Are We "It" Yet?

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Abstract

My 1995 paper on modeling Minsky's Financial Instability Hypothesis concluded with the statement that its "chaotic dynamics … should warn us against accepting a period of relative tranquility in a capitalist economy as anything other than a lull before the storm" ((Keen 1995, p. 634)). That storm duly arrived, after the lull of the "Great Moderation". Only a Fisher-Keynes-Minsky vision of the macroeconomy can make sense of this crisis, and the need for a fully fledged Minskian monetary dynamic macroeconomic model is now clearly acute.

I also introduce a new free tool for dynamic modeling which is tailored to modeling financial flows--QED. See pages 49-53 the Appendix for details.

Empirics

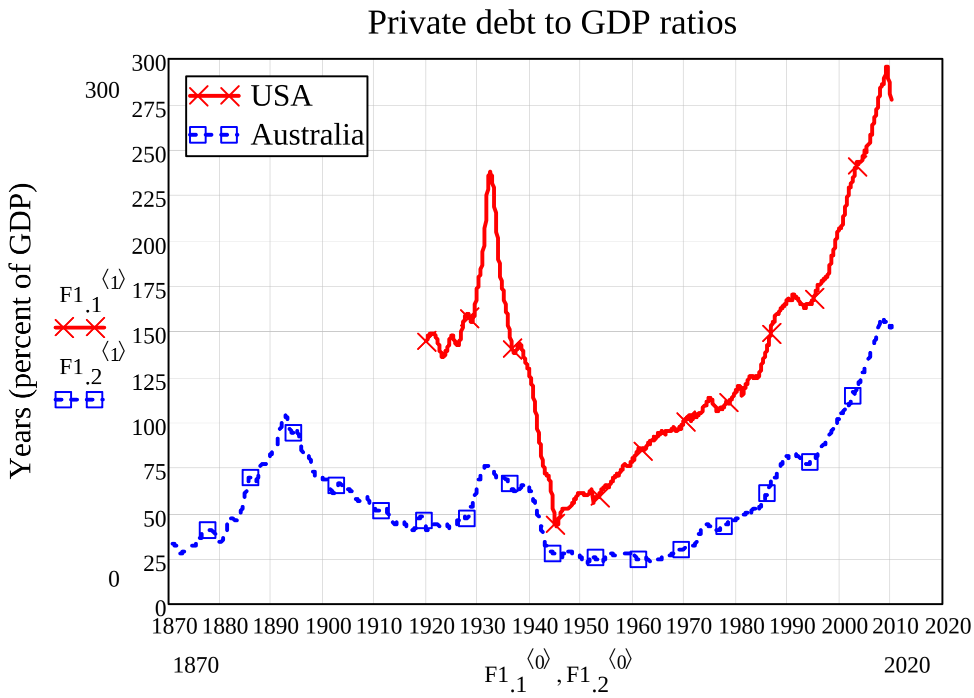
As Vicki Chick so succinctly put it, Minsky the Cassandra was an optimist ((Chick 2001)). The stabilizing mechanisms that Minsky initially felt would help prevent "It" from happening again ((Minsky 1982)) have been overwhelmed by a relentless accumulation of private sector debt, which have reached levels that dwarf those which caused "It" eighty years ago. Though "It" has not yet definitively happened again, neither did our forebears in the 1930s realize that they were in "It" at the time—as a perusal of the Wall Street Journal from those days will confirm:

> Market observers are watching the current rally closely since it has lasted about 10 days, or about the same as the technical rally starting in late April that gave way to a renewed bear movement. It's believed "ability of the rising trend to carry on for several days more would strengthen indications of a definite turn in the main trend of prices." (Dimitrovsky 2008, Wall Street Journal June 16 1931)

A comparison of 1930s data to today emphasizes that the same debt-deflationary factors that gave us the Great Depression are active now; the only differences are that both the private sector deflationary forces and the government reaction are much greater today.

Private sector debt is far higher today than in the 1930s, both in the USA and elsewhere in the OECD. The data shown in Figure 1 for the USA and Australia is replicated to varying degrees by most OECD nations ((See Table 1 in Battellino 2007, p. 14)).

Figure 1: Debt to GDP ratios in the USA and Australia over the long term



Flow of Funds Table L1+Census Data; RBA Table D02

So too is the impact of debt-financed economic activity, both as an engine of apparent prosperity during the "Great Moderation", and as the force causing the "Great Recession" now. Following Minsky, I regard aggregate demand in our dynamic credit-driven economy as the sum of GDP *plus the change in debt*:

> If income is to grow, the financial markets … must generate an aggregate demand that, aside from brief intervals, is ever rising. For real aggregate demand to be increasing, … it is necessary that current spending plans, summed over all sectors, be greater than current received income and that some market technique exist by which aggregate spending in excess of aggregate anticipated income can be financed. *It follows that over a period during which economic growth takes place, at least some sectors finance a part of their spending by emitting debt or selling assets.* (Minsky 1982, p. 6; emphasis added)

That debt-financed component of demand (where that demand is expended upon both commodity and asset markets) was far greater during the false boom after the 1990s recession than it was during the 1920s, and the negative contribution today is also larger than for the comparable time in the 1930s.

Figure 2 shows the levels of debt and GDP in 1920-1940, while Figure 3 shows how much debt added to demand during the 1920s, and subtracted from it during the 1930s.

Figure 2: Debt and GDP before and during the Great Depression

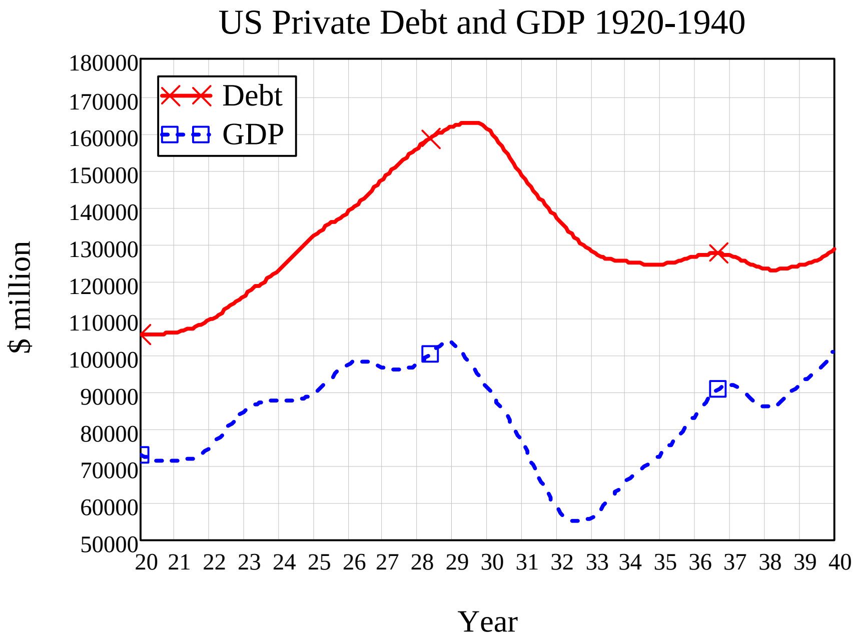
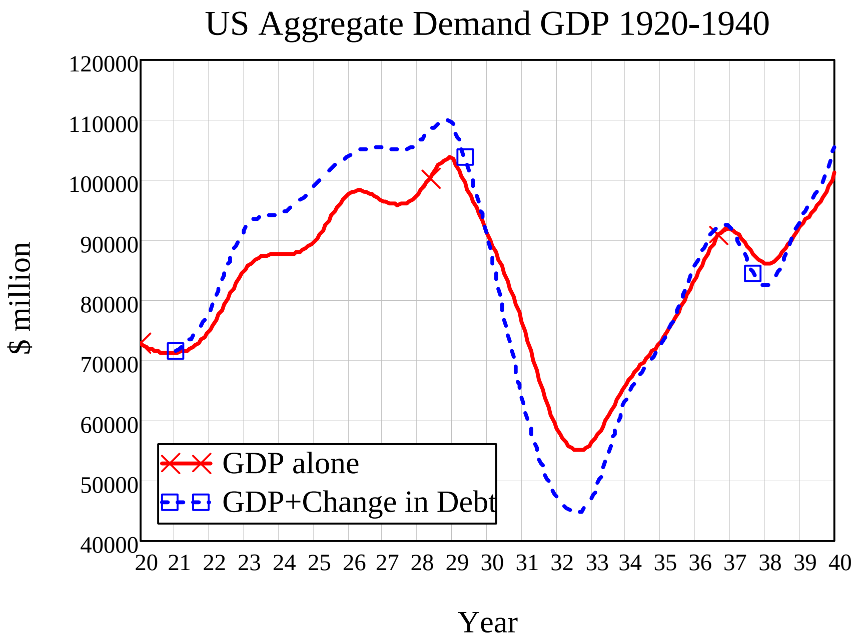


Figure 3: Aggregate demand as the sum of GDP plus the change in debt

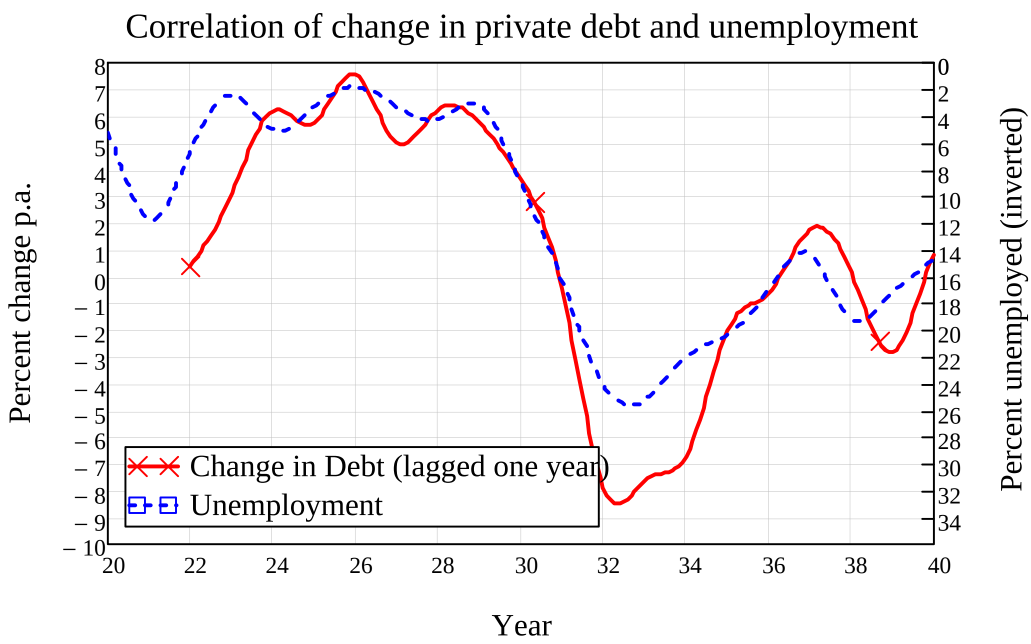


The change in debt was so great that it dominated the impact of GDP itself in determining changes in the level of employment. Figure 4 correlates the change in debt[1] with

[1] Lagged one year since the debt data is year-end annual.

unemployment; over the boom and bust years of 1920-1940, the correlation was -0.938—rising debt was strongly correlated with falling unemployment,[2] and vice versa.

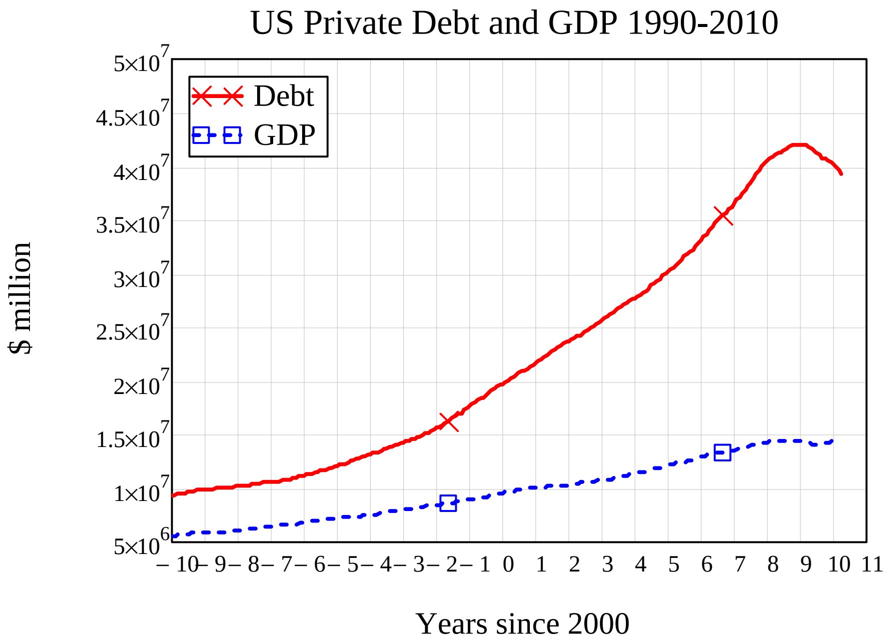
Figure 4: Change in debt and unemployment before and during the Great Depression



The same metrics have played out between 1990 and today, but with far greater force. As Figure 5 shows, the debt dominates GDP even more now than it did when "It" happened.

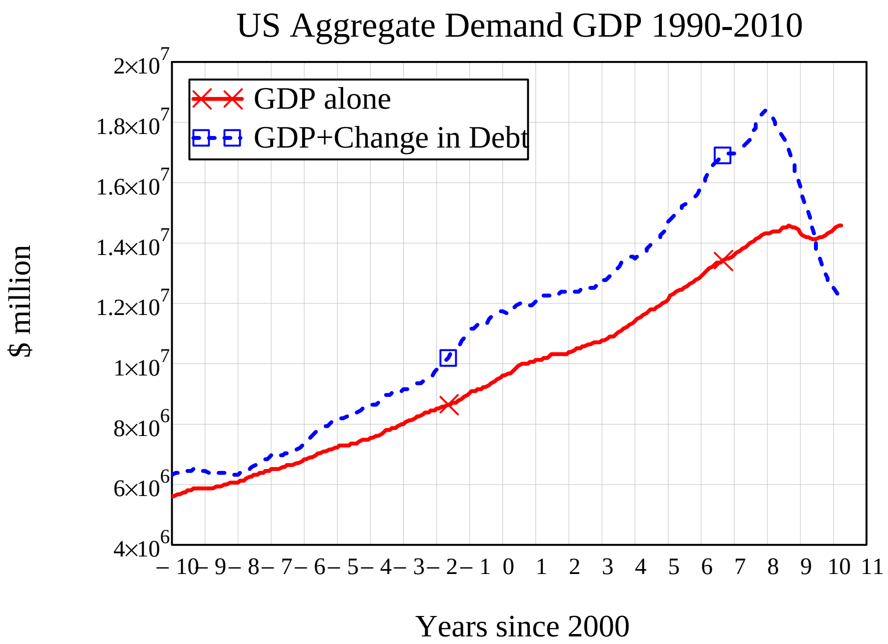
[2] The unemployment data is from http://www2.census.gov/prod2/statcomp/documents/CT1970p1-01.pdf.

Figure 5: Private debt and GDP 1990-2010



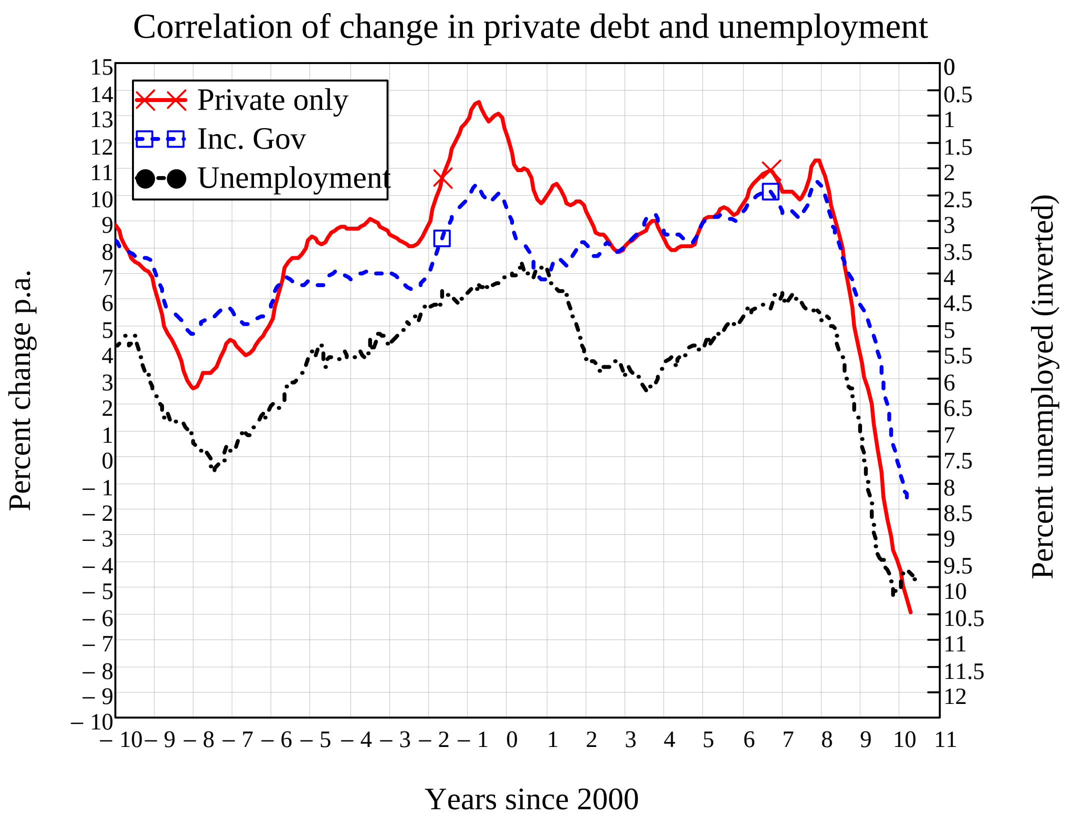
The debt contribution to demand during the boom years till 2008 is therefore much greater (Figure 6).

Figure 6: Aggregate demand 1990-2010



The correlation of changes in private debt[3] with unemployment, at -0.955 between 1990 and today, is even stronger than in the 1920-30s.

Figure 7: Change in debt and unemployment, 1990-2010



A useful metric in gauging the impact of debt on demand is to compare the change in debt to the sum of GDP plus the change in debt (the dynamic measure of aggregate demand as per (Minsky 1982, p. 6)). Figure 8 measures this from the point at which the debt contribution to demand was the greatest in the boom prior to the crises of 1930 and 2008—mid-1928 and December 2007 respectively. It also includes the contribution to aggregate demand from government debt.[4] This, more than any other measure, tells us that the GFC is bigger than the Great Depression, and that we are still in its early days.

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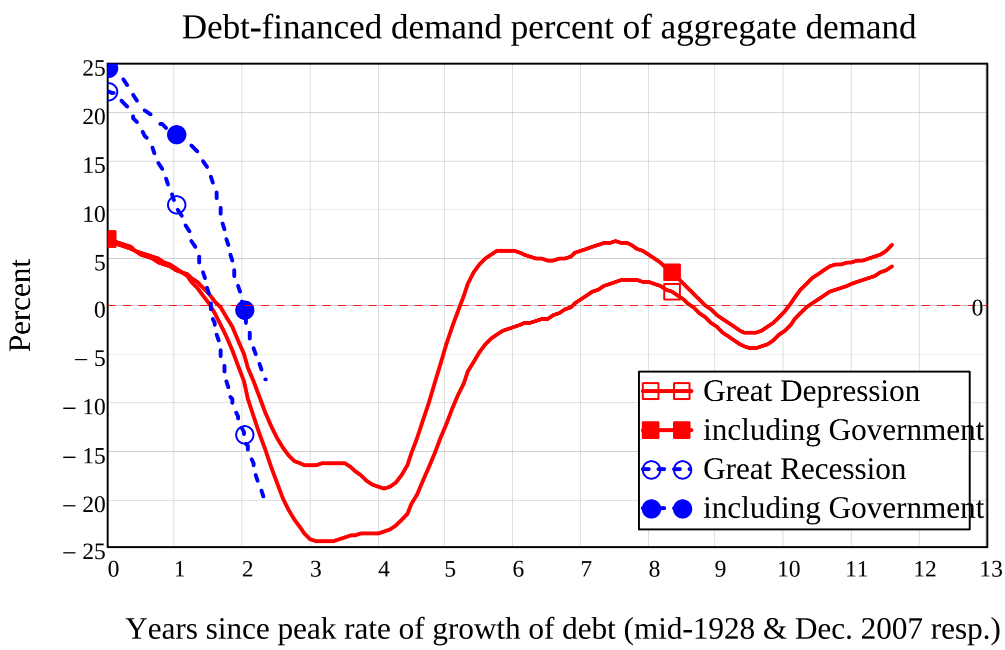
[3] The debt contribution in the 1920s is lagged one year; current data is unlagged, since debt data is collected on a more timely quarterly basis and the correlation between debt change and unemployment falls when the lag is increased, whereas its peak level in the 1920s was after a one year lag.

[4] This does not include the impact that the Federal Reserve can have of course, but it is a reasonable measure of the fiscal contribution.

Figure 8: The turnaround in debt-financed demand, Great Depression and today



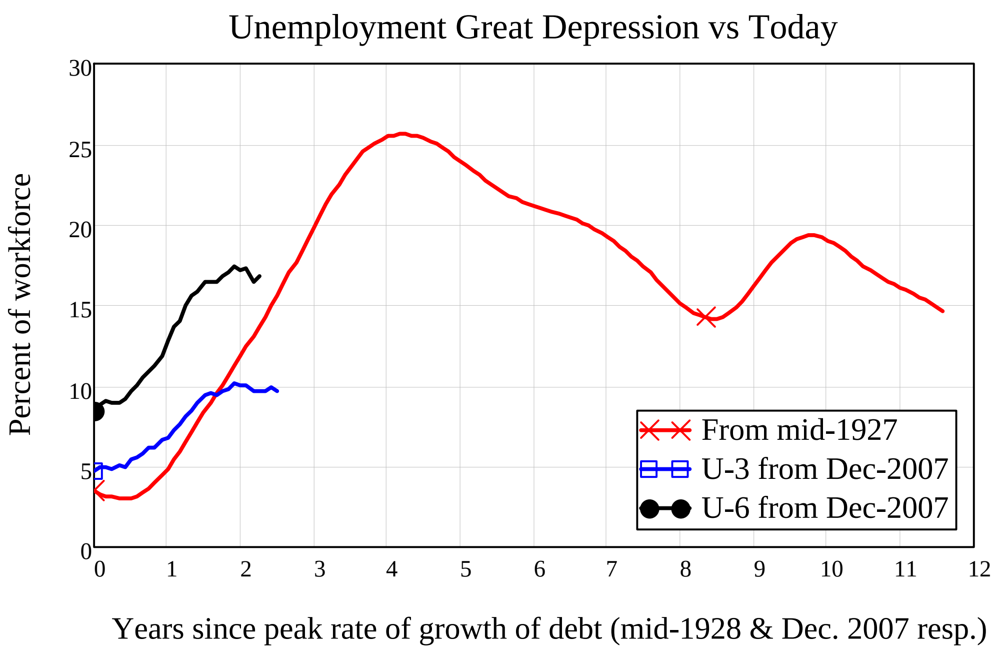
Firstly, the contribution to demand from rising private debt was far greater during the recent boom than during the Roaring Twenties—accounting for over 22% of aggregate demand versus a mere 8.7% in 1928. Secondly, the fall-off in debt-financed demand since the date of Peak Debt has been far sharper now than in the 1930s: in the 2 1/2 years since it began, we have gone from a positive 22% contribution to negative 20%; the comparable figure in 1931 (the equivalent date back then) was minus 12%.[5] Thirdly, the rate of decline in debt-financed demand shows no signs of abating: deleveraging appears unlikely to stabilize any time soon.

Finally, the addition of government debt to the picture emphasizes the crucial role that fiscal policy has played in attenuating the decline in private sector demand (reducing the net impact of changing debt to minus 8%), and the speed with which the Government reacted to this crisis, compared to the 1930s. But even with the Government's contribution, we are still on a similar trajectory to the Great Depression.

What we haven't yet experienced—at least in a sustained manner—is deflation. That, combined with the enormous fiscal stimulus, may explain why unemployment has stabilized to some degree now despite sustained private sector deleveraging, whereas it rose consistently in the 1930s (Figure 9).

[5] Though this may be clouded by the fact that the 1930s debt data is annual.

Figure 9: Comparing unemployment then and now



Here some credit may be due to "Helicopter Ben".[6] Though Bernanke and Greenspan clearly played a role in encouraging private debt to reach the heights it did, it is certainly conceivable that his enormous injection of base money into the system in late 2008 averted a nascent deflation (Figure 10).

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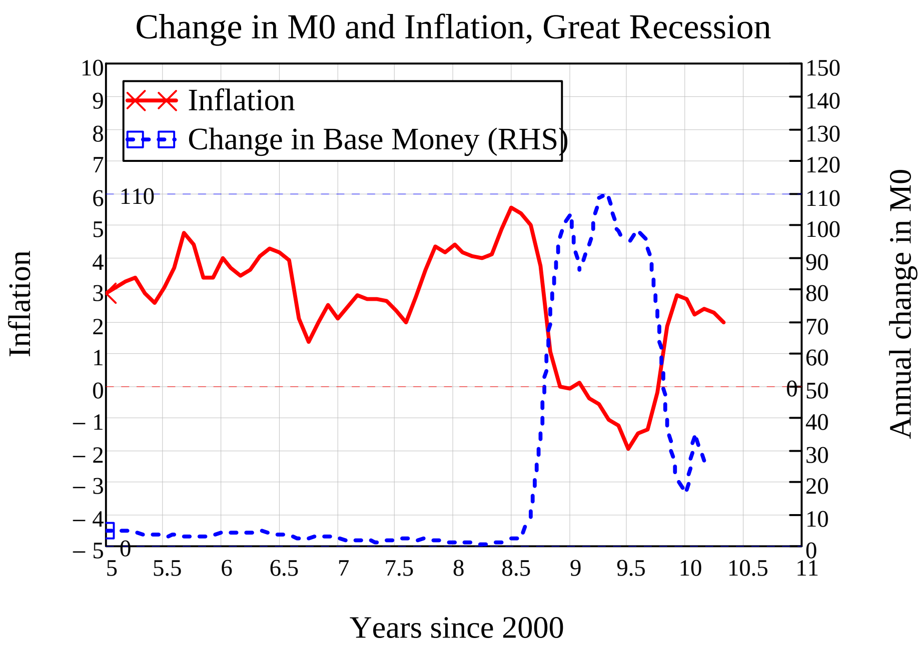
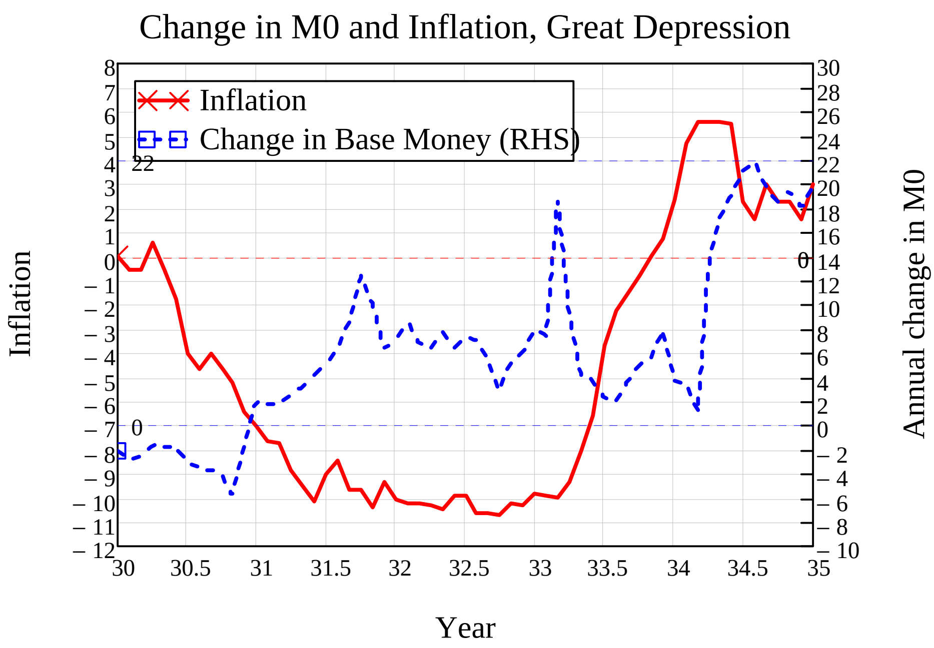
[6] This nickname could be seen as rather unfair, since Friedman was the originator of the Helicopter money analogy (Friedman, M. (1969). The Optimum Quantity of Money. The Optimum Quantity of Money and Other Essays. Chicago, MacMillan: 1-50.). However, given the paean he delivered to Friedman at his 90th birthday (Bernanke, B. S. (2002). Remarks by Governor Ben S. Bernanke. Conference to Honor Milton Friedman. University of Chicago, Chicago, Illinois.), perhaps Bernanke deserves it by association.

Figure 10: Inflation, deflation and base money growth 2005-Now



Here Bernanke is replaying the tune from 1930s—though much more loudly. Though he accused his 1930 counterparts of causing the Great Depression via tight monetary policy (Bernanke 2000, p. ix), a closer look at the data shows that he was merely more decisive and successful than his predecessors: they too boosted M0 in an attempt to restrain deflation, but nowhere near as much, as quickly, or in such a sustained way.

Figure 11: Inflation, deflation and base money growth in the 1930s

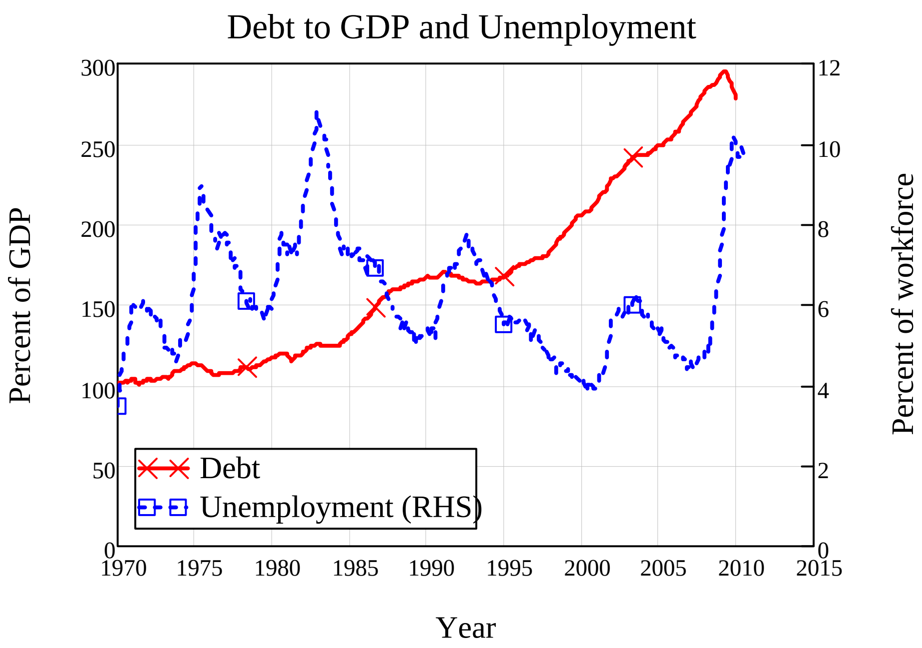


What he shares with them is partial responsibility for causing the Great Recession, since like them he ignored the impact of private debt on economic performance ((Bernanke 1995, p. 17) and (Bernanke 1983, p. 258 & note 5)),[7] when that—and not "improved control of inflation" ((Bernanke 2004))—was the real "positive" cause of the "Great Moderation, as it is now the defining negative factor of the Great Recession.

Whether this success can continue is now a moot point: the most recent inflation data suggests that the success of "the logic of the printing press" may be short-lived. The stubborn failure of the "V-shaped recovery" to display itself (insert Lazear 2009 reference) also reiterates the message of Figure 7: there has not been a sustained recovery in economic growth and unemployment since 1970 without an increase in private debt relative to GDP. For that unlikely revival to occur today, the economy would need to take a productive turn for the better at a time that its debt burden is the greatest it has ever been (Figure 12).

[7] At least in defence of the 1930s Fed, it can be said that Fisher and Minsky were not there to ignore, as Bernanke so completely did. Bernanke's treatment of Minsky is so superficial that it deserves highlighting: "Hyman Minsky (1977) and Charles Kindleberger (1978) have in several places argued for the inherent instability of the financial system, but in doing so have had to depart from the assumption of rational economic behavior… I do not deny the possible importance of irrationality in economic life; however, it seems that the best research strategy is to push the rationality postulate as far as it will go." Bernanke, B. S. (1983). "Nonmonetary Effects of the Financial Crisis in Propagation of the Great Depression." American Economic Review **73**(3): 257-276.

Figure 12: Debt to GDP and unemployment 1970-Now

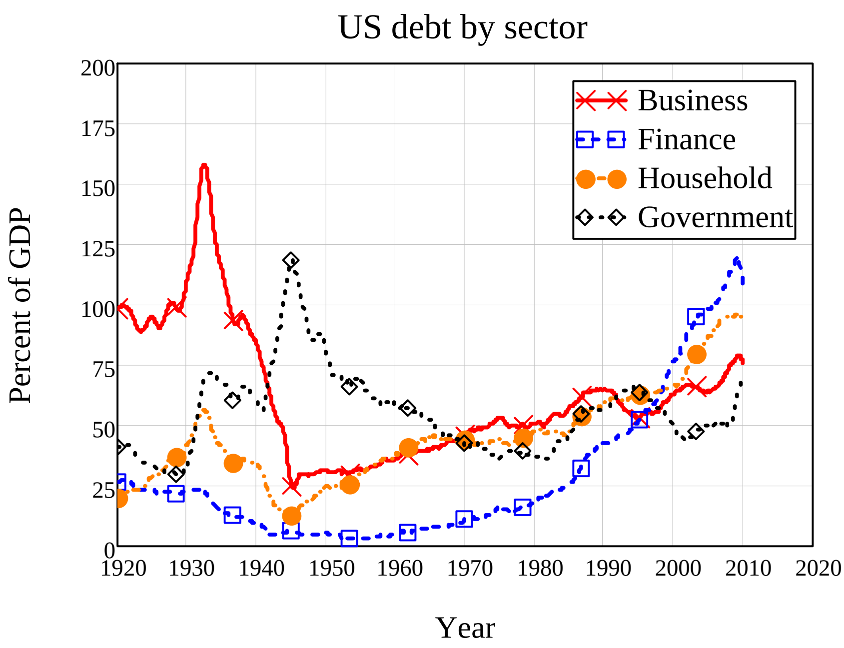


Debt-financed growth is also highly unlikely, since the transference of the bubble from one asset class to another that has been the by-product of the Fed's too-successful rescues in the past ((Minsky 1982, pp. 152-153.))[8] means that all private sectors are now debt-saturated: there is no-one in the private sector left to lend to (Figure 13).[9]

[8] "If a financial crisis occurs, the central bank must abandon any policy of constraint. Presumably the central bank should intervene before a collapse of market asset values that will lead to a serious depression. However, if it acts too soon and is too effective, there will be no appreciable pause in the expansion that made the policy of constraint necessary… If monetary conditions are eased too soon, then no substantial unlayering of balance sheets will be induced, and the total effect of monetary actions might very well be to reinforce the euphoric expansion."

[9] The blowout in the business debt ratio from 1930 to 1932 was due to deflation and falling output rather than rising debt.

Figure 13: US debt by sector, 1920-Now



Modeling Minsky

How do we make sense of this empirical reality? Certainly mainstream economics, with its equilibrium fetish and ignorance of credit, is a waste of time—it functioned more as a means to divert attention from what mattered in the economy than as a means to understand it. Minsky provides the foundation from which our predicament can be understood, but our rendition of his vision is still sparse compared to the worthless but elaborate Neoclassical tapestry. We need an inherently monetary, historically realistic and non-equilibrium macroeconomics.

My contribution to this has been to extend my original Minsky model ((Keen 1995))—built on the foundations of Goodwin's model of a cyclical economy (Goodwin 1967) —by developing models of endogenous money creation derived from Circuit Theory ((Graziani 1989), (Graziani 2003)), and by--tentatively--combining the two.

My basic Minsky model extended Goodwin's pioneering "predator-prey" model of a cyclical economy by replacing the unrealistic assumption that capitalist invest all their profits with the realistic nonlinear proposition that they invest more during booms and less during slumps—with the variation accommodated by a financial sector that lends money at interest. That led to a chaotic model which could, given appropriate initial conditions, generate a debt-induced crisis—but which had a stable equilibrium. This was part of the way towards Minsky. However, while the fact that the equilibrium was stable was consistent with (Fisher 1933, p. 339, point 9), it was rather awkward when judged against Minsky's famous statement that "Stability—or tranquility—in a world with a cyclical past and capitalist financial institutions is destabilizing" ((Minsky 1982, p. 101)).

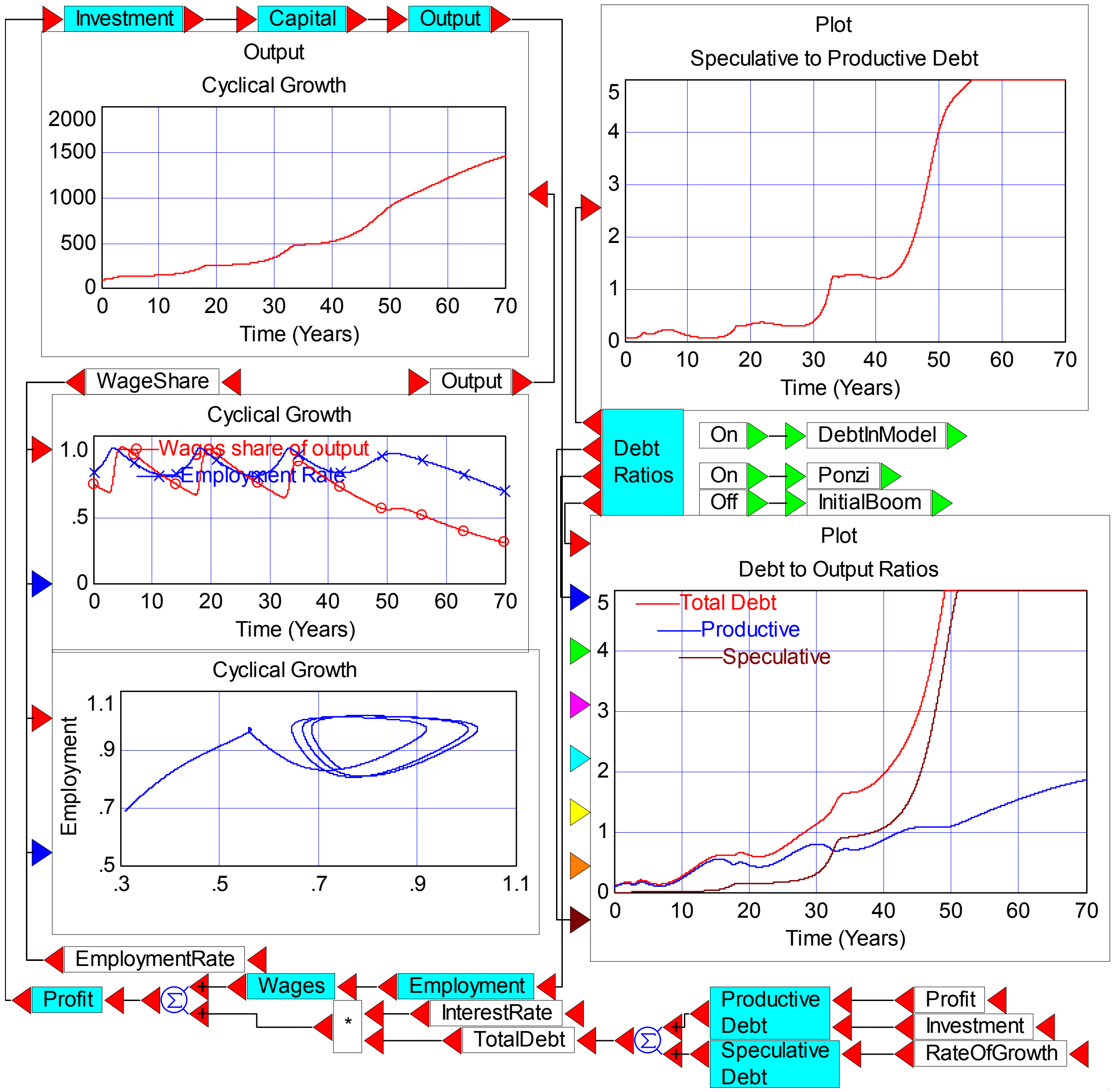
What was missing in my original Minsky model was Ponzi finance. Put simply, this is debt-financed speculation on asset prices, which we can now see as the driving force behind the accumulation of debt in the last two decades, and the consequent inflation of asset prices. In my original model, all debt was related to the construction of new capital equipment, which is inherently a non-Ponzi behavior. I introduced a simulacrum of Ponzi finance ((Keen 2009)), with additional debt being taken on when the rate of growth exceeds a threshold level, without adding to the capital stock (the 4th equation in (0.1)).[10] This simulates speculation on asset prices, though without explicitly modeling asset prices themselves.

$$\begin{aligned}
\frac{d}{dt}Y &= g \cdot Y \\
\frac{d}{dt}w &= P_C(\lambda) \cdot w \\
\frac{d}{dt}D &= I(\pi_r) \cdot Y - \Pi + P_K \\
\frac{d}{dt}P_K &= \kappa(g) \cdot Y \\
\frac{d}{dt}a &= \alpha \cdot a \\
\frac{d}{dt}N &= \beta \cdot N
\end{aligned} \tag{0.1}$$

That generated a model in which stability **was** destabilizing, and in which the level of debt that triggered a breakdown was rather closer to the current empirical record (see Figure 14).

[10] This model uses absolute values, whereas the variables in my 1995 paper were ratios of debt to income, employment to population, etc. See Table 11 on page 49 for details of the functions and parameter values.

Figure 14: The model in equation as a systems engineering flowchart



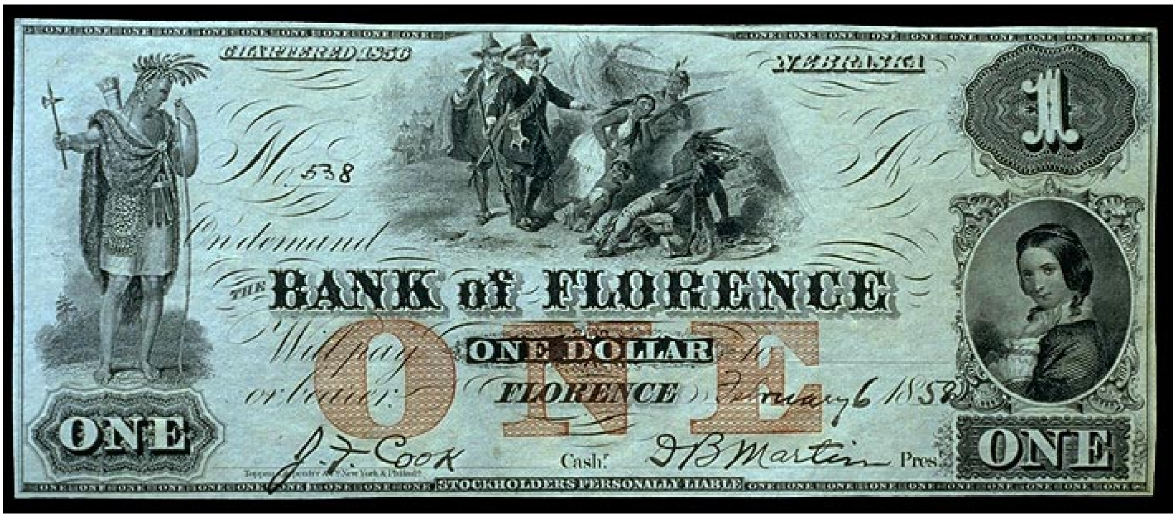
Circuit Theory

Though my Minsky model incorporates debt, it is not an explicitly monetary model, and the active role that the financial sector has played in causing this crisis makes it obvious that its own dynamics must be incorporated in any realistic model of our current predicament. Circuit theory gives the best foundation for understanding the dynamics of credit creation, but initial attempts to devise a model from this theory reached paradoxical results—in particular, the widespread conclusion that capitalists could not make profits in the aggregate if they had to pay interest on borrowed money, or if workers saved any of their wages ((Graziani 1989, p. 5); (Bellofiore, Davanzati et al. 2000, p. 410 note 9); (Rochon 2005, p. 125)).

It is relatively easy to show that this conventional Circuitist conclusion is the product of confusing stock—specifically here an initial injection of money into an economy—with a flow—the amount of economic activity that the stock of money can generate in a given time frame. I have done this by modeling a pure credit economy—one without fiat money in any sense—not because that is our actual financial system, but because it is simpler to illustrate that capitalists can borrow money, pay interest, and make a net profit in a model in which the only source of finance is privately issued debt.[11]

To avoid being distracted by several contentious but, in this context, side-issues amongst monetary theorists, I demonstrate that capitalists can indeed make monetary profits in a model of the short-lived 19th century "Free Banking" system ((Keen 2010)). The basic "constant money stock" model simulates a private bank that has printed ***N*** of its own dollar notes like those shown in Figure 15, and then lends them to firms, who hire workers that produce output that is then sold to capitalists, workers and bankers.

Figure 15: Bank of Florence (Nebraska) dollar note ((Smithsonian Institution 2010))[12]



The basic ***flow*** operations that apply in this system are that:

1. The bank lends notes from its vault $\boldsymbol{B_V}$ to the firms' deposit accounts $\boldsymbol{F_D}$;

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[11] In the process of devising this model, I have developed a new method of building dynamic models that is an extension of the Godley Social Accounting Matrix approach ((Godley and Lavoie 2007)), in which bank accounts are the primary variables and the modeling is in continuous time using differential rather than difference equations ((Keen 2008)). The method has been developed by a collaborator into a computer program called QED—for "Quesnay Economic Dynamics"—and this is now freely available from my website www.debtdeflation.com/blogs on the QED page. See Figure 36 to Figure 40 on pages 52 to 56 for screenshots of QED.

[12] Private note images In the Smithsonian's National Numismatic Collection can be found at the urls http://americanhistory.si.edu/collections/numismatics/survivin/103.htm to ../119... See http://americanhistory.si.edu/collections/numismatics/survivin/danatext.htm for an Art and Social History oriented presentation of these notes.

2. Firms pay interest on the loans from their deposit accounts to the bank's transactions account B_T;

3. The bank pays interest from its transactions account to the firms' deposit accounts;

4. Firms pay wages from their deposit accounts into workers' deposit accounts W_D;

5. The bank pays interest from its transactions account on workers' account balances;

6. Bank and workers pay for consumption of the output of firms; and

7. Firms repay their loans by transferring dollars from their deposit accounts to the bank's vault.

These operations are shown in the relevant rows in Table 1, and since, as Wynne Godley so properly insisted, "every flow comes from somewhere and goes somewhere" (Godley 1999, p. 394), these operations sum to zero on each row.

However there are operations in banking that are ***not*** flows, but accounting entries made on the debt ledger:

A. The recording of the lending of money by the bank to the firms on the debt ledger F_L;
B. The compounding of debt at the rate of interest;
C. The recording of payments of interest in row 2 above by deducting the amount paid from the level of outstanding debt; and
D. The recording of payments of principal in row 7 above by deducting the amount paid from the level of outstanding debt.

Table 1: Basic financial transactions in a Free Banking economy

Row	Transaction	Type	Bank Vault (B_V)	Bank Transaction (B_T)	Firm Loan (F_L)	Firm Deposit (F_D)	Worker Deposit (W_D)
1	Lend Money	Money Transfer	-A			A	
A	Record Loan	Ledger Entry			A		
B	Compound Debt	Ledger Entry			B		
2	Pay Interest	Money Transfer		C		-C	
C	Record Payment	Ledger Entry			-C		
3	Deposit Interest	Money Transfer		-D		D	

4	Wages	Money Transfer				-E	E
5	Deposit Interest	Money Transfer		-F			F
6	Consumption	Money Transfer		-G		G+H	-H
7	Repay Loan	Money Transfer	I			-I	
D	Record Repayment	Ledger Entry			-I		
	Sum of Flows		I-A	C-D-F-G	A+B-C-I	A-C+D-E+G+H-I	E+F-H

The columns in this table represent the equations of motion of this model of free banking, and the rate of change of each account is given by the symbolic sum of each column:

$$\begin{aligned}
\frac{d}{dt}B_V &= -A + I \\
\frac{d}{dt}B_T &= C - D - F - G \\
\frac{d}{dt}F_L &= A + B - C - I \\
\frac{d}{dt}F_D &= A - C + D - E + G + H - I \\
\frac{d}{dt}W_D &= E + F - H
\end{aligned} \tag{0.2}$$

With the substitutions shown in Table 2, the following model results:

$$\frac{d}{dt}B_V(t) = f_L \cdot F_L(t) - b_v \cdot B_V(t)$$
$$\frac{d}{dt}B_T(t) = r_L \cdot F_L(t) - r_D \cdot F_D(t) - r_D \cdot W_D(t) - b_T \cdot B_T(t)$$
$$\frac{d}{dt}F_L(t) = b_v \cdot B_V(t) + r_L \cdot F_L(t) - r_L \cdot F_L(t) - f_L \cdot F_L(t) \quad (0.3)$$
$$\frac{d}{dt}F_D(t) = b_v \cdot B_V(t) - r_L \cdot F_L(t) + r_D \cdot F_D(t) - f_D \cdot F_D(t) + b_T \cdot B_T(t) + w_D \cdot W_D(t) - f_L \cdot F_L(t)$$
$$\frac{d}{dt}W_D(t) = f_D \cdot F_D(t) + r_D \cdot W_D(t) - w_D \cdot W_D(t)$$

Table 2: Financial operations in the Free Banking model

Operation	Description	
A	Loans to firms at the rate b_V times the balance in the vault at time t $B_V(t)$	$b_v.B_V(t)$
B	The rate of interest on loans r_L times the level of loans at time t $F_L(t)$	$r_L.F_L(t)$
C	Payment of interest on loans	$r_L.F_L(t)$
D	Payment of interest on firm deposits $F_D(t)$ at the rate r_D	$r_D.F_D(t)$
E	Payment of wages by firms at the rate f_D times firm deposits at time t $F_D(t)$	$f_D.F_D(t)$
F	Payment of interest on deposits at the rate r_D	$r_D.W_D(t)$
G	Payment for goods by banks at the rate b_T times the level of the bank transaction account at time t $B_T(t)$	$b_T.B_T(t)$
H	Payment for goods by workers at the rate w_D times the level of the bank transaction account at time t $W_D(t)$	$w_D.W_D(t)$
I	Repayment of loans at the rate f_L times the outstanding loan balance at time t $F_L(t)$	$f_L.F_L(t)$

As is easily shown, with realistic parameter values (see Table 3; the values are explained later) this describes a self-sustaining system in which all accounts settle down to equilibrium values, and in which capitalists earn a monetary profit.

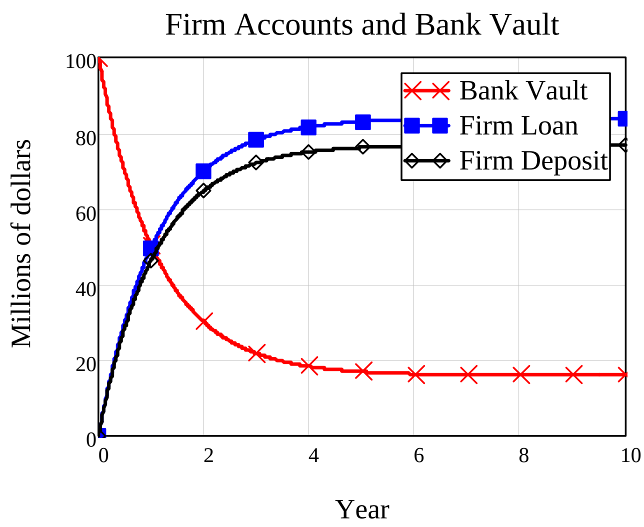
Table 3: Parameter values

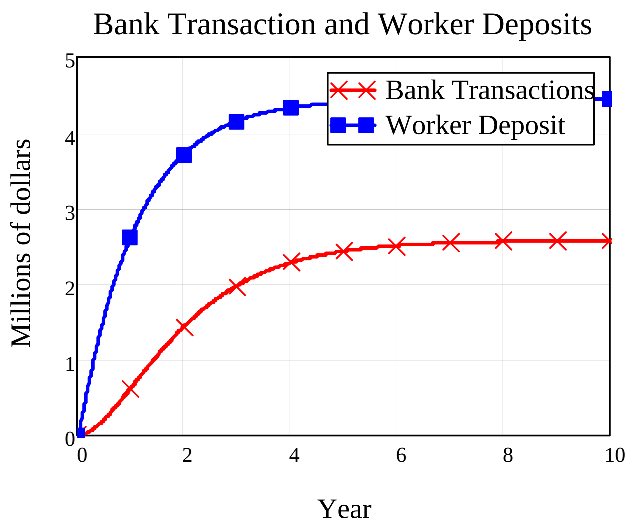
Parameter	Value	Description
b_V	¾	Rate of outflow of notes from the vault B_V

r_L	5%	Rate of interest on loans
r_D	2%	Rate of interest on deposits
f_D	2	Rate of outflow of notes from F_D to pay wages
b_T	1	Rate of outflow of notes from B_T to pay for bankers consumption
w_D	26	Rate of outflow of notes from W_D to pay for workers consumption
f_L	1/7	Rate of repayment of loans

Figure 16 shows the dynamics of this system; with an initial stock of N=100 million dollar notes.

Figure 16: Bank account balances over time





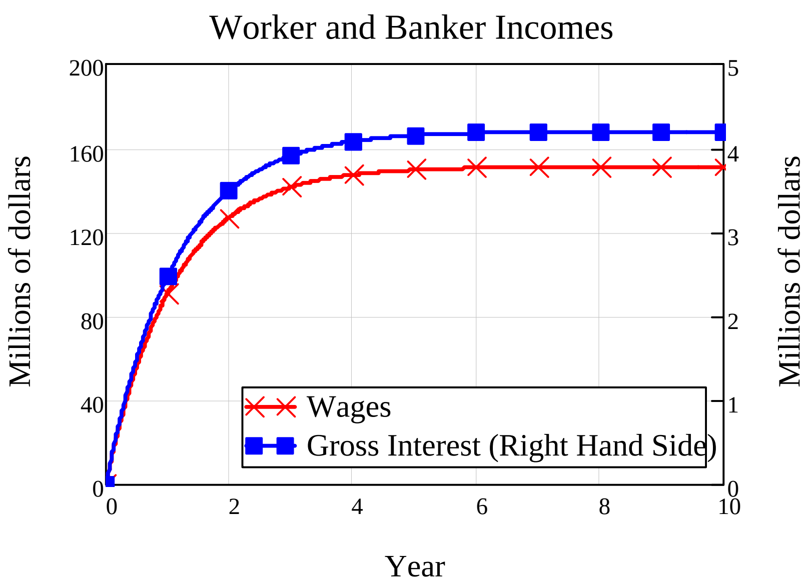
The equilibrium values can be solved for symbolically in this constant money stock model:

$$\begin{bmatrix} B_{V_e} \\ B_{T_e} \\ F_{L_e} \\ F_{D_e} \\ W_{D_e} \end{bmatrix} = \begin{bmatrix} f_L \\ b_V \cdot \dfrac{r_L - r_D}{b_T - r_D} \\ b_V \\ b_V \cdot \dfrac{(b_T - r_L)\cdot(w_D - r_D)}{(b_T - r_D)\cdot(f_D - r_D + w_D)} \\ b_V \cdot \dfrac{f_D \cdot (b_T - r_L)}{(b_T - r_D)\cdot(f_D - r_D + w_D)} \end{bmatrix} \cdot \frac{N}{b_V + f_L} \tag{4}$$

From account balances to incomes

The yearly wages of workers and gross interest earnings bankers can be calculated from the simulation, and they in part explain why, in contrast to the conventional belief amongst Circuitist writers, capitalists can borrow money, pay interest, and still make a profit. Though only $100 million worth of notes were created, the circulation of those notes generates workers' wages of $151 million per annum (given the parameter values used in this simulation), 1.5 times the size of the aggregate value of notes in circulation.

Figure 17: Wages and Gross Interest



This indicates the source of the Circuitist conundrums: *the stock of money has been confused with the amount of economic activity that money can finance over time*. A stock—the initial amount of notes created in this model—has been confused with a flow. [13] In fact, for a wide range of values for the parameter f_D, *the flows initiated by the money borrowed by the firms over a year exceed the size of the loan itself*.

This is possible because the stock money can circulate several times in one year—something that Marx accurately enunciated over a century ago in Volume II of *Capital* (though his numerical example is extremely large):

> "Let the period of turnover be 5 weeks, the working period 4 weeks... In a year of 50 weeks ... Capital I of £2,000, constantly employed in the working period, is therefore turned over 12½ times. 12½ times 2,000 makes £25,000." (Marx and Engels 1885, Chapter 16: The Turnover of Variable Capital)

Aggregate wages *and aggregate profits* therefore depend in part upon the turnover period between the outlay of money to finance production and the sale of that production. This turnover period can be substantially shorter than a year, in which case f_D will be substantially larger than 1, as I explain below.

The making of monetary profits

A second fundamental insight from Marx lets us explain what f_D is, and simultaneously derive an expression for profits: the annual wages bill reflects both the turnover period, and the way in which the surplus value generated in production is apportioned between capitalists and workers. The value of f_D therefore reflects two factors: the share of surplus (in Sraffa's sense) that accrues to workers;[14] and the turnover period measured in years—the time between *M* and *M+*. Labelling the share going to capitalists as ***s*** and the share to workers as ***(1-s)***, and labelling the turnover period as τ_S and expressing it as a fraction of a year, I can perform the substitution shown in Equation (5):

$$f_D = \frac{1-s}{\tau_S} \tag{5}$$

Money wages are therefore:

$$f_D \cdot F_D(t) = \frac{1-s}{\tau_S} \cdot F_D(t) \tag{6}$$

[13] This statement from Graziani 1989 is indicative of the error of confusing the initial loan with the volume of transactions that can be generated by such a loan over a year: "If on the other hand, wage-earners decide to keep part of their savings in the form of liquid balances (that is, banking deposits), firms will get back from the market less money than they have initially injected in it" (Graziani 1989, p. 520).

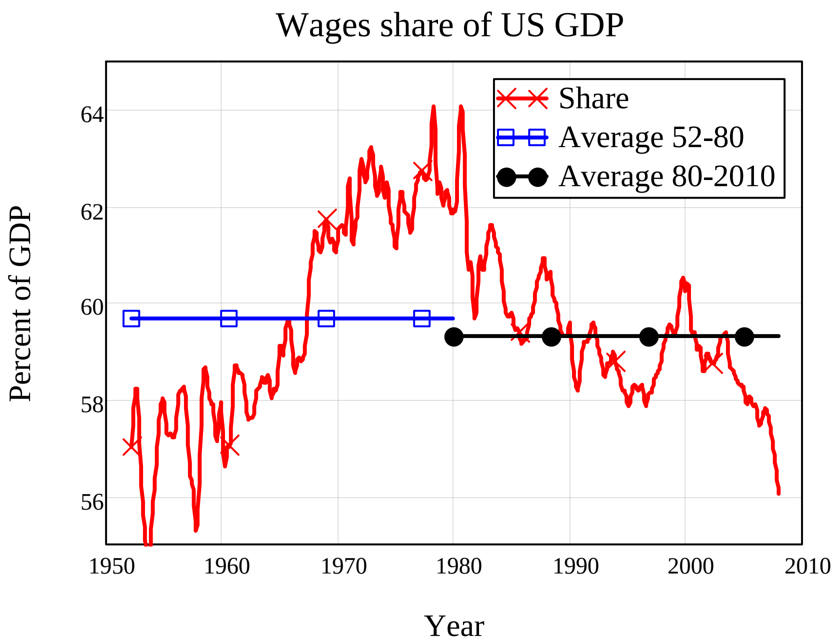
[14] I depart from Marx and follow Sraffa here, by specifying the division of surplus between capitalists and workers in such a way that the sum is 1. Thus if capitalists get s% of the surplus, workers get [1-s]%

Since national income resolves itself into wages and profits (interest income is a deduction from other income sources), we have also identified gross profit:[15]

$$\Pi(t) = \frac{s}{\tau_S} \cdot F_D(t) \quad (7)$$

Using a value of s=40%—which corresponds to historical norm of 60% of pre-interest income going to workers (see Figure 18)—this implies a value for τ_S of 0.3.

Figure 18: Wages percentage of US GDP

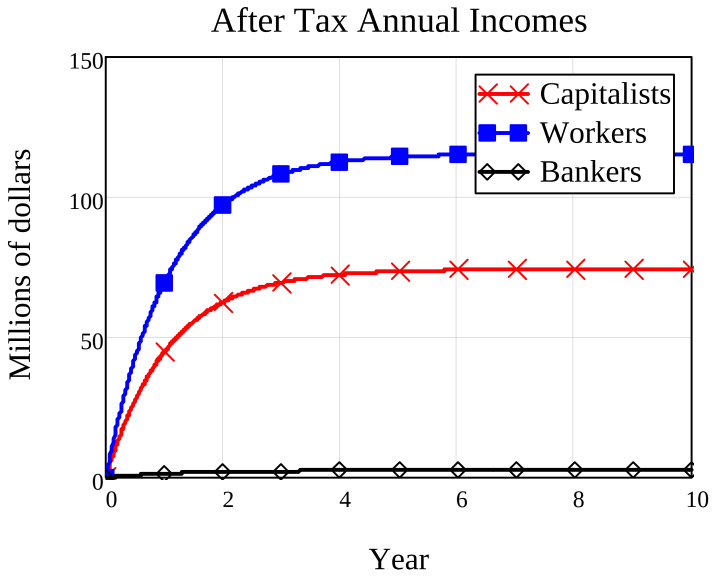


This means that the turnover period in Marx's terminology is roughly 16 weeks. This is much longer than in Marx's numerical illustration above, but still sufficient to give capitalists profits that are substantially greater than the servicing costs of debt. Figure 19 shows the annual incomes for each class in society over time; all are positive and the equilibrium levels (once account levels stabilize) are \$151 million, \$98 million and \$2.5 million for workers, capitalists and bankers respectively out of a national income of \$192 million (see Equation (8)).

[15] If this seems like a Milton Friedman magic trick ("Putting a rabbit into a hat in full view of the audience, and then expecting applause when he later pulls it out again", to quote Joan Robinson from a talk she gave to Sydney University students in 1974), bear with me—later I show that profits can also be derived from the production system.

$$\begin{aligned}
&\text{Workers: } \frac{1-s}{\tau_S}\cdot F_D(t)+r_D\cdot W_D(t)=151.33 \text{ in equilibrium}\\
&\text{Capitalists: } \frac{s}{\tau_S}\cdot F_D(t)+r_D\cdot F_D(t)-r_L\cdot F_L(t)=98.12 \text{ in equilibrium}\\
&\text{Bankers: } r_L\cdot F_L(t)-r_D\cdot\left(F_D(t)+W_D(t)\right)=2.57 \text{ in equilibrium}
\end{aligned} \tag{8}$$

Figure 19: Class incomes after interest payments



The value of τ_S also determines the ratio of nominal GDP to the proportion of the money stock in circulation (the equivalent of M1-M0 in monetary statistics, since in this pure credit model there is no fiat money), which is 3 given the parameters used in this simulation. This is within the highly volatile range suggested by historical data (see Figure 20).

Figure 20: US GDP to Money Supply ratios

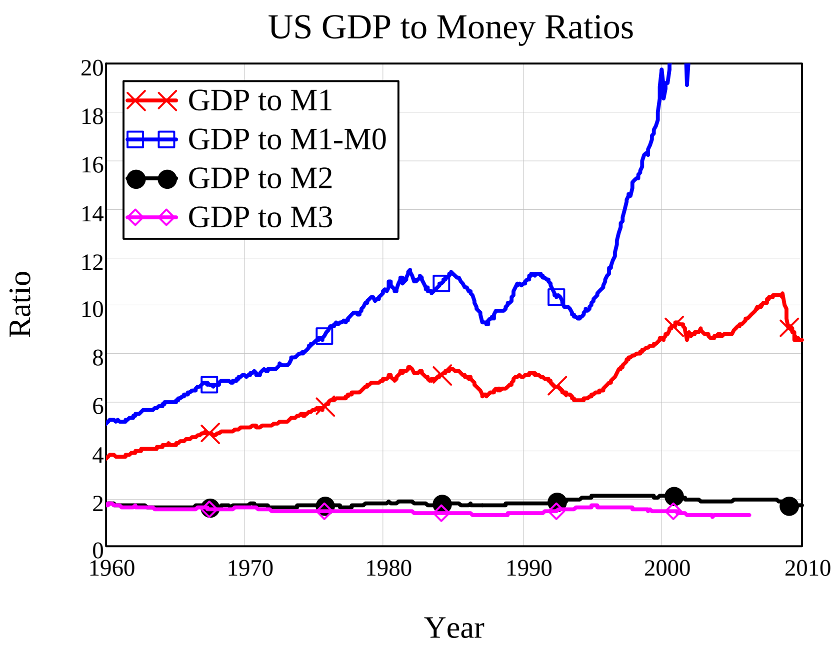


Table 4 summarises the equilibrium values for account balances, gross and net incomes in this hypothetical pure credit economy:

Table 4

	Account Balances	Class Incomes	Net Incomes
Bank Vault	16	N/A	N/A
Firm Loans	84	N/A	N/A
Firms	75.6081	100.811 (profits)	98.123
Workers	5.8205	151.216 (wages)	151.333
Bankers	2.5714	4.2 (debt servicing)	2.571
Totals	84 (Deposits)	252.027+4.2	252.027

Other parameters and time lags

The parameters $\boldsymbol{r_L}$ and $\boldsymbol{r_D}$ are nominal interest rates and their values are roughly in line with historical norms at times of low-inflation; that leaves the parameters $\boldsymbol{b_V}$, $\boldsymbol{f_L}$,$\boldsymbol{w_D}$ and $\boldsymbol{b_T}$ to account for.

The values for $\boldsymbol{b_V}$ and $\boldsymbol{f_L}$ were chosen so that the equilibrium value of B_V would be roughly the value noted by (Bodenhorn and Haupert 1996, p. 688) of 15 percent of available notes:

$$\frac{f_L}{b_V + f_L} = 0.16 \tag{9}$$

The parameters w_D and b_T signify how rapidly workers and bankers respectively spend their bank balances on the output produced by firms: workers turnover their accounts 26 times a year, while bankers turnover their account just once.

In the remainder of the paper, these parameters are expressed using the systems engineering concept of a time constant, which gives the fundamental frequency of a process.[16] In every case, the time constant is the inverse of the parameter used thus far; for instance, the value of 26 for w_D corresponds to workers' consumption having a fundamental frequency of 1/26th of a year, or two weeks.

Table 5: Time constants in the model

Parameter and value	Time constant and value	Meaning
$b_V = 3/4$	$\tau_V = 4/3 \cdot years$	Banks lend their reserve holdings of notes every 15 months
$f_L = 1/7$	$\tau_L = 7 \cdot years$	Firms repay their loans every 7 years
$w_D = 26$	$\tau_W = 1/26 \cdot years$	Workers spend their savings every 2 weeks
$b_T = 1$	$\tau_B = 1 \cdot year$	Bankers spend their savings every 1 year
	$\tau_P = 1 \cdot year$	Time constant in price setting (introduced in Equation (17))
	$\tau_M = 15 \cdot years$	Banks double the money supply every 15 years (introduced in Table 7 on page 31)

Production, prices and monetary profits

Consider a simple production system in which output is proportional to the labor input L with constant labor productivity a:

$$Q = a \cdot L \qquad (10)$$

Labor employed in turn equals the monetary flow of wages divided by the nominal wage rate W:

$$L = \frac{1-s}{\tau_S} \cdot F_D \div W \qquad (11)$$

[16] See http://en.wikipedia.org/wiki/Time_constant for an explanation of this concept.

Prices then link this physical output subsystem to the financial model above. In equilibrium, it must be the case that the physical flow of goods produced equals the monetary demand for them divided by the price level. We can therefore derive that in equilibrium, the price level will be a markup on the monetary wage, where the markup reflects the rate of surplus as defined in this paper.

To answer Rochon's vital question, ***M** becomes **M+** via a price-system markup on the physical surplus produced in the factory system*. This markup can be derived simply by considering demand and supply factors in equilibrium. The flow of demand is the sum of wages and profits (since interest payments are a transfer and do not contribute to the value of output—despite Wall Street's bleatings to the contrary). The monetary value of demand is thus:

$$D_M = \frac{1-s}{\tau_S} \cdot F_D + \frac{s}{\tau_S} \cdot F_D = \frac{F_D}{\tau_S} \qquad (12)$$

The physical units demanded equals this monetary demand divided by the price level:

$$D = \frac{D_M}{P} = \frac{1}{\tau_S} \cdot \frac{F_D}{P} \qquad (13)$$

In equilibrium this physical demand will equal the physical output of the economy:

$$Q_e = a \cdot \frac{1-s}{\tau_S} \cdot \frac{F_{D_e}}{W} = D_e = \frac{1}{\tau_S} \cdot \frac{F_{D_e}}{P_e} \qquad (14)$$

Solving for the equilibrium price P_e yields:

$$\begin{aligned} \frac{1}{\tau_S} \cdot \frac{F_{D_e}}{P_e} &= a \cdot \frac{1-s}{\tau_S} \cdot \frac{F_{D_e}}{W} \\ P_e &= \frac{1}{\tau_S} \cdot \frac{F_{D_e}}{a \cdot \frac{1-s}{\tau_S} \cdot \frac{F_{D_e}}{W}} \qquad (15) \\ P_e &= \frac{1}{(1-s)} \cdot \frac{W}{a} \end{aligned}$$

The markup is thus the inverse of workers' share of the surplus generated in production. Circuit theory therefore provides a monetary expression of Marx's theory of surplus value, as it was always intended to do.[17]

[17] Though this is not an endorsement of the Labour Theory of Value, which I reject on other grounds: see Keen, S. (1993). "Use-Value, Exchange Value, and the Demise of Marx's Labor Theory of Value." Journal

With these physical and price variables added to the system, we are now able to confirm that profit as derived from the financial flows table corresponds to profit as the difference between the monetary value of output and the wage bill (in this simple single-sectoral model).

Table 6: Parameters and variables for physical production subsystem

Variable, Parameter or Initial Condition	Definition	Value
a	Labour productivity ***a = Q/L***	2
W	Nominal wage	1
P_e	Equilibrium price $P_e = \frac{1}{(1-s)} \cdot \frac{W}{a}$	0.833
P_0	Initial Price	1
L_e	Equilibrium employment $L_e = \frac{1-s}{\tau_S} \cdot F_{De} \div W$	151.216
Q_e	Equilibrium output $Q_e = L_e \cdot a$	302.432

Using the values given in Table 6, it is easily confirmed that the equilibrium level of profits derived from the financial flows corresponds to the level derived from the physical production system:

$$\begin{aligned} &\frac{1-s}{\tau_S} \cdot F_{De} = 100.811 \\ &P_e \cdot Q_e - W \cdot L_e = 100.811 \end{aligned} \qquad (16)$$

The price relation given above applies also only in equilibrium. Out of equilibrium, it is reasonable to postulate a first-order convergence to this level, where the time constant τ_P reflects the time it takes firms to revise prices. This implies the following dynamic pricing equation:

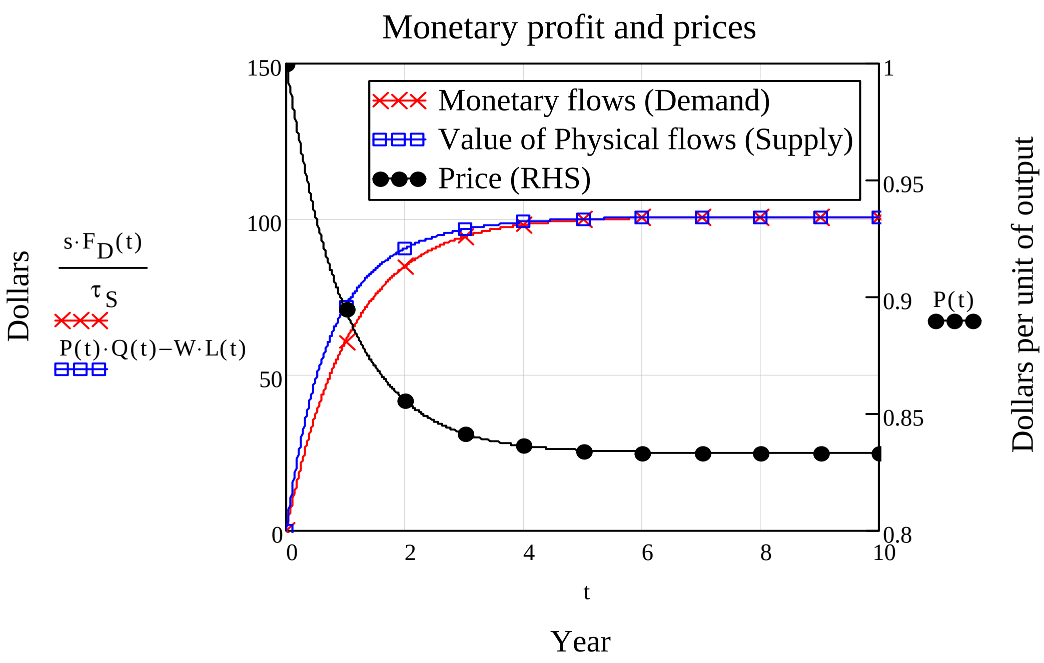
$$\frac{d}{dt}P = -\frac{1}{\tau_P} \cdot \left(P - \frac{1}{(1-s)} \cdot \frac{W}{a} \right) \qquad (17)$$

A simulation also confirms that the monetary flows (demand) and the monetary value of physical flows (supply) converge over time (Figure 21).

---

of the History of Economic Thought **15**(1): 107-121. and Keen, S. (1993). "The Misinterpretation of Marx's Theory of Value." Journal of the History of Economic Thought **15**(2): 282-300..

Figure 21: Supply, Demand and Price convergence



This solves the paradox of monetary profits: it was not a paradox at all, but a confusion of stocks with flows in previous attempts to understand the monetary circuit of production.

Analysing the GFC

We can now use this framework to consider one aspect of the current financial crisis: if a "credit crunch" occurs, what is the best way for government to address it?—by giving fiat money to the banks to lend, or by giving it to the debtors to spend?

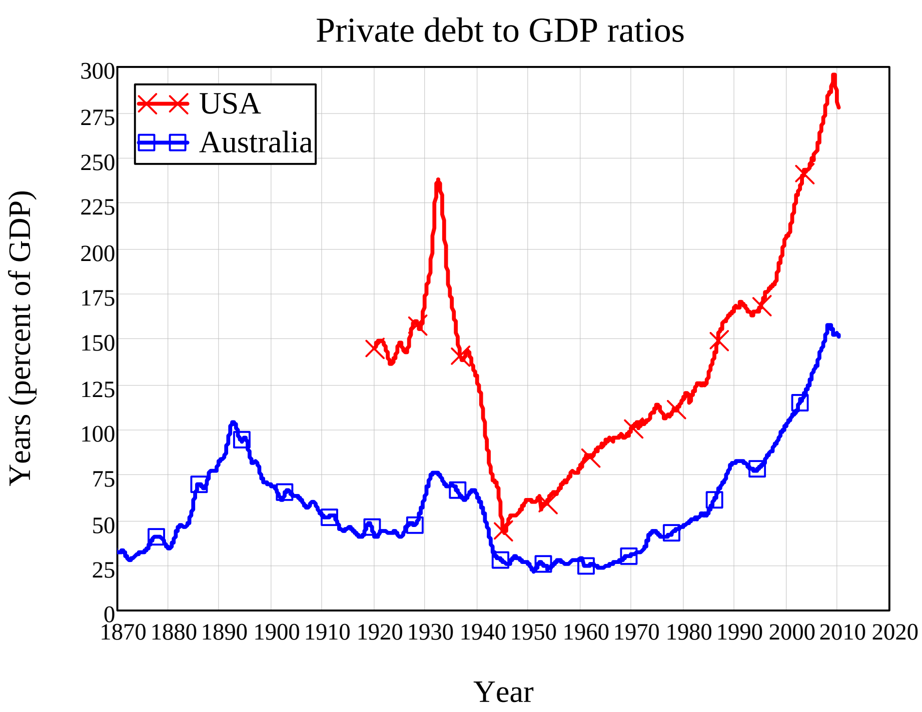
Our current crisis is, of course, more than merely a "credit crunch"—a temporary breakdown in the process of circulation of credit. It is also arguably a secular turning point in debt akin to that of the Great Depression ((Keen 2009)), as Figure 22 illustrates. However the model developed here can assess the differential impact of a sudden injection of fiat money[18] to rescue an economy that has experienced a sudden drop in the rate of circulation and creation of private credit. This is an important point, since although the scale of government response to the crisis was enormous across all affected nations, the nature of that response did vary: notably, the USA focused its attention on boosting bank reserves in the belief, as expressed by President Obama, that the money multiplier made refinancing the banks far more effective than rescuing the borrowers:

> And although there are a lot of Americans who understandably think that government money would be better spent going directly

[18] Modeled here as a "deus ex machina" injection of money into the system—the proper modeling of a mixed private credit-fiat money economy is the subject of a subsequent paper.

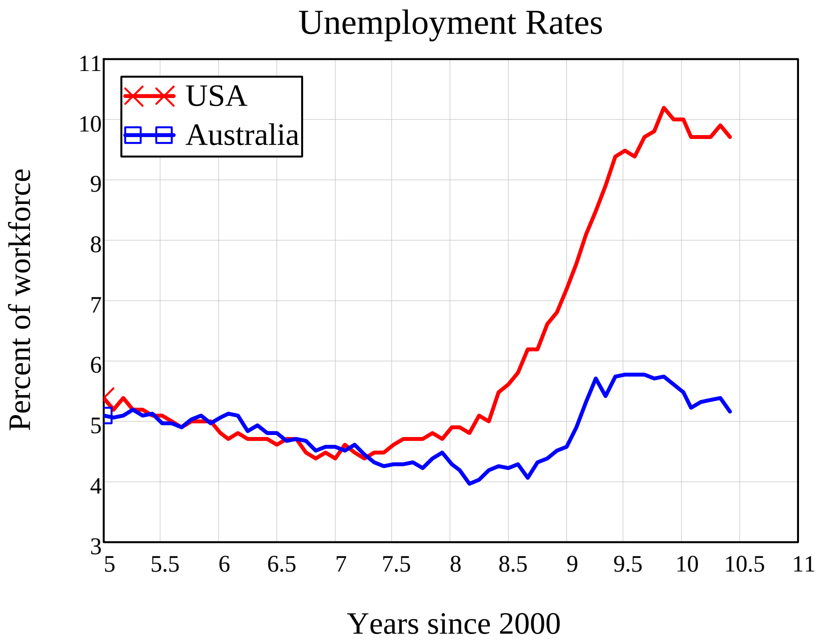
to families and businesses instead of banks – "where's our bailout?," they ask – the truth is that **a dollar of capital in a bank can actually result in eight or ten dollars of loans to families and businesses, a multiplier effect that can ultimately lead to a faster pace of economic growth**. (Obama 2009, p. 3. Emphasis added)

Figure 22: Private debt to GDP ratios, USA & Australia



The Australian policy response to the GFC, on the other hand, was pithily summed up in the advice given by its Treasury: “go early, go hard, go households” ((Gruen 2008)). Though many other factors differentiate these two countries—notably Australia’s position as a commodity producing supplier to China—the outcomes on unemployment imply that the Australian measures more successful than the American “money multiplier” approach (See Figure 23).

Figure 23: Unemployment rates USA and Australia



The model is extended in the next section to consider a growing economy, and then a differential response to a credit crunch is considered: an identical injection of funds at the same time into either the banks' equity accounts—simulating the USA's policy response—or into the Workers' Deposit accounts—simulating the Australian response.

Endogenous money creation and economic growth

To model a credit crunch in a growing economy, while otherwise maintaining the structure of the Free Banking/pure credit money model above, I move beyond the limitations of a pure paper money system to allow for endogenous money creation as described in (Moore 1979):

> "In the real world banks extend credit, creating deposits in the process, and look for the reserves later" ((Moore 1979, p. 539) citing (Holmes 1969, p. 73); see also more recently (Disyatat 2010, "loans drive deposits rather than the other way around", p. 7)).

In the model, new credit to sustain a growing economy is created by a simultaneous increase in the loan and deposit accounts for the borrower.[19]

[19] The Bank Vault is replaced by a Bank Equity account to signify that we are no longer working with a pure paper money system. I maintain the practice established in the Free Banking model that money is not destroyed when a loan is repaid, but is instead transferred to the bank's capital—in this case an Equity account rather than a 19th century Vault. As noted earlier, I dispute the conventional Post Keynesian belief that money is destroyed when debt is repaid, but –as with issues such as the source of money's value—that is a peripheral issue to the one I wish to consider in this section.

The financial flows in this system are given in Table 7. The two changes to Free Banking model are the addition of row 12 (and its ledger recording in row 13), with the qualitatively new operation of Money Creation being added to the previous operation of Money Transfer; and a "Deus Ex Machina" injection of fiat money into either Bank Equity or Worker Deposit accounts at a after a credit crunch.[20]

Table 7: Endogenous money creation

Row	Transaction	Type	Bank Equity (B_E)	Bank Transaction (B_T)	Firm Loan (F_L)	Firm Deposit (F_D)	Worker Deposit (W_D)
1	Lend Money	Money Transfer	-A			A	
2	Record Loan	Ledger Entry			A		
3	Compound Debt	Ledger Entry			B		
4	Pay Interest	Money Transfer		C		-C	
5	Record Payment	Ledger Entry			-C		
6	Deposit Interest	Money Transfer		-D		D	
7	Wages	Money Transfer				-E	E
8	Deposit Interest	Money Transfer		-F			F
9	Consumption	Money Transfer		-G		G+H	-H
10	Repay Loan	Money Transfer	I			-I	
11	Record Repayment	Ledger Entry			-I		
12	New Money	Money Creation				J	

[20] This is done simply to allow the modelling of an injection of fiat money like that Bernanke undertook in late 2008, without having to introduce an entire model of fiat money creation as well into this paper.

13	Record Loan	Ledger Entry			J		
14	Government policy	Exogenous injection into **either** B_E **or** W_D	K				
							K
	Sum of Flows		I-A+K	C-D-F-G	A+B-C-I+J	A-C+D-E+G+H-I+J	E+F-H+K

Again, simply to illustrate that the system is viable, a constant growth parameter τ_M has the banks doubling the stock of loans every 15 years (see Table 3 on page 18):

$$J = \frac{1}{\tau_M} \cdot F_L(t) \tag{18}$$

A credit crunch is simulated by varying the three crucial financial flow parameters τ_V, τ_L, and τ_M at an arbitrary time in the following simulation (at *t=25* years): τ_V and τ_M are doubled and τ_L is halved, representing banks halving their rates of circulation and creation of new money and firms trying to repay their loans twice as quickly. The government fiat-money rescue is modelled as a one-year long injection of a total of $100 million one year after the credit crunch.

Pre-credit crunch	Post-credit crunch	Impact of Credit Crunch
□$_V$ = 4/3 years $\tau_V = 4/3 \cdot years$	$\tau_V = 8/3 \cdot years$	Banks lend their reserve holdings of notes every 15 months
□$_L$= 7 years $\tau_L = 7 \cdot years$	$\tau_L = 3.5 \cdot years$	Firms repay their loans every 3.5 years
□$_M$= 15 years $\tau_M = 15 \cdot years$	$\tau_M = 30 \cdot years$	Banks double the money supply every 30 years
K=$100 million		Injected either into Bank Equity $\boldsymbol{B_E}$ or Worker Deposit $\boldsymbol{W_D}$ at year 26, one year after the credit crunch

Several extensions to the physical side of the model are required to model economic growth. In the absence of Ponzi speculation, growth in the money supply is only warranted if economic growth is occurring, which in turn requires a growing population and/ or labour productivity. These variables introduce the issue of the employment rate, and this in turn raises the possibility of variable money wages in response to the rate of unemployment—a Phillips curve.[21] These additional variables are specified in Equation
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$$\begin{aligned} \frac{d}{dt}a &= \alpha \cdot a \\ \frac{d}{dt}Pop &= \beta \cdot Pop \\ \frac{d}{dt}W &= P_h(\lambda) \cdot W \\ \lambda &= \frac{L}{Pop} \end{aligned} \tag{0.19}$$

The parameter values and functional form for this physical growth extension are shown in Table 8.

Table 8: Parameters and function for growth model

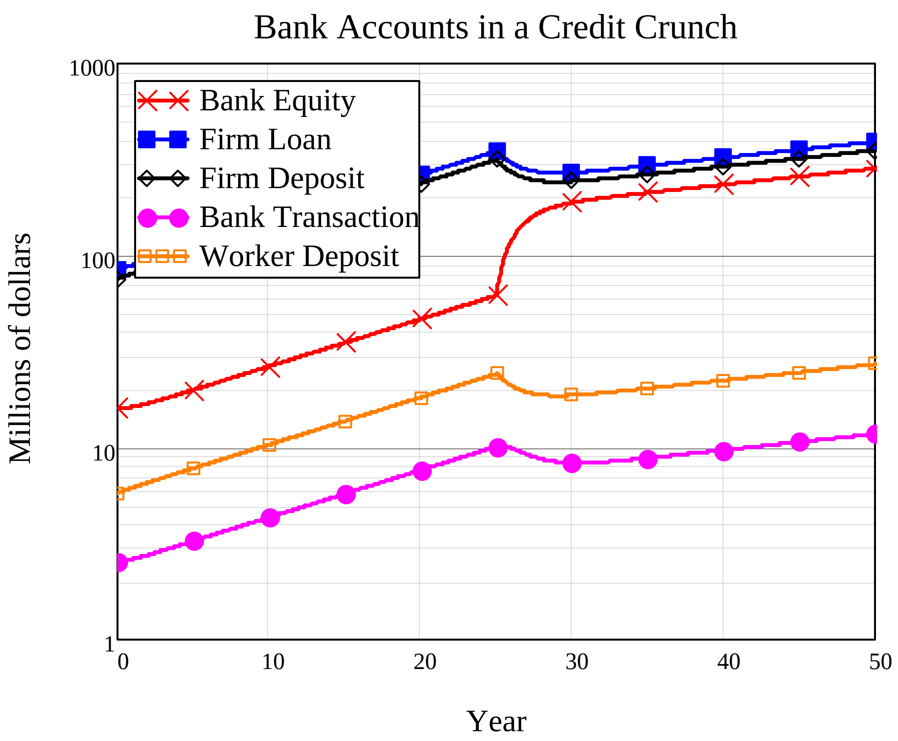
Variable or parameter	Description	Value
α	Rate of growth of labor productivity	1% p.a.
β	Rate of growth of population	2% p.a.
Pop	Population	Initial value = 160
λ	Employment rate	Initial value = 94.5%
$Ph(\lambda,\lambda_e,w_e,slope,\min)$ $= Ph(\lambda,94\%,0,1,-4\%)$	Phillips curve: $Ph(\lambda,\lambda_e,w_e,slope,\min) = (w_e - \min)\cdot e^{\frac{slope}{w_e-\min}}(\lambda-\lambda_e)+\min$	

Figure 24 shows the impact of the credit crunch upon bank accounts: loans and deposits fall while the proportion of the money supply that is lying idle in bank reserves rises dramatically.

---

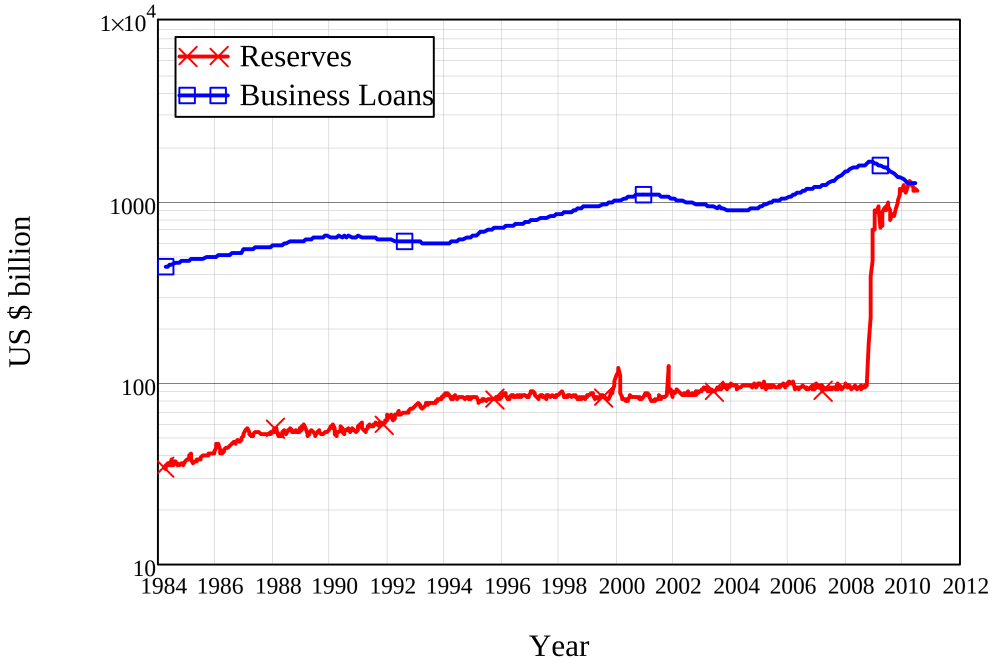
[21] The functional form used here is a generalised exponential function $g(x) = (y_0 - m)\cdot e^{\frac{s}{y_0-m}\cdot(x-x_0)} + m$, where x is the argument (in this case, the unemployment rate), (x_0,y_0) is a coordinate on the curve, *s* the slope of the curve at that point and *m* the minimum value of the function. In this simulation (x_0,y_0)=(0.92,0), *s*=1 and *m*=0.04; this means that at an unemployment rate of 8%, money wages do not change, they rise by 25% p.a. at full employment (0% unemployment), and they fall at a maximum rate of 4% p.a. at high levels of unemployment.

Figure 24: Bank accounts before and after a Credit Crunch



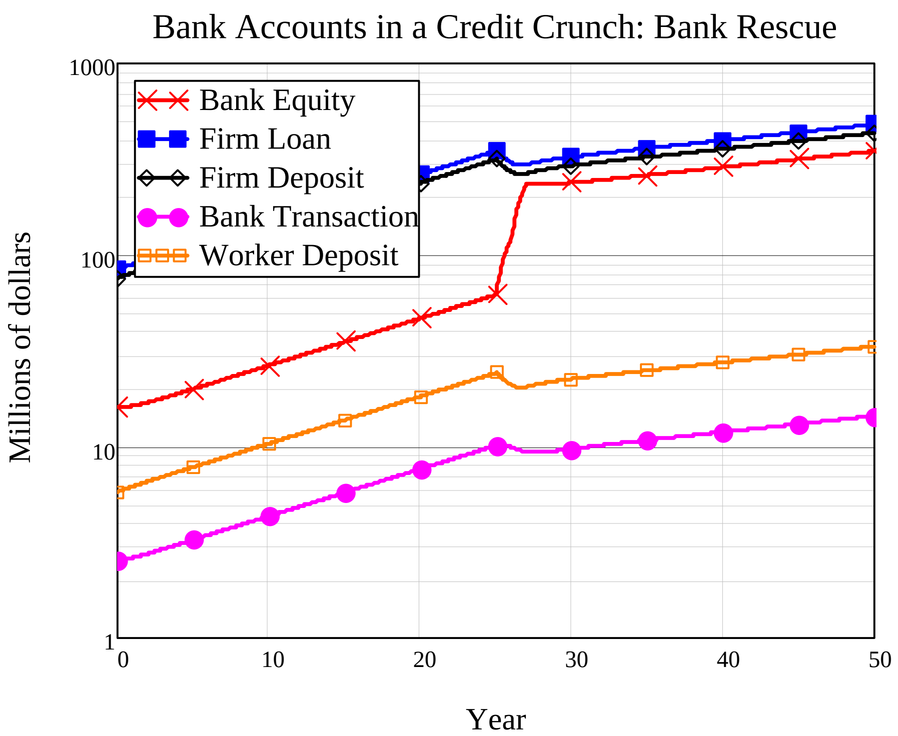
The US empirical data to date has displayed a similar pattern, though with a much sharper increase in bank reserves as shown in Figure 25.

Figure 25: St Louis FRED AJDRES and BUSLOANS



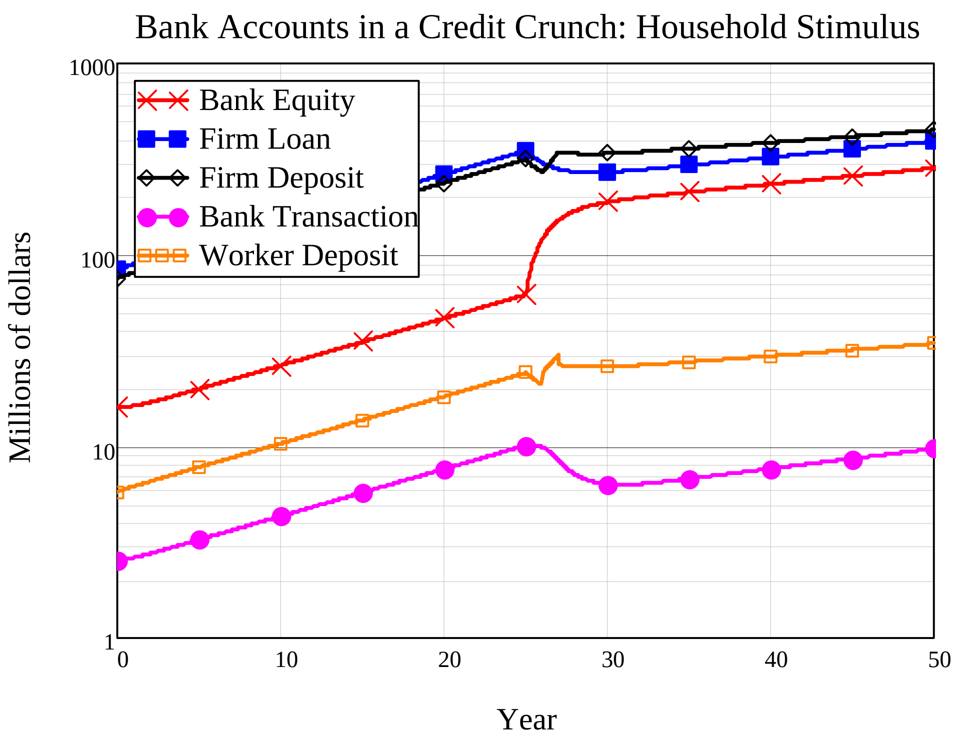
A very similar pattern to the empirical data is evident in the model when the US policy of increasing bank reserves is simulated (Figure 26).

Figure 26: Simulating US bank-oriented policy towards a credit crunch



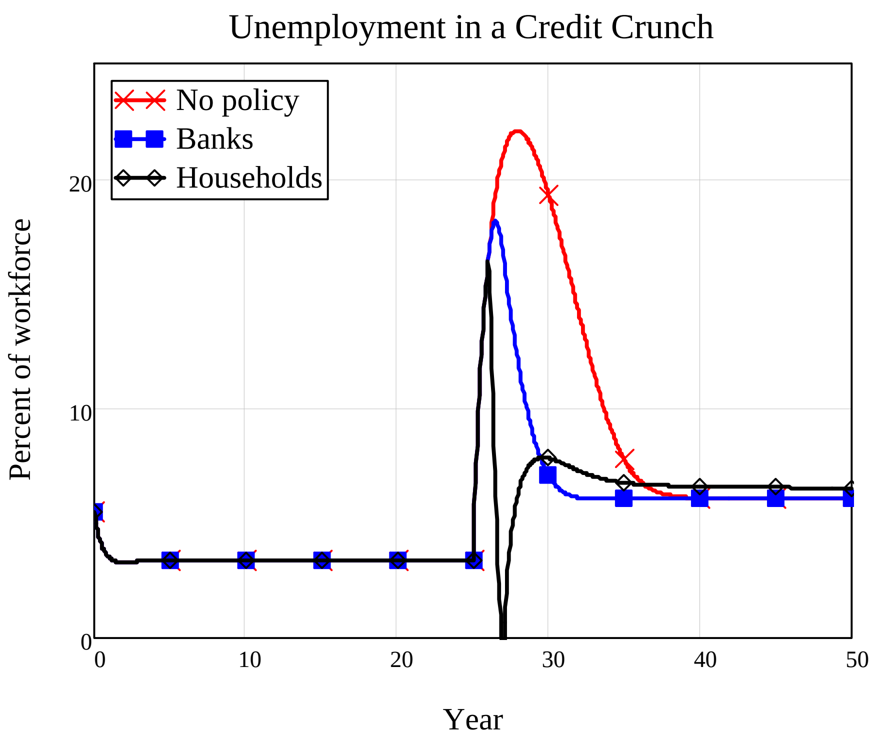
The simulation of the Australian household-oriented policies generates a very different dynamic
.

Figure 27: Simulating Australian household-oriented policy towards a credit crunch



Crucially from the policy perspective, the household-oriented approach has a far more immediate and substantial impact upon employment (Figure 28). Contrary to the expectations of President Obama and his mainstream economic advisers, there is far more “bang for your buck” out of a household rescue than out of a bank rescue.

Figure 28: Comparing bank-oriented and household-oriented policies



The paradox of monetary profits is therefore solved simply by avoiding the problem so wittily expressed by Kalecki, that economics is "the science of confusing stocks with flows" ((cited in Godley and Lavoie 2007)). With that confusion removed by working in a framework that explicitly records the flows between bank accounts and the production and consumption they drive, it is obvious that Circuit Theory achieves what it set out to do: to provide a strictly monetary foundation for the Marx-Schumpeter-Keynes-Minsky tradition in economics. As an explicitly monetary model, it also provides an excellent foundation for explaining the processes that led to the "Great Recession", and for testing possible policy responses to it.

Monetary Minsky

To develop an explicitly monetary Minsky model, I use the same tabular approach to modelling the financial system, but include nonlinear functions that model the real-world phenomenon that firms borrow money during booms to finance "euphoric" expectations and invest less than profits during slumps.

Table 9: Financial operations in a basic monetary Minsky model

	Bank Equity	Bank Transaction	Firm Loan	Firm Deposit	Worker Deposit
	B_E	B_T	FL	F_D	W_D
Compound Debt			A		
Pay interest		B		-B	

Record payment			-B		
Debt-financed investment			C	C	
Wages				-D	D
Deposit interest		-E-F		E	F
Consumption		-G		G+H	-H
Debt repayment	I			-I	
Record repayment			-I		
Lend from capital	-J			J	
Record Loan			J		

Whereas the previous model replaced these flow markers with constant parameters, in this model nonlinear functions that mimic general tendencies in actual behaviour--workers securing higher nominal wage rises when unemployment is low, capitalists investing more than profits when the rate of profit is high.

Table 10: Substitutions

Operation	Description	
A	Loan Interest	$r_L \cdot F_L(t)$
B	Payment of interest on loan	$r_L \cdot F_L(t)$
C	Investment as a nonlinear function of the rate of profit	$Inv\left(\pi_r(t)\right) \cdot Y(t)$
D	Wages (**W**) as a nonlinear function of the rate of employment and the rate of inflation	$W\left(\lambda(t), \frac{1}{P}\frac{dP}{dt}\right) \cdot \frac{Y_r(t)}{a(t)}$
E	Interest on Firm deposits	$r_D \cdot F_D(t)$
F	Interest on workers deposits	$r_D \cdot W_D(t)$
G	Bank consumption	$\frac{B_T(t)}{\tau_B}$
H	Worker consumption	$\frac{W_D(t)}{\tau_W}$

I	Loan repayment as a nonlinear function of the rate of profit	$\frac{F_L(t)}{\tau_{RL}(\pi_r(t))}$
J	Relending by banks as a function of the rate of profit	$\frac{B_E(t)}{\tau_{LC}(\pi_r(t))}$

The following model of financial flows results:

Figure 29: Financial sector dynamic model, generated in Mathcad

$$\text{System}(M_1) \rightarrow \left(\begin{array}{c} \frac{d}{dt}B_C(t) = \frac{F_L(t)}{\tau_{RL}(\pi_r(t))} - \frac{B_C(t)}{\tau_{LC}(\pi_r(t))} \\ \frac{d}{dt}B_T(t) = r_L \cdot F_L(t) - r_D \cdot F_D(t) - r_D \cdot W_D(t) - \frac{B_{PL}(t)}{\tau_B} \\ \frac{d}{dt}F_L(t) = \frac{B_C(t)}{\tau_{LC}(\pi_r(t))} - \frac{F_L(t)}{\tau_{RL}(\pi_r(t))} + P_C(t) \cdot Y_r(t) \cdot Inv(\pi_r(t)) \\ \frac{d}{dt}F_D(t) = r_D \cdot F_D(t) - r_L \cdot F_L(t) + \frac{B_C(t)}{\tau_{LC}(\pi_r(t))} - \frac{F_L(t)}{\tau_{RL}(\pi_r(t))} + \frac{B_{PL}(t)}{\tau_B} + \frac{W_D(t)}{\tau_W} + P_C(t) \cdot Y_r(t) \cdot Inv(\pi_r(t)) - \frac{W(t) \cdot Y_r(t)}{a(t)} \\ \frac{d}{dt}W_D(t) = r_D \cdot W_D(t) - \frac{W_D(t)}{\tau_W} + \frac{W(t) \cdot Y_r(t)}{a(t)} \end{array} \right)$$

This now has to be combined with a model of the labour and physical flows, in which physical output is now a function of capital as in the original Goodwin model:

$$Y_r(t) = \frac{K_r(t)}{v} \qquad (0.20)$$

The rate of change of physical capital is a function of investment minus depreciation, where investment is a nonlinear function of the rate of profit:

$$\frac{d}{dt}K_r(t) = K_r(t)\left(\frac{Inv(\pi_r(t))}{v} - \delta\right) \qquad (0.21)$$

The rate of profit is the monetary value of output minus wages and interest payments, divided by the monetary valuation of the capital stock:

$$\pi_r(t) = \frac{P_C(t) \cdot Y_r(t) - W(t) \cdot L(t) - r_L \cdot F_L(t)}{v \cdot P_K(t) \cdot Y_r(t)} \qquad (0.22)$$

Prices, labor productivity and population growth are as defined earlier. Wage setting however has one modification: nominal wages are shown as responding to both the employment level and the rate of inflation:[22]

$$\frac{d}{dt}W = P_h(\lambda)\cdot W - \frac{1}{\tau_P}\cdot\left(P - \frac{1}{(1-s)}\cdot\frac{W}{a}\right) \quad (0.23)$$

The full system is now as shown in Figure 30.

Figure 30: Full monetary Minsky model

Financial Sector

$$\frac{d}{dt}B_C(t) = \frac{F_L(t)}{\tau_{RL}(g(t))} - \frac{B_C(t)}{\tau_{LC}(g(t))}$$

$$\frac{d}{dt}B_{PL}(t) = r_L\cdot F_L(t) - r_D\cdot F_D(t) - r_D\cdot W_D(t) - \frac{B_{PL}(t)}{\tau_B}$$

$$\frac{d}{dt}F_L(t) = \frac{B_C(t)}{\tau_{LC}(g(t))} - \frac{F_L(t)}{\tau_{RL}(g(t))} + P_C(t)\cdot Y_r(t)\cdot Inv(\pi_r(t))$$

$$\frac{d}{dt}F_D(t) = r_D\cdot F_D(t) - r_L\cdot F_L(t) + \frac{B_C(t)}{\tau_{LC}(g(t))} - \frac{F_L(t)}{\tau_{RL}(g(t))} + \frac{B_{PL}(t)}{\tau_B} + \frac{W_D(t)}{\tau_W} - \frac{Y_r(t)\cdot W(t)}{a(t)} + P_C(t)\cdot Y_r(t)\cdot Inv(\pi_r(t))$$

$$\frac{d}{dt}W_D(t) = r_D\cdot W_D(t) - \frac{W_D(t)}{\tau_W} + \frac{Y_r(t)\cdot W(t)}{a(t)}$$

System states and algebraic relations

Level of output $Y_r(t) = \frac{K_r(t)}{v}$

Rate of Profit $\pi_r(t) = \frac{P_C(t)\cdot Y_r(t) - W(t)\cdot\frac{Y_r(t)}{a(t)} - r_L\cdot F_L(t)}{v\cdot P_C(t)\cdot Y_r(t)}$

Rate of employment $\lambda(t) = \frac{Y_r(t)}{a(t)\cdot N(t)}$

Rate of real economic growth $g(t) = \frac{Inv(\pi_r(t))}{v} - \delta$

Rate of change of wages $\frac{d}{dt}W(t) = Ph(\lambda(t))\cdot W((t)) + \frac{-1}{\tau_{Pc}}\cdot\left[P_C(t) - \frac{W(t)}{a(t)\cdot(1-s)}\right]$

Rate of change of prices $\frac{d}{dt}P_C(t) = \frac{-1}{\tau_{Pc}}\cdot\left[P_C(t) - \frac{W(t)}{a(t)\cdot(1-s)}\right]$

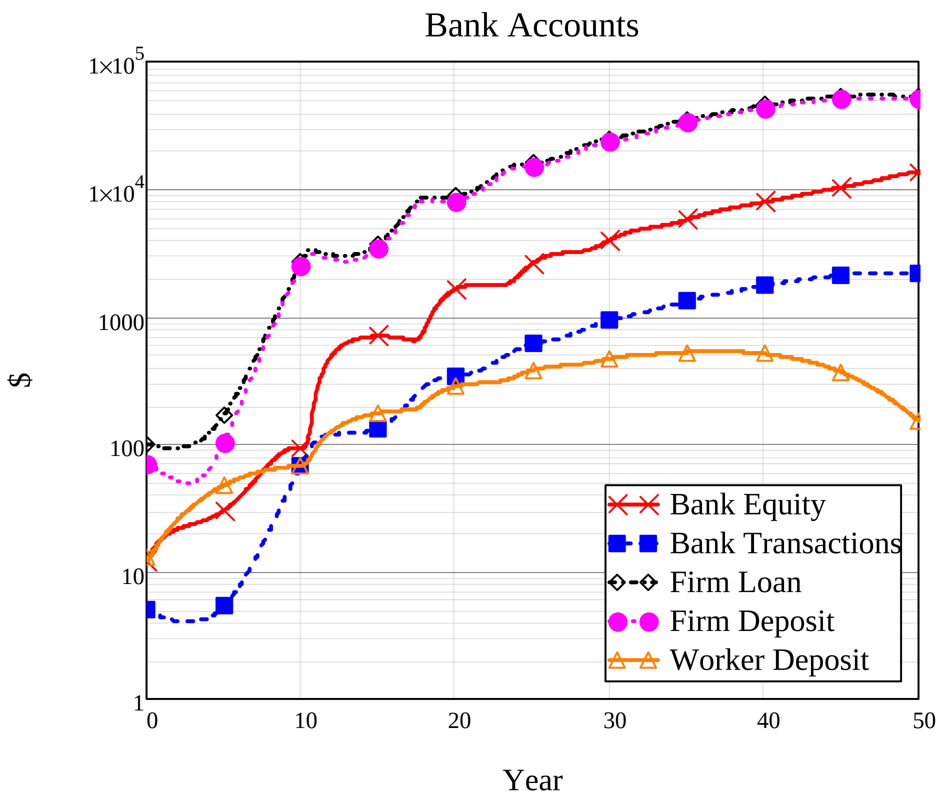
Rate of change of capital stock $\frac{d}{dt}K_r(t) = K_r(t)\cdot\left(\frac{Inv(\pi_r(t))}{v} - \delta\right)$

Rates of growth of population and productivity $\frac{d}{dt}a(t) = \alpha\cdot a(t)$ $\frac{d}{dt}N(t) = \beta\cdot N(t)$

[22] Later extensions will introduce more realistic lagged responses here, as well as variability in the markup (which appears to be pro-cyclical).

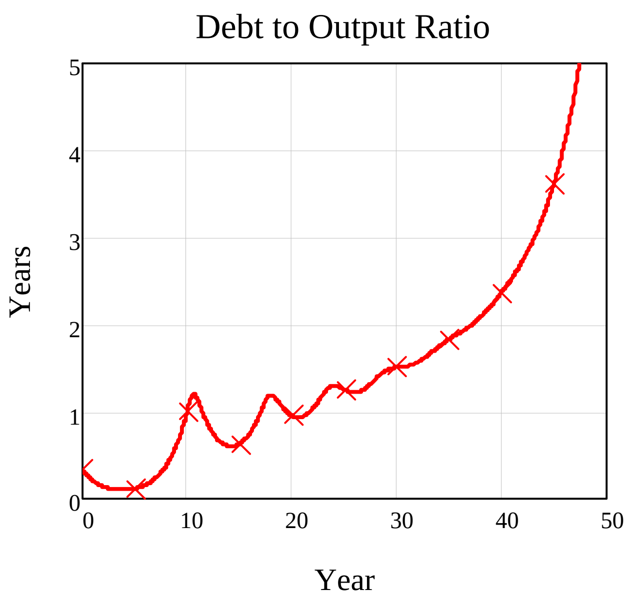
The dynamics of this system combine the short-term trade-cycle behavior of the earlier non-monetary model, and add the phenomenon of a debt-deflation, in which falling prices amplify the debt to GDP ratio once the crisis commences.

Figure 31: Bank accounts



This is a model only of the process by which a crisis develops; it does not contemplate what might happen in its aftermath to end it--such as bankruptcy and debt moratoria reducing the outstanding debt and allowing economic activity to commence again. The terminal collapse that follows from the runaway growth of debt in this model emphasises the point that Michael Hudson has made so often: "Debts that can't be repaid, won't be repaid".

Figure 32: Cyclically rising debt to GDP



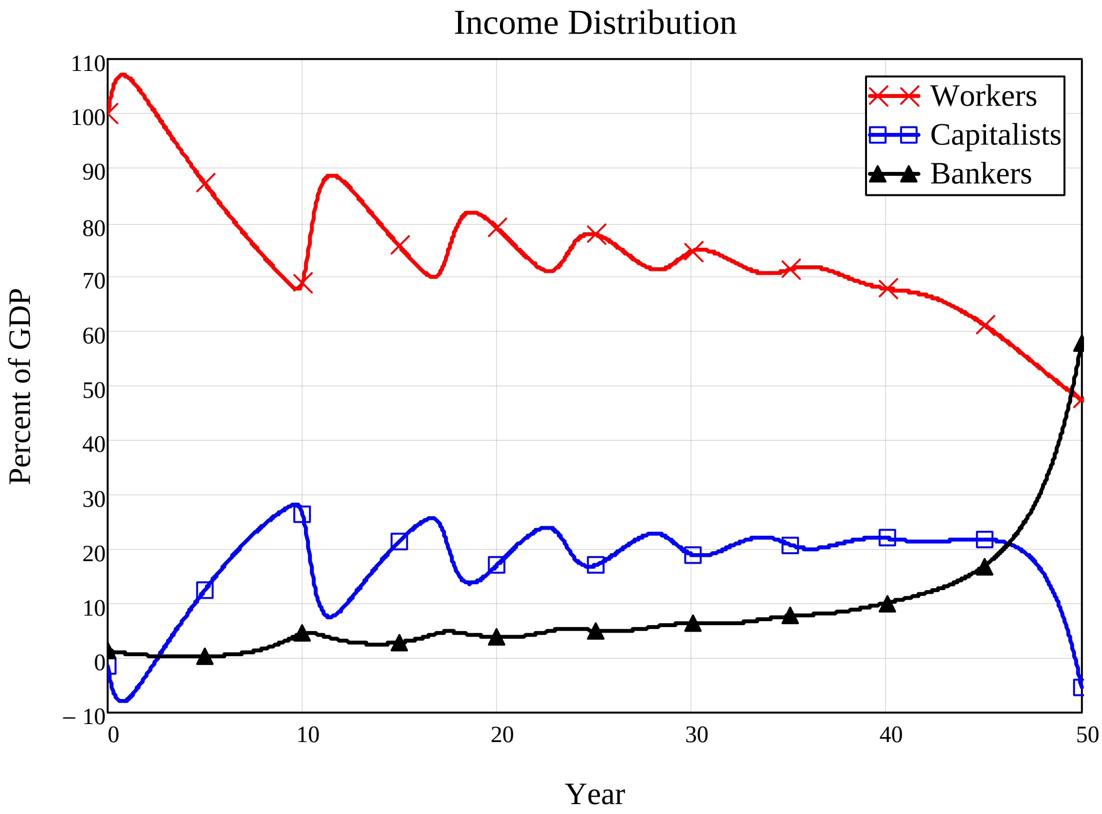
The employment-wages share dynamics of the original Goodwin model give way to a financial vortex that drives wages share cyclically down prior to the complete debt-deflationary collapse.

Figure 33: Wage share falls cyclically as debt deflation approaches

The final debt-driven collapse, in which both wages and profitability plunge, gives the lie to the neoclassical perception that crises are caused by wages being too high, and the solution to the crisis is to reduce wages.

What their blinkered ignorance of the role of the finance sector obscures is that the essential class conflict in financial capitalism is not between workers and capitalists, but between financial and industrial capital. The rising level of debt directly leads to a falling worker share of GDP, while leaving industrial capital's share unaffected until the final collapse drives it too into oblivion.

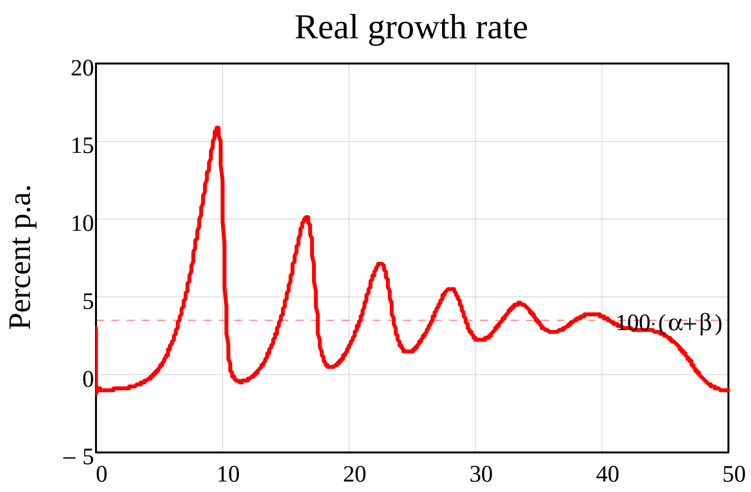
Figure 34: Income distribution cycles and the secular trend to falling wages and a rising finance share

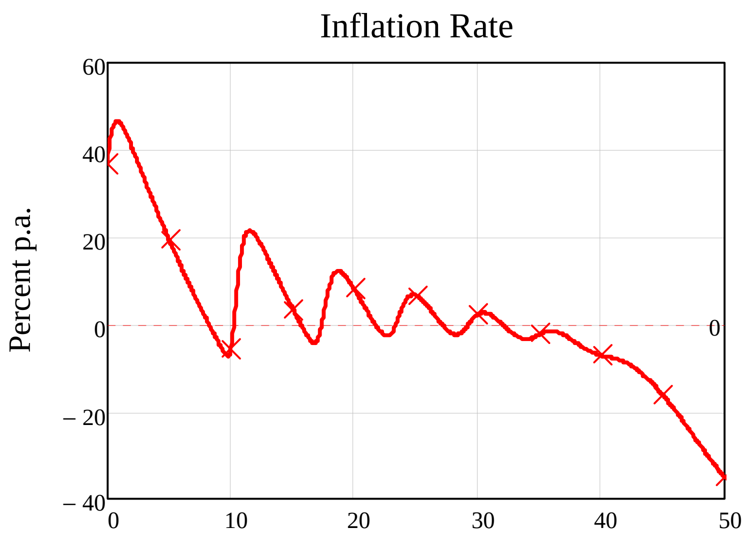


The macroeconomic performance before the crisis would also fool any economist who ignored the role of the finance sector and the danger of a rising debt to GDP ratio--as indeed neoclassical economists did in the runup to this crisis, when the waxed lyrical about "The Great Moderation":

> As it turned out, the low-inflation era of the past two decades has seen not only significant improvements in economic growth and productivity but also a marked reduction in economic volatility, both in the United States and abroad, a phenomenon that has been dubbed "the Great Moderation." Recessions have become less frequent and milder, and quarter-to-quarter volatility in output and employment has declined significantly as well. The sources of the Great Moderation remain somewhat controversial, but as I have argued elsewhere, there is evidence for the view that improved control of inflation has contributed in important measure to this welcome change in the economy. (Bernanke 2004)

Figure 35: Moderation is not good for your economic health





c

Instead of a sign of economic success, the "Great Moderation" was a sign of failure. It was the lull before the storm of the Great Recession, where the lull was driven by the same force that caused the storm: rising debt relative to GDP in an economy that had become beholden to Ponzi finance.

Appendix

Table 11: Details of the Minsky model with Ponzi Finance extension in Equation(0.1)

Element	*Equation*	*Comments, parameters and initial values*

Output	$Y = K/v$	Capital stock and the accelerator determines output; $Y(0) = 300$; $v = 3$
Capital stock	$\frac{d}{dt}K = I(\pi_r)\cdot Y - \gamma \cdot K$	The rate of change of capital stock is investment minus depreciation; □ = 1%
Profit	$\Pi = Y - W - r\cdot D$	Profit is output minus wages and interest payments; $R = 3\%$
Profit rate	$\pi_r = \Pi / K = \Pi / (v \cdot Y)$	–
Wage bill	$W = w\cdot L$	The wage bill is wages times labour employed
Wages	$\frac{1}{w}\cdot\frac{d}{dt}w = P_C(\lambda)$	A Phillips curve relation for wage determination; $w(0) = 1$
Employment rate	$\lambda = L/N$	–
Labour	$L = Y/a$	Output and labor productivity determine employment
Debt	$\frac{d}{dt}D = I - \Pi + P_K$	The rate of change of debt equals investment minus profits plus speculation; $D(0) = 0$
Speculation	$\frac{d}{dt}P_K = \kappa(g)\cdot Y$	The rate of change of Ponzi speculation is a non-linear function of the rate of growth; P□(0) = 0
Rate of growth	$g = (I(\pi_r)/v) - \gamma$	–
Investment	$I(\pi_r) = G_{\text{Exp}}(\pi_r, 3\%, 3\%, 1, 0)$	Investment is a non-linear function of the rate of profit
Phillips curve	$P_C(\lambda) = G_{\text{Exp}}(\lambda, 96\%, 0, 2, -4\%)$	Wage change is a non-linear function of the rate of employment
Ponzi behaviour	$\kappa(g) = G_{\text{Exp}}(g, 3\%, 0, 3, -25\%)$	Speculation is a non-linear

		function of the rate of growth
Generalised exponential	$G_{\text{Exp}}(x, x_v, y_v, s, m) = (y_v - m) \cdot e^{\frac{s}{y_v - m} \cdot (x - x_v)} + m$	Generalised exponential; arguments (x_v, y_v) coordinates, slope at (x_v, y_v) and minimum value *m*
Population	$\frac{d}{dt} N = \beta \cdot N$	□ = 1%; *N*(0) = 330
Labour productivity	$\frac{d}{dt} a = \alpha \cdot a$	□ = 2%; *a*(0) = 1

QED

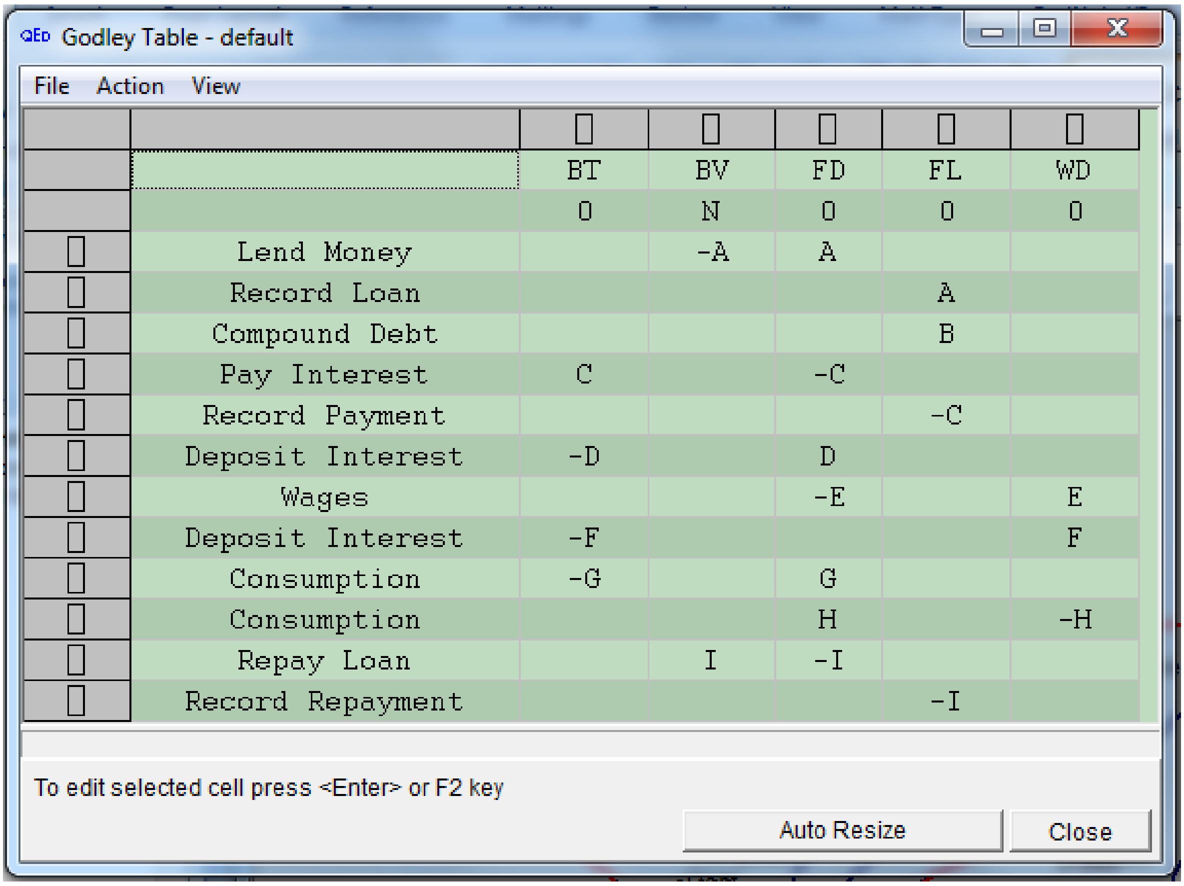
QED stand for “Quesnay Economic Dynamics”. It is a new software program that has been developed by a correspondent and collaborator (who for the moment wishes to remain anonymous) which implements my tabular method of developing differential equations.

It can be downloaded for free from www.debtdeflation.com/blogs/qed. Updates will be posted frequently as is developed further over time.

To test run the program, choose File/Open and select the model “FreeBankingModel.sgr”. This is the first model developed in this paper. To see the model itself, click on the “Actions” menu item and select “Godley Table”.[23] This table will then appear:

[23] I had originally called this the Quesnay Table in honour of Quesnay's Tableau Economique, but altered the name to recognise Wynne Godley's contributions to economic dynamics.

Godley Table



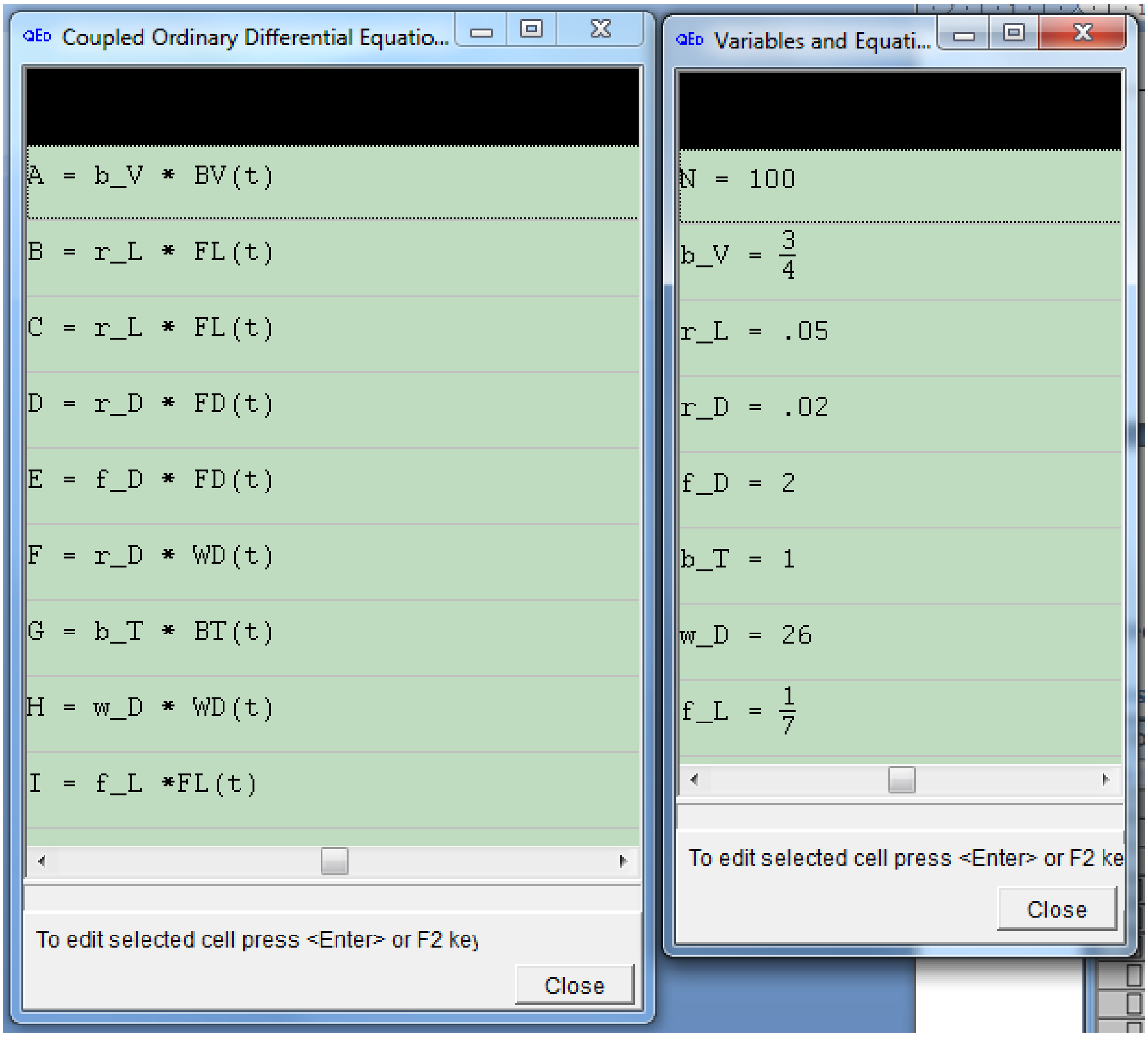
	BT	BV	FD	FL	WD
	0	N	0	0	0
Lend Money		-A	A		
Record Loan				A	
Compound Debt				B	
Pay Interest	C		-C		
Record Payment				-C	
Deposit Interest	-D		D		
Wages			-E		E
Deposit Interest	-F				F
Consumption	-G		G		
Consumption			H		-H
Repay Loan		I	-I		
Record Repayment				-I	

Figure 36: The core of QED, the Godley Table

Variables and Equations

The equations in the model are stored in two other tables accessible from the “Actions” menu item on the main window: ”Var/Equations” and “C.O.D. Equations” respectively. The former gives values to parameters and the like; the latter gives the equations for the flows between the accounts:

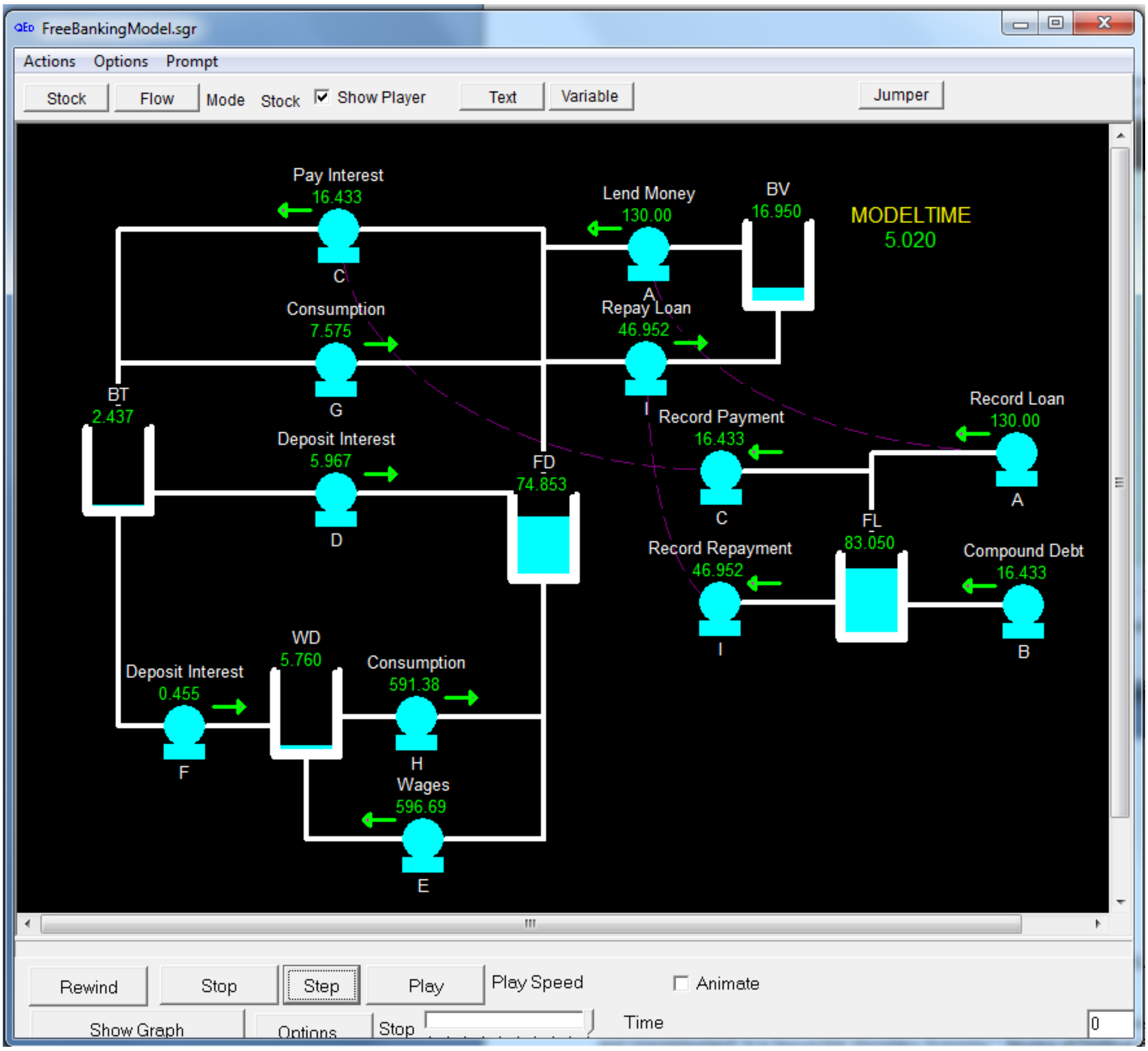
Figure 37: The elements of the dynamic system are defined here



To run the model, click on the “Phillips Diagram” menu item on the main QED program window, which will show the following dynamic flowchart that was generated by this table. Now click on the “Show Player” checkbox at the top of the window, and a player will appear down the bottom. Click on “Play” and the amounts in the reservoirs (bank accounts) and flow valves (labelled A to I and with the same descriptors as in the left hand column of the Quesnay Table) will change. If you run it for five years (watch the “MODELTIME” counter in the top right hand side of the diagram and click on Stop), you should see the following:

Phillips Diagram

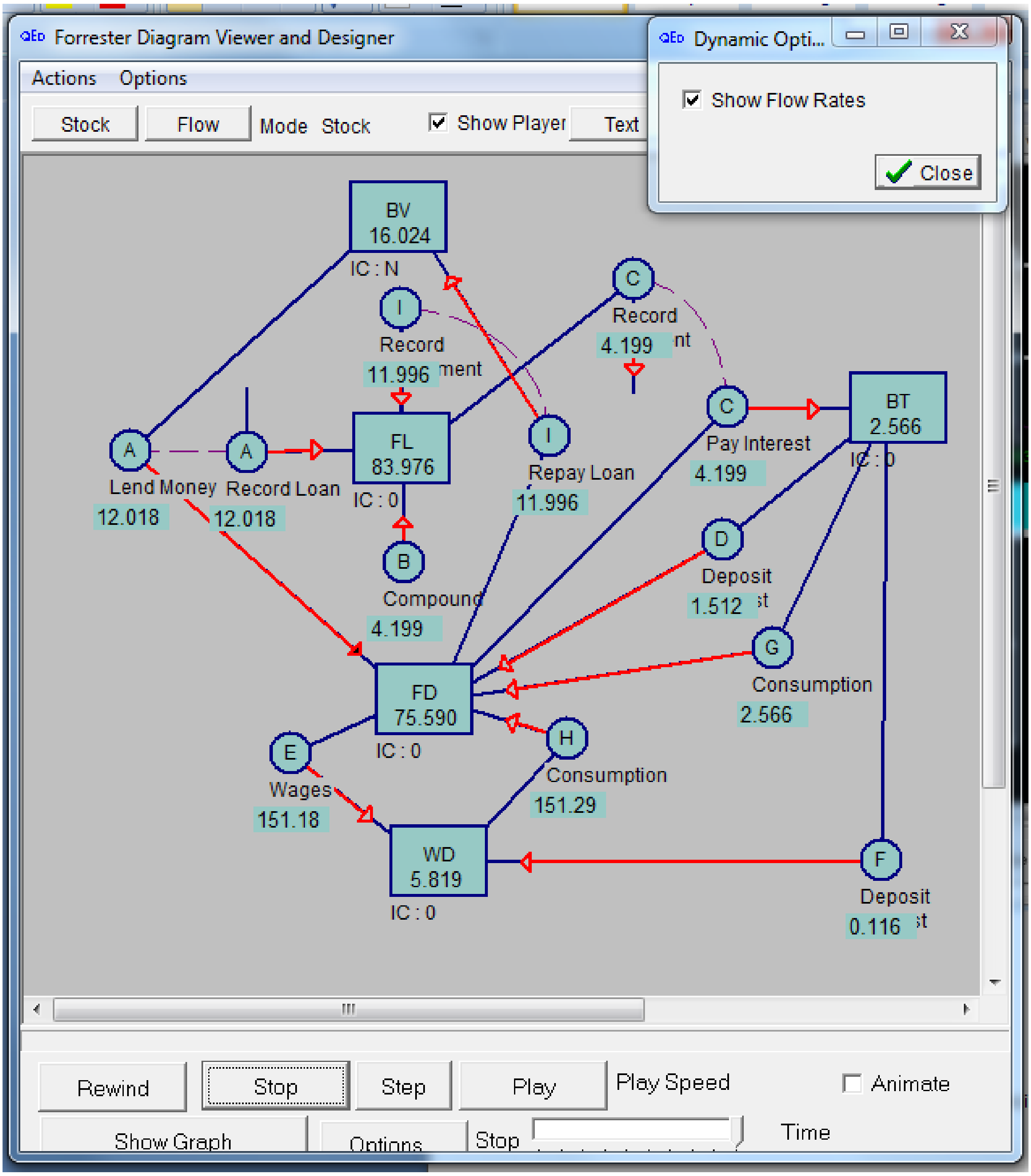
Figure 38: The simulation is displayed live in a "hydraulic" model, in honour of Bill Phillips



There is also a "Forrester Diagram", which is more like a conventional systems engineering program. You can also add variables and relations between them here, as with programs like Vissim and Simulink--click on the type of entity to be created (Stock, flow, text, variable) and insert a new one by holding down the control key when you click anywhere on the diagram. Double-click on any entity to see and/or alter its definition.

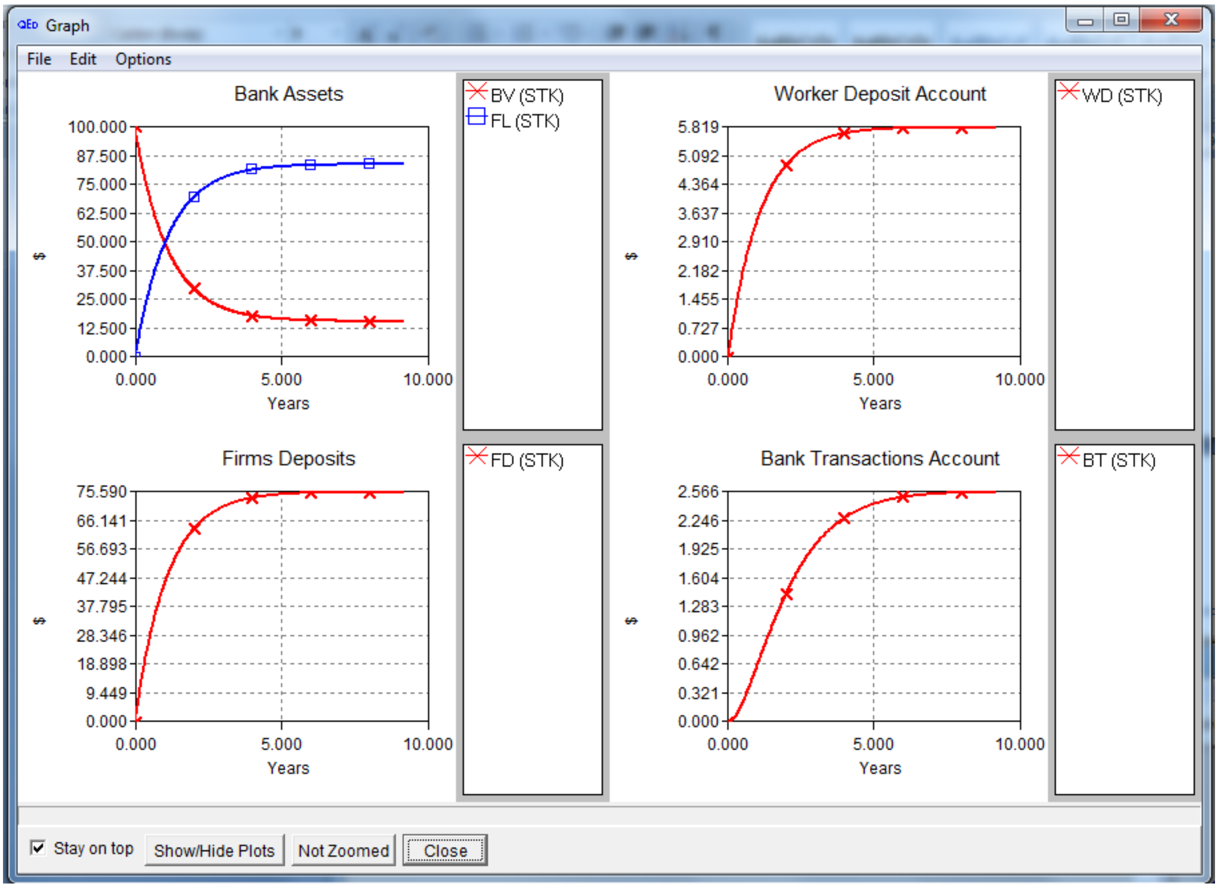
Forrester Diagram

Figure 39: Similar to programs like Simulink, this diagram is produced automatically from the Godley Table



There's a lot more to the program, as you will find if you play with it, using the two models here and also developing your own models. To my knowledge it's the only program around that uses a tabular interface to develop dynamic models, and also provides seamless each-way development of a systems engineering diagram from a table of equations. It is ideally suited to modelling financial flows, and it's my (and my collaborator's) contribution to helping the world understand how money works–which is the first step in understanding why our financial system has performed so badly.

Figure 40: Up to four graph surfaces can be defined



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