be set up to use the accounting convention of using DR (debit) and CR (credit).

1. The Consumption Sector lends to the Investment Sector via the flow "*Lend*" from the account Dep_{Cons} to the account Dep_{Inv};
2. The Investment sector makes Interest payments "*Int*" to the consumption sector;
3. The Banking Sector charges the Consumption Sector an intermediation fee "Int_{Fee}";
4. The investment Sector makes debt repayments to the Consumption Sector ("*Repay*");
5. The Consumption Sector hires Workers via the flow "$Wages_C$";
6. The investment Sector hires Workers via the flow "$Wages_I$";
7. The Investment Sector purchases consumption goods ("$Cons_I$");
8. The Consumption Sector purchases investment goods ("$Cons_C$");
9. Workers purchase consumer goods ("$Cons_W$"); and
10. Bankers purchase consumer goods ("$Cons_B$");

Table 1: Loanable Funds model from the Banking Sector's perspective

	Banking Sector	Assets	Liabilities			Equity
Flows	Accounts	Reserves	Dep_{Cons}	Dep_{Inv}	Workers	$Bankers_{NW}$
1	Lending		Lend	-Lend		
2	Interest Payments		-Int	Int		
3	Bank Intermediation Fee		Int_{Fee}			$-Int_{Fee}$
4	Debt Repayment		-Repay	Repay		
5	Hire workers (Cons)		$Wages_C$		$-Wages_C$	
6	Hire workers (Inv)			$Wages_I$	$-Wages_I$	
7	Intersectoral purchases by Inv		$-Cons_I$	$Cons_I$		
8	Intersectoral purchases by Cons		$Cons_C$	$-Cons_C$		
9	Workers consumption		$-Cons_W$		$Cons_W$	
10	Bankers consumption		$-Cons_B$			$Cons_B$

Lending from the consumption to the investment sector is recorded in the account *Loans*, which is an asset of the consumption sector as shown in its financial account (see Table 2; it also appears as a liability of the Investment Sector in its table of accounts; Table 2 also displays the dynamics of the Consumption Sector's net worth in the column "$Cons_{NW}$").

Table 2: Loanable Funds model from the Consumption Sector's perspective

	Consumption Sector	Assets		Equity
Flows	Accounts	Dep_{Cons}	Loans	$Cons_{NW}$
1	Lending	-Lend	Lend	
2	Interest Payments	Int		-Int
3	Bank Intermediation Fee	$-Int_{Fee}$		Int_{Fee}
4	Debt Repayment	Repay	-Repay	
5	Hire workers (Cons)	$-Wages_C$		$Wages_C$
6	Intersectoral purchases by Inv	$Cons_I$		$-Cons_I$
7	Intersectoral purchases by Cons	$-Cons_C$		$Cons_C$
8	Workers consumption	$Cons_W$		$-Cons_W$
9	Bankers consumption	$Cons_B$		$-Cons_B$

Since (for the sake of simplicity) holdings of cash are ignored in this model, money is the sum of the amounts in the four deposit accounts Dep_{Cons}, Dep_{Inv}, *Workers*, and $Bankers_{NW}$ shown in Table 1, while debt is the amount in the account *Loans* shown in Table 2. Equation (0.2) shows the equations for the dynamics of money and debt in the model, with the first 4 equations derived from Table 1 showing the dynamics of money in the system while the final equation, derived from Table 2, shows the dynamics of debt.

$$\begin{aligned}
\frac{d}{dt}\mathrm{Dep}_{\mathrm{Cons}} &= \mathrm{Int}+\mathrm{Repay}+\mathrm{Inv}_{\mathrm{Buy}}+\mathrm{Cons}_W+\mathrm{Cons}_B \\
&\quad -\left(\mathrm{Lend}+\mathrm{Int}_{\mathrm{Fee}}+\mathrm{Wages}_C+\mathrm{Cons}_{\mathrm{Buy}}\right) \\
\frac{d}{dt}\mathrm{Dep}_{\mathrm{Inv}} &= \mathrm{Lend}+\mathrm{Cons}_{\mathrm{Buy}}-\left(\mathrm{Int}+\mathrm{Repay}+\mathrm{Wages}_I+\mathrm{Inv}_{\mathrm{Buy}}\right) \\
\frac{d}{dt}\mathrm{Workers} &= \mathrm{Wages}_C+\mathrm{Wages}_I-\mathrm{Cons}_W \\
\frac{d}{dt}\mathrm{Bankers}_{\mathrm{NW}} &= \mathrm{Int}_{\mathrm{Fee}}-\mathrm{Cons}_B \\
\frac{d\mathrm{Loans}}{dt} &= \mathrm{Lend}-\mathrm{Repay}
\end{aligned} \tag{0.2}$$

Defining money M as the sum of the first four accounts, it is obvious that the change in the amount of money is zero:

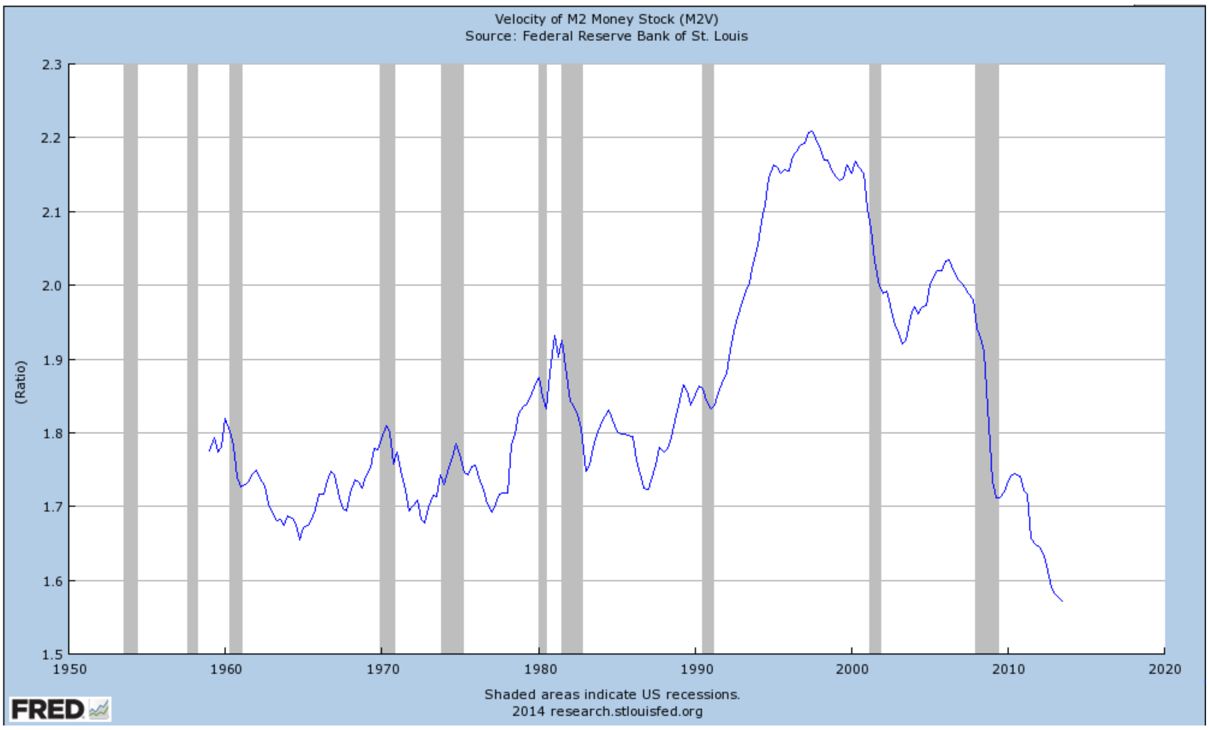
$$\begin{aligned}
M(t) &= \mathrm{Dep}_{\mathrm{Cons}}(t)+\mathrm{Dep}_{\mathrm{Inv}}(t)+\mathrm{Workers}(t)+\mathrm{Bankers}_{\mathrm{NW}}(t) \\
\frac{d}{dt}M(t) &= 0
\end{aligned} \tag{0.3}$$

Therefore the amount of money—which for convenience we can treat this as having been created by government fiat, without needing to specify a government sector in the model—remains constant:

$$M(t)=\int_0^t 0\cdot ds = M(0) \tag{0.4}$$

Without having to define a full economic model, we can now specify aggregate demand *AD* as being equivalent to the turnover of the money in the economy, using the velocity of money ***v*** (see Figure 3 and Equation (0.5)).

Figure 3: Velocity of M2 money stock in the USA 1960-2013



As is well known, contrary to Milton Friedman's claims (Friedman 1948; Friedman 1959; Friedman 1969; Friedman and Schwartz 1963), the velocity of money is not a constant—"it is also apparent that money velocities are procyclical and quite volatile" (Kydland and Prescott 1990, p. 14). However the identity that $v \equiv Y/M$ can be used in this simple model to map from the money stock to the level of aggregate demand.

Using the subscript *LM* to indicate that this is aggregate demand in a Loanable Funds model, we have that aggregate demand at time *t* is the velocity of money times the stock of money at that time:

$$AD_{LF}(t) = v(t) \cdot M(0) \qquad (0.5)$$

Aggregate demand across any defined time period t_2-t_1 will therefore be this instantaneous flow times the time period itself:

$$AD_{LF(t_2-t_1)} = v(t) \cdot (t_2 - t_1) \cdot M(0) \qquad (0.6)$$

Finally, using *D* for brevity in place of *Loans* in Equation (0.7), it is obvious that there is no link between the dynamics of debt and either the stock or the turnover of money, and therefore there is no direct relation between private debt and aggregate demand.[9] The amount of money in circulation remains constant:

[9] Though there can be indirect effects via related changes to the velocity of money—and via extraordinary events like a liquidity trap, which was the focus of Eggertsson and Krugman's paper but is not considered here.

$$\frac{d}{dt}D(t)=\mathrm{Lend}(t)-\mathrm{Repay}(t) \qquad (0.7)$$

Given the absence of a relationship between lending and the money supply, the amount of debt in existence can rise or fall substantially with only a minor impact on macroeconomic activity via related changes in the velocity of money:[10]

4. A monetary model of Endogenous Money

This structural model of Loanable Funds shown in Figure 2 is converted into a model of Endogenous Money by three simple changes:

- *Loans* are shifted from the assets of the consumption sector to the assets of the banking sector;
- Interest payments are transferred to the equity account of the banking sector, Bankers_{NW}; and
- Since banks are loan originators in this model and receive interest payments, the intermediation fee is deleted.

This revised model is shown in Figure 4 and Table 3.[11] The changes between the Loanable Funds model in Table 1 and the Endogenous Money model of Table 3 all occur in the first four rows, with the row for an intermediation fee deleted, and locations of the flows *Lend*, *Int* and *Repay* altered as indicated by the arrows. The two tables are otherwise identical.

[10] Any effect will be via the impact of a change in the distribution of money which affect its overall velocity of circulation.

[11] Changes to other tables are derivative of those shown here and are not reproduced for the sake of brevity.

Figure 4: Endogenous Money model in *Minsky*

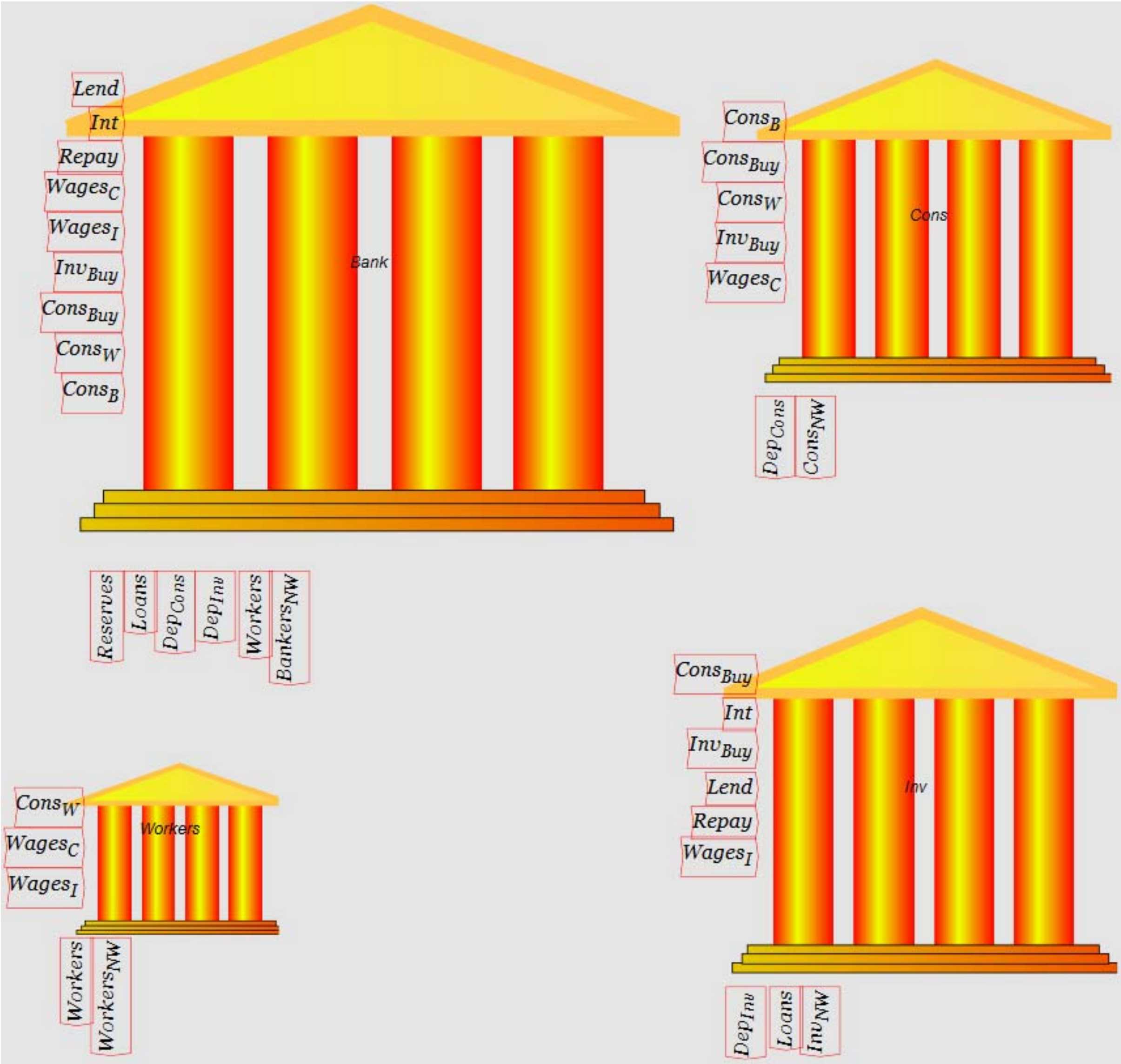


Table 3: Endogenous Money model from the banking sector's perspective

	Banking Sector	Assets		Liabilities			Equity
Flows	Accounts	Reserves	Loans	Dep_{Cons}	Dep_{Inv}	Workers	$Bankers_{NW}$
1	Lending		Lend		-Lend		
2	Interest Payments				Int		-Int
3	Debt Repayment		-Repay		Repay		
4	Hire workers (Cons)			$Wages_C$		$-Wages_C$	
5	Hire workers (Inv)				$Wages_I$	$-Wages_I$	
6	Intersectoral purchases by Inv			$-Cons_I$	$Cons_I$		
7	Intersectoral purchases by Cons			$Cons_C$	$-Cons_C$		
8	Workers consumption			$-Cons_W$		$Cons_W$	
9	Bankers consumption			$-Cons_B$			$Cons_B$

The money and debt equations of this model are:

$$
\begin{aligned}
\frac{d\text{Dep}_{\text{Cons}}}{dt} &= \text{Inv}_{\text{Buy}} + \text{Cons}_W + \text{Cons}_B - \left(\text{Wages}_C + \text{Cons}_{\text{Buy}}\right) \\
\frac{d\text{Dep}_{\text{Inv}}}{dt} &= \text{Lend} + \text{Cons}_{\text{Buy}} - \left(\text{Int} + \text{Repay} + \text{Wages}_I + \text{Inv}_{\text{Buy}}\right) \\
\frac{d\text{Workers}}{dt} &= \text{Wages}_C + \text{Wages}_I - \text{Cons}_W \\
\frac{d\text{Bankers}_{\text{NW}}}{dt} &= \text{Int} - \text{Cons}_B \\
\frac{d\text{Loans}}{dt} &= \text{Lend} - \text{Repay}
\end{aligned}
\tag{0.8}
$$

Despite the simplicity of the changes needed to move from Loanable Funds to Endogenous Money, the dynamics of money are now profoundly different. The rate of change of money is precisely equal to the rate of change of debt:

$$\frac{d}{dt}M(t) = \text{Lend}(t) - \text{Repay}(t) = \frac{d}{dt}D(t) \tag{0.9}$$

The stock of money in the economy is therefore the sum of the initial level of money in existence, plus the new money created by the extension of new loans from the banking sector to the investment sector. Assuming for convenience that *D(0)=0*, this yields:

$$M(t) = \int_0^t \frac{d}{ds}D(s)\cdot ds = M(0) + D(t) \tag{0.10}$$

Using the subscript *EM* to indicate that this is an Endogenous Money model, aggregate demand is therefore

$$AD_{EM}(t) = v(t)\cdot\left(M(0) + D(t)\right) \tag{0.11}$$

Aggregate demand during some given time period t_2-t_1 is therefore:

$$
\begin{aligned}
AD_{EM(t_2-t_1)} &= v(t)\cdot(t_2-t_1)\cdot\int_{t_1}^{t_2}\frac{d}{ds}D(s)\cdot ds \\
&= v(t)\cdot(t_2-t_1)\cdot\left(M(0) + \left(D(t_2) - D(t_1)\right)\right)
\end{aligned}
\tag{0.12}
$$

We can now compare the symbolic measure of nominal aggregate demand in an Endogenous Money model with its counterpart in a Loanable Funds model (the numerical values of velocity, demand and debt will clearly differ substantially, as the simulations in Section 6 illustrate) to identify the substantive difference between a Loanable Funds view of the monetary system and that of Endogenous Money:

$$AD_{EM(t_2-t_1)} - AD_{LF(t_2-t_1)} = v(t)\cdot(t_2-t_1)\cdot\left(\left(D(t_2) - D(t_1)\right)\right) \tag{0.13}$$

The Loanable Funds model thus omits the contribution of the change in debt to the level of aggregate demand.

5. Occam's Razor passes Endogenous Money & fails Loanable Funds

If banks make loans to non-banks—as is manifestly the case—and create money in doing so by crediting the deposit accounts of their borrowers—as even the staunch advocate of Loanable Funds Paul Krugman has conceded—then the Loanable Funds model is too extreme a simplification of the nature of capitalism. As Einstein put it in relation to physics:

> It can scarcely be denied that the supreme goal of all theory is to make the irreducible basic elements as simple and as few as possible *without having to surrender the adequate representation of a single datum of experience*. (Einstein 1934, p. 165, emphasis added)

Omitting the capacity of banks to create money, and the impact this has on key macroeconomic aggregates omits a vital "datum of experience" from macroeconomic models. The capacity of bank lending to alter the level of aggregate demand means that banks, debt and money must be included in any adequate model of macroeconomics.

In particular, the acknowledgement of the macroeconomic significance of Endogenous Money requires a dynamic redefinition of aggregate demand to include the change in debt.[12] Though this model excludes second-order effects such as demand for idle cash balances (Rowe 2013), the generic formula relating aggregate demand (*AD*) to income (*Y*) and the change of debt is:

$$AD_{(t_2-t_1)} = Y_{(t_2-t_1)} = Y_{(t_1-t_0)} + v(t)\cdot(t_2-t_1)\cdot\left(\left(D(t_2)-D(t_1)\right)\right) \quad (0.14)$$

This formula corrects a rule of thumb proposition that I have previously asserted, that aggregate demand is the sum of income plus the change in debt (Keen 2014; see also Krugman 2013b).[13] The correct proposition is that, in a world in which the banking sector endogenously creates new money by creating new loans, aggregate demand in a given period is the sum of aggregate demand at the beginning of that period, plus the change in debt over the period *multiplied by the velocity of money*.

If we consider a time period of one year so that $(t_2-t_1)=1$ and $t_1=0$, and specifying the average velocity of money over that year as *v(1)* and the change in debt as *ΔD(1)*, we have

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[12] Aggregate supply also needs to be redefined, since a large proportion of borrowed money is used for asset purchases, but this topic is not covered in this paper.

[13] In the post "Secular Stagnation Arithmetic", Krugman made the observation that "underneath the apparent stability of the Great Moderation lurked a rapid rise in debt that is now being unwound… Debt was rising by around 2 percent of GDP annually; that's not going to happen in future, which a naïve calculation suggests means a reduction in demand, other things equal, of around 2 percent of GDP." This is similar to my arguments prior to this paper, though as I note in Keen 2014 (and prove here), Krugman's proposition is incompatible with Loanable Funds.

$$AD(1) = Y(0) + v(1)\cdot \Delta D(1) \quad (0.15)$$

Equations (0.14) and (0.15) enable us to operationalize Keynes's distinction between *ex-ante* and *ex-post*, while proving the consistency of this dynamic formula with the standard macroeconomic accounting identity that expenditure equals income. In words, these equations assert that ex-post expenditure equals ex-ante expenditure (and hence income), plus the velocity of money multiplied by the ex-post change in debt.

Since the velocity of money comfortably exceeds unity (though it is highly variable and pro-cyclical), the numerical impact of the change in debt on aggregate demand is therefore *larger* than I have claimed in research prior to developing this formal proof (Keen 2014; see also Rowe 2013).[14]

6. Simulating Loanable Funds and Endogenous Money

A simulation of the two models confirms the importance of including the change in debt in aggregate demand. The simple models used here are identical except for the structure of lending, so that the differences in their behavior reflects simply that issue. The models use simple variable time parameters to relate the various monetary flows to each other and the monetary stocks, so that the results do not depend on any behavioral assumptions (see the Appendix for the model equations and default parameter values). The values of two of these parameters—the lending and repayment rates—are varied over the simulations shown in Figure 5 and Figure 6.

[14] Nick Rowe verbally derived a similar formula that acknowledged the role of the change in debt in increasing demand, while omitting the impact of the velocity of circulation: "Aggregate actual nominal income equals aggregate expected nominal income plus amount of new money created by the banking system minus increase in the stock of money demanded. Nothing in the above violates any national income accounting identity." (http://worthwhile.typepad.com/worthwhile_canadian_initi/2013/08/what-steve-keen-is-maybe-trying-to-say.html). Rowe's statement that the banking sector can create new money indicates that his analysis here went beyond the limitations of the Loanable Funds model.

Figure 5: Loanable Funds simulation in Minsky

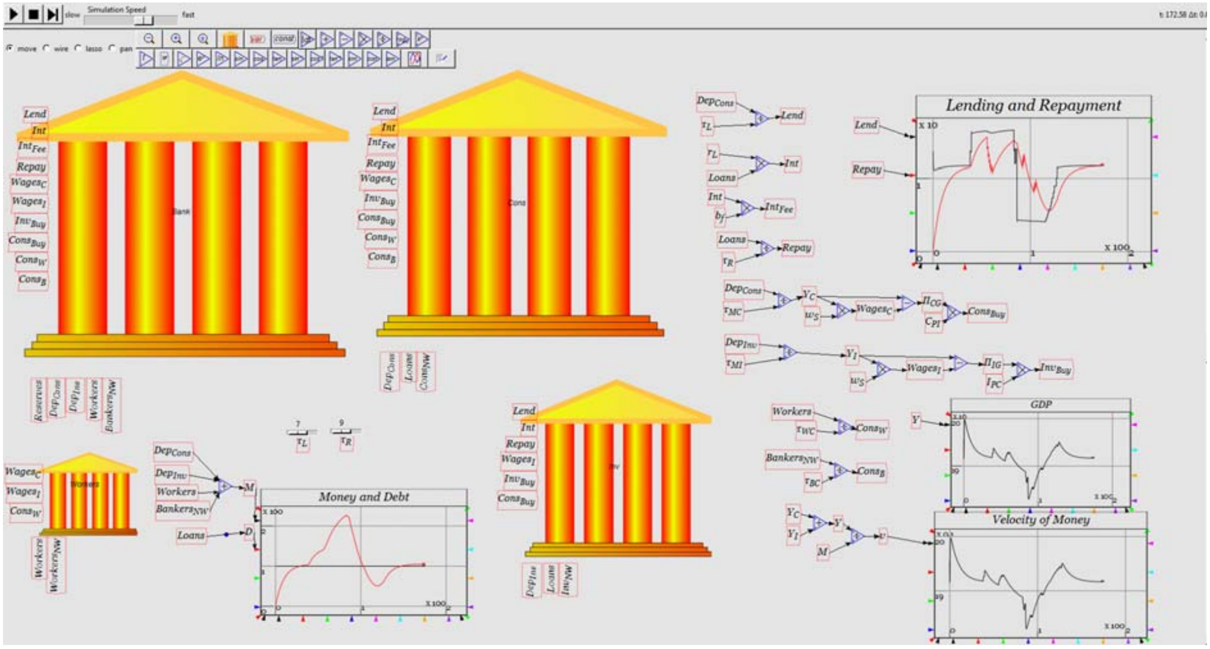
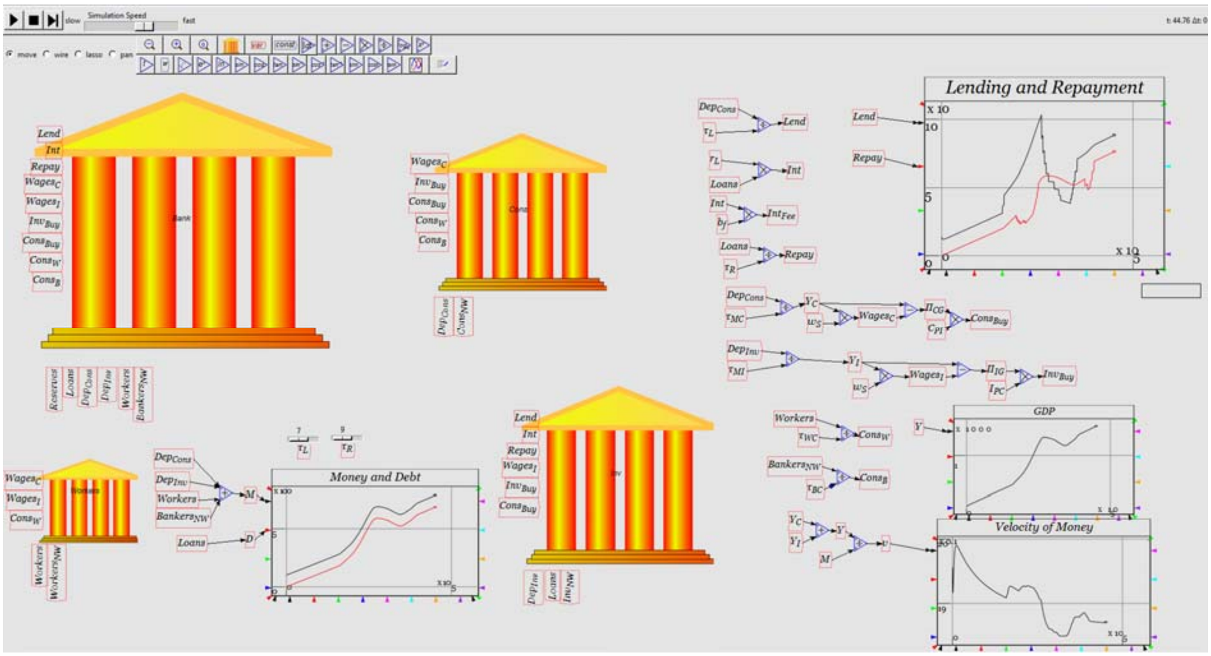


Figure 6: Endogenous Money simulation in Minsky



Variations in the lending and repayment rates have a minor effect on income in the Loanable Funds model (see Figure 7) because they impact upon the velocity of circulation of money (see Figure 8). However the level does not rise (or fall) significantly, and there is no trend, since variations in the level of debt have no impact upon the money supply, which remains constant (see Figure 9).

Figure 7: GDP as a function of Lending & Repayment rates in Loanable Funds

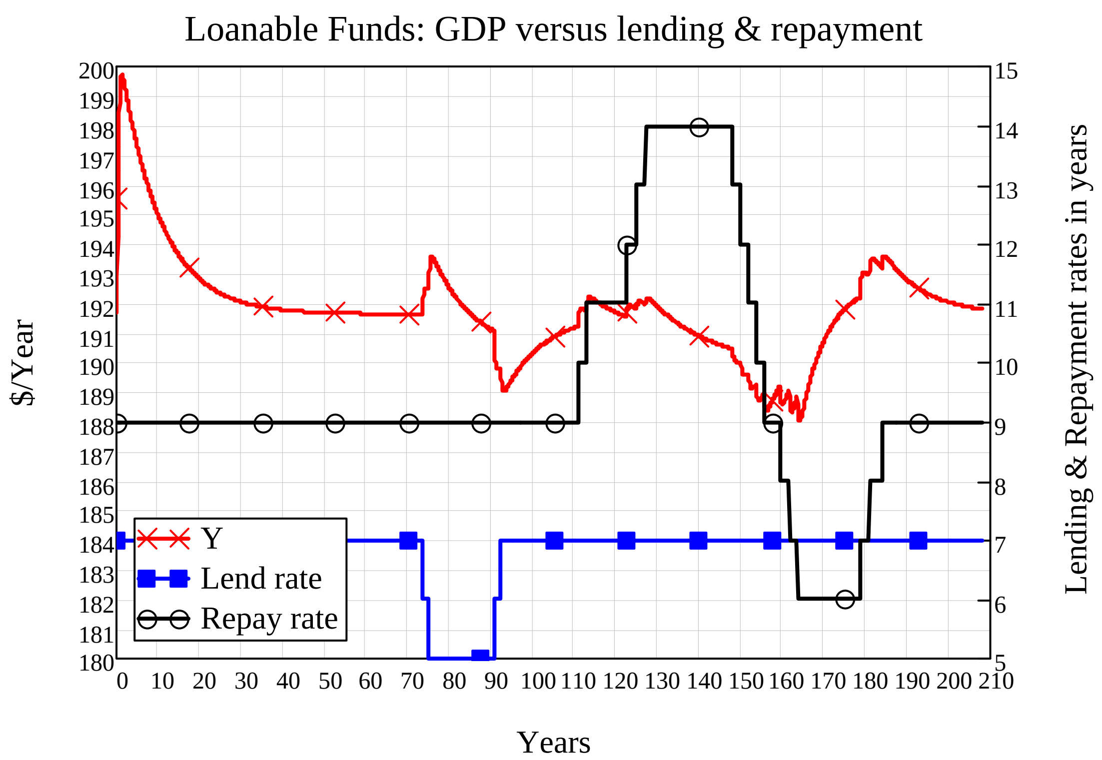


Figure 8: Money velocity as a function of Lending & Repayment rates in Loanable Funds

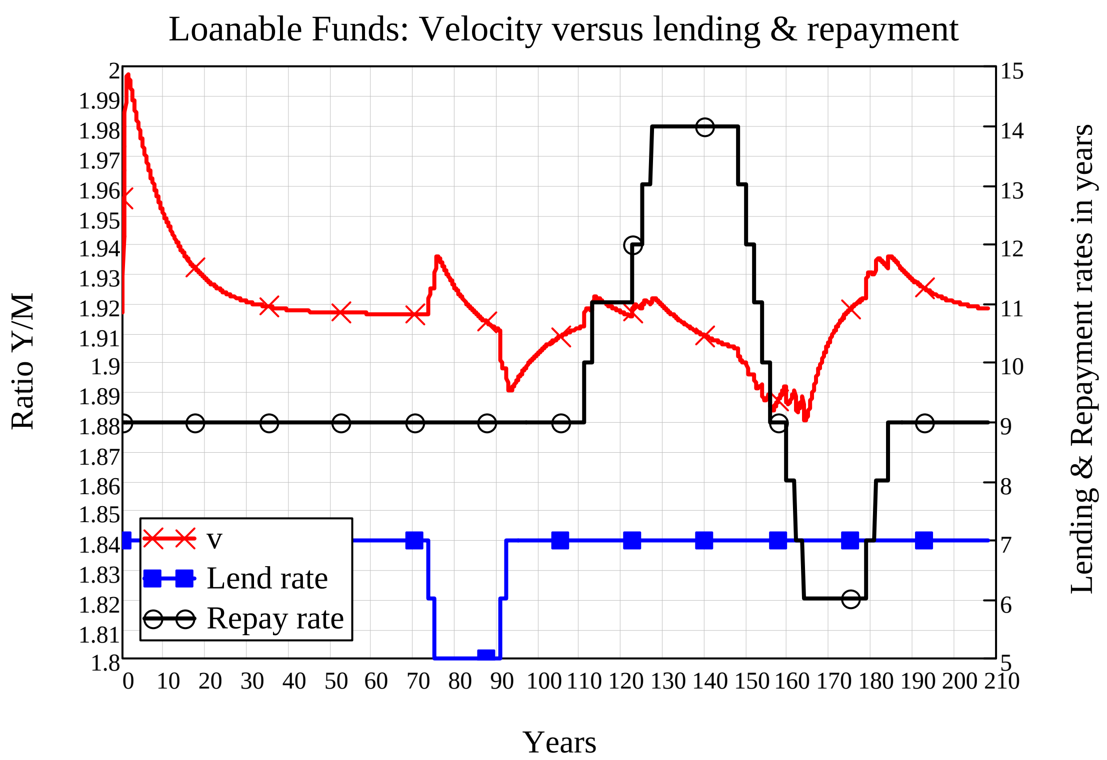
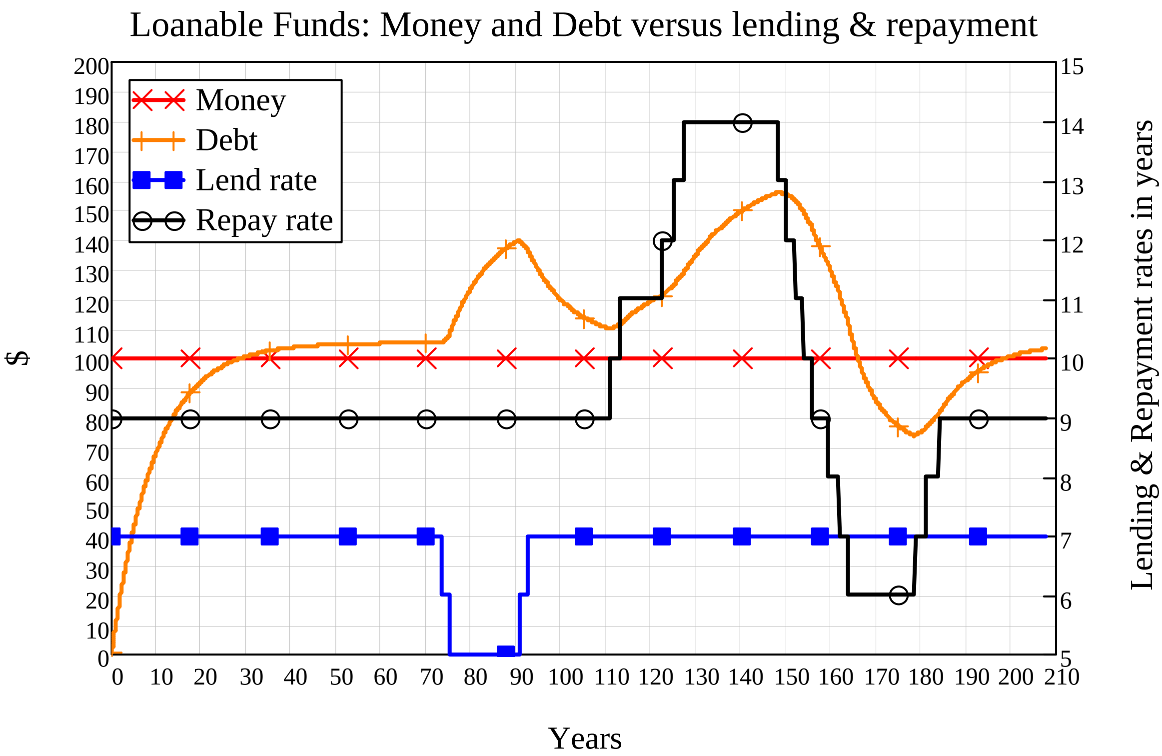


Figure 9: Money and Debt as functions of Lending & Repayment rates in Loanable Funds



In contrast, variations in the lending and repayment rates have a dramatic impact upon GDP in the Endogenous Money model (see Figure 10), because as well as having an impact upon the velocity of money (see Figure 11) they alter the rate of creation and destruction of money (see Figure 12).

Figure 10: GDP as a function of Lending & Repayment rates in Endogenous Money

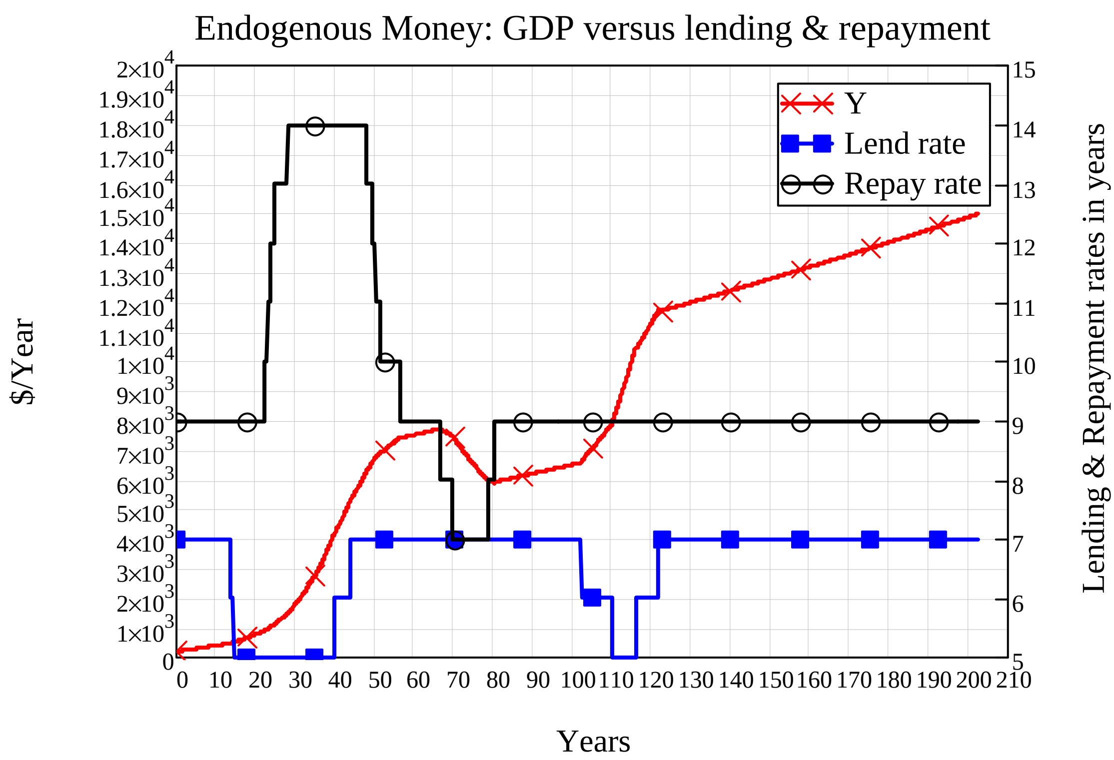


Figure 11: Money velocity as a function of Lending & Repayment rates in Endogenous Money

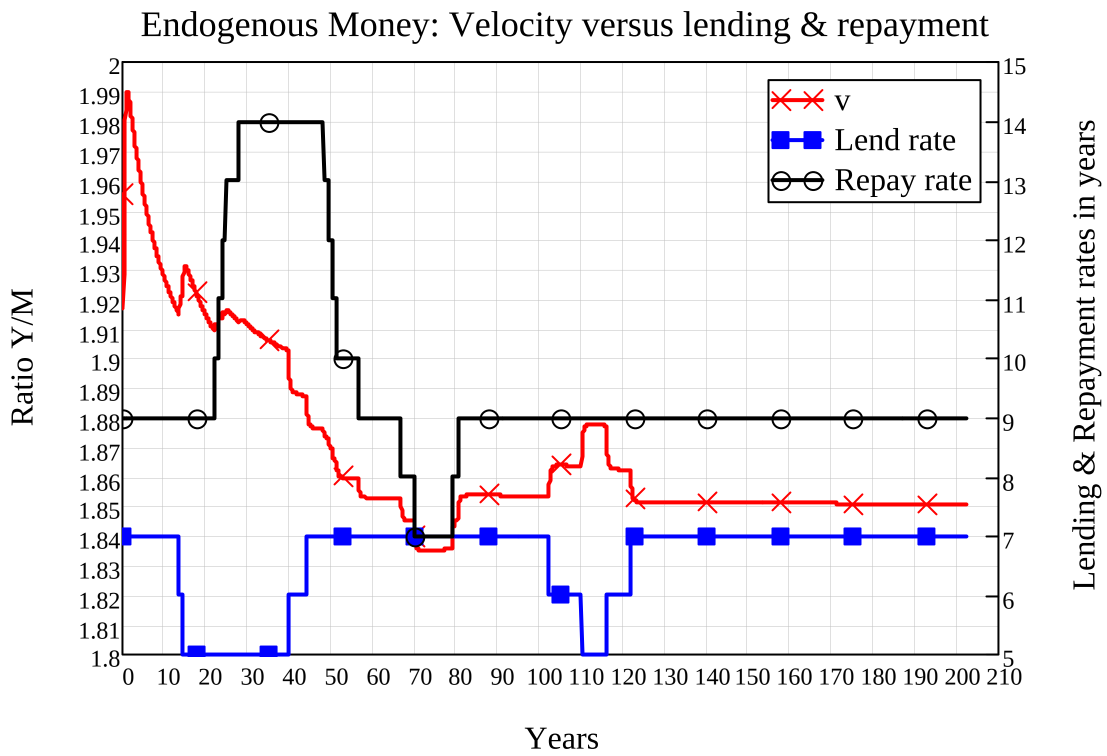
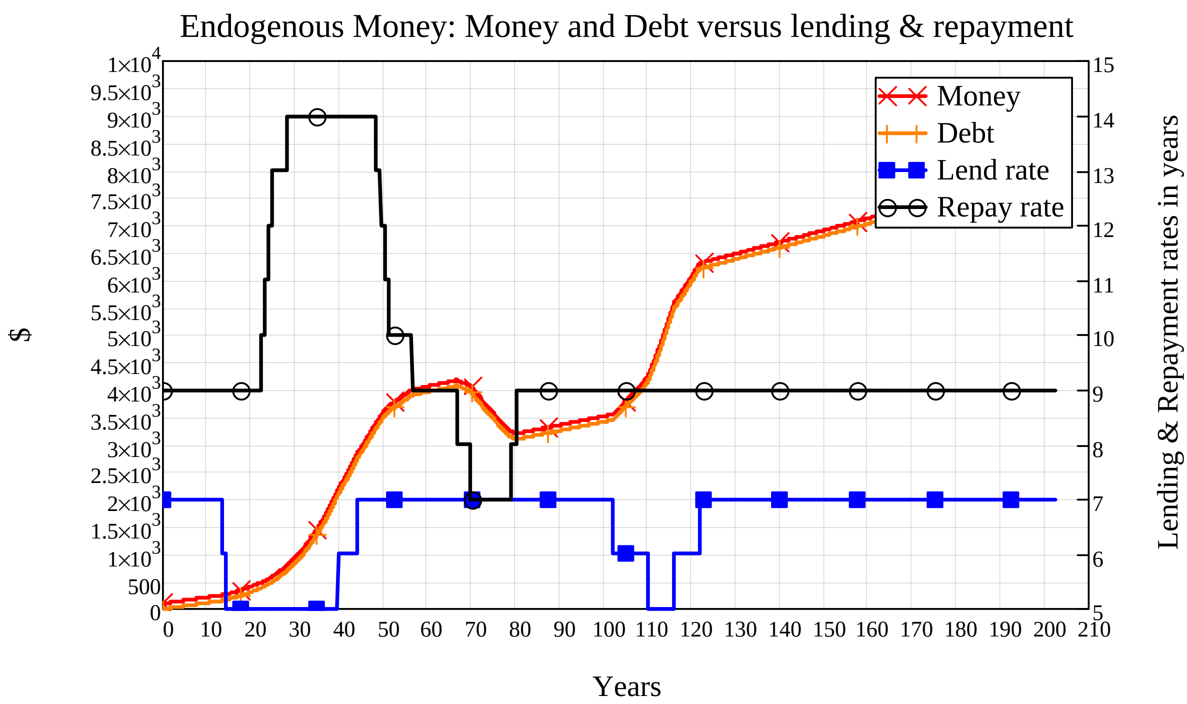


Figure 12: Money and Debt as functions of Lending & Repayment rates in Endogenous Money



7. Modeling financial instability

The preceding proof provides a theoretical justification for the key role given to the level and change in aggregate private debt in Minsky's Financial Instability Hypothesis. Empirical research by Fama and French provided further support, by concluding that the correlations they found (including a 0.79 correlation between aggregate corporate investment and change in long term corporate debt) "confirm the impression that debt plays a key role in accommodating year-by-year variation in investment" (Fama and French 1999, p. 1954).[15]

Minsky provided a succinct summary of his Financial Instability Hypothesis, which emphasized the central of private debt to his analysis (Minsky 1978; reprinted in Minsky 1982):

> The natural starting place for analyzing the relation between debt and income is to take an economy with a cyclical past that is now doing well. The inherited debt reflects the history of the economy, which includes a period in the not too distant past in which the economy did not do well. Acceptable liability structures are based upon some margin of safety so that expected cash flows, even in periods when the economy is not doing well, will cover contractual debt payments. As the period over which the economy does well lengthens, two things become evident in board rooms. Existing debts are easily validated and units that were heavily in debt prospered; it paid to lever. After the event it becomes apparent that the margins of safety built into debt structures were too great. As a result, over a period in which the economy does well, views about acceptable debt structure change. In the dealmaking that goes on between banks, investment bankers, and businessmen, the acceptable amount of debt to use in financing various types of activity and positions increases. This increase in the weight of debt financing raises the market price of capital assets and increases investment. As this continues the economy is transformed into a boom economy.
>
> Stable growth is inconsistent with the manner in which investment is determined in an economy in which debt-financed ownership of capital assets exists, and the extent to which such debt financing can be carried is market determined. It follows that the fundamental instability of a capitalist economy is upward. The tendency to transform doing well into a speculative investment boom is the basic instability in a capitalist economy. (Minsky 1982, pp. 66-67)

I modeled this process by extending Goodwin's cyclical growth model—in which profit-rate-motivated investment and employment-rate-motivated wage demands generated a closed limit cycle in employment and income distribution (Goodwin 1967)—to include debt-financed investment. Goodwin's model reduced to two coupled differential equations in the employment rate (λ) and wages share of output (ω), where $\lambda_{fn}(\lambda)$ is a Phillips-curve relation and $I_{fn}(\pi_r)$ is an investment function depending on the rate of profit $\pi_r = \Pi/Y$:[16]

---

[15] Were the Loanable Funds model empirically valid, this debt-financed investment by the corporate sector would be offset by less income-financed consumption by the household sector. However since the Endogenous Money model is empirically valid, the increased debt-financed investment by the corporate sector is an important and volatile addition to aggregate demand.

[16] α, β and γ are respectively the rate of growth of labor productivity, population, and the rate of depreciation

$$\begin{aligned}\frac{d\lambda}{dt}&=\lambda\cdot\left(\frac{I_{fn}(\pi_r)}{v}-(\alpha+\beta+\delta)\right)\\ \frac{d\omega}{dt}&=\omega\cdot\left(\lambda_{fn}(\lambda)-\alpha\right)\end{aligned}\qquad(0.16)$$

I replaced Goodwin's "starkly schematized" (Goodwin 1967, p. 54) assumption that investment equalled profit at all times with an investment function in which investment exceeded profit at high rates of profit, and was below profit at low rates. An equation to represent debt-financed investment was added—Equation (0.17)—and profit was redefined as earnings net of interest payments $\left(\Pi=Y-W-r\cdot D\right)$:

$$\frac{d}{dt}D=I-\Pi\quad(0.17)$$

This transformed Goodwin's model into a three-state model of Minsky's hypothesis, with the extra equation being the dynamics of the private debt to output ratio $d=D/Y$ (see Keen 2013, pp. 236-38 for the derivation):[17]

$$\begin{aligned}\frac{d\lambda}{dt}&=\lambda\cdot\left(\frac{I_{fn}(\pi)}{v}-(\alpha+\beta+\delta)\right)\\ \frac{d\omega}{dt}&=\omega\cdot\left(\lambda_{fn}(\lambda)-\alpha\right)\\ \frac{d}{dt}d&=I(\pi)-\pi-d\cdot\left(\frac{I(\pi)}{v}-\delta\right)\end{aligned}\qquad(0.18)$$

In (Keen 1995; Keen 2000) I used nonlinear functions for both investment determination and wage setting; here I use linear functions to emphasize that both the cyclical behavior of Goodwin's model and the debt-induced breakdown in the Minsky model are endemic, rather than being products of the assumed functional forms. In the simulations shown in Figure 13 and Figure 14, the investment and wage change functions are:

$$\begin{aligned}I_{\mathrm{fn}}(\pi_r)&=(\pi_r-\pi_E)\times\pi_{\mathrm{S}}\\ \lambda_{\mathrm{fn}}(\lambda)&=\lambda_S\times(\lambda-\lambda_0)\end{aligned}\qquad(0.19)$$

Figure 13 shows the fixed cycle in Goodwin's basic model.

[17] The equations in both models as simulated in ***Minsky*** are shown in pages 5-5 in the Appendix.

Figure 13: Goodwin's model with linear behavioral functions simulated in Minsky

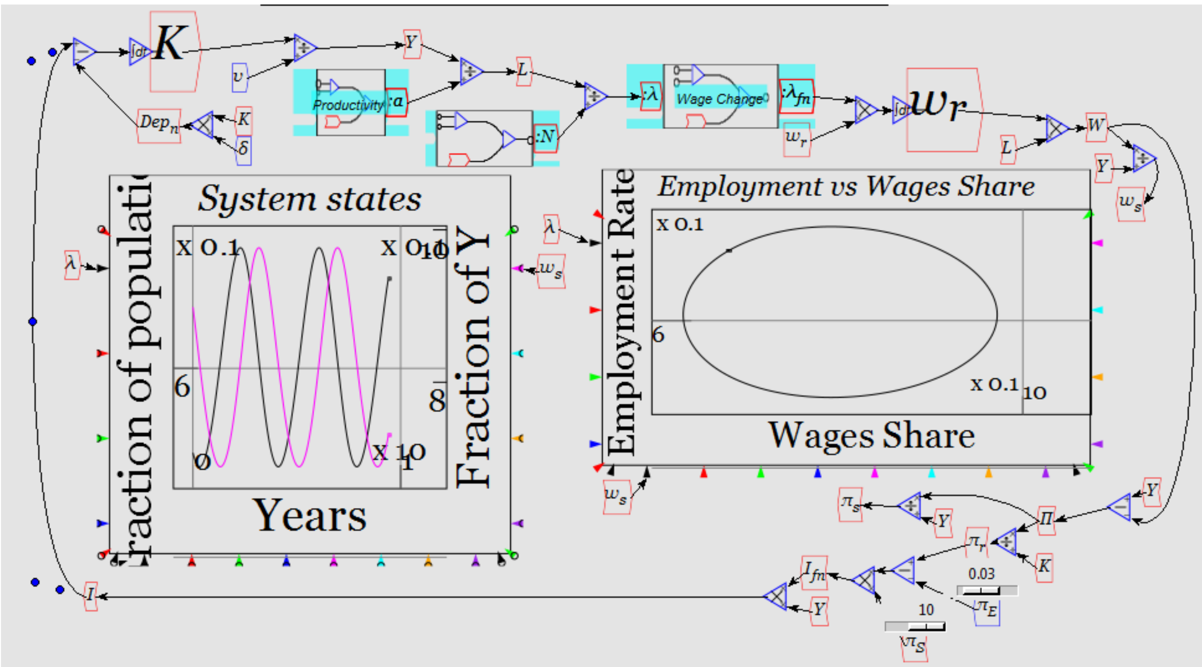
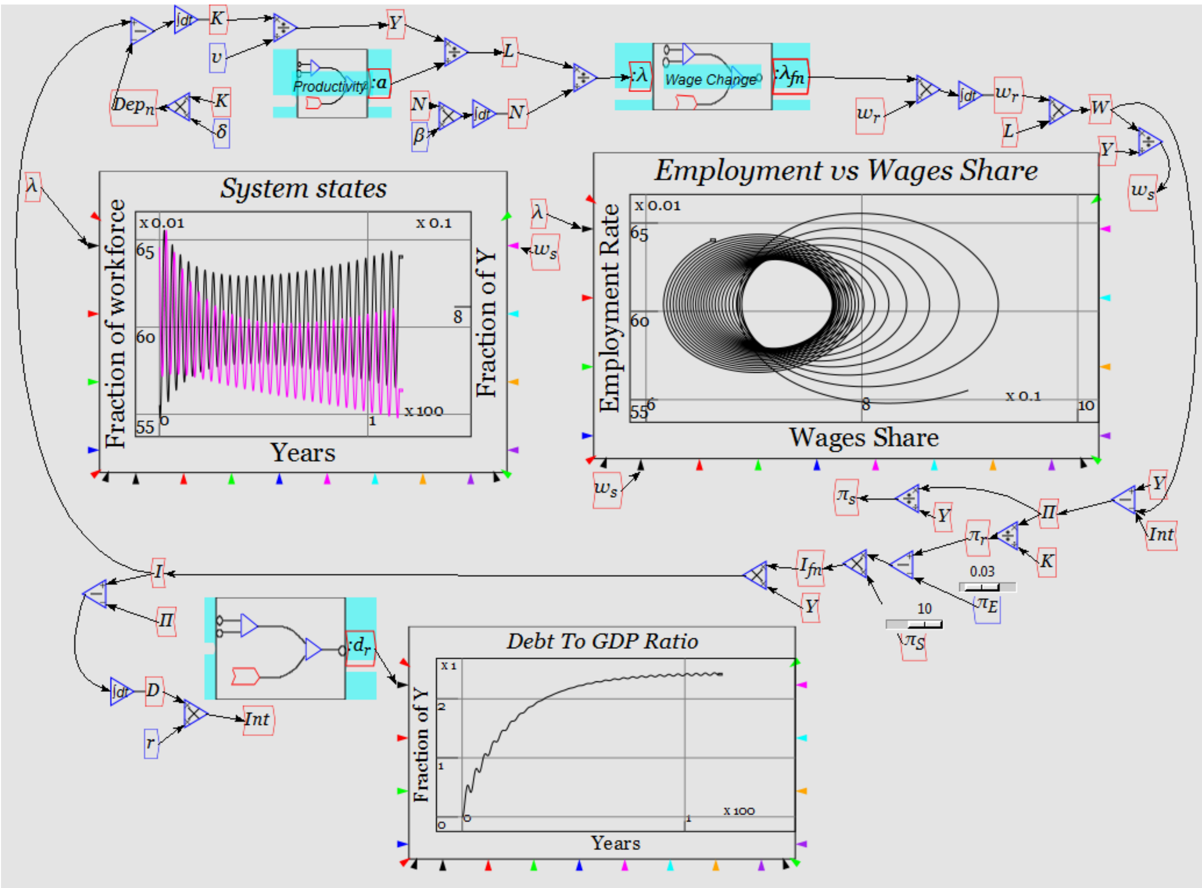


Figure 14 shows a typical run of the Minsky model, which has three key characteristics:

- The initial behavior of the model involves a reduction in the volatility of employment and output—effectively a "Great Moderation";
- Workers' share of output has a secular tendency to fall; and
- The initial reduction in employment and output volatility gives way to increasing volatility as the debt to output level rises (with the ultimate outcome of a debt-induced collapse in output and employment).[18]

[18] These cycles are more extreme in magnitude but qualitatively identical to those in Keen 1995 & 2000, indicating that the main role of nonlinear behavioral relations in complex system models is not to generate cycles themselves, but to confine cycles to more realistic levels.

Figure 14: Minsky's FIH with linear behavioral functions simulated in Minsky

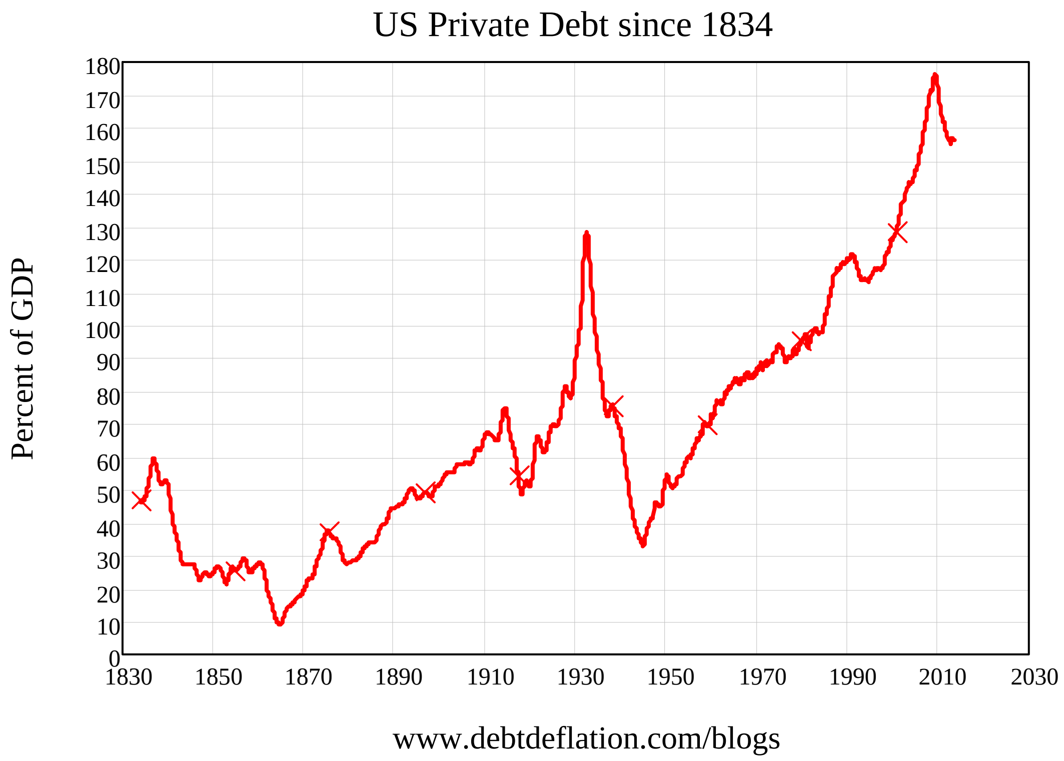


The fact that this simple model generated outcomes that, in a very stylized way, mirror the empirical record of the recent economic past, emphasizes the importance of developing an approach to macroeconomics in which banks and private debt play integral roles. The empirical data, interpreted in the light of the theoretical arguments given here, further emphasizes the importance of paying close policy attention to the hitherto ignored phenomenon of the growth of private debt.

8. Empirical Data

Fortunately, though mainstream economic theory has ignored the role of private debt, statistical agencies have collected the data. Figure 15 is an imputed series combining actual Federal Reserve quarterly data on household plus non-financial corporate debt since 1952 (and yearly data from 1945 till 1952) with US Census data from 1916-1970, and partial Census data on bank loans from 1834 to 1970 (Census 1949; Census 1975).

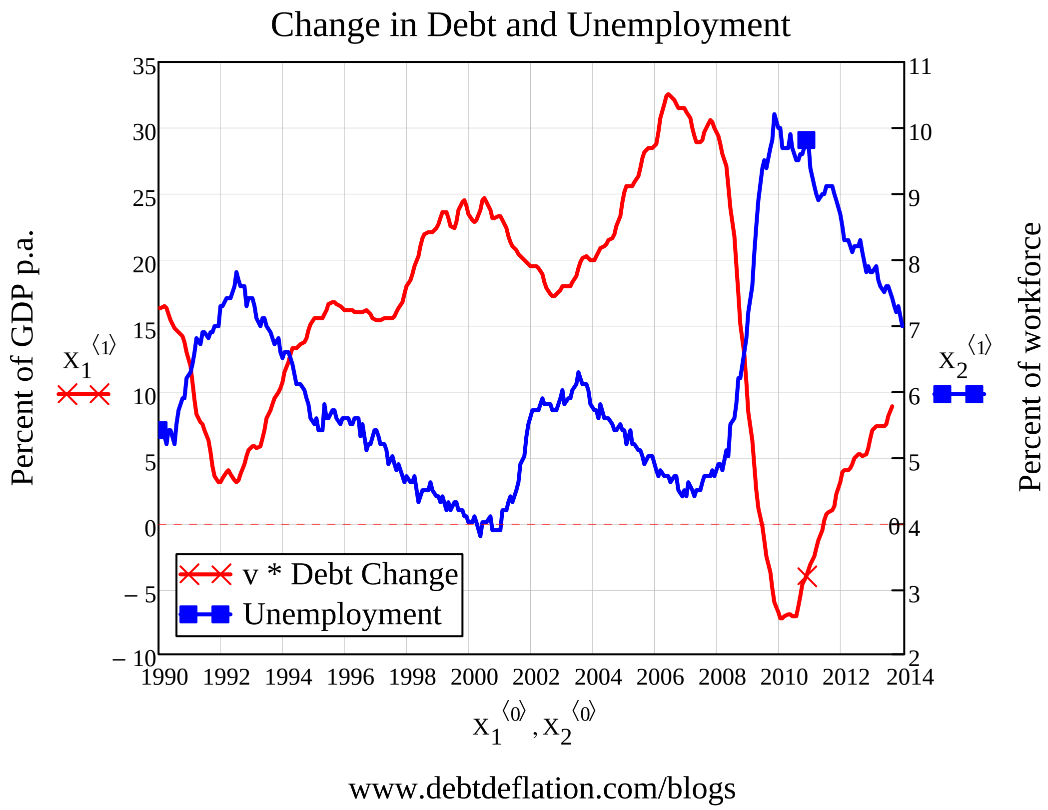
Figure 15: US private debt since 1834



The causal role of the change in debt in aggregate demand identified in this paper implies that there should be a strong empirical relationship between change in debt and macroeconomic data such as the unemployment rate—in contrast to the Loanable-Funds-based presumption that "Absent implausibly large differences in marginal spending propensities among the groups … pure redistributions should have no significant macro-economic effects…" (Bernanke 2000, p. 24).[19] This Loanable Funds presumption is strongly rejected by the data. As Figure 16 shows, the correlation of the change in debt times velocity (divided by GDP) with the level of unemployment since 1990 is -0.92.[20]

[19] There are also strong correlations between change in debt and the level of asset prices, since a substantial proportion of borrowing today is for speculative purchases of existing assets, but this topic will not be considered in this paper.
[20] This correlation is slightly higher than that found for the correlation of the change in debt alone as a percentage of GDP with unemployment: -0.923 versus -0.899. The correlation of the percentage change in debt with unemployment for this time period is ever higher at -0.97.

Figure 16: Change in debt times velocity and US Unemployment (Correlation -0.92)

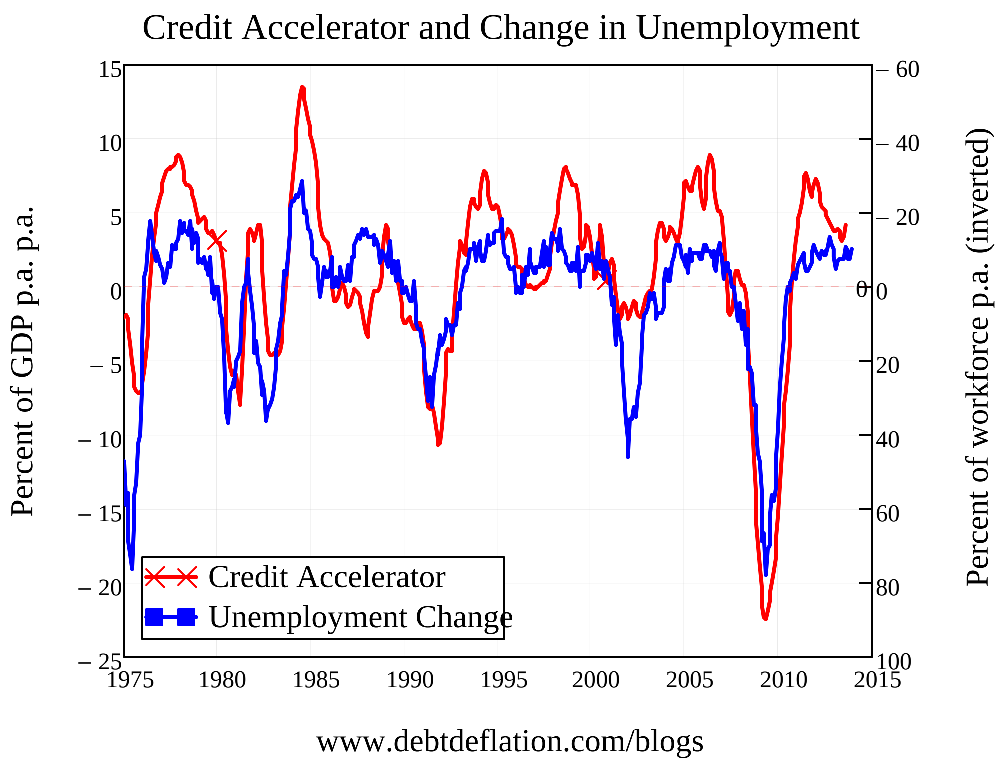


The first difference of (0.14) also implies a strong relationship between the change in the change in debt over two time periods and change in unemployment over that period. Setting $t_2 - t_1 = t_1 - t_0 = \Delta t$, the change in aggregate demand between periods t_2-t_1 and t_1-t_0 (normalized by dividing by Y_{t_0}) is:

$$\frac{AD_{t_2-t_1} - AD_{t_1-t_0}}{Y_{t_0}} = \frac{Y_{t_1} - Y_{t_0}}{Y_{t_0}} + v(t) \cdot \Delta t \cdot \frac{D_{t_0} + D_{t_2} - 2 \cdot D_{t_1}}{Y_{t_0}} \qquad (0.20)$$

Setting $\Delta t = 1$, the correlation between equation (0.20), which we term the Credit Accelerator (see also Biggs and Mayer 2010; Biggs, et al. 2010), and the annual percentage change in the unemployment rate over the period from 1975 till today is -0.78 (see Figure 17).

Figure 17: Credit acceleration and change in unemployment (Correlation -0.78)



9. Conclusion

Given that bank lending creates money and repayment of debt destroys it, the change in debt plays an integral role in macroeconomics by dynamically varying the level of aggregate demand. The omission of this factor from mainstream economic models is the reason that these models failed to warn of the dangers of the dramatic buildup in private debt since WWII—and especially since 1993, when the debt-financed recovery from the 1990s recession took the aggregate private debt level past the peak caused by deflation in the 1930s (see Figure 15). It is also the reason why they failed to anticipate the crisis that began in 2007, and instead predicted that, as the OECD put it in June 2007, "the current economic situation is in many ways better than what we have experienced in years… Our central forecast remains indeed quite benign" (OECD 2007). Policy makers relying upon mainstream economists as experts on the functioning of the economy thus not only received no warning about the worst economic crisis since the Great Depression, but were falsely led to expect benign rather than malignant economic conditions.

The erroneous neglect of the dynamics of private debt by the economics profession has therefore resulted in enormous social and economic harm to society. This is the opposite of the intended goal of economic theory and policy. If economic theory and policy are to fulfil their intended role, it is imperative that a reformed macroeconomics be developed in which banks, money and the dynamics of debt play integral roles.

10. Appendix

1. Loanable Funds model

Differential equations for money and debt

$$\begin{aligned}
\frac{d\text{Dep}_{\text{Cons}}}{dt} &= \text{Int} + \text{Repay} + \text{Inv}_{\text{Buy}} + \text{Cons}_W + \text{Cons}_B \\
&\quad - \left(\text{Lend} + \text{Int}_{\text{Fee}} + \text{Wages}_C + \text{Cons}_{\text{Buy}}\right) \\
\frac{d\text{Dep}_{\text{Inv}}}{dt} &= \text{Lend} + \text{Cons}_{\text{Buy}} - \left(\text{Int} + \text{Repay} + \text{Wages}_I + \text{Inv}_{\text{Buy}}\right) \\
\frac{d\text{Workers}}{dt} &= \text{Wages}_C + \text{Wages}_I - \text{Cons}_W \\
\frac{d\text{Bankers}_{\text{NW}}}{dt} &= \text{Int}_{\text{Fee}} - \text{Cons}_B \\
\frac{d\text{Loans}}{dt} &= \text{Lend} - \text{Repay} \\
\frac{d\text{Reserves}}{dt} &= 0
\end{aligned} \tag{0.21}$$

Other differential equations

$$\begin{aligned}
\frac{d\text{Cons}_{\text{NW}}}{dt} &= \text{Int} + \text{Inv}_{\text{Buy}} + \text{Cons}_W + \text{Cons}_B - \left(\text{Int}_{\text{Fee}} + \text{Wages}_C + \text{Cons}_{\text{Buy}}\right) \\
\frac{d\text{Inv}_{\text{NW}}}{dt} &= \text{Cons}_{\text{Buy}} - \left(\text{Int} + \text{Wages}_I + \text{Inv}_{\text{Buy}}\right) \\
\frac{d\text{Workers}_{\text{NW}}}{dt} &= \text{Wages}_C + \text{Wages}_I - \text{Cons}_W
\end{aligned} \tag{0.22}$$

2. Endogenous Money model

Differential equations for money and debt

$$\begin{aligned}
\frac{d\text{Dep}_{\text{Cons}}}{dt} &= \text{Inv}_{\text{Buy}} + \text{Cons}_W + \text{Cons}_B - \left(\text{Wages}_C + \text{Cons}_{\text{Buy}}\right) \\
\frac{d\text{Dep}_{\text{Inv}}}{dt} &= \text{Lend} + \text{Cons}_{\text{Buy}} - \left(\text{Int} + \text{Repay} + \text{Wages}_I + \text{Inv}_{\text{Buy}}\right) \\
\frac{d\text{Workers}}{dt} &= \text{Wages}_C + \text{Wages}_I - \text{Cons}_W \\
\frac{d\text{Bankers}_{\text{NW}}}{dt} &= \text{Int} - \text{Cons}_B \\
\frac{d\text{Loans}}{dt} &= \text{Lend} - \text{Repay} \\
\frac{d\text{Reserves}}{dt} &= 0
\end{aligned} \tag{0.23}$$

Other differential equations

$$
\begin{aligned}
\frac{d\mathrm{Cons}_{\mathrm{NW}}}{dt} &= \mathrm{Inv}_{\mathrm{Buy}} + \mathrm{Cons}_{W} + \mathrm{Cons}_{B} - \left(\mathrm{Wages}_{C} + \mathrm{Cons}_{\mathrm{Buy}}\right) \\
\frac{d\mathrm{Inv}_{\mathrm{NW}}}{dt} &= \mathrm{Cons}_{\mathrm{Buy}} - \left(\mathrm{Int} + \mathrm{Wages}_{I} + \mathrm{Inv}_{\mathrm{Buy}}\right) \\
\frac{d\mathrm{Workers}_{\mathrm{NW}}}{dt} &= \mathrm{Wages}_{C} + \mathrm{Wages}_{I} - \mathrm{Cons}_{W}
\end{aligned}
\tag{0.24}
$$

Common Definitions

$$
\begin{aligned}
& v = \frac{Y}{M} \\
& \Pi_{\mathrm{CG}} = Y_C - \mathrm{Wages}_C \\
& \Pi_{\mathrm{IG}} = Y_I - \mathrm{Wages}_I \\
& \mathrm{Y} = \mathrm{Y}_{\mathrm{C}} + \mathrm{Y}_{\mathrm{I}} \\
& \mathrm{Wages}_I = Y_I \times w_S \\
& \mathrm{Wages}_C = Y_C \times w_S \\
& \mathrm{Repay} = \frac{\mathrm{Loans}}{\tau_R} \\
& Y_C = \frac{\mathrm{Dep}_{\mathrm{Cons}}}{\tau_{\mathrm{MC}}} \\
& Y_I = \frac{\mathrm{Dep}_{\mathrm{Inv}}}{\tau_{\mathrm{MI}}} \\
& M = \mathrm{Dep}_{\mathrm{Cons}} + \mathrm{Dep}_{\mathrm{Inv}} + \mathrm{Workers} + \mathrm{Bankers}_{\mathrm{NW}} \\
& \mathrm{Inv}_{\mathrm{Buy}} = \Pi_{\mathrm{IG}} \times I_{\mathrm{PC}} \\
& \mathrm{Int}_{\mathrm{Fee}} = \mathrm{Int} \times b_f \\
& \mathrm{Int} = r_L \times \mathrm{Loans} \\
& \mathrm{Lend} = \frac{\mathrm{Dep}_{\mathrm{Cons}}}{\tau_L} \\
& \mathrm{Cons}_W = \frac{\mathrm{Workers}}{\tau_{\mathrm{WC}}} \\
& \mathrm{Cons}_{\mathrm{Buy}} = \Pi_{\mathrm{CG}} \times C_{\mathrm{PI}} \\
& \mathrm{Cons}_B = \frac{\mathrm{Bankers}_{\mathrm{NW}}}{\tau_{\mathrm{BC}}} \\
& D = \mathrm{Loans}
\end{aligned}
\tag{0.25}
$$

Common Parameters to Loanable Funds and Endogenous Money models

$$\begin{aligned}
&\mathrm{w_S} = 0.7\\
&C_{\mathrm{PI}} = 0.5\\
&\tau_{\mathrm{WC}} = 0.08\\
&\tau_R = 9\\
&\tau_{\mathrm{MI}} = 0.25\\
&\tau_{\mathrm{MC}} = 0.5 \qquad (0.26)\\
&\tau_L = 7\\
&\tau_{\mathrm{BC}} = 1\\
&\mathrm{r_L} = 0.04\\
&\mathrm{b_f} = 0.1\\
&I_{\mathrm{PC}} = 0.1
\end{aligned}$$

3. Goodwin model

$$\begin{aligned}
&\frac{dK}{dt} = I - K \times \delta\\
&\frac{dw_r}{dt} = \lambda_{\mathrm{fn}} \times w_r\\
&\frac{dN}{dt} = N \times \beta\\
&\frac{da}{dt} = a \times \alpha\\
&I = I_{\mathrm{fn}} \times Y\\
&I_{\mathrm{fn}} = \left(\pi_r - \pi_E\right) \times \pi_{\mathrm{S}}\\
&\lambda_{\mathrm{fn}} = \lambda_{\mathrm{S}} \times \left(\lambda - \lambda_0\right)\\
&w_s = \frac{W}{Y}\\
&\pi_s = \frac{\Pi}{Y}\\
&\lambda = \frac{L}{\mathrm{N}}\\
&\Pi = Y - W\\
&W = \mathrm{w}_r \times L\\
&\pi_r = \frac{\Pi}{K} \qquad (0.27)\\
&Y = \frac{\mathrm{K}}{v}\\
&L = \frac{Y}{a}
\end{aligned}$$

4. Minsky model (new and modified equations only)

$$\begin{aligned}
\frac{dD}{dt} &= I - \Pi \\
\Pi &= Y - \left(W + \text{Int}\right) \\
\text{Int} &= \text{D} \times r
\end{aligned} \tag{0.28}$$

5. Common parameters to Goodwin & Minsky models

$$\begin{aligned}
\alpha &= 0.02 \\
\beta &= 0.025 \\
\delta &= 0.05 \\
\text{r} &= 0.05 \\
\text{v} &= 3 \\
\lambda_S &= 5 \\
\lambda_0 &= 0.6 \\
\pi_E &= 0.03 \\
\pi_S &= 10 \\
\text{K}(0) &= 300 \\
\text{N}(0) &= 180 \\
\text{a}(0) &= 1 \\
\text{w}_r(0) &= 0.9 \\
\text{D}(0) &= 0
\end{aligned} \tag{0.29}$$

6. Minsky

Minsky is an addition to the family of system dynamics programs that began with Jay Forrester's pioneering work on developing a visual metaphor for constructing and simulating dynamic models of complex social and economic processes (Forrester 1968). Forrester's metaphor was the flowchart (see Figure 18): a drawing of the relationships in a system became the framework for developing a mathematical model of that system:

> The proposed model structure and method of solution retain a one-to-one correspondence between the presumed form of the real economic world and the quantities, coefficients, variables, and decision criteria of the model. Formulation in terms of a "flow diagram" is possible so that a pictorial representation of the relationships within the system is available at all times. (Forrester 2003p. 344)

Figure 18: The first system dynamics diagram from Forrester 2003 (1956)

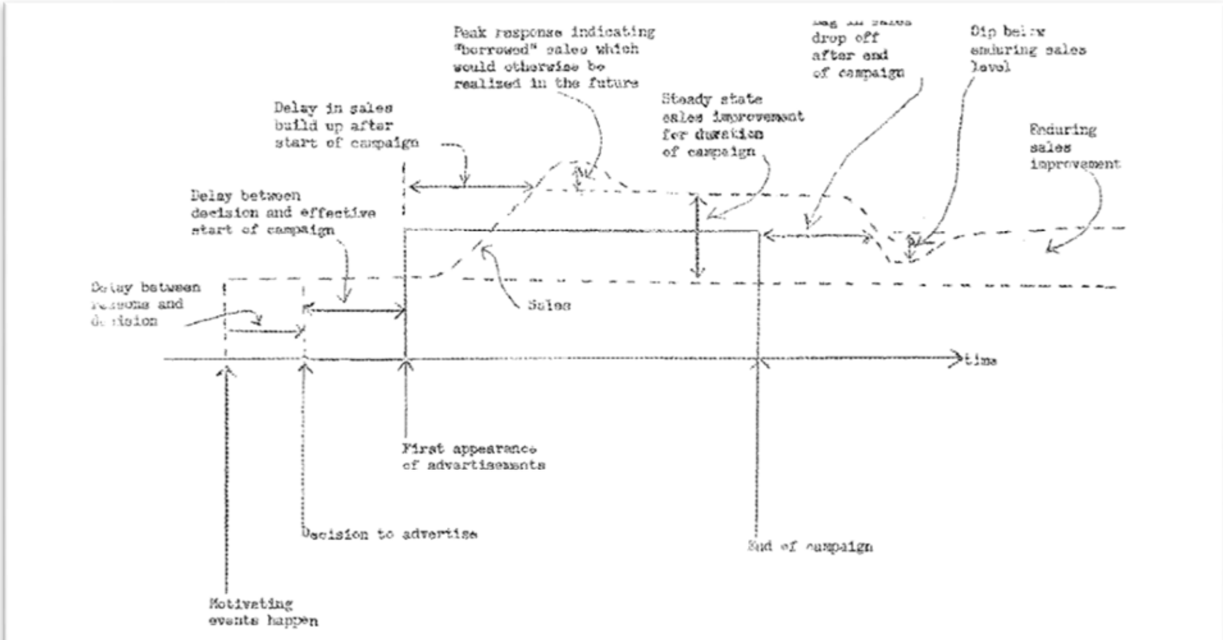


Fig. 1. Timing and extent of effects of an advertising compaign

There are now at least a dozen programs implementing this modeling philosophy, ranging from the free Open Source program *Xcos* to the $20,000-a-copy commercial program Simulink. This paradigm is now pervasive in engineering, but it failed to take root in economics, despite the fact that Forrester's concept was twice anticipated in economics—firstly by Irving Fisher in 1891 with a hydraulic model for calculating equilibrium values in a Walrasian model (Brainard and Scarf), and then by the engineer-turned economist Bill Phillips with genuinely dynamic analog computer systems (Hayes 2011; Leeson 1994a; Leeson 1994b; Leeson 1995; Leeson 2000; Phillips 1950; Phillips 1954; Phillips 1957) some years before Forrester. However, there was no development in economics comparable to Forrester's innovation (in conjunction with the computer programmers Phyllis Fox and Alexander Pugh--see Lane 2007) of a digital computer program—DYNAMO—to provide a general purpose foundation for building dynamic models of complex systems.

Figure 19: Fisher's 1891 hydraulic machine for calculating Walrasian equilibrium prices, from Brainard and Scarf, p. 69

Figure 5

Fisher's apparatus.

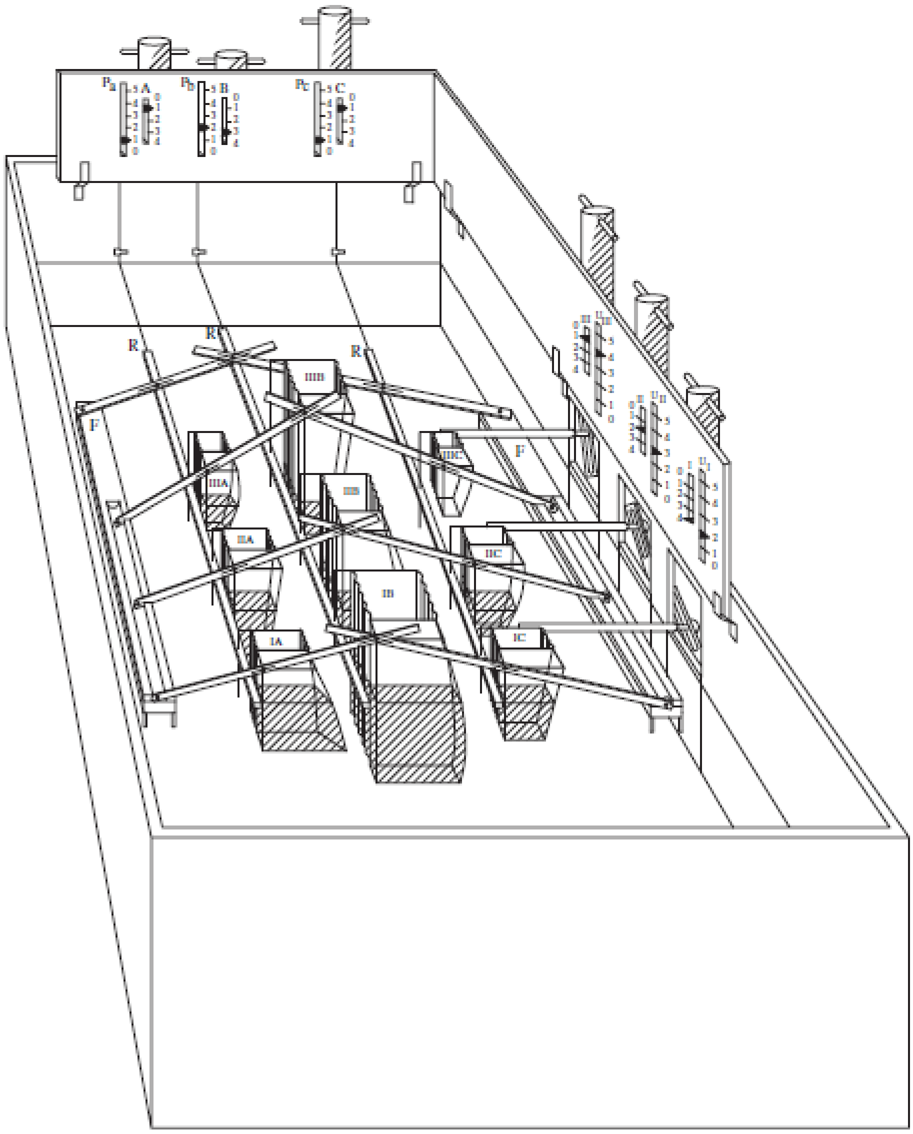


Figure 20: Phillips's schematic diagram of a dynamic multiplier-accelerator model, from Phillips 1954, p. 306

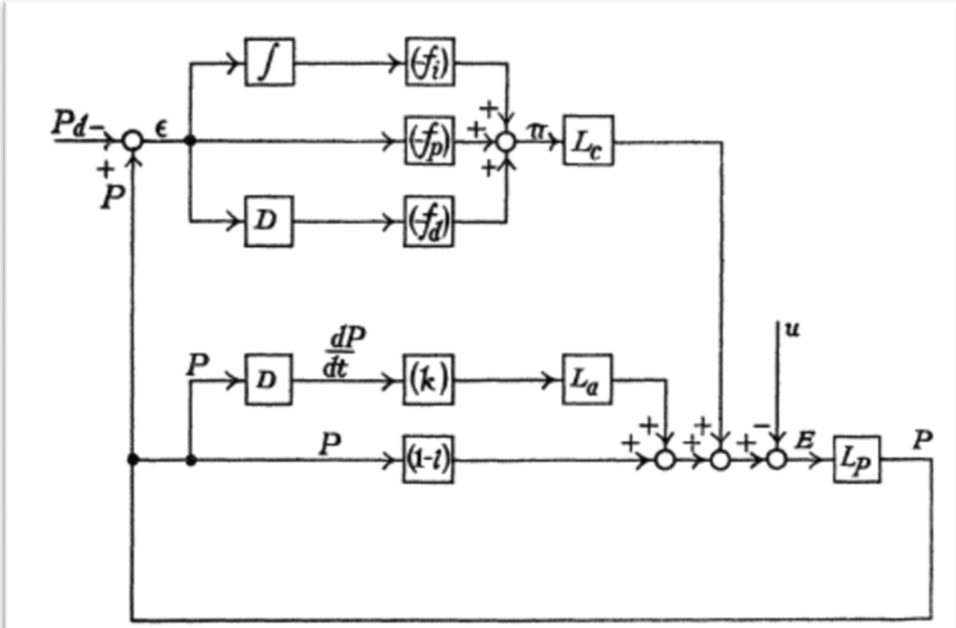
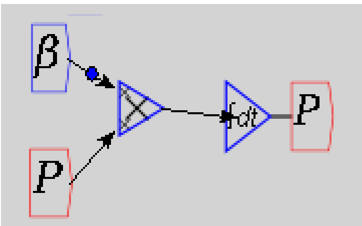


FIG. 10

The core paradigm in system dynamics programs is the construction of mathematical equations via flowcharts identical in spirit to that developed by Phillips (see Figure 20). For example, Figure 21 is the system dynamics equivalent of the differential equation for exponential population growth $\frac{d}{dt}P = \beta \times P$.

Figure 21: A simple algebraic equation in a system dynamics program (Minsky)

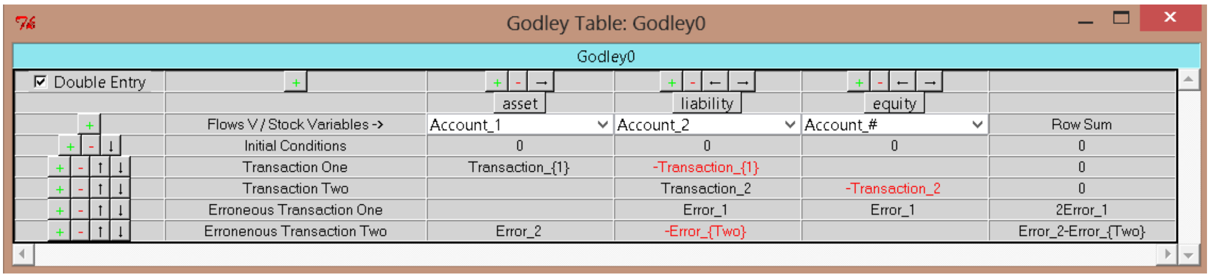


Simple expressions like this are just as easily rendered in equations or standard text-oriented computer programs, but the system dynamics approach makes it easier to comprehend much more complex models—hence its dominance in the engineering field today.

Minsky provides this classic system dynamics approach, and also adds a new method of constructing differential equations to the system dynamics toolkit that is superior for modelling financial flows: the Godley Table. Based on the accounting concept of double-entry bookkeeping, each column represents the dynamic equation of a given financial account, while each row represents transactions between accounts. This is a more natural way to portray financial transactions which also helps enforce the fundamental rules of accounting—that Assets equal Liabilities plus Equity.

Minsky ensures this in three ways. Firstly, all row operations in a Godley Table must sum to zero—otherwise an error is flagged. Secondly, the source of any transaction is shown as a positive while the destination (or “sink” in system dynamics parlance) is shown as a negative.[21] Thirdly, Assets are shown as positive while Liabilities and Equity are shown as negative. Figure 22 illustrates these three conventions—including showing what happens when they are breached.

Figure 22: A sample Godley Table


Godley Table: Godley0

Godley0

Double Entry					
		asset	liability	equity	
	Flows V / Stock Variables ->	Account_1	Account_2	Account_#	Row Sum
	Initial Conditions	0	0	0	0
	Transaction One	Transaction_{1}	-Transaction_{1}		0
	Transaction Two		Transaction_2	-Transaction_2	0
	Erroneous Transaction One		Error_1	Error_1	2Error_1
	Erronenous Transaction Two	Error_2	-Error_{Two}		Error_2-Error_{Two}

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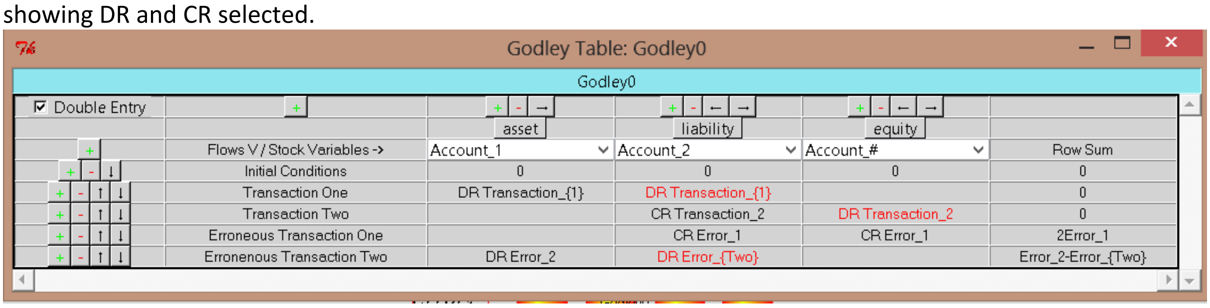
[21] The accounting convention of DR and CR can also be used. The figure below is Figure 22 with the option of showing DR and CR selected.


Godley Table: Godley0

Godley0

Double Entry					
		asset	liability	equity	
	Flows V / Stock Variables ->	Account_1	Account_2	Account_#	Row Sum
	Initial Conditions	0	0	0	0
	Transaction One	DR Transaction_{1}	DR Transaction_{1}		0
	Transaction Two		CR Transaction_2	DR Transaction_2	0
	Erroneous Transaction One		CR Error_1	CR Error_1	2Error_1
	Erronenous Transaction Two	DR Error_2	DR Error_{Two}		Error_2-Error_{Two}

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