

# Developing a Monetary Model of Financial Instability

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Minsky's "Financial Instability Hypothesis" has a long pedigree, which can be traced back through Schumpeter, Keynes and Fisher to, arguably, Marx (Keen 2001). Of all these forebears, the one that on reflection seems most crucial to Minsky's vision is Schumpeter. In *The Theory of Economic Development*, Schumpeter developed a verbal evolutionary model of the trade cycle, in which the instability of capitalism was essential to its creative industrial force. In the Financial Instability Hypothesis, Minsky focused on the financial aspects of this cycle that could occasionally divert it from creative innovation to paralysing and ultimately futile debt-financed speculation. If Schumpeter is, as Joan Robinson once remarked, "Marx with the adjectives changed", then Minsky is Schumpeter with added debt.

## Minsky's hypothesis

Minsky's analysis of a financial cycle begins at a time when the economy is doing well (the rate of economic growth equals or exceeds that needed to reduce unemployment), but firms are conservative in their portfolio management (debt to equity ratios are low and profit to interest cover is high), and this conservatism is shared by banks, who are only willing to fund cash-flow shortfalls or low-risk investments. The cause of this high and universally practised risk aversion is the memory of a not too distant system-wide financial failure, when many investment projects foundered, many firms could not finance their borrowings, and many banks had to write off bad debts. Because of this recent experience, both sides of the borrowing relationship prefer extremely conservative estimates of prospective cash flows: their risk premiums are very high.

However, the combination of a growing economy and conservatively financed investment means that most projects succeed. Two things gradually become evident to managers and bankers: "Existing debts are easily validated and units that were heavily in debt prospered: it pays to lever." (Minsky 1977, 1982: 65). As a result, both managers and bankers come to regard the previously accepted risk premium as excessive. Investment projects are evaluated using less conservative estimates of prospective cash flows, so that with these rising expectations go rising investment and asset prices. The general decline in risk aversion thus sets off both growth in investment and exponential growth in the price level of assets, which is the foundation both of the boom and its eventual collapse.

More external finance is needed to fund the increased level of investment and the speculative purchase of assets, and these external funds are forthcoming because the banking sector shares the increased optimism of investors (Minsky 1970, 1982: 121). This results in an increase in the accepted debt to equity ratio and falling profit to interest cover, a decrease in liquidity, and accelerated growth of credit--Minsky shares the empirically-supported Post Keynesian perspective that the money supply is endogenously determined (see Table 1 below, which summarises the results from the empirical research of the decidedly neoclassical authors Kydland & Prescott 1990 on the timing of financial aggregates).

## Table 1: Kydland & Prescott (1990) results

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Variable	Neoclassical expectation	Empirical result
Real wages	Negative correlation with GDP	Positive correlation with GDP
CPI	Pro-cyclical	Anti-cyclical
Base Money ( $M_0$ )	Leads GDP	Lags GDP (1 quarter)
Credit Money ( $M_2 - M_1$ )	Lags $M_0$	Leads $M_0$ (3 quarters)

Credit-money is thus created independently of and prior to government-created money, which plays a reactive rather than a leading role in money formation. In a regulated environment, the expansion of credit money may manifest itself primarily via the growth of non-bank financial intermediaries; in a deregulated environment, there will simply be a rapid increase in the money supply--and, *pari passu*, debt. Depending upon how the money supply is measured, these changes will be recorded as either an increase in the relevant measure of the money supply, or in an increase in the velocity of money circulation.

This phase of the cycle marks the beginning of what Minsky calls "the euphoric economy" (Minsky 1970, 1982: 120-124), where both lenders and borrowers believe that the future is assured, and therefore that most investments will succeed. Asset prices are revalued upward as previous valuations are perceived to be based on mistakenly conservative grounds. Highly liquid, low-yielding financial instruments are devalued, leading to a rise in the interest rates offered by them as their purveyors fight to retain market share.

Financial institutions now accept liability structures both for themselves and their customers "that, in a more sober expectational climate, they would have rejected" (Minsky 1970, 1982: 123.). The liquidity of firms is simultaneously reduced by the rise in debt to equity ratios, making firms more susceptible to increased interest rates. The general decrease in liquidity and the rise in interest paid on highly liquid instruments triggers a market-based increase in the interest rate, even without any attempt by monetary authorities to control the boom. However the increased cost of credit does little to temper the boom, since the rate of asset price inflation results in anticipated yields from speculative investments which far exceed prevailing interest rates. The elasticity of demand for credit with respect to interest rates therefore falls.

The condition of euphoria permits the development of an important class of actors in Minsky's drama, the Ponzi financiers. These capitalists profit by trading assets on a rising market, and incur significant debt in the process. The servicing costs for Ponzi debtors exceed the cash flows of the businesses they own, but the capital appreciation they anticipate far exceeds the interest bill. They therefore play an important role in pushing up the market interest rate, and an equally important role in increasing the fragility of the system to a reversal in the growth of asset values.

Rising interest rates and increasing debt to equity ratios eventually affect the viability of many business activities, reducing the interest rate cover, turning projects which were originally conservatively funded into speculative ones, and making ones which were speculative "Ponzi". Such businesses will find themselves having to sell assets to finance their debt servicing—and this entry of new sellers into the market for assets pricks the exponential growth of asset prices. With the price boom checked, Ponzi financiers now find themselves with assets which can no longer be traded at a profit, and levels of debt which cannot be serviced from the cash flows of the businesses they now control. Banks which financed these assets purchases now find that their leading customers can no longer pay their debts—and this realisation leads initially to a further bank-driven increase in interest rates. Liquidity is suddenly much more highly prized, holders of illiquid assets attempt to sell them in return for liquidity. The asset market becomes flooded and the euphoria becomes a panic, the boom becomes a slump.

As the boom collapses, the fundamental problem facing the economy is one of excessive divergence between the debts incurred to purchase assets, and the cash flows generated by them—with those cash flows depending both upon the level of investment and the rate of inflation. The level of investment has collapsed in the aftermath of the boom, leaving only two

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forces which can bring asset prices and cash flows back into harmony: asset price deflation, or current price inflation. This dilemma is the foundation of Minsky's iconoclastic perception of the role of inflation, and his explanation for the stagflation of the 70s and early 80s.

Minsky argues that if the rate of inflation is high at the time of the crisis, then though the collapse of the boom causes investment to slump and economic growth to falter, rising cash flows rapidly enable the repayment of debt incurred during the boom. The economy can thus emerge from the crisis with diminished growth and high inflation, but few bankruptcies and a sustained decrease in liquidity. Thus though this course involves the twin "bads" of inflation and initially low growth, it is a self-correcting mechanism in that a prolonged slump is avoided. However the conditions are soon re-established for the cycle to repeat itself, and the avoidance of a true calamity is likely to lead to a secular decrease in liquidity preference.

If the rate of inflation is low at the time of the crisis, then cash flows will remain inadequate relative to the debt structures in place. Firms whose interest bills exceed their cash flows will be forced to undertake extreme measures: they will have to sell assets, attempt to increase their cash flows at the expense of their competitors, or go bankrupt. In contrast to the inflationary course, all three classes of action tend to further depress the current price level, thus at least partially exacerbating the original imbalance.

If assets are sold as going concerns, then those who buy them face a lower cost of capital, and can undercut their rivals in the current goods market. If assets are broken up, then the producer goods and commodities that constitute them compete at reduced prices with new output from competitors. If firms attempt to increase cash flows by reducing their markups, they will be matched by other competitors in similar circumstances, thus leading if anything to further reduced cash flows and a general reduction in the price level. If firms go bankrupt, their stocks and assets will be sold into depressed markets, thus further reducing current prices. The asset price deflation route is therefore not self-correcting but rather self-reinforcing, and is Minsky's explanation of a depression.

Thus while Minsky sees inflation as having deleterious effects during a relatively stable period of economic growth, he perceives it in quite a different light during a time of crisis. The fundamental problem during a financial crisis is the imbalance between the debts incurred to purchase assets, and the cash flows those assets generate. A high rate of inflation during a crisis enables debts which were based on unrealistic expectations to be nonetheless validated, albeit over a longer period than planned and with far less real gain to the investors. A low rate of inflation will mean that those debts cannot be met, with consequent "domino" effects even for investments which were not unrealistic.

The above sketch basically describes Minsky's perception of an economy in the absence of a government sector. With Big Government, the picture changes in two ways, due to the impact of fiscal deficits and Reserve Bank interventions on corporate cash flows. With a developed social security system, the collapse in cash flows which occurs when a boom becomes a panic will be at least partly ameliorated by a fall in tax revenues and a rise in government spending—the classic "automatic stabilisers", though this time seen in a more monetary light. The collapse in credit can also be tempered or even reversed by rapid action by the Reserve Bank to increase liquidity. With both these forces operating in all Western economies since WWII, Minsky expected the conventional cycle to be marked by "chronic and ... accelerating inflation" (Minsky 1980b, 1982: 85).

However by the end of the 1980s, the cost pressures which coincided with the slump of the early 70s had long since been eliminated, by 15 years of high unemployment, and the diminution of OPEC's cartel power. From the 1980s on, therefore, a debt deflation became once again "one of the possible states in which our type of capitalist economy can find itself" (Minsky 1982, p. xi). Minsky, I believe, had confidence that the Big Government factor would prevent such a calamitous outcome; time, I fear, has proven Minsky to be an optimist.

### **Modelling Minsky: Stage One**


I have always regarded Minsky's vision of capitalism as a compelling one, but in our mathematically-obsessed and equilibrium-fixated discipline, it was never going to get widespread traction without both a mathematical rendition, and overwhelming empirical evidence

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of economic disequilibrium. I could do nothing about the latter but rely upon time; I made providing the former one of my major research projects.

Minsky's own attempts to mathematically model his thesis led nowhere, arguably because the dynamic foundation he initially chose--Hicks's second order difference equation trade cycle model--was itself an inadequate model of capitalism's cyclical nature (Keen 2000). He abandoned this framework shortly after completing his PhD thesis, and later shifted to using Kaleckian identities to provide an accounting framework for his views; but these were never developed beyond mere identities into a dynamic model of his hypothesis.

Following a lead from Blatt, I developed a model of the FIH as a simple extension to Goodwin's "predator-prey" model of the business cycle. Goodwin's model had just two classes--workers and capitalists--and linear behavioural forms for both classes, but generated both growth (out of assumed technical progress and population growth) and a cycle caused by the multiplicative interaction of income shares and employment:

 Goodwin Linear Model

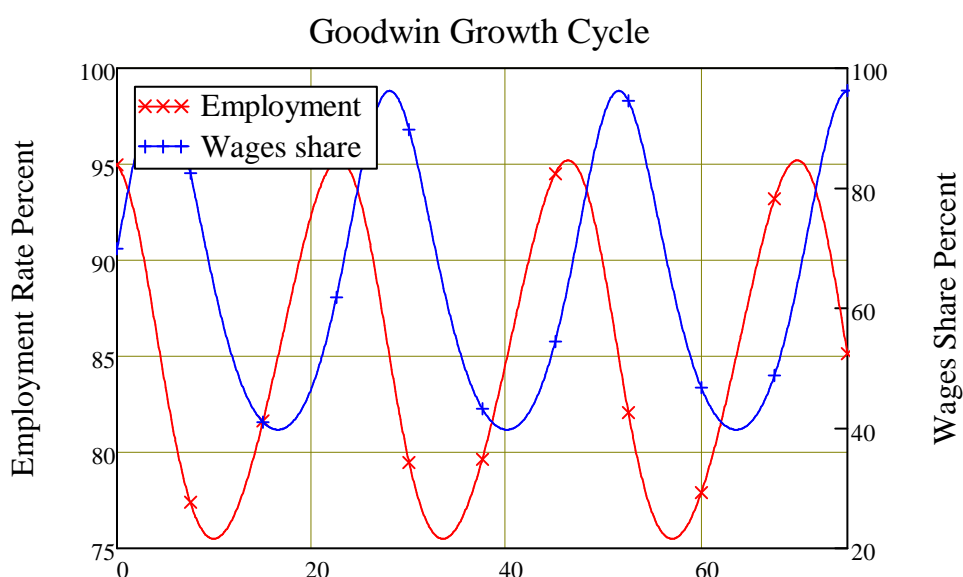
$$\frac{d}{dt}\omega(t) = \omega(t) \cdot (PC_g(\lambda(t)) - \alpha)$$

$$\frac{d}{dt}\lambda(t) = \lambda(t) \cdot \left( \frac{I_g\left(\frac{1 - \omega(t)}{v}\right)}{v} - \gamma - \alpha - \beta \right)$$

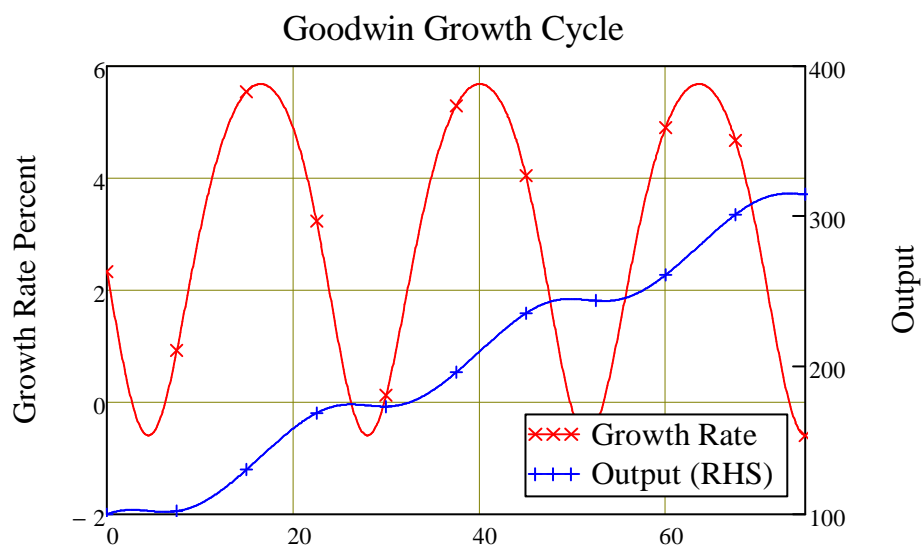
$\omega$  is the wages share of output ( $\omega = \frac{W}{Y}$ ) where the wage bill  $W$  equals the real wage times

employment ( $W = w \cdot L$ ),  $\lambda$  is the rate of employment ( $\lambda = \frac{L}{N}$ ),  $\alpha$  the rate of technical change,  $\beta$  the rate of population growth,  $\gamma$  the rate of depreciation, and  $v$  the capital-output ratio.  $PC_g$  is the employment-wage change relation (Phillips Curve--which is linear at this stage), and  $I_g$  the profit-investment relation--which is also linear. The resulting cyclical growth model is simulated below.

**Figure 1: Goodwin growth cycle model**



**Figure 2: Goodwin growth cycle model**



Goodwin's model can be reduced to two incontrovertible statements, combined with two extremely simple behavioural propositions:

- Wages share of output will increase if the rate of growth of real wages exceeds labour productivity; and
- Employment will rise if the rate of economic growth exceeds the sum of technical change and labour productivity; together with
- Real wages are positively related to the level of employment; and
- Investment is related to the rate of profit.

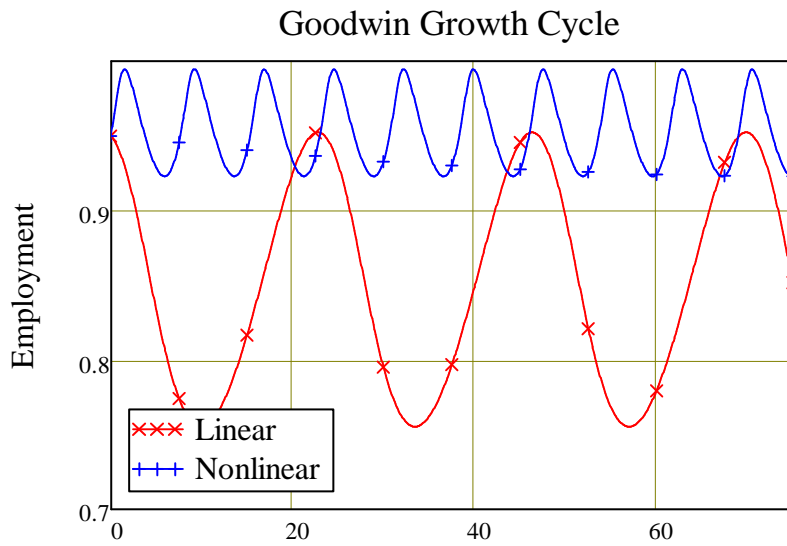
I added a Minskian flavour to this model by adding one more incontrovertible statement:

- Banks lend money at interest

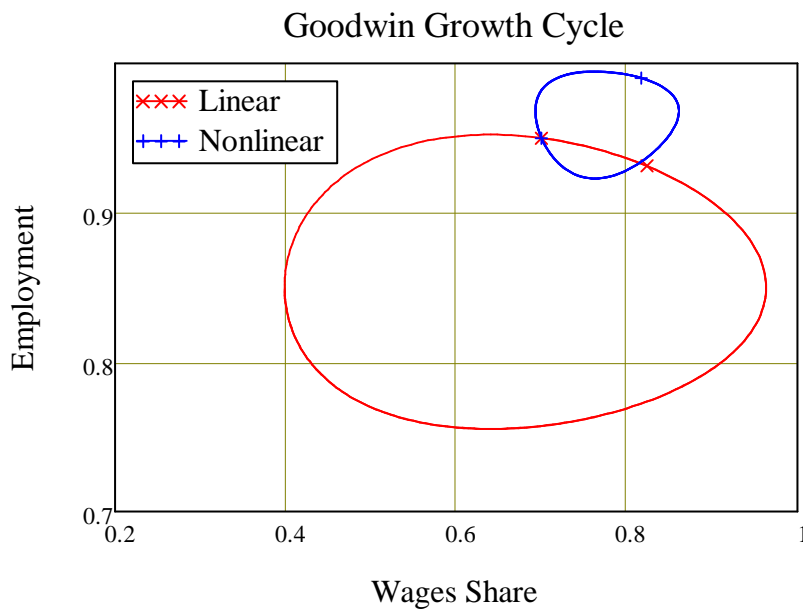
To make room for banks and debt in the model, I had to replace Goodwin's unrealistic linear investment relation--that capitalists invest all their profits--with the far more realistic proposition that investment is nonlinearly related to the rate of profit. Prior to the introduction of debt, this (and a nonlinear Phillips curve) made the model's dynamics more realistic--both in terms of the reduced range of the system variables and its increased frequency--but the limit cycle nature of the model remained.

Goodwin Nonlinear Model

**Figure 3: Nonlinear vs Linear relations in Goodwin model**



**Figure 4: Nonlinear vs Linear relations in Goodwin model**



 Minsky Basic

With a nonlinear investment function, investment could now exceed profits during a boom--where profits are now defined as net of interest charges ( $\Pi = Y - W - r \cdot D$ )--and fall below profits during a slump, with the difference between the two driving change in debt:

$\frac{d}{dt}D = I - \Pi$  (a proposition empirically confirmed by Fama and French). This introduced a third

dimension into the model (expressed in terms of the debt to output ratio  $d = \frac{D}{Y}$ ), which made a substantial qualitative difference to it, as can be expected (May, 1965):

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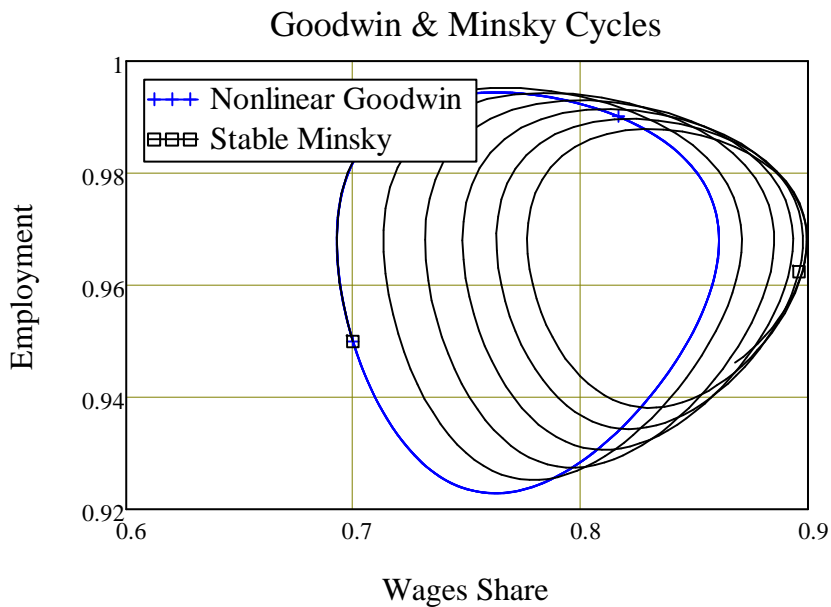
$$\frac{d}{dt}\omega(t) = \omega(t) \cdot (\text{PC}_k(\lambda(t)) - \alpha)$$

$$\frac{d}{dt}\lambda(t) = \lambda(t) \cdot \left[ \frac{I_k\left(\left(\frac{1 - \omega(t) - r \cdot d(t)}{v}\right)\right)}{v} - \gamma - \alpha - \beta \right]$$

$$\frac{d}{dt}d(t) = \left[ I_k\left(\frac{1 - \omega(t) - r \cdot d(t)}{v}\right) - (1 - \omega(t) - r \cdot d(t)) \right] - d(t) \cdot \left( \frac{I_k\left(\frac{1 - \omega(t) - r \cdot d(t)}{v}\right)}{v} - \gamma \right)$$

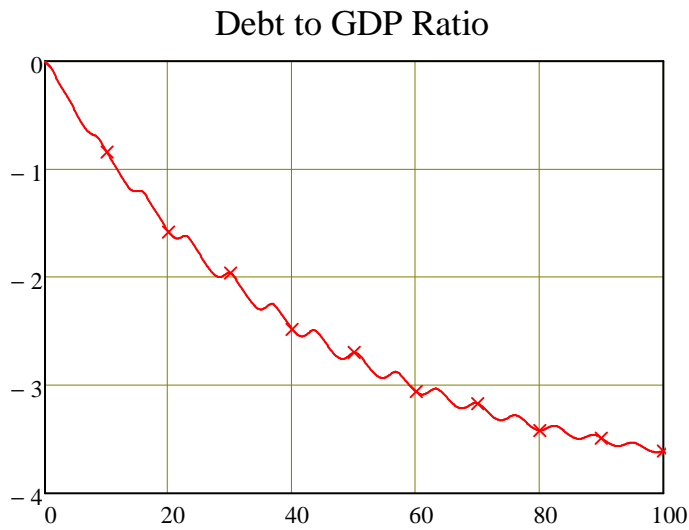
The additional terms are to the original Goodwin model are the (net) real rate of interest  $r$ , and the debt to output ratio  $d$ .  $\text{PC}_k$  and  $I_k$  are now exponential wage change and investment functions, as detailed in the Appendix. The cycle was no longer closed but open, and with the same initial conditions as for the two Goodwin models simulated above, also stable.

**Figure 5: Goodwin & stable Minsky model**



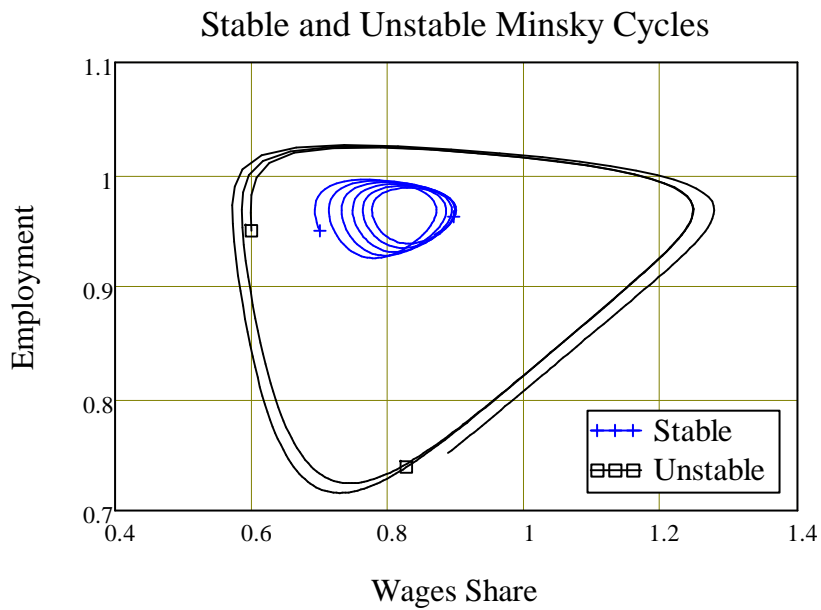
This stability was dependent, however, upon initial conditions that generated a "negative" equilibrium ratio of debt to GDP--or in other words, capitalists accumulating net positive financial assets.

**Figure 6: Debt in a stable Minsky model**

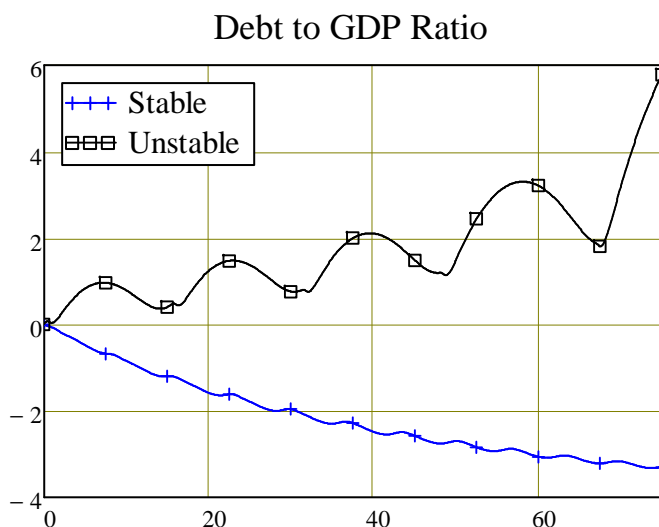


Initial conditions that generated a more empirically valid positive debt to GDP ratio generated a very different (if empirically unrealistic, in this uncalibrated model) dynamic profile:

**Figure 7: Stable & Unstable Minsky models**



**Figure 8: Debt in an Unstable Minsky model**



This was still a very simple model, which needed considerable development before it could be evaluated against or fitted to empirical data. I regarded the introduction of a price level as crucial, since it introduced the possibility of a deflation-induced crisis, in addition to one driven by excessive debt alone, and also the prospect that inflation could reduce the debt burden, as occurred during the period of "Stagflation". It would also reduce the variability of income shares, in line with the empirical record (I developed a model with lagged price dynamics, but did not publish any results from it due to other research commitments).

Despite these shortcomings, I nonetheless expected that the basic model's pattern, of the debt to GDP ratio ratcheting up over time, would be vaguely reflected in the statistics.

### The Ponzi Economy

If only I had been so lucky. One look at the data made it obvious that what we had--at least in Australia--was not so much a ratchet, as a rocket. The debt to GDP ratio was rising exponentially at 4.2% per annum, and had been doing so for over 43 years. The empirical record was much worse than the most pessimistic simulation my model could generate.

Data

**Figure 9: Australia's private debt ratio, 1953-2007**

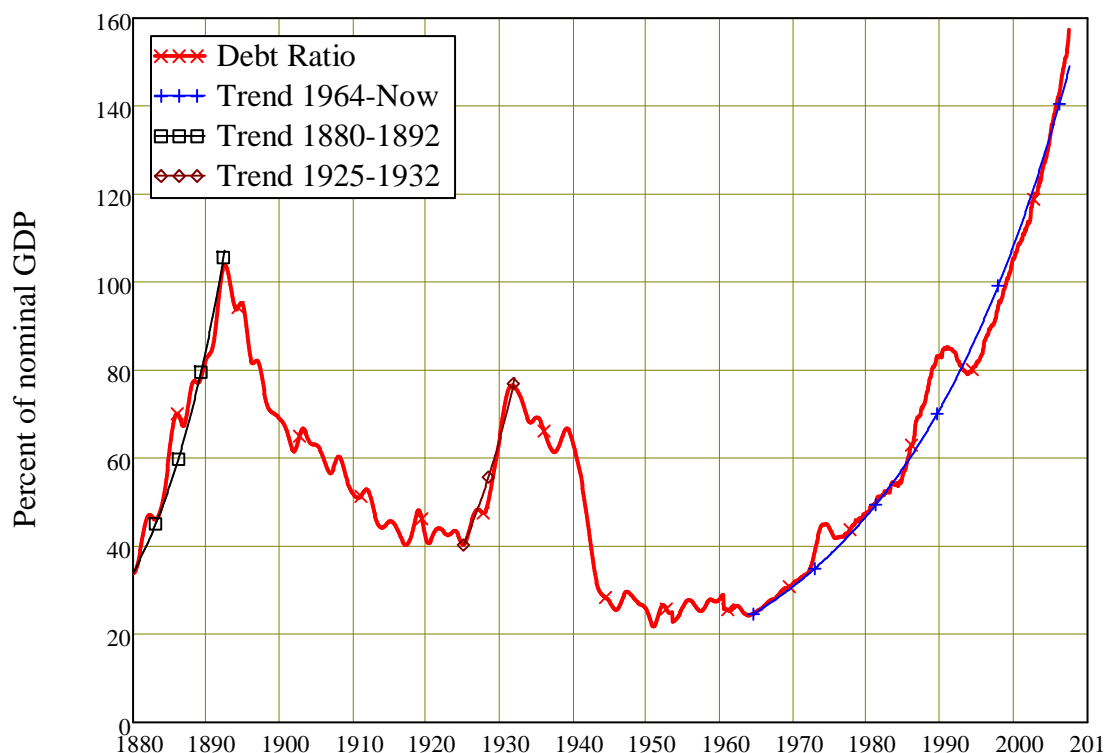


Long term data recently released by the RBA shows that this bubble is the largest and most sustained in Australia's financial history--dwarfing both the 1880s Melbourne Land Boom and the Roaring Twenties in the peak debt ratio reached, the duration of the bubble, and the aggregate increase in debt (the data here has also been augmented by market share data from RDP1999-06 to infer aggregate debt prior to 1953, whereas Battellino 2007 only showed bank credit prior to 1953).

**Figure 10: Australia's private debt ratio, 1880-2007**

Long Term

Debt to GDP: The Long Term View



The only way in which this bubble is anaemic compared to its predecessors is in its rate of increase. Both the 1880s and 1920s bubbles were short, sharp affairs, with the debt ratio rising by over 9% per annum over the comparatively short time spans of 12.5 and 7 years respectively. This bubble has risen at the comparatively sedate rate of 4.2% per annum (though it has accelerated in recent years to 6% p.a.). However, rather in keeping with the "frog in boiling water" parable, this may have helped the debt ratio reach previously unscaleable heights. The 1880s bubble tripled the debt ratio in its 12 years; the current bubble has increased the debt ratio more than sixfold over its 43 years.

**Table 2: Exponential growth correlation figures for three bubbles**

Correlation Tables


	0	1	2	3
0	"Variable"	"Credit"	"Credit"	"Credit"
1	"Compared to"	"GDP"	"GDP"	"GDP"
2	"Start Date"	1880	1925	1964.5
3	"End Date"	1892.5	1932	2007.5
$G_{01} =$ 4	"Growth Rate"	9.2	9.5	4.2
5	"Correlation %"	97.9	97.6	99.1
6	"Doubling Period"	7.5	7.3	16.6
7	"Duration"	12.5	7	43
8	"Initial Value"	33.9	40.3	24.7
9	"Final Value"	103.9	76.2	157.3
10	"Increase %"	206.5	88.8	538.1

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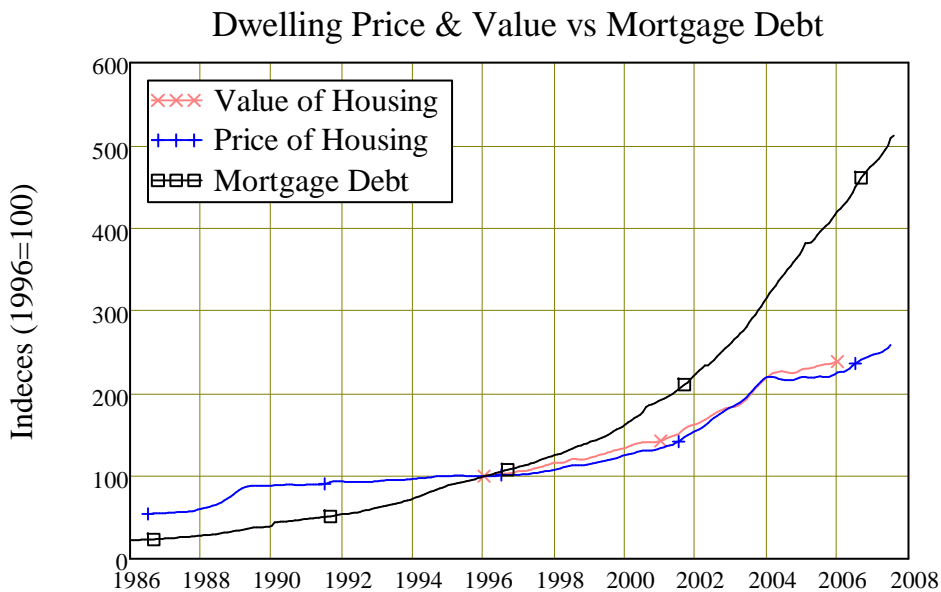
The correlation coefficient of 0.991 between the data (from mid-1964) and a simple exponential relationship is also staggering. This indicated that the major deficiency of my basic Minsky model was not so much the absence of price-level effects, as the absence of endogenous money creation and "Ponzi financing".

In my basic model, all borrowing leads ultimately to additional productive capacity, whereas Minsky's hypothesis reserves a large role for "Ponzi financiers", who profit simply by buying and selling assets on a rising market. In the real world, a growing proportion of borrowed money was clearly directed at the speculative purchase of assets--which increases debt but does not add to productive capacity. With Australia's historic obsession with home ownership, it is apparent that Ponzi behaviour extends well outside the boardroom.

The phenomena of debt rising faster than the value of assets, and widespread borrowing for speculation rather than investment, are clearly visible in the Australian data on housing assets and debt. Since 1996, house prices have risen by 258% while mortgage debt has risen twice as much--by 512%.

 Dwelling Value and Mortgage Indices

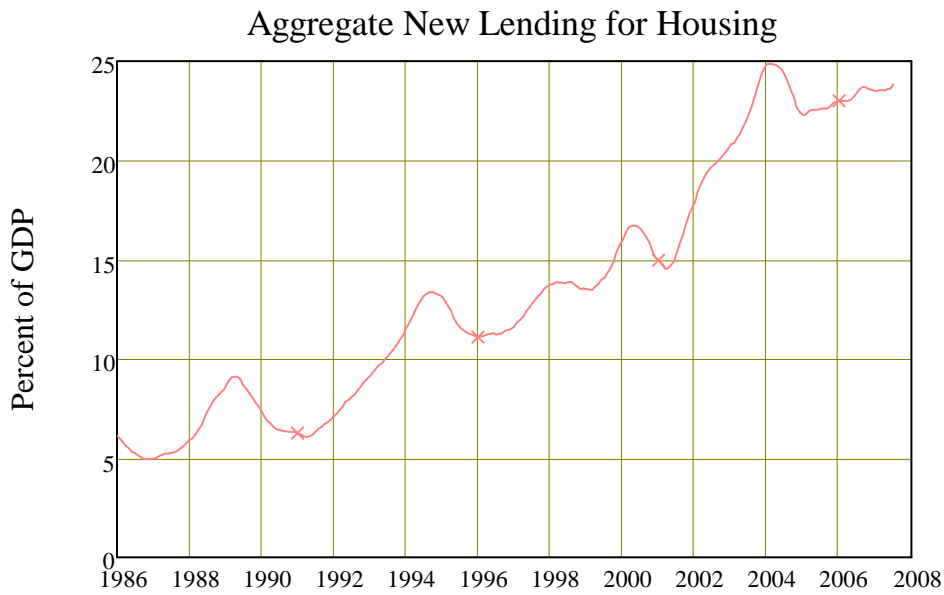
**Figure 11: Rising debt outstrips rising house prices**



The driving force behind this rise in both house prices and mortgage debt has been an unprecedented increase in lending for housing, which has risen from a low of 5 percent of GDP in 1986 to a peak of 25 percent at the apogee of the housing bubble in 2004.

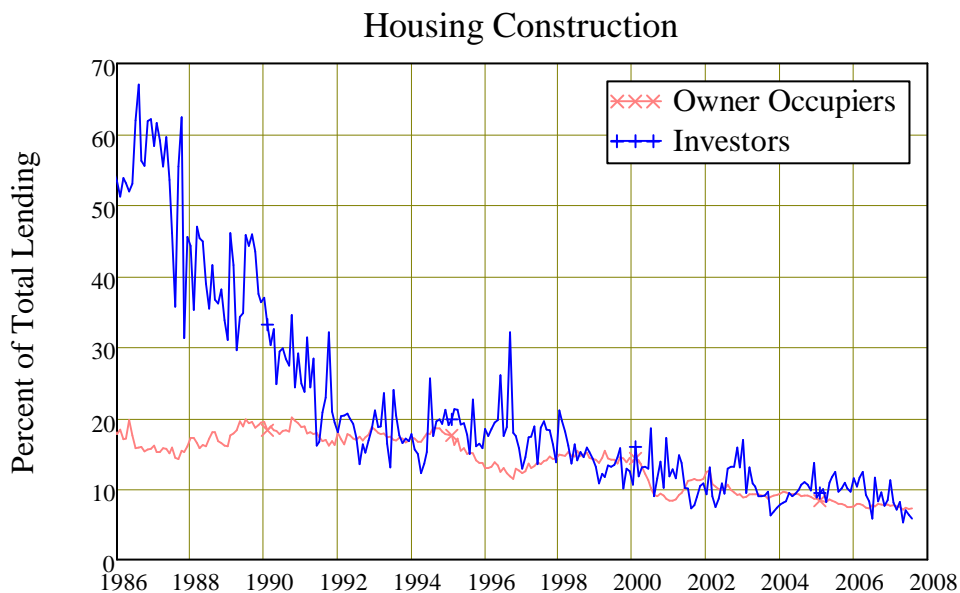
**Figure 12: Fuelling the Ponzi process**

Figure 05 Data



However, as the level of debt financing rose, the proportion of mortgage borrowing that finances actual housing construction rapidly diminished, in true Ponzi fashion, from a high of over 60 percent of all lending to investors (in 1986) and 20 percent for owner-occupiers (in 1990) to under 8 percent for both groups today.

**Figure 13: Not investing, speculating**



In addition to Ponzi investing, the other key aspect of Minsky's hypothesis that was not captured by my 1995 paper was the endogeneity of the money supply. The empirical importance of this issue is emphasised by the correlation table below. Minsky's hypothesis argues that both lenders and borrowers share euphoric expectations about the economy, in

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contrast to neoclassical theories of financial instability that target imbalances in information as the cause of excessive debt--the so-called asymmetric information analysis of financial bubbles. Such theories (references to be supplied) imply that the borrower is *more* aware of deficiencies in an investment project than the lender, since the borrower is privy to more information about a project's viability.

If this were the case, then one might expect that bubble-like trends in lending would be more evident in disaggregated data than aggregate data, and more apparent over short-term periods than over the longer term. Yet the highest correlation between debt and an exponential fit occurs for *aggregate* debt since 1964--the disaggregated debt series have *lower* correlations over the longer term.

**Table 3: Correlations for aggregate and disaggregated debt**

	0	1	2	3	4
$C_{01} =$	"Variable"	"All Credit"	"Business"	"Mortgage"	"Personal"
1	"Compared to"	"GDP"	"GDP"	"GDP"	"GDP"
2	"Start Date"	1964.5	1976.75	1976.667	1976.75
3	"End Date"	2007.5	2007.5	2007.5	2007.5
4	"Growth Rate"	4.175	3.076	5.769	2.985
5	"Correlation %"	99.14	74.683	98.076	88.84

This implies that there is something in the process of endogenous money creation itself that amplifies the trend towards Ponzi Financing: in addition to the general analysis of euphoric expectations that Minsky provides for all actors in the financial system, something in the motivations of credit providers encourages them to increase the debt to income ratio over time. A proper model of Minsky's hypothesis therefore necessitated that it be expressed in a strictly monetary form. A first step in this process was the development of a model of endogenous money creation.

### A model of endogenous money creation

The Post Keynesian school of thought in general rejects the view that credit money is determined by a "money multiplier" relationship with government-created money; however, they had not developed an accepted, coherent model of how money could be created in the absence of a money multiplier process. The following model, based on the work of the European "Circuitist" School (Graziani 1989, 2004) sets out such a model in double-entry book-keeping format.

The model is deliberately stylised and skeletal--no behavioural relations are posited, all functions are linear, and there is no government sector at all. However, all these aspects of reality can later be introduced into this monetary skeleton.

There are three (classes of) agents: banks who lend money to firms, and record all transactions between agents as transfers between deposit accounts; firms who own factories that produce output; and workers who work in those factories. All class accounts are aggregated--no inter-class or inter-bank dynamics are considered (though again these can be added in future developments).

The process of endogenous money creation begins with the granting of a loan  $L$  by the bank to the firm, and two accounts are needed to record this: a loan account  $F_L$  which records the amount the firm owes, and a deposit account  $F_D$  where the money created by the loan is deposited.

**Table 4: The initiation of a loan**

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Account Type	Loan	Deposit
Account	Firm Loan	Firm Deposit
Name	$F_L$	$F_D$
Initial Loan	$\$L$	$\$L$

A loan imposes payment obligations on both the borrower and the lender: the firm must pay interest on the loan, while the bank must pay interest on the balance in the deposit account. The rate of interest on loans is  $r_L$ , on deposits  $r_D$ , and  $r_L > r_D$ . Since all payments are transfers between bank deposit accounts, a third account is now needed: the bank's deposit account  $B_D$ . The firm's payment of interest on its debt  $r_L F_L$  is deducted from its deposit account and paid into the bank's, and this fact is also recorded against the outstanding debt so that it does not grow; the bank then transfers the lesser amount  $r_D F_D$  from its deposit account to the firm's. This flow process is recorded in the next table, along with the sum of the transfers between deposit accounts (which is of course zero at this stage):

**Table 5: Fundamental loan payment flow commitments**

Account Type	Loan	Deposit		
Account	...	...	Bank De-posit	Sum
Name	$F_L$	$F_D$	$B_D$	$\Sigma$
Interest	$r_L \cdot F_L -$ $r_L \cdot F_L =$ $0$	$r_D \cdot F_D -$ $r_L \cdot F_L$	$r_L \cdot F_L -$ $r_D \cdot F_D$	$0$

The firm has borrowed to finance production, and for this workers must be hired. This necessitates a fourth account  $W_D$  for Workers' Deposits, and a flow of wages at the rate  $w F_D$  out of the firm's deposit account and into the workers. Now that workers have bank balances, they too must be paid interest at the rate  $r_D$  times the balance in their accounts; this is transferred out of the bank's Deposit account, for another zero sum transfer. With the firm producing output, workers and bankers purchase commodities with additional flows  $\omega W_D$  and  $\beta B_D$  respectively, which both flow into the firm's deposit account.

**Table 6: Complete loan financial flow commitments**

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Account Type	Loan	Deposit			
Name	$F_L$	$F_D$	$B_D$	$W_D$	$\Sigma$
Interest	0	$r_D \cdot F_D - r_L \cdot F_L$	$r_D \cdot F_D$	0	0
Wages	0	$-w \cdot F_D$	0	$w \cdot F_D$	0
Interest	0	0	$-r_D \cdot W_D$	$r_D \cdot W_D$	0
Consumption	0	$\beta \cdot B_D + \omega \cdot W_D$	$-\beta \cdot B_D$	$-\omega \cdot W_D$	0

These flows now define a closed system in which the total amount of money is conserved; the model can be constructed by summing the entries in each column to deduce a differential equation for the relevant account:

Endogenous money creation model: Conservative system

$$\frac{d}{dt} F_L(t) = 0$$

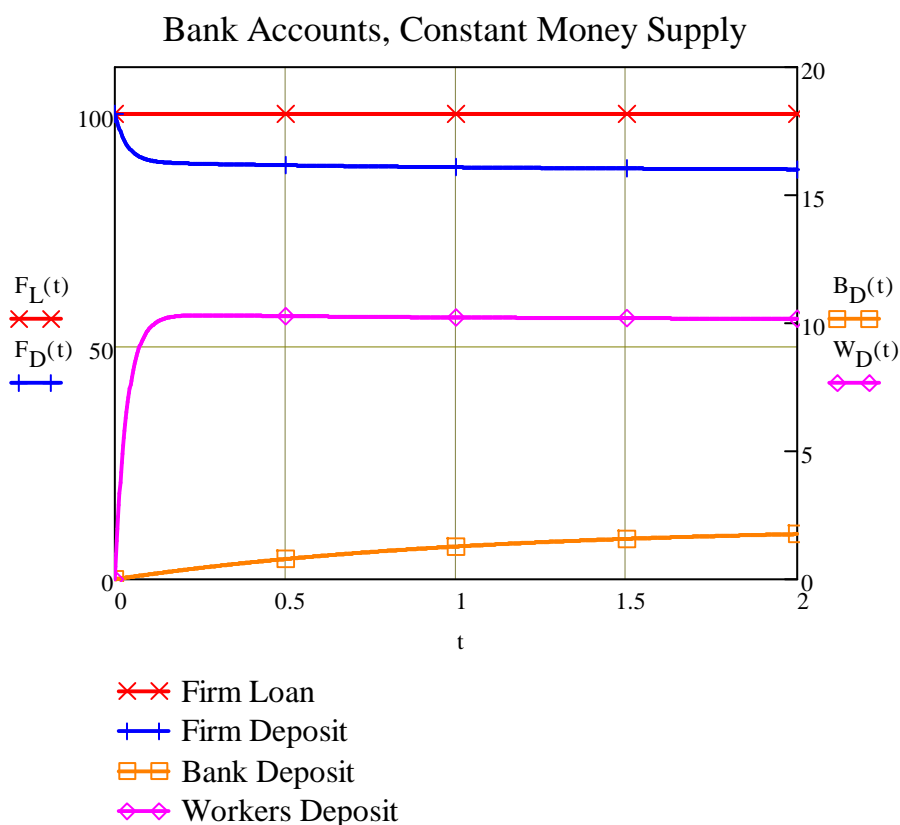
$$\frac{d}{dt} F_D(t) = -(r_L \cdot F_L(t)) + r_D \cdot F_D(t) - w \cdot F_D(t) + \omega \cdot W_D(t) + \beta \cdot B_D(t)$$

$$\frac{d}{dt} B_D(t) = r_L \cdot F_L(t) - r_D \cdot F_D(t) - r_D \cdot W_D(t) - \beta \cdot B_D(t)$$

$$\frac{d}{dt} W_D(t) = w \cdot F_D(t) + r_D \cdot W_D(t) - \omega \cdot W_D(t)$$

The model can now be simulated; the graph below shows a sample run with parameter values of  $r_L = 5\%$ ,  $r_D = 3\%$ ,  $w = 3$ ,  $\omega = 26$ ,  $\beta = 1$ ,  $L = 100$  (the terms  $w$ ,  $\omega$  and  $\beta$  are inverse time lags--so that, for example a value of 26 for  $\omega$  means that workers spend their wages over 1/26th of a year (the time dimension of the model)).

**Figure 14: A pure credit system of transaction accounts**



The term  $w \cdot F_D(t)$  represents workers' share of income from production, which in the classical tradition is assumed to produce a surplus over inputs that is apportioned between workers and capitalists in accord with their relative bargaining power. The wage flow to workers thus represents their share in the surplus  $(1 - s)$  times the turnover period  $P$  between financing production and the receipt of sales revenue. The wage flow is therefore  $w \cdot F_D(t) = (1 - s) \cdot P \cdot F_D(t)$  and the profit flow is  $s \cdot P \cdot F_D(t)$  (which is a subset of the transactions shown above in account  $F_D$ ). Making these substitutions so that income flows can be identified yields an equivalent model, which can be used to derive income flows as well as transactional balances. It is easily shown that this model is consistent with positive incomes for all three classes over time (see Keen 2007).

However my interest here is to extend the model to explore the motivations that might inspire the observed behaviour of financial institutions, of extending credit. I therefore introduce one new account  $B_V$ , and three new flows:  $L_R \cdot F_L$ ,  $R_L \cdot B_V$ , and  $N_M \cdot F_D$ .

Explaining each of these in turn, the new account  $B_V$  is the repository for the repayment of any existing loans, and the place from which new loans are extended. In keeping with the Circuitist model of a pure credit economy, it must not be possible for the bank to profit from "seignorage". The only way to ensure this in this simple stylised model is to "quarantine" loan repayments from the account the bank uses to fund its own expenditures (both purchase of intermediate goods, and consumption by the rentier class)

$L_R$  is the coefficient for the repayment of loans is proportional, which is modelled as being proportional to the level of loans outstanding. This repayment is financed by a deduction from the  $F_D$  account and a matching payment into the  $B_V$  account. Since the debt is reduced by this payment, the amount  $L_R \cdot F_L(t)$  is also deducted from the debt record kept in the  $F_L$  account.

Once there are repaid funds in the  $B_V$  account, they are available to be re-lent. If this occurs, then as part of a loan agreement a matching record of this transfer of funds from  $B_V$  to  $F_D$  is made in the  $F_L$  account.

## Developing a Monetary Model of Financial Instability

Finally, the crux of the model is to show how new money can be endogenously created in a pure credit economy, in the complete absence of a government sector and fiat money creation (though this additional source of money creation can be introduced into the model later). Here the process is simply a continuous flow extension of the initial condition extension of the loan  $L$  that began the process. The bank allows the firm to increase its debt at the rate of  $N_M$ , and enters the matching amount of money into the firm's deposit account (the process is analogous to what occurs when any of us purchase a commodity using our credit cards: our debt is increased by the amount of the purchase, and simultaneously, that amount of money is credited to the retailer's account).

Unlike all the previous entries into the double-entry table, there is no offsetting deduction from any other deposit account, or from an asset account as in the case of the repayment of and recycling of loans: the creation of new money is not a transaction. In the language of dynamic systems analysis, the model is therefore dissipative rather than conservative.

The full model is set out in the following table:

**Table 7: Loan flows with repayment, recycling and new money**

Account Type	Asset		Liability			
Account	...	Vault	...	...	...	...
Name	$F_L$	$B_V$	$F_D$	$B_D$	$W_D$	$\sum$
Interest			$r_D \cdot F_D -$ $r_L \cdot F_L$	$r_L \cdot F_L -$ $r_D \cdot F_D$		0
Wages			$-(1-s) \cdot$ $P \cdot F_D$		$(1-s) \cdot$ $P \cdot F_D$	0
Interest				$-r_D \cdot$ $W_D$	$r_D \cdot W_D$	0
Consumption			$\beta \cdot B_D +$ $\omega \cdot W_D$	$-\beta \cdot B_D$	$-\omega \cdot W_D$	0
New Loans	$N_M \cdot F_L$		$N_M \cdot F_L$			$N_M \cdot F_L$
Repayment	$-L_R \cdot$ $F_L$	$L_R \cdot F_L$	$-L_R \cdot$ $F_L$			$-L_R \cdot$ $F_L$
Recycling	$R_L \cdot B_V$	$-R_L \cdot$ $B_V$	$R_L \cdot B_V$			$R_L \cdot B_V$

Reading down the columns yields the following system of coupled ODEs:

$$\frac{d}{dt} F_L(t) = N_M \cdot F_L(t) - L_R \cdot F_L(t) + R_L \cdot B_V(t)$$


$$\frac{d}{dt} B_V(t) = L_R \cdot F_L(t) - R_L \cdot B_V(t)$$

$$\begin{aligned} \frac{d}{dt} F_D(t) = & (r_D \cdot F_D(t) - r_L \cdot F_L(t)) - [(1-s) \cdot P \cdot F_D(t)] + (\omega \cdot W_D(t) + \beta \cdot B_D(t)) \dots \\ & + (N_M \cdot F_L(t) - (L_R \cdot F_L(t) + (R_L \cdot B_V(t))) \end{aligned}$$

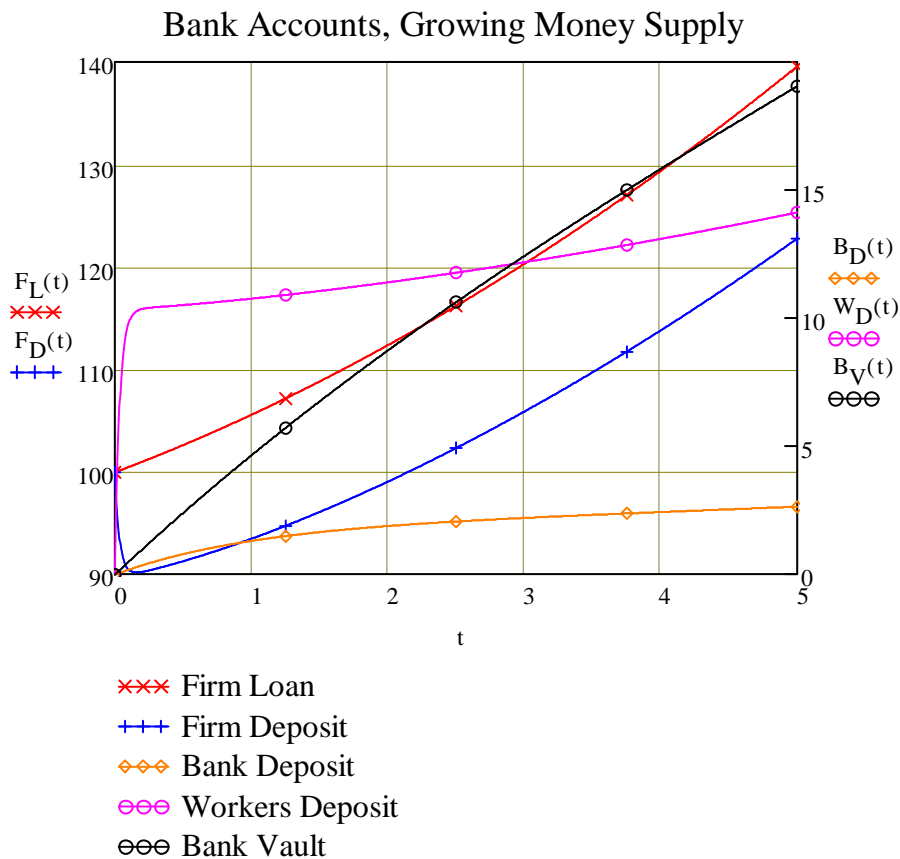
## Developing a Monetary Model of Financial Instability

$$\frac{d}{dt}B_D(t) = r_L \cdot F_L(t) - r_D \cdot F_D(t) - r_D \cdot W_D(t) - \beta \cdot B_D(t)$$

$$\frac{d}{dt}W_D(t) = (1 - s) \cdot P \cdot F_D(t) + r_D \cdot W_D(t) - \omega \cdot W_D(t)$$

 Endogenous Money Creation

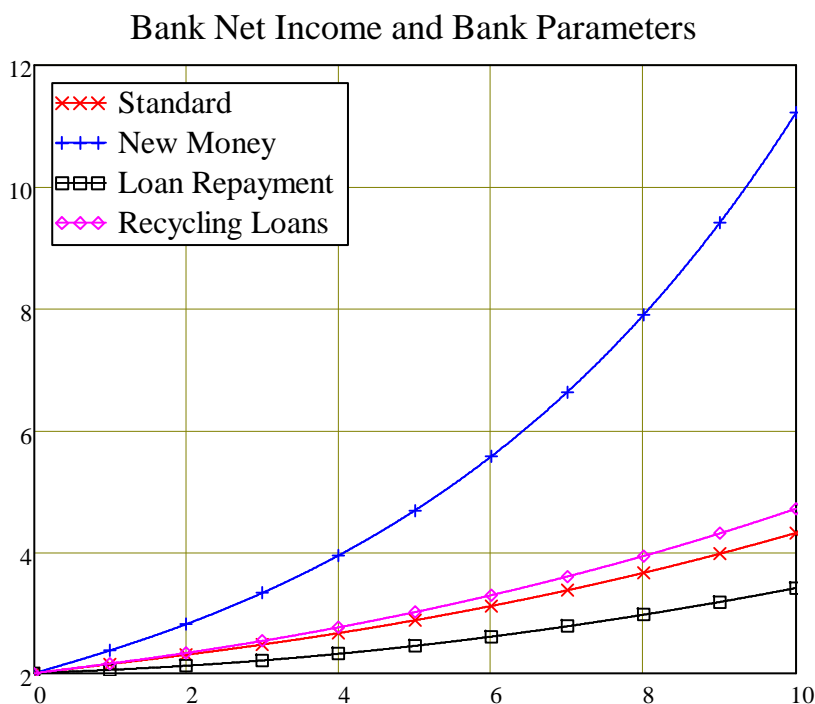
**Figure 15: A pure credit system with endogenous money creations**



This more complete model lets us see what happens to bank income when key parameters are altered--the rate of loan repayment, the speed at which repaid loans are "recycled", and the rate of new money creation. The simulations below show the impact on incomes of doubling each of the parameter values  $N_M$ ,  $L_R$  and  $R_L$ , while holding all other values constant.

Bank Parameters and Income

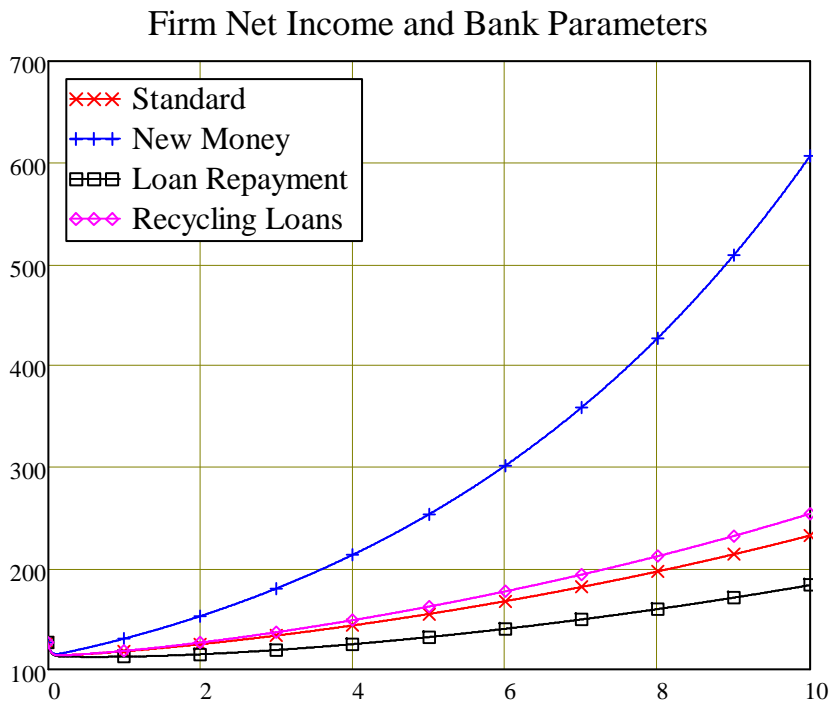
**Figure 16: Bank income as a function of credit parameters**



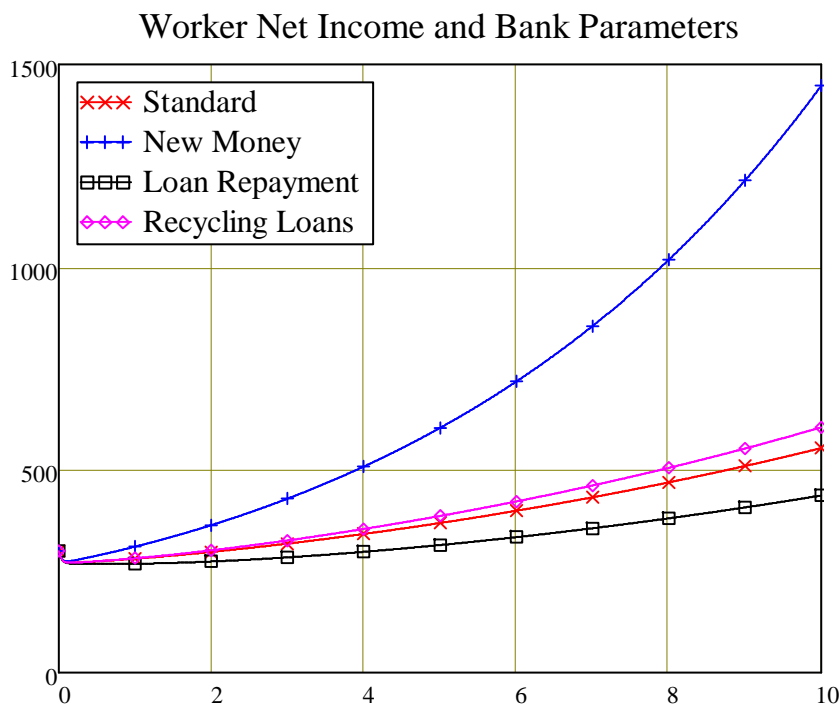
The result for the bank confirms intuition: the bank's income will rise if it creates more new money, recycles more repaid loans, and if old loans are not repaid. There is thus an inherent bias in a credit money system to increase the level of indebtedness: we cannot rely upon market mechanisms to limit the level of debt creation to some "optimal" level. Instead, if the institutional arrangements of society allow it, financial institutions have a motivation to increase debt levels relative to incomes.

What might confound intuition is that the incentive to the bank to extend credit is *not* balanced by the firm's reluctance to take on new debt. Such thinking emanates from seeing issues of income distribution in a static sense, in which a gain for one group at a point in time requires a loss for another. However, in this dynamic setting, a greater rate of growth of money supply, a greater amount of money in circulation (since repaying loans takes money out of circulation until it is re-lent), and implicitly a greater rate of growth of production means a greater rate of growth of income for all (including workers--though of course as it stands the model is too simple to consider feedback effects that could alter the distribution of income).


**Figure 17: Firm income as a function of credit parameters**



**Figure 18: Worker income as a function of credit parameters**



That is, unless borrowing does not lead to higher aggregate incomes, but instead higher debt relative to incomes--or in other words, if borrowing is undertaken for the purpose of buying existing assets rather than installing new productive capacity.

 Endogenous money creation model: Balances

## A Ponzi preliminary--a monetary version of Goodwin

I had hoped to have a complete monetary model of the FIH ready for this conference. Regrettably I have not had the time to complete this, but below I express the preliminary of Goodwin's model in monetary absolute value form (versus the usual real and ratio statement) and with a "Phillips curve" argument that reflects Phillips' original arguments (that the rate of change of money wages is a function of the rate of employment, the rate of change of employment, and lagged cost pressures).

### **Definitions**

$Y_r = \frac{K_r}{v}$                       Output is given by a simple accelerator relation between capital stock K and output Y

$L = \frac{Y_r}{a}$                       Employment L is output divided by labor productivity a, where this grows exponentially:

$Y = Y_r \cdot P_c$                       Money output is real output times the price level

$\frac{1}{a} \cdot \left( \frac{d}{dt} a \right) = \alpha$                       Exponential productivity growth

$\lambda = \frac{L}{N}$                       The employment rate  $\lambda$  is employment L divided by population N, where this grows exponentially:

$\frac{1}{N} \cdot \left( \frac{d}{dt} N \right) = \beta$                       Exponential population growth

$\Omega = W \cdot L = w \cdot P_c \cdot L$                       The wages bill is the wage rate times employment

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$$\Pi = Y - \Omega \quad \text{Profit is output minus wages}$$

$$I = I\left(\frac{\Pi}{K}\right) \cdot \Pi \quad \text{The money value of investment is a nonlinear function of the money rate of profit times the money value of profits.}$$

$$K = K_I \cdot P_K \quad \text{Nominal value of capital is the capital stock times the capital price index}$$

$$I_I = \frac{I}{P_K} \quad \text{The real addition to capital stock is money investment divided by the capital price index}$$

$$\frac{d}{dt} K_I = I_I - \gamma \cdot K_I \quad \text{Investment minus depreciation determines the rate of change of capital}$$

$$w = \frac{W}{P_C} \quad \text{The real wage is the money wage divided by the price level}$$

$$\Omega = W \cdot L \quad \text{The wage bill is the money wage times the level of employment}$$

$$\omega = \frac{w}{a} \quad \text{The wages share of output equals the real wage divided by labor productivity}$$

$$\omega = \frac{\Omega}{Y} = \frac{W \cdot L}{Y_I \cdot P_C} = \frac{W \cdot L}{a \cdot L \cdot P_C} = \frac{W}{a \cdot P_C} = \frac{w}{a}$$

$$\frac{\Pi}{K} = \frac{\pi \cdot P_C}{v \cdot P_K} \quad \text{The rate of profit equals the profit share divided by the accelerator times the ratio of capital prices to consumer prices}$$

$$\frac{\Pi}{K} = \frac{\Pi}{K_I \cdot P_K} = \frac{\Pi}{v \cdot \frac{Y}{P_C} \cdot P_K} = \frac{\Pi \cdot P_C}{v \cdot Y \cdot P_K} = \frac{\pi \cdot P_C}{v \cdot P_K}$$

### ***Differential relations***

$$\frac{1}{W} \cdot \left( \frac{d}{dt} W \right) = P_h \left( \lambda, \frac{d}{dt} \lambda, \text{lagged}(\text{inf}) \right) = P_h \left( \lambda, \frac{d}{dt} \lambda, dW_{dp} \right)$$

The rate of change of wages is a function of the level of employment, the rate of change of employment, and a lagged response to the rate of inflation

$$\frac{d}{dt} dW_{dp} = \frac{-1}{\tau_W} \cdot \left[ dW_{dp} - \frac{1}{P_C} \cdot \left( \frac{d}{dt} P_C \right) \right]$$

Prices are a markup over prime costs in equilibrium:

$$P_{Ce} = (1 + \theta) \cdot \frac{W \cdot L}{Y_I} = (1 + \theta) \cdot \frac{W \cdot L}{L \cdot a} = (1 + \theta) \cdot \frac{W}{a}$$

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Prices adjust with a lag:

$$\frac{d}{dt}P_C = \frac{-1}{\tau_P} \left[ P_C - (1 + \theta) \cdot \frac{W}{a} \right]$$

This results in an sixth-order system of coupled ODEs (where two of those ODEs, for technological change and population growth) result from the transition from a ratio to an absolute value model). The key system states are now the capital stock, the money wage, and the price level (where that in turn has a dependence on a lagged response of workers to inflation)--and the form of the model is remarkably simple, given its increased complexity. The system states for the standard Goodwin model (employment and the wages share of output) are now algebraically derived from these new system states.

$$\frac{d}{dt}K_I = K_I \left[ I \left( \frac{\Pi}{K} \right) \cdot \left( \frac{\Pi}{K} \right) - \gamma \right]$$


$$\frac{d}{dt}W = W \cdot P_h \left( \lambda, \frac{d}{dt}\lambda, dW_{dp} \right)$$

$$\frac{d}{dt}P_C = \frac{-1}{\tau_P} \left[ P_C - (1 + \theta) \cdot \frac{W}{a} \right]$$

$$\frac{d}{dt}dW_{dp} = \frac{-1}{\tau_W} \left[ dW_{dp} + \frac{1}{\tau_P} \cdot [1 - (1 + \theta) \cdot \omega] \right]$$

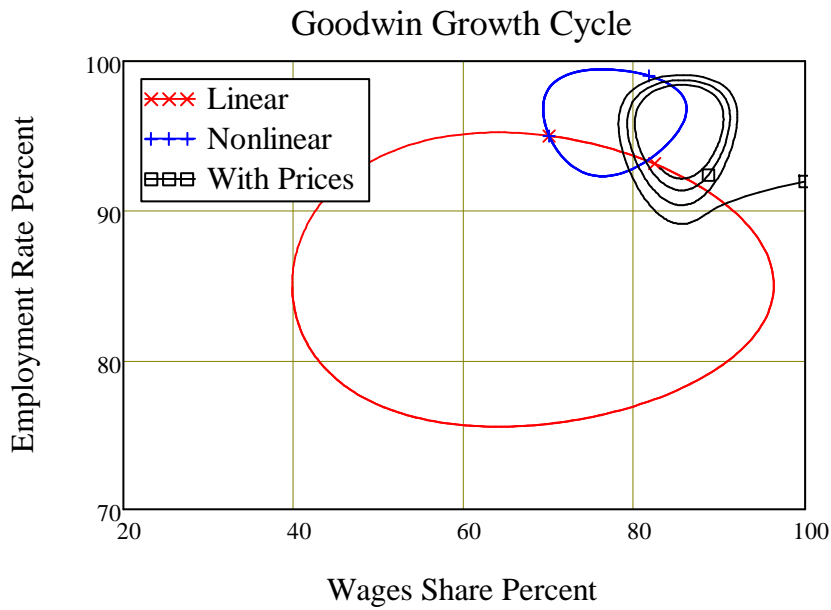
$$\frac{d}{dt}a(t) = \alpha \cdot a(t)$$

$$\frac{d}{dt}N(t) = \beta \cdot N(t)$$

 Goodwin with prices

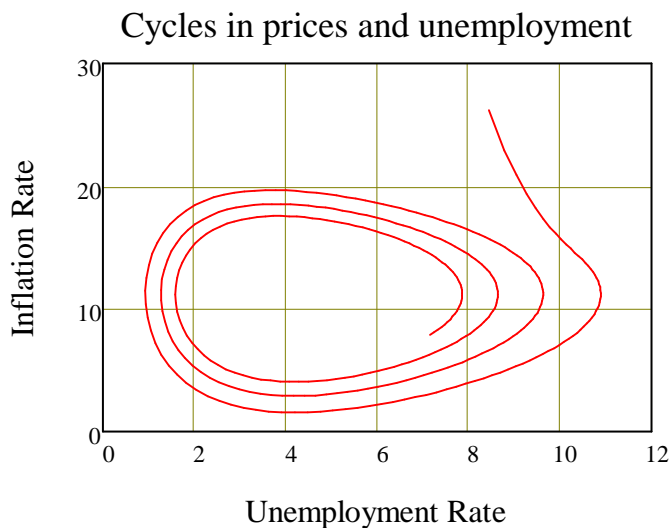
This still uncalibrated model makes two qualitative changes to the basic model: it is now open, and the degree of income distribution volatility is reduced by the impact of prices.

**Figure 19: Goodwin with prices**



There are now also cycles in inflation and the rate of unemployment--which is rather more in keeping with Phillips's original intentions than the bastardised "static" Phillips curve of conventional macroeconomics:

**Figure 20: Phillips "cycles" rather than a Phillips curve**



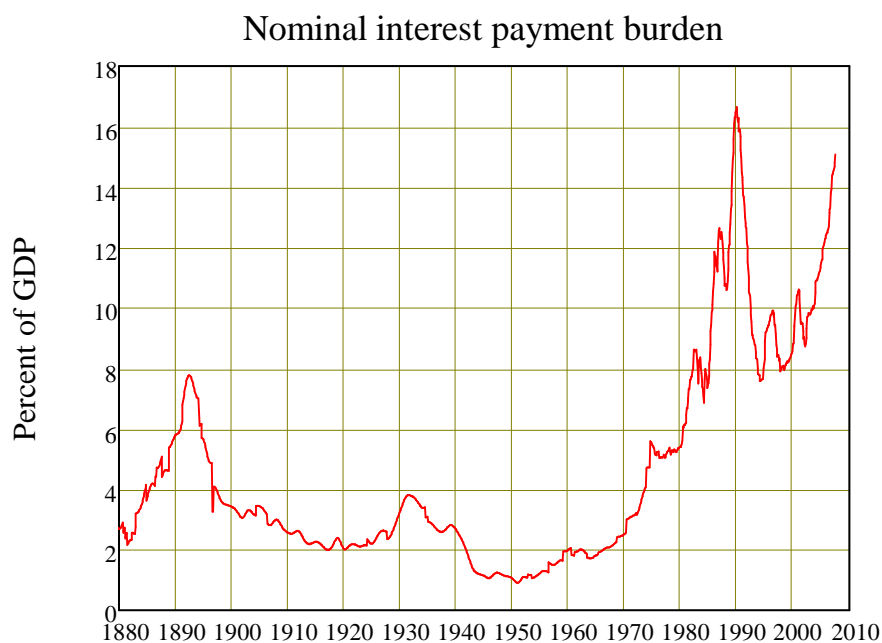
In this form, the model is now ready for the development of a fully monetary expression of Minsky's hypothesis--including ultimately the existence of "Ponzi financing", in which borrowed money, as well as financing physical investment, also finances speculation on the price of capital assets. I hope that this will provide the foundation of a more complete model that will give some guidance to economic policy should we, as I believe is now inevitable, experience a debt-induced Depression in the near future.

This would be especially likely if the debt burden is amplified by deflation. The nominal

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interest payment burden on the economy--the product of average nominal interest rates times the debt to GDP ratio--is already approaching the levels experienced during the 1990s recession, when nominal rates, at 19.9%, were more than twice as high as they are now (9.6%):

**Figure 21: Nominal interest payments as percent of GDP**

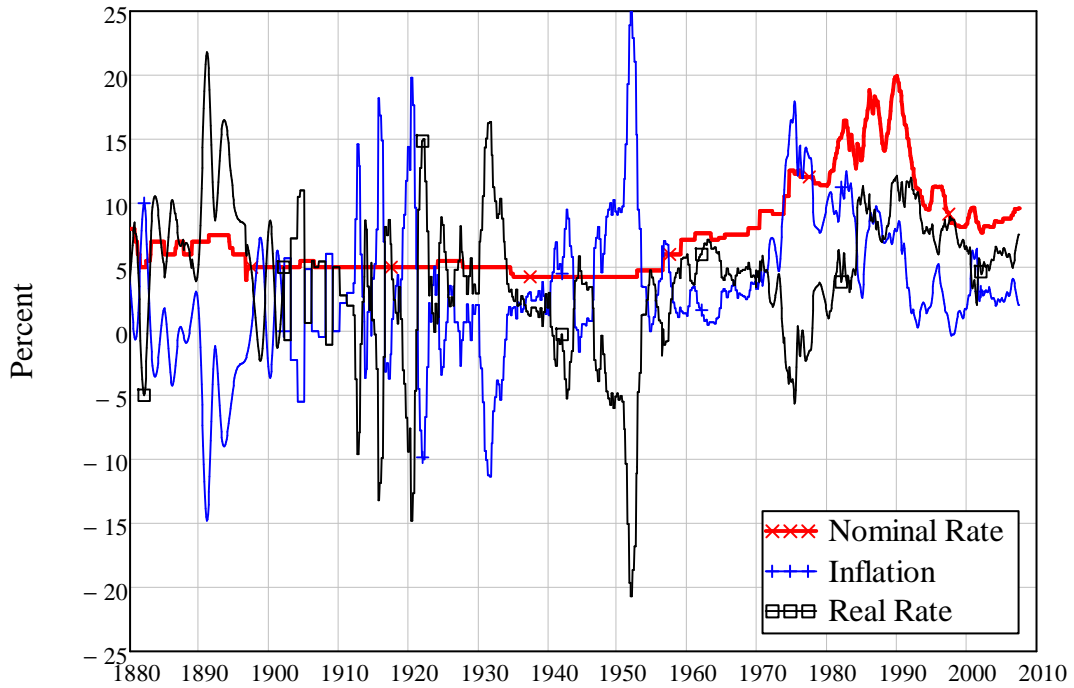


However, the debt burden on the economy in 1990 was substantially reduced by the much higher inflation rate that applied then: the weighted average real rate was 12.1% in 1990, versus 7.5% now:



**Figure 22: Nominal and real interest rates**

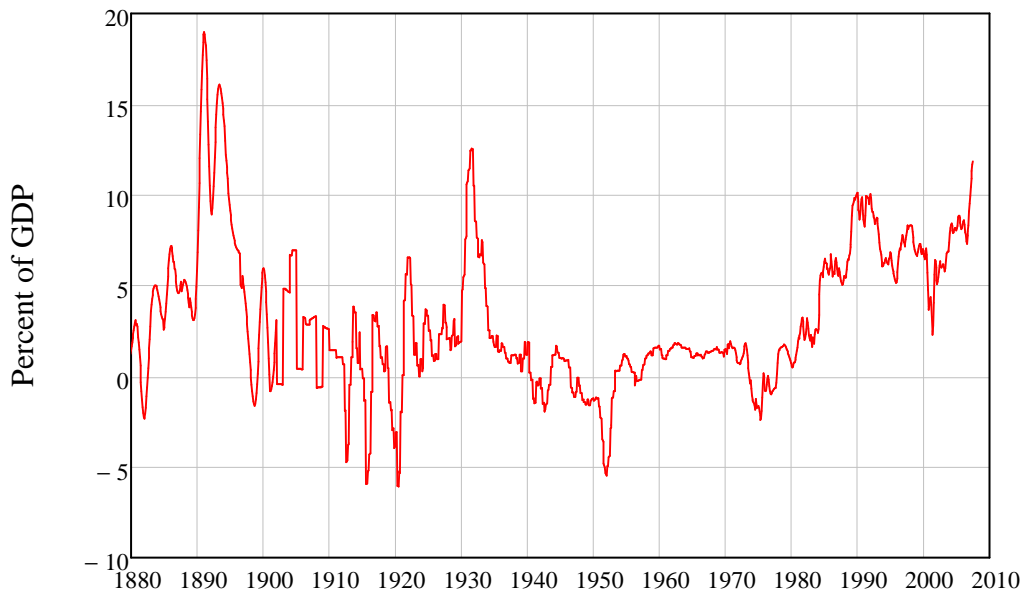
Interest Rates & Inflation



The real interest payment burden on the economy is now substantially higher than in 1990 (11.8% versus 10%), and it is the highest level of financial stress Australia has ever experienced outside the 1890 and 1930 debt-deflations.

**Figure 23: The real interest payment burden**

Inflation-adjusted interest payment burden



Of course, it is possible to claim, as RBA Deputy Governor Ric Battellino did just last month, that this time is different, because this time most debt is owed by households rather than

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businesses, and because households have a lower gearing ratio than businesses, they therefore could manage to service even more debt than the current level:

I don't think anybody knows what the sustainable level of gearing is for the household sector in aggregate, but given that there are still large sections of the household sector with no debt, it is likely to be higher than current levels. (Battelino 2007)

For my part, I hope he is right. But I can't help hearing an echo of Irving Fisher here, before he developed the Debt Deflation Theory of Great Depressions: "we are living in a new era...".

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