9
The Dynamics of the Monetary Circuit

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Introduction

As is well known, Keynes (1936) asserted that a monetary economy differs fundamentally from a barter economy. However, he provided no a priori foundation for his analysis that clearly ruled out a barter framework, which left the way open for Hicks's Walrasian interpretation of *The General Theory*, and the ultimate decline of Keynesian economics.

It is an undoubted strength of the monetary circuit approach to have improved upon Keynes's analysis in this regard, by giving a definitive basis on which a monetary economy cannot be analysed from a barter perspective. This is that, in a truly monetary economy, a token – and not a commodity – is accepted as the final means of payment. From this it also follows that banks are an essential component of a monetary economy (they cannot be simply subsumed within the firm sector); and that transactions are not bilateral – that is, an exchange of two commodities between two agents at a price that is fundamentally relative – but tripartite, with a buyer A purchasing a commodity from a seller B by directing the bank C to transfer money 'tokens' from the buyer's account to the seller's. This is an exchange of one commodity between two agents, mediated by a third, at a price that is fundamentally monetary. All payments are, in essence, transfers between bank accounts.

Unfortunately, this substantial conceptual advance appeared to lead to an impasse. Attempts by many (though not all) authors to put Graziani's (1989) insights into a mathematical model reached the conclusion that net profit was zero in a monetary production economy.

Rochon's (2005) thoughtful survey of this literature put the dilemma nicely:

> The existence of monetary profits at the macroeconomic (aggregate) level has always been a conundrum for theoreticians of the monetary circuit. [...] Indeed, not only are firms unable to create profits, they also cannot raise sufficient funds to cover the payment of interest. In other words, how can *M* become *M′*? (Rochon, 2005, p. 125)

This is a paradoxical result, since, as Rochon (2005) makes evident, Marx also looms large in the monetary circuit tradition. In Marx's schema, net profits are positive and represent the surplus from production. How could it be that the attempt to give Marx's analysis an explicitly monetary flavour could end up destroying one of Marx's key insights, that profit emanates from the surplus generated in production?[1]

In this chapter, we show that this paradox is in fact an illusion, which results mainly from the use of inappropriate modelling techniques – and also, we argue, from a misspecification of the nature of debt. With an appropriate dynamic framework, and an appropriate understanding of debt, it is easily shown that positive profits are compatible with the monetary circuit in a pure credit economy – so long as that economy generates a physical surplus in Marx's sense. Many other currently accepted circuitist impressions about the monetary circuit – such as the need for continuous injections of money to sustain constant economic activity, and the destruction of money by the repayment of debt – are also shown to be erroneous. The correction of these errors substantially strengthens monetary circuit analysis, even though it requires the abandonment of several established circuitist conventions.

The framework

The appropriate modelling framework is deceptively simple, and a natural extension of the insight that, in a monetary economy, payments for goods and services are made via transfers between bank accounts. The monetary circuit can be modelled by considering why the firm sector takes out loans – to finance production in the expectation of making a profit – and then detailing the money flows between bank accounts that loans give rise to, from the point of view of the banking sector, in a double-entry bookkeeping system. Each column in the accounting table records the flows that determine the value of an account at any point in time, and each row represents a particular type of transaction between accounts.

This technique bears a familiar resemblance to the social accounting matrix (SAM) or stock–flow consistent (SFC) approach championed by Godley and Lavoie (2007), in that, as with the SFC approach, the intention is to accurately account for all relations in the system. But there are substantive differences:

1. Time is modelled continuously rather than discretely.
2. The model-system states are bank transaction accounts (with assets and liabilities accounted for separately).
3. Wage, profit, and rentier incomes are not aggregated.
4. The system does not have the restrictions that are applied to the SFC approach, though we apply a principle analogous to the SFC approach, which considers that '[e]ach row and column of the flow matrix sums to zero on the principle that every flow comes from somewhere and goes somewhere' (Godley, 1999, p. 394; see also Godley and Lavoie, 2007, p. 9):
   (a) The columns of the table do not sum to zero, but instead return the equations of the model.
   (b) Entries in the rows of the table do not necessarily sum to zero.
   (c) There is no '*n*th equation rule', as in the SFC framework.

Continuous time

A continuous time formulation is inherently superior to the discrete time approach commonly used in economics, on at least four grounds:

1. While every individual economic transaction, like every birth, is a discrete event, these transactions – also like births – are dispersed through time. Aggregate economic processes are thus better captured by continuous-time equations – as indeed is population growth in biology, radioactive decay in physics, and so on.
2. Time dependencies in discrete-time models often force unrealistic compromises on the modeller – as Godley (1999, p. 409) noted when he pointed out that '[he has] introduced lags [...] whenever simultaneous interdependence threatened to generate meaningless oscillations'. No such problem exists in a continuous-time model – in part because of the third, and major, advantage of this approach over discrete-time modelling.
3. In a continuous-time model, all entries in the equations are flows. In a discrete-time formulation, while most entries are flows, some

are stocks (for example, Table 1 in Godley (1999) lists 11 flow variables and 6 stocks), and stocks have to be explicitly linked with flows via equations of the form: $Stock_{t+1} = Stock_t + Flow_t$. Stocks in a continuous-time model are the value of its system states, which are given by the integral of the flows, and the basic equation is $d/dt\ Stock = \Sigma Flows$. There is thus no danger of misspecifying a stock as a flow – a perennial problem in economic modelling.[2] Nor is there a danger of not properly linking a flow to a stock variable: once a flow is introduced into the model, it is automatically linked to the appropriate stock via its differential equation.

4. Finally, time dependencies are much more easily handled in continuous-time form. For example, consumption is subject to a much shorter time delay than investment. However, accounting for this in a discrete-time framework means having difference equations of the form $C_{t+1} = F(Y_t)$ for consumption and $I_{t+52} = F(\Pi_t)$ for investment (indicating a week's lag for consumption and a year's lag for investment). In practice, to make their models tractable, researchers frequently use the same time delays (typically a year) for variables that beat to a very different drum, leading to serious distortions of the underlying dynamics. No such problem exists with continuous-time modelling, where very different time lags can easily be mixed – and they can even be variable, as shown below.

Transaction accounts rather than economic entities

The transactions approach is a natural expression of the monetary circuit view. A crucial advantage of having bank accounts as the fundamental system states – rather than aggregate economic agents like 'households' – is that the actual financial transactions of the system are explicitly shown, and separated from physical transfers. This includes the endogenous creation of money: in a credit-money system, money is created in bank accounts, and the transactions paradigm allows this to be modelled directly. In contrast, even in Godley's sophisticated SFC framework, the modelling of endogenous money creation is implicit rather than explicit.

The transactions paradigm is also the basis of the next three points of difference between our work and Godley's.

No household sector

In most SAM-based work, profits from firms, net interest income from financial transactions, and wages are aggregated into the income of a household sector (see again Table 1 in Godley, 1999). We accept Graziani's (1989) stricture that the behaviour of different entities and social classes is different, and this is lost by aggregating all classes into the amorphous unit 'households'. The transactions-accounts basis of the model facilitates this disaggregated approach.

Absence of column–row restrictions

Since the columns sum the flows into and out of any given transaction account (and the dynamics of the record of debt), the model's differential equations are derived simply by adding up the columns: the columns therefore do not sum to zero. The major departure from the SFC approach, however, is that while rows normally do sum to zero, this is no longer compulsory. Though transactions between deposit accounts necessarily sum to zero, not all entries in bank accounts are in fact transactions (while others affect transfers between bank assets and bank liabilities, which must be separated for analytic reasons). In particular, when Moore's (1988) 'line of credit' concept of endogenous money growth is introduced, an entry occurs in the credit account of firms for which there is a matching entry in firms' record of debt, but no matching transaction transfer from any other account. This is the source of endogenous money growth, which is explicitly modelled in this framework.

No *n*th equation rule

As Godley and Lavoie (2007) remark, the fact that the *n*th equation is determined by the other $n-1$ equations in their models is related to the same rule that applies in Walrasian economics, where the *n*th market's equilibrium is automatic if the other $n-1$ markets are in equilibrium. This feature arises from the mixed stock–flow nature of the SAM framework. No such closure rule is required in differential-equation models, where the model is fully specified by its flows and a set of initial conditions – of which there is one per system state (or stock).

Debt as a data record versus 'negative money'

One crucial way in which our analysis differs from the norm for researchers in the endogenous-money tradition is that we treat debt, not as a bank account as such, nor as 'negative money', but as a data record of the legal obligations of a borrower to a bank. The argument that repaying debt destroys money – and therefore that debt is, in effect, 'negative money' – is commonplace in the endogenous-money literature, with writers routinely surmising that money is destroyed when debt is repaid:

> As soon as firms repay their debt to the banks, the money initially created is destroyed (Graziani, 1989, p. 5).

> If debts are to banks, then the payments which fulfill commitments on debts destroy 'money'. In a normally functioning capitalist economy, in which money is mainly debts to banks, money is constantly being created and destroyed (Minsky, 1980, p. 506).

This implies that money used to repay a debt goes into a debt account, and negates the equivalent sum of debt. While this is intuitively appealing, we believe that it is a fundamental misspecification of the nature of debt.

First, one of the essential differences between commodities and money is that the former are destroyed – or at least depreciated – in use, whereas money does not depreciate by use. To treat money as effectively indestructible when used in transactions, and yet destroyed when used to repay debt, is incongruous.

Second, though the apt framework for considering the models below is a purely electronic payments system, consider, as a thought experiment, a pure credit banking system using an entirely paper money, and issuing its own notes as money.[3] If a debt to a bank were repaid, would it make sense for the bank to duly destroy the returned notes? Of course not: the bank would instead record that the outstanding debt has been reduced, and store the returned notes in its vault, ready for relending. The one stricture, to avoid the problem of seigniorage identified by Graziani (1989), is that the notes that repay debt must be treated differently from those that represent the bank's income from the spread between its loan and deposit rates of interest. The latter can be used by the bank to finance the purchase of goods (whether as intermediate inputs or consumption expenditure by bankers); the former cannot.

This same stricture applies to electronically generated and stored money today. Repayments must be treated differently from interest payments: the latter can be used to finance bank expenditure, the former cannot.

Finally, if debt were truly an account holding 'negative money', then the only way it could be reduced would be by paying 'positive money' into it – in other words, by repaying the debt. Debt, however, can also be reduced by bankruptcy, when a lender is forced to write off a debt that the borrower is unable to repay. Equally, as illustrated later in this chapter, debt can grow via compound interest if the borrower (or, more correctly, the borrowing sector) does not meet all of its debt-servicing obligations – and this growth of debt is not matched by any corresponding growth in money. These manifest realities of debt emphasize that the debt account is not a repository for money – negative or otherwise – as are other accounts in the system, but a data record of the amount owed.

The model

In all the models presented in this chapter, we consider the Wicksellian ideal of a pure credit economy, with no government sector – and therefore no fiat money and no money multiplier. There are three classes of agents, namely, capitalists (that is, the firm sector), bankers (that is, the banking sector), and workers. In the initial models, production is not explicitly modelled (a simple labour-only production model is introduced later), but is assumed to take place in the background to the financial flows.

At its very simplest, a loan necessitates the paying of interest on outstanding debt and deposit balances, enables the firm to hire workers to produce commodities for sale, gives the workers wages with which to purchase commodities, and gives the bank income for the purchase of intermediate goods and consumption expenditure (from the spread between loan and deposit interest charges on outstanding balances). Three deposit accounts are needed – one for each of the three classes of capitalists, workers, and bankers – while one record of debt is also required, to record lending from bankers to capitalists.

The balanced flows that are needed to capture this financial activity are proportional to the outstanding balances in the accounts at any given time. Using F_L, F_D, B_D, and W_D as symbols for the firm loan, firm deposit, bank deposit, and worker deposit accounts respectively, r_L for the rate of interest on loans, and r_D for the rate of interest on deposits, w as the parameter for the flow of wages payments from firms to workers, β as the parameter for banks' purchases from firms, and ω as the parameter for workers' purchases, we derive Table 9.1 (we assume that the interest

Table 9.1 Basic model without money growth

	Assets		*Liabilities*			
	Loans (F_L)	*Sum* (Σ)	*Deposits* (F_D)	(B_D)	(W_D)	*Sum* (Σ)
Interest	$r_L \cdot F_L - r_L \cdot F_L$	0	$r_D \cdot F_D - r_L \cdot F_L$	$r_L \cdot F_L - r_D \cdot F_D - r_D \cdot W_D$	$r_D \cdot W_D$	0
Wages			$-w \cdot F_D$		$w \cdot F_D$	0
Consumption			$\beta \cdot B_D + \omega \cdot W_D$	$-\beta \cdot B_D$	$-\omega \cdot W_D$	0

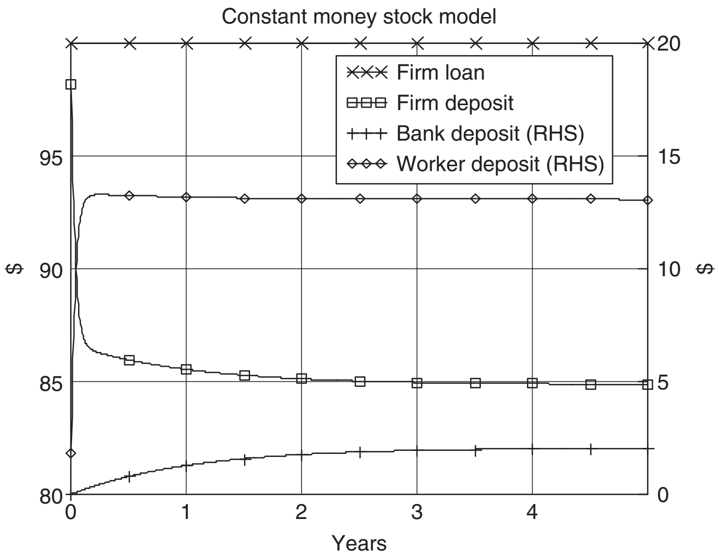

Figure 9.1 Account dynamics with no debt repayment

the firm sector pays on its debt to the bank is such that the level of debt does not change).

This model is constructed by adding up the entries in each column and expressing them as the differential equation of each account:

$$\frac{d}{dt}F_L = 0$$

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

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

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

Given the initial condition of an initial loan of L dollars, and values for the parameters, this model can be simulated as shown in Figure 9.1.[4]

A symbolic solution can also be found for account balances, and two of the three income flows in the model: wages, which equal $w \cdot F_D$, and gross interest payments of $r_L \cdot F_L$. However, to solve for the third income class – firms' profits – we need to unpack what the symbol w stands for in the model considered.

Here we construct an explicit link between Graziani, Marx, and Sraffa – and an implicit link with production – by recognizing that the wage represents the workers' share in the surplus generated in production (in Sraffa's sense that wages and profits are shares in the surplus of output over inputs in a productive economy). This surplus is the product of two factors: (i) the relative shares of workers and capitalists in the surplus, and (ii) the turnover period between the financing of production and the sale of output. Using s (where $0 < s < 1$) to represent the capitalists' share of the net surplus, and S to represent how often production turns over in a year, we can note that $w = (1 - s) \cdot S$, and derive a symbolic solution for the equilibrium level of each account. Using an example value of $s = 1/3$, so that $S = 6$,[5] we get

$$\begin{bmatrix} F_{L_{Eq}} \\ F_{D_{Eq}} \\ B_{D_Eq} \\ W_{D_Eq} \end{bmatrix} = L \cdot \begin{bmatrix} 1 \\ \dfrac{(\beta - r_L) \cdot (\omega - r_D)}{(\beta - r_D) \cdot ((1 - s) \cdot S + \omega - r_D)} \\ \dfrac{(r_L - r_D)}{(\beta - r_D)} \\ \dfrac{(\beta - r_L) \cdot (1 - s) \cdot S}{(\beta - r_D) \cdot ((1 - s) \cdot S + \omega - r_D)} \end{bmatrix} = \begin{bmatrix} 100 \\ 84.867 \\ 2.062 \\ 13.071 \end{bmatrix}$$

All classes of economic agents earn positive incomes, both from class incomes, and in terms of total income receipts including earnings from interest. The equilibrium yearly class earnings are

$$\begin{bmatrix} Wage_{Eq} \\ Profit_{Eq} \\ Interest_{Eq} \end{bmatrix} = \begin{bmatrix} (1 - s) \cdot S \cdot F_{D_{Eq}} \\ s \cdot S \cdot F_{D_{Eq}} \\ r_L \cdot F_{L_{Ee}} \end{bmatrix} = \begin{bmatrix} 339.467 \\ 169.733 \\ 5 \end{bmatrix}$$

while the equilibrium yearly incomes are

$$\begin{bmatrix} Workers_{Eq} \\ Capitalists_{Eq} \\ Bankers_{Eq} \end{bmatrix} = \begin{bmatrix} (1 - s) \cdot S \cdot F_{D_E} + r_D \cdot W_{DE} \\ s \cdot S \cdot F_{D_E} + r_D \cdot F_{DE} - r_L \cdot F_{LE} \\ r_L \cdot F_{LE} - r_D \cdot (W_{DE} + F_{DE}) \end{bmatrix} = \begin{bmatrix} 339.859 \\ 167.279 \\ 2.602 \end{bmatrix}$$

The results of this model contradict many circuitist papers on a range of issues. As can be seen from the matrix above, all classes of economic agents earn positive incomes, and these incomes substantially exceed the initial size of the loan. A constant level of economic activity is sustained with a constant level of money – there is no need for continuing injections of money to sustain economic activity. And clearly, firms' profits substantially exceed the interest bill on the outstanding debt: it is quite possible for firms to borrow money and make profits in the aggregate.

Our contrary results indicate the validity of Kalecki's wry engineer-based observation on economics when he first became acquainted with it, as recounted by Godley and Lavoie (2007, p. 1), that economics 'is the science of confusing stocks with flows'. The stock of debt at any point in time generates a stock of active money deposits that enables a flow of incomes. The sum of these flows over a year can easily exceed the outstanding stock of money at any point in time – and the ratio between the sum of income flows over a year and the money stock tells us the velocity of circulation of money.[6] The previous circuitist conclusions all arose from either mistaking a stock for a flow, or from the erroneous belief that the maximum value of a flow over time (income) was set by the size of the initial stock (money).

This is, however, prior to considering the repayment of debt. Here the flow table format makes it easy to consider the issue of how debt should be treated: as 'negative money' – the standard circuitist perspective (and indeed that of Minsky) – or as a data record, with the repaid money necessarily residing in another asset account.

Repayment of debt: 'negative money' or a bank asset?

Table 9.2 models the conventional treatment of debt as 'negative money', and of the repayment of debt as necessarily destroying money. A flow of $l_R \cdot F_L$ is repaid,[7] which results in a deduction from the firms' deposit account and an identical deduction from the firms' loan account. Both bank liabilities (the sum of deposit accounts, including the bank's own deposits) and bank assets fall.

As Figure 9.2 shows, all accounts gradually taper to zero over time, and hence economic activity ceases – whereas if firms do not repay their debt, economic activity can continue indefinitely. This makes the repayment of debt rather foolish from everyone's point of view: if debt really is negative money, then it is in everyone's interests (bankers, capitalists, and workers alike) that it never be repaid.

However, if debt is in fact a record of a legal obligation, and money is not destroyed when debt is repaid, but instead stored as an asset of the bank – in the bank vault (B_V), so to speak – then a very different picture emerges. The repayment of debt keeps bank assets constant, but alters their form from active loans to passive reserves. Once the bank has reserves, they can be relent at the rate $m_R \cdot B_V$, enabling a constant level of economic activity to be maintained, as in the original model

PROOF

Table 9.2 Model with debt as negative money

	Assets		*Liabilities*			
	Loans (F_L)	*Sum* (Σ)	*Deposits* (F_D)	(B_D)	(W_D)	*Sum* (Σ)
Interest	$r_L \cdot F_L - r_L \cdot F_L$	0	$r_D \cdot F_D - r_L \cdot F_L$	$r_L \cdot F_L - r_D \cdot F_D - r_D \cdot W_D$	$r_D \cdot W_D$	0
Wages			$-(1-s) \cdot S \cdot F_D$		$(1-s) \cdot S \cdot F_D$	0
Consumption			$\beta \cdot B_D + \omega \cdot W_D$	$-\beta \cdot B_D$	$-\omega \cdot W_D$	0
Repayment	$-l_R \cdot F_L$	$-l_R \cdot F_L$	$-l_R \cdot F_L$			$-l_R \cdot F_L$

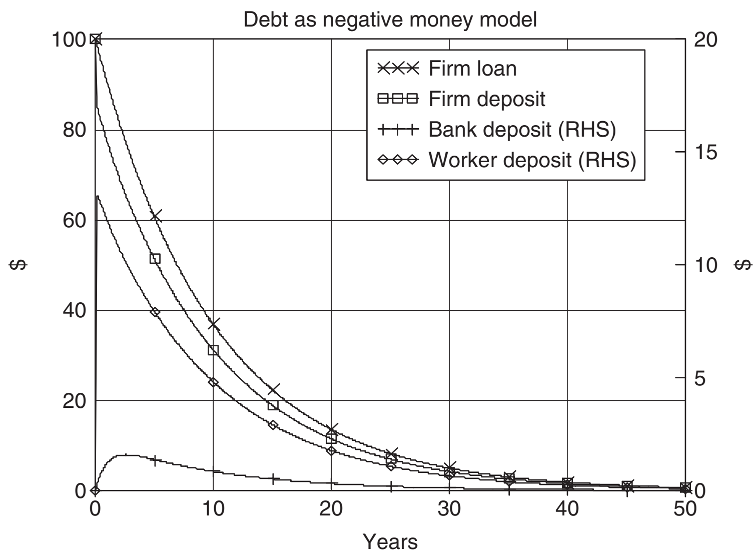

Figure 9.2 Debt as negative money

without debt repayment (though at a lower level of activity, since the level of active deposits falls).[8] This preferred perspective is shown in Table 9.3.

In contrast to the 'debt as negative money' model, the model shown in Table 9.3 behaves similarly to the previous model without debt repayment, in that a constant level of economic activity is sustained

Table 9.3 Model with debt as ledger entry

	Assets			*Liabilities*			
	Loans (F_L)	*Vault* (B_V)	*Sum* (Σ)	*Deposits* (F_D)	(B_D)	(W_D)	*Sum* (Σ)
Interest	$r_L \cdot F_L - r_L \cdot F_L$		0	$r_D \cdot F_D - r_L \cdot F_L$	$r_L \cdot F_L - r_D \cdot F_D - r_D \cdot W_D$	$r_D \cdot W_D$	0
Wages				$-(1-s)\cdot S \cdot F_D$		$(1-s)\cdot S \cdot F_D$	0
Consumption				$\beta \cdot B_D + \omega \cdot W_D$	$-\beta \cdot B_D$	$-\omega \cdot W_D$	0
Repayment	$-l_R \cdot F_L$	$l_R \cdot F_L$	0	$-l_R \cdot F_L$			$-l_R \cdot F_L$
Relending	$m_R \cdot B_V$	$-m_R \cdot B_V$	0	$m_R \cdot B_V$			$m_R \cdot B_V$

from a single injection of money. The new account equilibria are as follows:

$$\begin{bmatrix} F_{L_{Eq}} \\ B_{V_{Eq}} \\ F_{D_{Eq}} \\ B_{D_{Eq}} \\ W_{D_{Eq}} \end{bmatrix} = \frac{L \cdot m_R}{l_R + m_R} \cdot \begin{bmatrix} 1 \\ l_R/m_R \\ \dfrac{(\beta - r_L)\cdot(\omega - r_D)}{(\beta - r_D)\cdot((1-s)\cdot S + \omega - r_D)} \\ \dfrac{(r_L - r_D)}{(\beta - r_D)} \\ \dfrac{(\beta - r_L)\cdot(1-s)\cdot S}{(\beta - r_D)\cdot((1-s)\cdot S + \omega - r_D)} \end{bmatrix} = \begin{bmatrix} 97.561 \\ 2.439 \\ 82.797 \\ 2.012 \\ 12.753 \end{bmatrix}$$

As before, these equilibria are consistent with positive (if lower) incomes for all classes of economic agents:

$$\begin{bmatrix} Wage_{Eq} \\ Profit_{Eq} \\ Interest_{Eq} \end{bmatrix} = \begin{bmatrix} (1-s)\cdot S \cdot F_{D_{Eq}} \\ s \cdot S \cdot F_{D_{Eq}} \\ r_L \cdot F_{L_{Ee}} \end{bmatrix} = \begin{bmatrix} 331.187 \\ 165.593 \\ 4.878 \end{bmatrix}$$

Let us now expand the model by relaxing one assumption above – that all debt-servicing commitments are met – and by modelling the creation of money. For the sake of clarity, let us also treat each stage in the money-circulation process separately, introduce a graphical formalism for representing the monetary circuit,[9] and – as a prelude to modelling a credit crunch – use time lags in place of the parameters β, ω, l_R, and m_R.[10]

The creation of money

The key step in the creation of money is deceptively simple: credit money is created when the banking sector grants the firm sector new purchasing power, in return for the firm sector accepting that its indebtedness to the banking sector has increased by the same amount. This is introduced by adding to the model a new parameter, n_M,[11] to represent the annual rate of creation of money. As before, the system is developed in a double-entry bookkeeping table, but this time each row represents a distinct stage in the monetary-circulation process. We also carefully note the nature of each stage, which enables four distinct types of monetary transactions to be identified:

1. Interest on the firm sector's outstanding debt F_L accrues at the rate r_L. This is not a flow, but a ledger entry of compound interest: the right to add to the debt that is granted by the debt contract.
2. Interest is paid by the banking sector at the rate r_D on the firm sector's outstanding deposit account balance F_D. This is a contractual flow: no purchase or goods exchange is affected by it, but it is necessitated by the banking sector's obligations to its depositors.
3. The firm sector's payments of interest at the rate of r_L on its outstanding debt F_L is another contractual flow. The term $(1 - \delta_d)$ allows for the possibility that the firm sector's payments are insufficient to pay the full interest due (which reflects the failure of some firms to repay their debts, and can be a precursor to bankruptcy), and therefore the remainder of the debt-servicing obligation that is not met $(\delta_d \cdot r_L \cdot F_L)$ is capitalized in a ledger entry, and added to the outstanding debt.
4. The firm uses a proportion of its account balance F_D to hire workers, this proportion reflecting (i) the workers' share of the net surplus in production $(1 - s)$ (where $0 < s < 1$), and (ii) the time lag between laying out the money to finance production and receiving payment for commodities sold (shown here as τ_S, where this represents the fraction of a year the process takes). This is a commodity/service purchase flow: money flows one way (firm to worker) in return for labour flowing the other way in the factory sector, to produce commodities for sale by the firm sector.
5. Once workers have positive bank balances W_D, the bank sector is obligated to pay interest to them at the rate r_D.
6. Bankers and workers then spend a proportion of their bank balances buying commodities from the firm sector at the rates τ_B and τ_W respectively; these, like (4), are commodity/service purchase flows,

Table 9.4 Full model with money creation

	Assets			*Liabilities*			
	Loans (F_L)	*Vault* (B_V)	*Sum* (Σ)	*Deposits* (F_D)	(B_D)	(W_D)	*Sum* (Σ)
Accumulation	$r_L \cdot F_L$		$r_L \cdot F_L$				
Interest F_D				$r_D \cdot F_D$	$-r_D \cdot F_D$		0
Interest payment	$-(1-\delta_d)\cdot r_L \cdot F_L$		$-(1-\delta_d)\cdot r_L \cdot F_L$	$-(1-\delta_d)\cdot r_L \cdot F_L$	$(1-\delta_d)\cdot r_L \cdot F_L$		0
Wages				$-(1-s)\cdot F_D/\tau_S$		$(1-s)\cdot F_D/\tau_S$	0
Interest W_D					$-r_D \cdot W_D$	$r_D \cdot W_D$	0
Consumption				$B_D/\tau_\beta + W_D/\tau_\omega$	$-B_D/\tau_\beta$	$-W_D/\tau_\omega$	0
Loan repayment	$-F_L/\tau_L$	F_L/τ_L	0	$-F_L/\tau_L$			$-F_L/\tau_L$
Money relending	B_V/τ_M	$-B_V/\tau_M$	0	B_V/τ_M			B_V/τ_M
Money	$n_M \cdot F_D$		$n_M \cdot F_D$	$n_M \cdot F_D$			$n_M \cdot F_D$

with money flowing from workers and bankers to firms in return for commodities flowing in the other direction.

7. The firm sector can repay a proportion of its debt F_L at the rate τ_L.
8. The bank sector relends at the rate τ_M from its vault; this loan is a transfer of money from B_V to F_D, which the bank then records on its debt ledger F_L as a corresponding increase in the firm sector's indebtedness.
9. Lastly, the bank sector can grant new credit to the firm sector at the rate $n_M \cdot F_D$.[12] The additional debt is shown by an equivalent entry in the debt ledger, so that both bank assets and bank liabilities grow by the same amount.

The relevant book entries are shown in Table 9.4.

These nine stages can be represented by four distinct types of transfers:

1. Ledger entries, which are not actual flows of money but are obligated by the contractual relations in the monetary system. Thus compound interest on a loan is not a flow, but a legally enforced right that the loan contract gives to the bank to compound the level of debt at the agreed rate of interest. For this class of relationship we use the symbol - - -▸.
2. Flows of money that are driven, not by the amount of money in either the source or recipient account, but by the amount outstanding on the debt ledger. Here we use the symbol ■—▷.

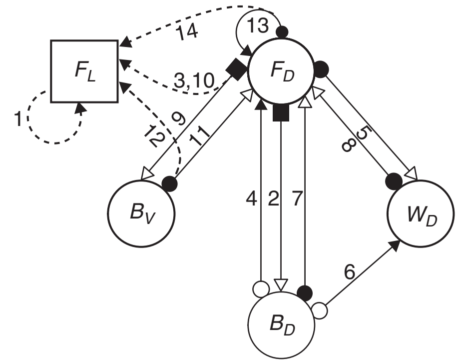

Figure 9.3 The four types of flow dynamics: - - -▸: ledger entry induced by source variable; ■—▹: cash flow induced by destination variable; ○—▸: cash flow induced by source variable; ●—▹: cash flow induced by ledger entry

3. Flows where the rate of flow is a function of the amount of money in the recipient account, indicated by ○—▸ in Figure 9.3. These again are not flows as economists have conventionally thought about them – that is, as money flowing in one direction in return for goods flowing in the other direction – but instead are a function of the legal relationships in finance, where in return for depositing funds at a bank, the bank is obliged to pay interest on the amount of the deposit.
4. Flows where the rate of flow is a function of the amount of money in the source account are indicated by ●—▹. These alone are flows as economists conventionally think of them: money flows from one account to another in return for work (payment of wages), goods (consumption by workers and bankers), or in return for accepting the legal responsibility of new debt.

Table 9.5 shows the 14 relationships in the monetary circuit using this graphical system. These 14 related flows are represented graphically in Figure 9.3.

As before, the equations of motion of this system can be constructed by simply adding up the columns of Table 9.4:

$$\frac{d}{dt}F_L = r_L \cdot F_L - (1-\delta_d) \cdot r_L \cdot F_L - \frac{F_L}{\tau_L} + \frac{B_V}{\tau_M} + n_M \cdot F_D$$

$$\frac{d}{dt}B_V = \frac{F_L}{\tau_L} - \frac{B_V}{\tau_M}$$

Table 9.5 Links and types of links in full model

Number	*Source*	*Link*	*Type*	*Destination*	*Formula*	*Description*
1	F_L	- - -▸	1	F_L	$r_L \cdot F_L$	Ledger recording of compound interest
2	F_D	■—▷	2	B_D	$(1-\delta_d) \cdot r_L \cdot F_L$	Payment of interest on outstanding debt
3	F_D	- - -▸	1	F_L	$(1-\delta_d) \cdot r_L \cdot F_L$	Ledger recording of interest payment
4	B_D	○—▸	3	F_D	$r_D \cdot F_D$	Interest on firm sector's deposit account
5	F_D	●—▷	4	W_D	$\frac{1-s}{\tau_S} \cdot F_D$	Wages paid to workers
6	B_D	○—▸	3	W_D	$r_D \cdot W_D$	Interest on workers' deposit accounts
7	B_D	●—▷	4	F_D	$\frac{B_D}{\tau_\beta}$	Consumption by bankers
8	W_D	●—▷	4	F_D	$\frac{W_D}{\tau_\omega}$	Consumption by workers
9	F_D	■—▷	2	B_V	$\frac{F_L}{\tau_L}$	Repayment of debt
10	F_D	- - -▸	1	F_L	$-\frac{F_L}{\tau_L}$	Ledger recording of repayment of debt
11	B_V	●—▷	4	F_D	$\frac{B_V}{\tau_M}$	Relending from bank vault
12	B_V	- - -▸	1	F_L	$\frac{B_V}{\tau_M}$	Ledger recording of bank relending
13	F_D	●—▷	4	F_D	$n_M \cdot F_D$	Creation of money
14	F_L	- - -▸	1	F_L	$n_M \cdot F_D$	Creation of new debt

$$
\begin{aligned}
\frac{d}{dt}F_D &= r_D \cdot F_D - (1-\delta_d) \cdot r_L \cdot F_L - \frac{1-s}{\tau_S} \cdot F_D + \frac{B_D}{\tau_\beta} + \frac{W_D}{\tau_\omega} \\
&\quad - \frac{F_L}{\tau_L} + \frac{B_V}{\tau_M} + n_M \cdot F_D \\
\frac{d}{dt}B_D &= -r_D \cdot F_D + (1-\delta_d) \cdot r_L \cdot F_L - r_D \cdot W_D - \frac{B_D}{\tau_\beta} \\
\frac{d}{dt}W_D &= \frac{1-s}{\tau_S} \cdot F_D + r_D \cdot W_D - \frac{W_D}{\tau_\omega}
\end{aligned}
$$

The transaction-account dynamics of this model are shown in Figure 9.4, and the income dynamics in Figure 9.5.

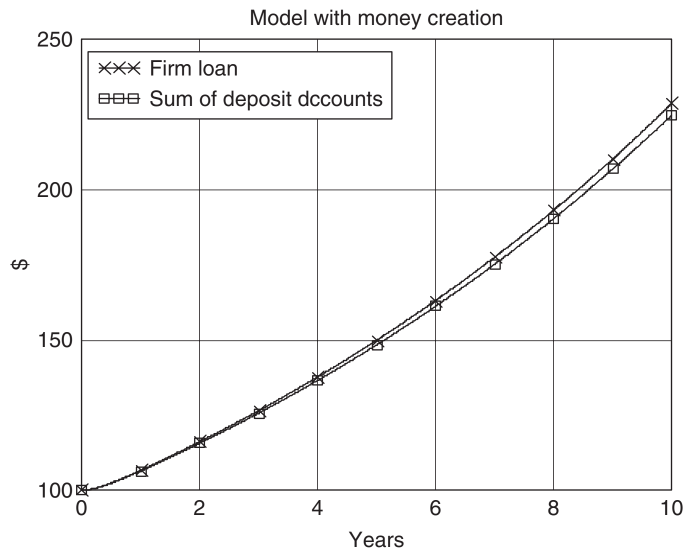

Figure 9.4 Loan and deposit dynamics with money creation

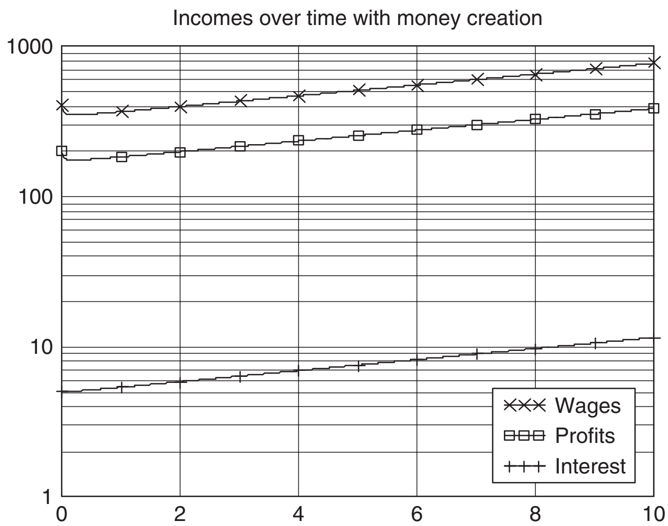

Figure 9.5 Income dynamics with money creation

As is obvious, both transaction-account balances and incomes grow over time, so that a growing stock of money finances a growing level of real economic activity – which, in this model, is treated as implicit (the increasing stock of money is enabling an increasing level of employment and flow of goods). One realistic difference between this and the previous no-growth model is the divergence between loans and deposits. Loans equalled deposits in the previous model because of the unrealistic assumption that the firm sector precisely met its debt-repayment obligations. Relaxing this assumption, by allowing that a proportion δ_d of repayments are not made, gives a result which accords with actual economic data, namely, that loans exceed deposits.[13]

As it stands, this model shows that the circuitist vision fills its objectives of showing the essentially monetary nature of capitalism, and explaining how the surplus generated in production is monetized by the process of monetary circulation. It is, however, a skeletal model, in that the behavioural parameters in the model – the values of τ_B, τ_W, τ_L, and so on – are constant. Flesh can be added to the skeleton by making these values functions of time, and of other system states. The full development of this model is a work in progress, but its potential can be demonstrated here by using it to model a credit crunch.

A 'credit crunch'

There is no doubt that the US economy began to experience a 'credit crunch' in late 2007 – a process marked by a sudden switch from the willing provision of new debt to an unwillingness by lenders to lend, and a sudden switch from risk-seeking to risk-averse behaviour by borrowers.

These basic phenomena can be modelled in this framework by changing several of the model's key parameters:

1. Reducing the value of the money-creation parameter n_M, to signify a reduced willingness by lenders to lend.
2. Increasing the time lag for the relending of repaid debt τ_M, to signify the same reluctance.
3. Reducing the time lag for debt repayment τ_L, to signify a desire by borrowers to reduce their debt exposure.
4. Increasing the value of δ_d, to signify an increase in the proportion of firms that fail to meet their interest-payment commitments.

In the following simulations, all key parameters were altered by a multiplier of 3: thus at the time of the credit crunch, the rate of money

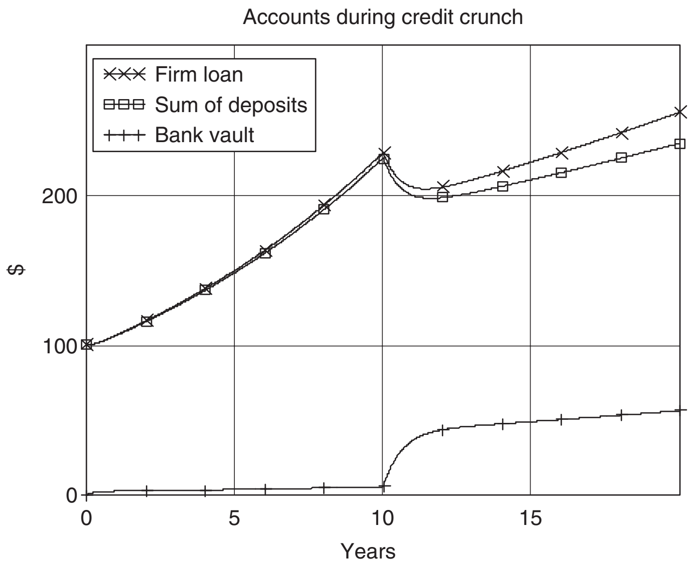

Figure 9.6 Loan and deposit dynamics during a credit crunch

creation and the rate of recycling were reduced by two-thirds, while the rate of repayment of outstanding debt and the level of non-payment of interest tripled.

As Figures 9.6 and 9.7 indicate, the changes to these parameters do indeed simulate a 'credit crunch', with a sudden and sharp drop in both the amount of money in circulation and loans, and a sudden rise in the level of inactive funds in the bank vault. As accounts drop, so do incomes; ultimately, both accounts and incomes return to pre-crunch levels, but after a substantial time lag and with a slower rate of growth (given the lower monetary-parameter values).

It is also possible to show, with a rudimentary production system, that this monetary phenomenon has real effects.

The monetary to real transmission mechanism

Linking this model of monetary dynamics to a model of real output necessarily raises the vexed issue of a price mechanism. As is well known, there is a sharp divide between neoclassical economists, who posit a supply and demand mechanism for price determination, and post-Keynesian economists who, in line with Kalecki, posit a

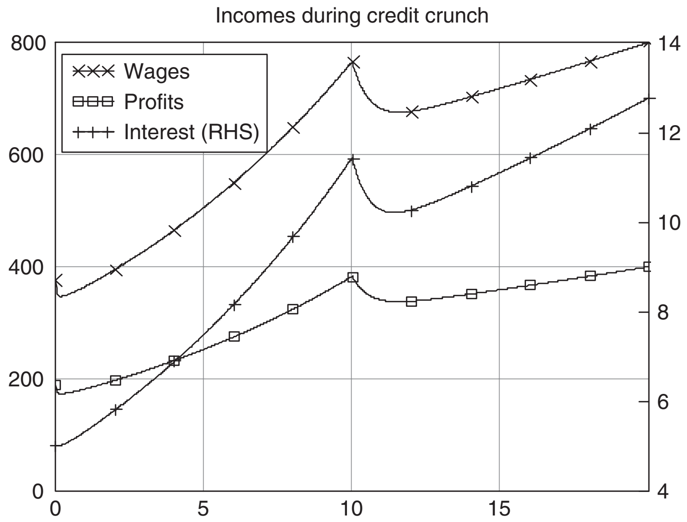

Figure 9.7 Income dynamics during a credit crunch

cost-plus analysis,[14] – with empirical research strongly supporting the latter perspective (see Lee, 1998). For the sake of simplicity, the model presented below uses a 'neoclassical' mechanism, but with a surprisingly non-neoclassical outcome.

The key links between the monetary sector and the real sector in this model are as follows:

1. The flow of wages sustains a stock L of workers hired for a wage W who produce output Q in factories, so that $Q = a \cdot L$, where a represents labour productivity.[15]
2. The output is then sold to capitalists, workers, and bankers with a price level P that responds with a lag τ_P to the gap between the monetary value of output $(P \cdot Q)$ and demand, where this is the sum of the commodity-expenditure flows from the three classes of agents in the model.[16]

The equations needed to include these links are three algebraic relations for output, labour, and demand,[17] and one additional differential equation for prices:

$$Q = a \cdot L$$

$$L = \frac{s}{\tau_S} \cdot \frac{F_D}{W}$$

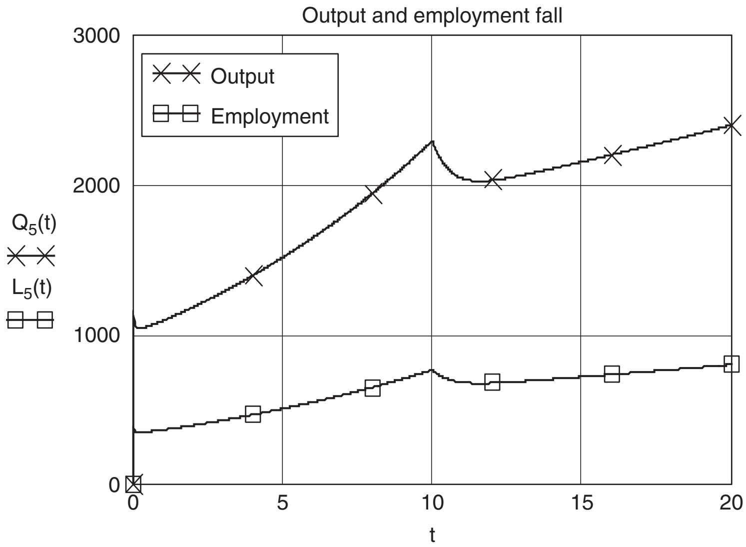

Figure 9.8 Output and employment with a credit crunch

$$\frac{d}{dt}P = -\frac{1}{\tau_P} \cdot P \cdot \left(\frac{Q - D/P}{Q}\right)$$
$$D = \frac{s}{\tau_S} \cdot F_D + \frac{B_D}{\tau_\beta} + \frac{W_D}{\tau_\omega}$$

Output and employment behave as one would expect in a credit crunch, falling abruptly (Figure 9.8). Against expectations, the price index rises rather than falls because of the credit crunch (Figure 9.9). A neoclassical pricing mechanism thus has a distinctly non-neoclassical outcome in this dynamic setting. Neoclassical economists might surmise that this is an artefact of the wage rate W being a constant in this model, and that were the wage flexible downwards, the credit crunch would indeed be absorbed by a price adjustment with little or no effect on output and employment. A more general model would be needed to theoretically evaluate this likely rebuttal, but a very strong empirical case can be made that falling wages would only exacerbate the impact of a credit crunch.

The real-world credit crunch

As Keynes (1936, pp. 268–9) argued:

> [t]he method of increasing the quantity of money in terms of wage-units by decreasing the wage-unit increases proportionately the

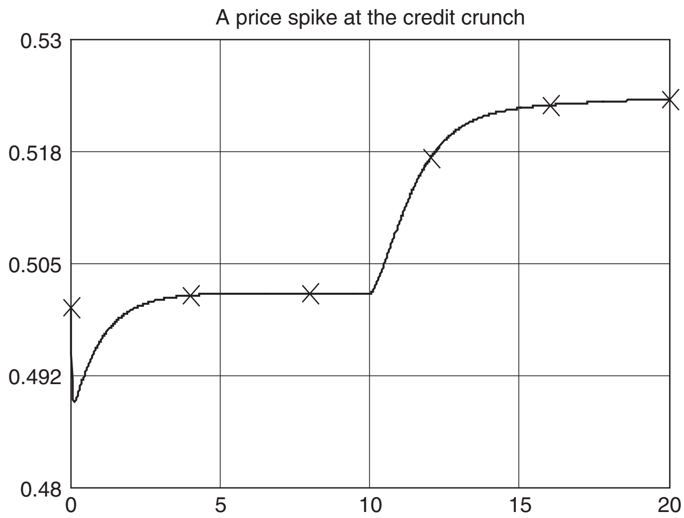

Figure 9.9 Price dynamics with a credit crunch

> burden of debt; whereas the method of producing the same result by increasing the quantity of money whilst leaving the wage-unit unchanged has the opposite effect. Having regard to the excessive burden of many types of debt, it can only be an inexperienced person who would prefer the former.

Keynes's stricture against reducing money wages during a debt-induced downturn is all the more valid today. Not only would a reduction in money wages reduce the price level – and thus increase the debt-repayment burden – but also today, workers are debtors to an unprecedented degree.

The United States is tottering under the weight of the greatest debt burden in its financial history (and several OECD countries are in a similar or worse state). As Figure 9.10 indicates, the US current debt levels (relative to GDP) exceed even that reached during the Great Depression, when plunging real output and deflation running at over 10 per cent per year increased the private-debt-to-GDP ratio from 150 per cent in late 1929 to 215 per cent by 1932.

That burden is disproportionately borne by households, and workers, when compared to any previous speculative bubble. At the time of writing the ratio of household debt to GDP is almost twice the peak it reached during the Great Depression, and courtesy of the 'subprime

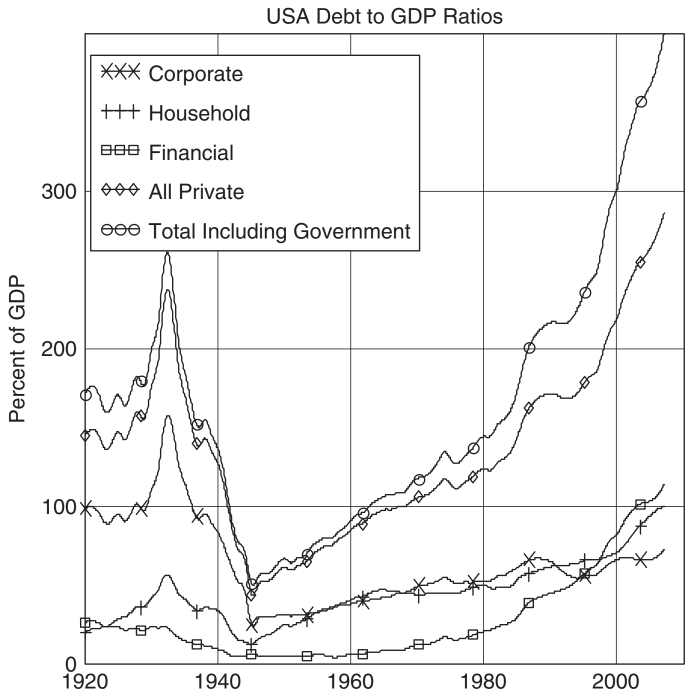

Figure 9.10 Long-term US debt-to-GDP ratios

loans' phenomenon, a large proportion of that debt is owed by middle-to-low-income earners. A reduction in money wages would further reduce their capacity to service their debts, which would only add to the deflationary impact of the US excessive debt.

Concluding remarks

This chapter has shown how the monetary circuit framework can explain what Graziani (1989) set out to explain: the process by which the surplus generated in production is monetized. This, however, is merely the first step in explaining the dynamics of a monetary production economy. The basic skeleton of a pure credit economy given here can be enriched further by disaggregating the banking sector – and therefore introducing another set of triangular relations between banks and a central bank that fulfils the role of a settlement institution between banks – and by disaggregating production to capture intersectoral financial dynamics.

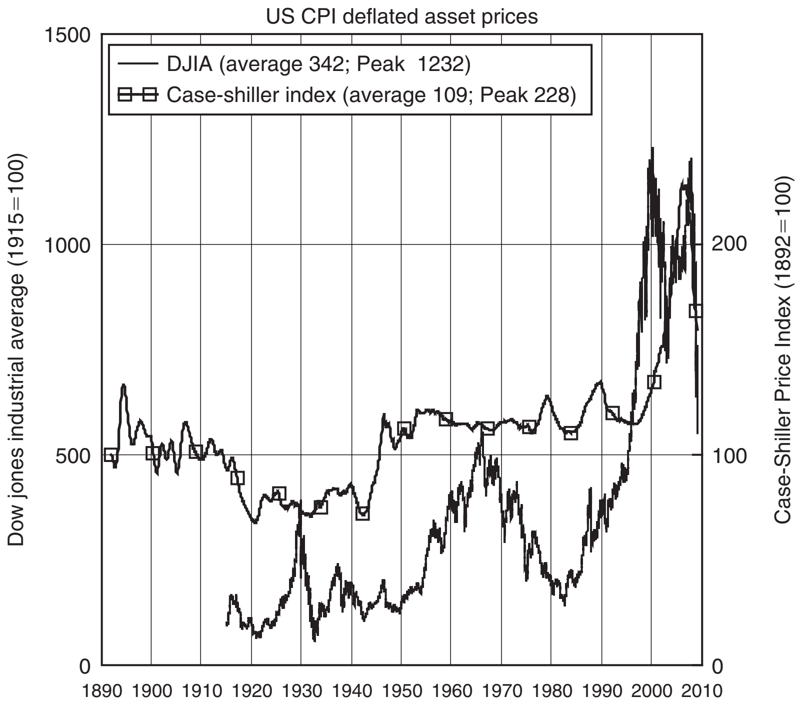

Figure 9.11 US asset prices deflated by CPI

The creation of fiat money has to be added to model the actual mixed credit–fiat economy in which we live.

Most important, from the point of view of explaining the modern phenomenon of what is surely the greatest speculative bubble of all time, borrowing purely for the sake of speculation has to be added to the production-oriented borrowing that is the focus of this model. Ponzi-financing, which plays such a key role in Minsky's 'financial instability hypothesis', has been the driving force behind the unprecedented accumulation of debt (relative to income) that is the hallmark of our times.

This borrowing is driven by expectations of asset-price appreciation, and the bubble itself drives that price appreciation. The scale of the debt is obvious from Figure 9.10; the scale of the asset-price-appreciation bubble can best be seen by applying one key aspect of Minsky's hypothesis, namely, that there are two price levels in capitalism – one for commodities, the other for capital assets – and deflating asset prices by the consumer price index (Figure 9.11). The results are truly dramatic. In stark contrast to Greenspan's well-known remark that an asset bubble cannot be identified until after it has burst, the bubbles in both the share and housing markets were obvious by mid-1994 and 1996 respectively. By mid-1995 and 2000, they had reached levels that had never previously been experienced. By the time they burst, they were 3.7 and 2.1 times their long-term averages. What is opaque from a neoclassical/Austrian perspective is obvious from a Minskian standpoint.

The endogenous creation of credit money – fuelled by appreciating asset prices that are themselves a product of the expansion of credit money – is an essential aspect of this process. For that reason alone, our model of capitalism must be a monetary one. Keynes made the case, Minsky explained the dynamics, and Graziani gave us the *ab initio* principles on which a monetary analysis of capitalism must be based. The current, almost surely secular crisis adds urgency to the task of developing a true understanding of the monetary dynamics of capitalism.

Notes

1. We are not endorsing a labour theory of value here, which in fact we explicitly reject (see Keen, 1993). However, Marx's insight that surplus is the source of profit transcends the veracity of the labour theory of value.
2. The volume written by Godley and Lavoie (2007, p. 1) opens with the wonderful remark by Kalecki that economics 'is the science of confusing stocks with flows'.
3. As Yakovenko (2007, p. 5) notes, '[t]he physical medium of money is not essential here', and a more natural analogy for the pure credit system outlined here is a completely electronic banking system. The physical analogy, however, better makes the mental point that the destruction of money when a debt is repaid does not make sense. Such systems existed in nineteenth-century America (Chown, 1944, pp. 181–90) – though many such banks clearly behaved in ways that amounted to seigniorage.
4. The fact that some parameter values exceed 1 is explained later.
5. This means that the time lag between producing output and earning revenue from selling it is equal to two months.
6. With the parameter values used in this simulation, the velocity of money commences at 6.05 and converges to 5.142 – so annual incomes are equivalent to 5.142 times the stock of deposits.
7. In this simulation l_R equals 10 per cent.
8. These are not reserves in the modern institutional sense – as they cannot be lent out – but the reservoir of funds that would accumulate as loans were repaid in a pure credit system, which could then be lent out again. In the following simulation, we set m_R equal to 4, which means that the stock of inactive money turns over four times per year.
9. This method was developed for another paper in conjunction with Dr Jeffrey Dambacher of Australia's CSIRO (Commonwealth Scientific and Industrial

Research Organization), and is based on the qualitative dynamic modelling approach developed in mathematical biology.

10. The term ω represented how many times workers' expenditure turned over in the time frame of the model. Thus $\omega = 26$ meant that workers spent their wages 26 times per year. In a time lag formulation, this is restated as '$\tau_W = 1/26$', so that the turnover period for workers' expenditure is 1/26th of a year – or equivalently that workers spend their wages every two weeks.
11. We assume that $n_M = 0.1$, so that the rate of creation of money is 10 per cent per year.
12. This could equally be shown as being proportional to debt ($n_M \cdot F_L$).
13. In a more complete model, this would in part be attenuated by incorporating bankruptcy (which reduces debt without reducing money), and amplified by capital raisings by the banking sector – which increases bank reserves by transferring funds from deposits (thus reducing them) without reducing the level of loans.
14. Kalecki's position is much richer than just this of course, with an allowance for at least two price mechanisms, and variable mark-ups (Kalecki, 1942, pp. 126–7). See Kriesler (1987) for a thorough exposition and Keen (1998) for a proof that contra Kalecki's price dynamics are compatible with input–output dynamics.
15. Capital is taken for granted in this simple model. Of course, in a more realistic and necessarily multi-sectoral model, production would depend as well on a stock of machinery and a flow of commodity inputs.
16. In this simple model, capitalists are assumed to spend their share of the monetized value of the surplus $s/\tau_S \cdot F_D$ on commodities.
17. A more complete model would make these differential equations with their own time lags.

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