



Economic Studies Conference

What's Wrong with Modern Macroeconomics



6 - 7 November 2009 CESifo Conference Centre, Munich

Liquidity Constraints and Non-Market Clearing: A Recipe for Recession?

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July, 2009 Revised October 2009

Abstract

In their ‘workhorse model of money and liquidity’, Kiyotaki and Moore (2008) show how a tightening of credit constraints can cut current investment and future aggregate supply. Despite these fluctuations in investment, however, aggregate demand matches current supply via a flex-price ‘Pigou effect’ that changes the value of real balances and so consumption. By switching from a flex-price to a fix-price characterisation of goods and labour markets, we find that demand failure can emerge after a liquidity shock.

This extension of the KM framework offers an alternative ‘workhorse’ macro-model to that of Michael Woodford: it is in fact an updated version of Bernanke and Blinder (1988).

Keywords: Credit Constraint; Temporary Equilibrium; Liquidity Shock; Asset Mispricing.

JEL codes: B22, E12, E20, E30, E44.

Acknowledgements

We are grateful to Peter Hammond, Andrew Powell and Alessandro Ribucci for comments; and to Han Hao Li, Giovanni Melina, and Federico di Pace for research assistance, funded by World Economy and Finance programme of the ESRC.

Introduction

In *The Winter's Tale*, Leontes king of Sicilia - maddened with jealousy - imprisons his wife Hermione and exiles their new-born daughter, whereupon the queen falls into a faint and is carried to a chapel nearby. With her reported death, the chapel is visited regularly by the now-contrite king. When sixteen long years have passed, the banished daughter returns, and queen Hermione reveals herself to be alive, though disguised at first as a temple-statue; but soon reconciliation is finally achieved.

Like the queen of Sicilia, the Keynesian policy paradigm of macroeconomic stabilisation has suffered in silence for many years now. Discredited and discarded in the stagflation that followed the oil price shocks of the 70s and 80s, it has nevertheless been preserved in textbooks as a dumb memento from times past. A new and seemingly successful paradigm has emerged meantime; and, for many years and in many countries, there has been a Great Moderation of inflation. Now that this new paradigm is challenged by a severe global credit crunch – which it failed to predict and cannot explain - important questions arise. Will the theory of macro stabilisation be revived – and if so in what form? Can it be reconciled with the DSGE paradigm?

Section 1 The reigning paradigm

Woodford's masterly monograph on *Interest and Prices*, published in 2003, was the capstone of a decisive shift in monetary economics from looking at the quantity of money to the cost of borrowing (i.e. from Friedman back to Wicksell). More than that, the framework - the embodiment of the new paradigm – is inspired by an over-arching vision: to create a new synthesis reconciling mainline macroeconomics with dynamic General Equilibrium, as practised by Real Business Cycle theorists in particular. Replacing the Keynesian IS curve by the inter-temporal Euler equation of a representative household with rational expectations is a potent symbol of this

synthesis.¹ The omission of ‘money’ from the title of Woodford’s monograph is another. Inertia in the adjustment of wages captured by the Phillips curve is retained, however.

The key elements of the new paradigm are indicated in schematic form, in Table 1 below, where the boxes in bold type indicate the key elements Woodford has selected from the RBC approach (in the first row), and from the orthodox Keynesian approach (in the second).

	Supply conditions	Goods market	Money market
RBC (representative agent with RE)	Productive efficiency (Flex-price, FE)	Inter-temporal optimisation (Euler equation)	Efficient contracts (money an epiphenomenon)
Keynesian Orthodoxy	Fix-price, UE (Phillips curve)	Agg. Demand (IS)	Liquidity Preference (LM)

Table 1 Woodford’s synthesis: the New Paradigm

The combination of optimising behaviour by a representative agent with model-consistent or rational expectations leads to the comforting conclusion that the private economy is fundamentally stable: the risks to stability that Woodford discusses arise in the public sector - from unchecked public spending, for example, or inappropriate interest rate setting by the Central Bank.

With the device of a representative agent ruling out the need for private sector financial intermediation, adding the Euler condition of inter-temporal efficiency may seem innocuous enough. But as Kiyotaki (1998) points out, it means that, courtesy of the DSGE paradigm, macroeconomics has effectively followed in the footsteps of General Equilibrium theory where – as in Debreu’s *Theory of Value* – the static model of trade in goods and services is elegantly and effortlessly extended over time (and states) without regard to issues of asymmetric information, contract enforcement and default.

¹ Effectively the Keynesian consumption function of the *General Theory* is replaced by the ‘Ramsey Rule’ published in 1928.

What if – perish the thought! – this extension should be the Achilles heel of dynamic General Equilibrium? What if – in the absence of collateral or other credible enforcement – the ‘core’ of the inter-temporal GE model is not sub-game perfect, as Peter Hammond (1979) put it in his reflections on Frank Hahn’s inaugural lecture²? Well then – in his words – Humpty Dumpty will have a great fall! But not just GE as we know it: so too the synthesis so carefully constructed by Woodford and his co-workers to be GE-compatible.

Does it matter? As credit crunch triggers global recession, the crucial role played by finance in oiling the wheels of the world economy has been demonstrated beyond doubt. In the sixteen months to mid-2009, for example, the US unemployment rate doubled from 4.8 per cent to 9.5 percent, and, according to one observer, ‘the rate may not peak until 2010, in the 10.5-11 percent range.’³ In the view of some economic historians, indeed, “the world is currently undergoing an economic shock every bit as big as the Great Depression shock of 1929-302”, Eichengreen and O’Rourke (2009).

“The good news”, they add, “is that the policy response is very different”; and they go on to show how much more sharply interest rates have been cut and fiscal deficits expanded than in the 1930s – see Figures 1 and 2.

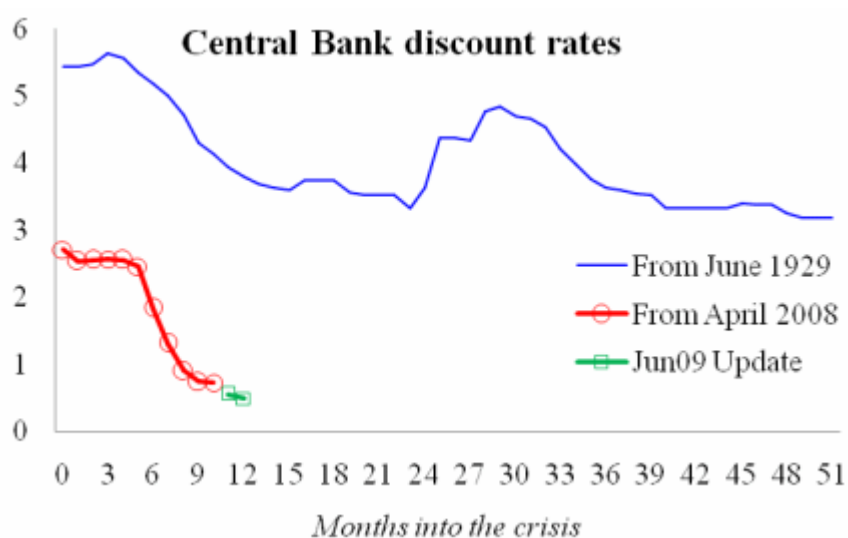


Figure 1 Central Bank Discount Rates – Now and Then

² ‘On the Notion of Equilibrium in Economics’

³ Mohamed El-Arian, ‘American jobs data are worse than we think’ FT July 3, 2009

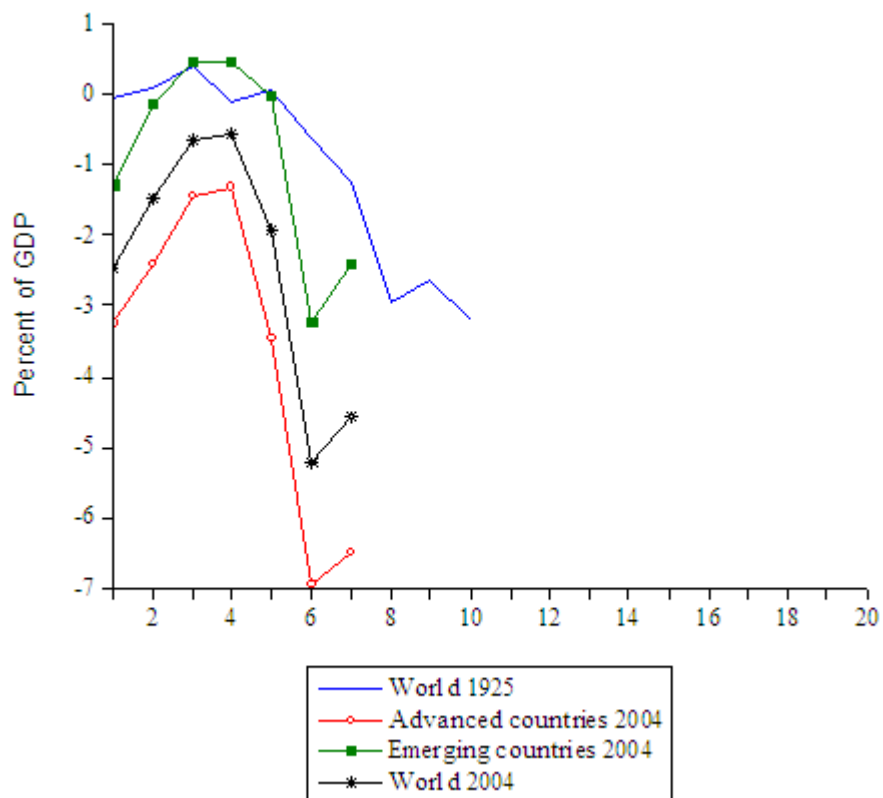


Figure 2 Budget Surpluses and Deficits -- Now and Then

In addition, there has been extraordinary financial intervention to avoid systemic collapse of the financial systems. Figures for the US and UK, published by the Bank of England, indicate that in total the intervention involves commitments of about three quarters of GDP, table 2.

Table 2. Size of financial system support measures

Trillions (local currencies)

	<u>United Kingdom</u>		<u>United States</u>	
	Jan. 2007	Latest 2009	Jan. 2007	Latest 2009
Available central bank support				
Current direct lending to financial institutions	0.05	0.10	0.04	0.44
Asset purchases and other loans	–	0.15	–	3.32
Collateral swaps	–	0.19	–	0.20
Central bank currency swap lines	–	No limit	–	No limit
Available government support				
Guarantees of financial institutions' liabilities	–	0.37	–	2.08

Insurance of financial assets	–	0.46	–	3.74
Capital injections to banks and special purpose vehicles	–	0.06	–	0.70
Increase in public sector support	–	1.26	–	10.44
Memo: US dollar amount	–	2.06	–	10.44
Percentage of GDP	–	88%	–	73%
Memo: Actual size of central bank's balance sheet	0.09	0.22	0.91	2.09
Percentage of GDP	6	15	7	15

Source: *Bank of England Financial Stability Report* (2009, June, p.20).

These acts of monetary and fiscal stabilisation policy owe little if anything to the synthesis that DSGE symbolises, where financial intermediation is irrelevant and fiscal policy ineffective. If the new paradigm has failed to connect with these world-shaking macroeconomic developments, what are the alternatives?

Woodford has recently proposed a revision of his approach which introduces heterogeneous agents and financial frictions, Cúrdia and Woodford (2008). Rather than entering the fray aroused by this attempted revision, see Goodhart (2008), we consider instead the reconstruction of monetary theory to include credit constraints offered by Kiyotaki and Moore (2008), hereafter KM.

Section 2 The Kiyotaki and Moore temporary equilibrium approach

We begin by observing that the KM approach effectively describes another, different synthesis. The authors explicitly say they do not want to stray too far from RBC - and they assume flexible prices and full employment. But the postulation of credit constraints on workers and entrepreneurs leads to a short-run equilibrium described by equations for goods and money market clearing – rather like IS/LM curves. With reference to Table 1, indeed, it appears that the resulting synthesis is the exact complement of that proposed by Woodford! Production is relatively efficient, thanks to the flexibility of wages and prices, but credit constraints limit the degree of impact of inter-temporal optimization, and lead to a precautionary demand for money. As the reformulated relations do include some inter-temporal optimisation, it would be

wrong to conclude that it is a return to the *status quo ante*. Better to think of it as a sketch of sub-game perfect general equilibrium, or SPGE!

In what follows, we briefly outline the key features of this reconstruction and then suggest two significant modifications.

As an **alternative to the representative agent assumption**, the key idea is that investors are *ex ante* identical, but only a fraction actually turn out have ideas that will generate investment in the next period. This is rather like the specification of Diamond and Dybvig (1983) in their classic paper on banking, where agents identical *ex ante* turn out to have patient or impatient consumer preferences. Here the application is to investment not consumption, but, as for Diamond and Dybvig, there is no insurance market to handle the risk (of needing cash in a hurry).

Rational expectations prevail in the stock market; but **credit markets are far from perfect**. Workers choose not to hold money and they cannot borrow: so **households are income constrained** with all wages are spent on consumption. Firms can optimise over time but they face limits both in terms of new shares they can issue and in terms of reselling the shares of others (and there are no banks to supply loans). To ensure that investment opportunities are not wasted, firms therefore adopt precautionary strategies: in particular they hold money. Prices and wages are perfectly flexible and the markets for goods and labour both clear.

These constraints on inter-temporal arbitrage lead to a Hicksian type of temporary equilibrium analysis, in two respects. First - as the future is, for most agents, cut off from the present - one looks at money and goods market equilibrium in the short run. Second, as there liquidity risks that cannot be insured, there is a precautionary demand for money.

What emerges is a model where shocks to credit and goods markets interact to determine short-term equilibrium. In sharp contrast to the fix-price Hicksian IS/LM approach, however, prices and wages are perfectly flexible and there is **continuous**

market clearing with full employment. What goods and money markets determine is the real price of equity and the aggregate price level⁴.

One implication of these market imperfections demonstrated by KM comes from imposing infinitely repeated, deterministic and predictable shifts in productivity. The consumption- smoothing predicted by RBC is blocked by the credit constraints: real share prices adjust to ensure pro-cyclical investment, but the price level moves counter-cyclically – as one might expect under a flex-price model where the quantity of money is fixed and output fluctuates.

Of more immediate interest are the effects of unanticipated liquidity shocks, modelled as stochastic changes in the ‘resaleability constraint’ affecting corporate investment. On such matters RBC models may be silent, but in KM model, unanticipated credit constraints cut investment and the real value of shares, but full employment prevails, however. “Because output is not affected with full employment,” we are told, “consumption increases to restore goods market equilibrium”. How so? As the price level falls and the real value of money increases, it seems that there’s a Pigou effect at work here increasing the consumption of entrepreneurs.

Section 3 Two significant modifications.

How do we adapt the framework just described? The first modification is to **drop the assumption of perfectly flexible prices and wages** in favour of nominal rigidity⁵: Woodford uses Calvo contracts, we use a fix-price approach.

Why assume perfect flexibility of wages and prices and continuous market-clearing in the first place? The answer surely lies in the rules of the academic game, where relaxing too many key assumptions of the paradigm at once is not seen as scientifically progressive⁶. To show that – in the presence of credit constraints - monetary policy can have real effects even with perfect flexibility of wages and prices and continuous market-clearing is theoretically impressive. But, from the perspective

⁴ Similar, in this respect, to the flex-price variant discussed in Blanchard’s 1981 paper on output and the stock market.

⁵ See Bewley(2002) , for example or the discussion in Akerlof and Shiller (2009).

⁶This observation we owe to Jordi Gali.

of macroeconomics rather than monetary theory, there is a different question worth posing: can the framework Kiyotaki and Moore have developed be used so as to achieve a synthesis between DGE and orthodox macroeconomics?

This is, of course, the challenge that Woodford took up in writing his monograph at a time when inflation was seen as the central problem in macroeconomics: now, at a time of recession and unemployment, one looks for a different synthesis.

The result of dropping the assumption of flexible wages and prices is immediate. A credit crunch will cut investment *and consumption*, so there will be underused resources. Since the impact of a liquidity squeeze can be seen in terms of its effects on aggregate demand and on portfolio balance, what emerges is a type of updated IS/LM analysis whose origins lie in RBC. The framework we discuss below is effectively an updated version of Bernanke and Blinder (1988) incorporating both credit constraints and intertemporal optimisation.

Our second - more controversial - modification is to **drop the rational expectations assumption** as applied to the stock market. As Koo (2008) has pointed out with respect to Japan in particular, bursting asset bubbles are another key ingredient for recessions⁷.

Does it matter that banks are omitted?

Before proceeding further, consider the objection that this approach ignores the potential role of banks in providing liquidity insurance. For consumers who are *ex post* heterogeneous this was shown in the classic paper by Diamond and Dybvig. By postulating the existence of banks, won't the liquidity problems faced by heterogeneous investors disappear? Would that the world were that simple! For, as Diamond and Dybvig warned, the banks supply of liquidity insurance is subject to spectacular coordination problems in the form of bank runs⁸. Moreover, the explicit or implicit promise by the authorities to insure the banks themselves (FDIC guarantees or lender of last resort facilities) can, in turn, have perverse effects on

⁷ The balance sheet effects of a bubble collapsing on highly indebted firms is explored in Miller and Stiglitz (2009).

⁸ For the view that the current credit crisis is largely a run on shadow banks, see Milne (2009).

banks incentives, Hellman, Murdock and Stiglitz (2000). Far from solving the problem facing investors, banks can make things worse – as they appear to have done under regulatory regimes operating with a ‘light touch’. In these circumstances, leaving banks out of the frame while looking at the impact of credit constraints seems a reasonable compromise!

Section 4 Non Market Clearing in a fix-price context: the model

The flex-price assumption of the workhorse model of Kiyotaki and Moore may be theoretically attractive, but makes no claim to historical realism. The fit of the original Phillips curve to UK data 1861 -1913, provides empirical evidence for sticky prices under the Gold Standard for example⁹. More recently, New Keynesian macro-economists like Woodford have chosen to capture wage-price stickiness by the analytical device of Calvo contracts, which allow for revision in response to expected future events. For present purposes, we adopt a simpler fix-price perspective.

With money wages and prices fixed, goods and labour markets may fail to clear, as in fix-price macroeconomics of the 1970s for example. There will be no Pigou effect to stabilise aggregate demand in the face of a fall of investment if prices are inflexible downward: and a fall in demand will contract employment if the real wage is determined by bargaining, as in Layard and Nickell (1987) and Manning (1990). For convenience, we assume that at full employment the bargaining wage is the market clearing wage; and that this real wage is maintained even when the demand for labour falls.

In this case, the two equations of the KM model will determine real price of equities and output (not price level and the equity price), conditional on the credit constraints. Before considering how a liquidity squeeze on investors can lead to recession, we discuss the nature of goods market equilibrium, GM, determining output and asset market equilibrium, AM, describing portfolio balance.

⁹ As the breakdown of the Phillips Curve in the 1980s suggests, however, such price stability is regime dependent.

(a) Aggregate demand for net output and goods market equilibrium¹⁰

For a firm with production function

$$y_t = A_t k_t^\gamma l_t^{1-\gamma}$$

which adjusts output by varying employment at a constant real wage w , the residual income available to entrepreneurs (x), the excess of production over the wage bill, varies with y as follows:

$$x(y_t; w_t, k_t) = y_t - w l_t = y_t - w \left(\frac{y_t}{A_t} \right)^{\frac{1}{1-\gamma}} k_t^{-\frac{\gamma}{1-\gamma}}$$

Expressed as a rate of return on the (constant) capital employed, this may be written for brevity as

$$r_t = r(x_t) = \frac{x_t}{k_t} = \frac{y_t}{k_t} - w \left(\frac{y_t}{A_t k_t} \right)^{\frac{1}{1-\gamma}}$$

which is increasing in y_t in the range from 0 to the point where the marginal product of labour equals the real wage.

Turning to aggregates, assume that (for $q_t > 1$) aggregate demand for investment is given by KM (2008, equation 22):

$$(1 - \theta q_t) I_t = \pi \left\{ \beta \left[(r_t + \lambda \phi_t q_t) K_t + p_t M_t \right] - (1 - \beta) (1 - \phi_t) \lambda q_t^R K_t \right\}$$

where K_t and M_t refer to the total stock of capital and money and it is assumed that the gross investment is non-negative. Goods market equilibrium, GM, the balancing the net output of goods with the demand for investment *plus* consumption from the two types of entrepreneurs, is given by their equation 23, which can be written as follows:

$$r(x_t) K_t = I_t + (1 - \beta) \left\{ \left[r(x_t) + (1 - \pi + \pi \phi_t) \lambda q_t + \pi (1 - \phi_t) \lambda q_t^R \right] K_t + p_t M_t \right\}.$$

¹⁰ i.e. output *less* what is consumed by employees, $y_t - w l = \pi_t$

where the variable q_t^R is defined as $q_t^R = \frac{1-\theta q_t}{1-\theta}$. While in the flex price case the rate of return is a function of K_t and the productivity parameter A_t , here it depends on the variable level of net output x_t .

If, in addition, the price level is fixed, then there will be no Pigou effect to ensure full employment. Assume the level of output (and hence the return on capital) adjusts to bring supply and demand into balance. ‘While workers spend what they earn, entrepreneurs earn what they spend’, as Kalecki put it.

Note that, other things being equal, an incremental increase in r_t increases the demand for investment:

$$dI_t = \frac{\pi\beta K_t dr_t}{1-\theta q_t}$$

and entrepreneurial consumption:

$$dC_t = (1-\beta)K_t dr_t.$$

Consequently the total effect on demand for net output is

$$\left(\frac{\pi\beta}{1-\theta q_t} + (1-\beta) \right) K_t dr_t$$

For stability at an interior solution (with excess supply of labour), we need

$$\left(\frac{\pi\beta}{1-\theta q_t} + (1-\beta) \right) < 1 \quad \text{or} \quad \frac{1-\pi}{\theta} > q_t.$$

But as we are assuming $q_t > 1$, this condition can be written as $\pi + \theta < 1$, a restriction on ‘induced investment’ such that the fraction who have new ideas *plus* the amount they can raise as outside finance must be less than 1.

The ‘fix-price macroeconomic’ framework, is much as described earlier in the writings of Benassy (1975) and Malinvaud (1977) for example, and illustrated in Figure 3. The bottom panel on the left shows how the wage bill varies with employment at the fixed real wage. The bottom right panel shows how the residual income available to entrepreneurs falls away as employment falls. So too does

demand by entrepreneurs as shown in the top panel, where the marginal propensity to spend is $\delta+\theta$. Note that, for convenience, demand is shown at a constant real share price. (How the share price reflects the precautionary demand for money is discussed in the next section.)

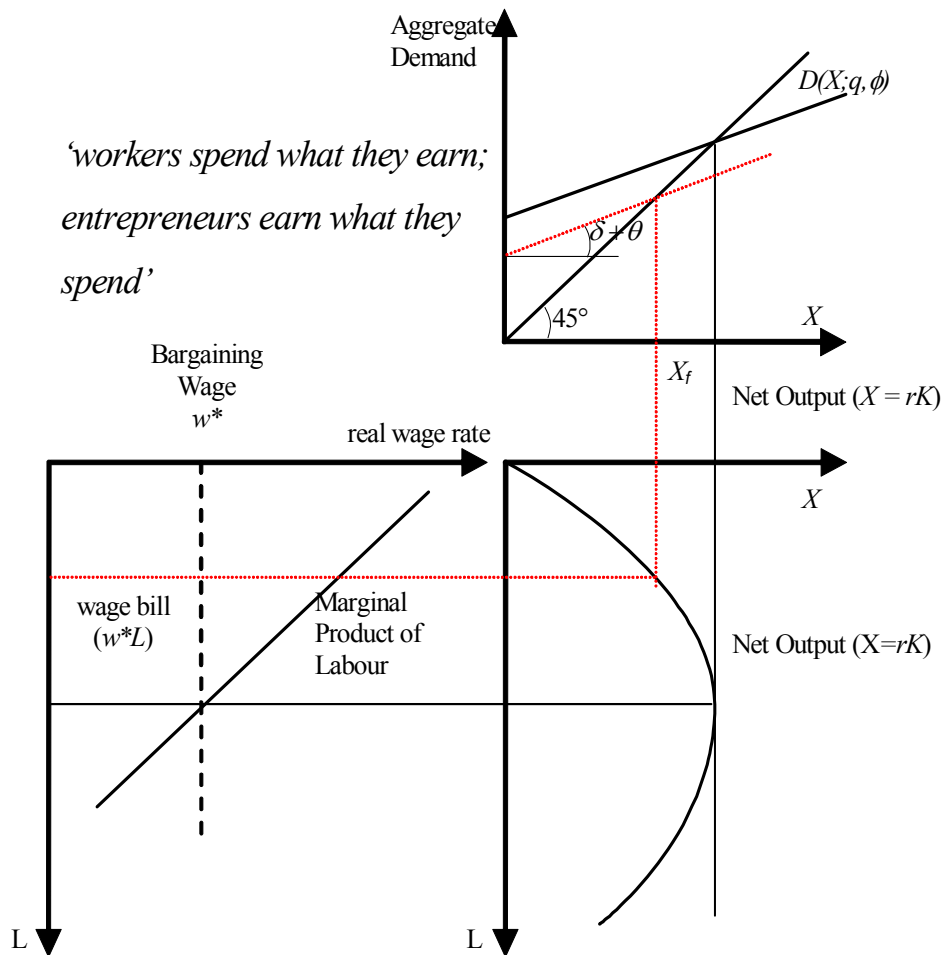


Figure 3 The determination of net output , given q_t

Portfolio balance, the price of equity (q_t), and the price of money¹¹ (p_t)

The other requirement for short run equilibrium is that the current price of capital, q_t satisfy portfolio balance, specified in KM (2008, equation 24) as:

¹¹ Constant in fix price models.

$$(1-\pi)E_t \left[\frac{(r_{t+1} + \lambda q_{t+1})/q_t - p_{t+1}/p_t}{(r_{t+1} + \lambda q_{t+1})N_{t+1}^s + p_{t+1}M} \right] = \pi E_t \left[\frac{p_{t+1}/p_t - [r_{t+1} + \phi_{t+1}\lambda q_{t+1} + (1-\phi_{t+1})\lambda q_{t+1}^R]/q_t}{[r_{t+1} + \phi_{t+1}\lambda q_{t+1} + (1-\phi_{t+1})\lambda q_{t+1}^R]N_{t+1}^s + p_{t+1}M} \right]$$

which depends heavily on future expectations of the price of capital, the price of money, and the return on capital. The term N_{t+1}^s indicating the value of the equity held by non-investing entrepreneurs next period is defined as:

$$N_{t+1}^s = \theta I_t + \phi_t \pi \lambda K_t + (1-\pi)\lambda K_t .$$

We have seen that, as in Blanchard (1981), goods market equilibrium GM is increasing in q . But, from numerical simulation, we find that the AM equilibrium slopes down as is shown in Figure 4 corresponding to the ‘bad news’ case of Blanchard (1981).

Stationary values for the level of production define the goods market equilibrium shown in linearized form as the upward sloping schedule GM in figure 4.

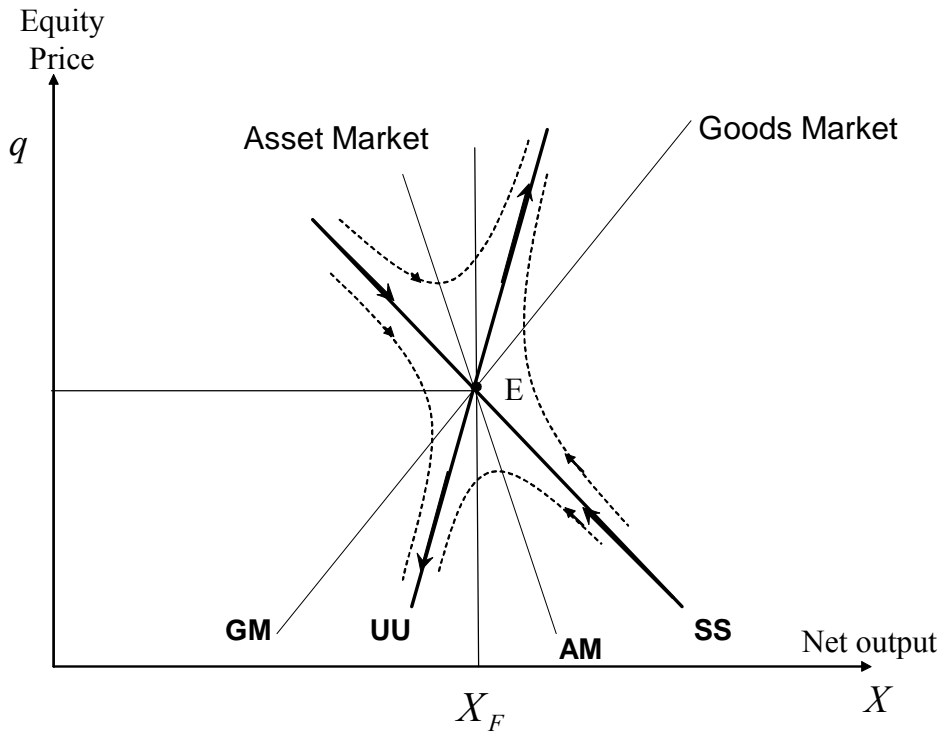


Figure 4. Phase diagram of the linearised system

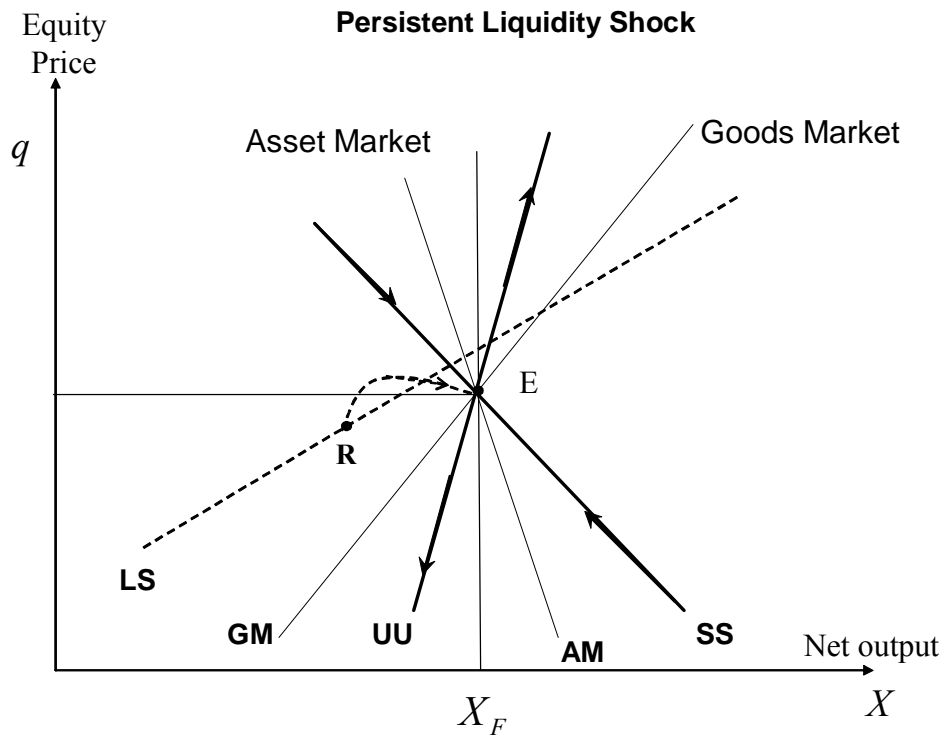
Stationary values for the stock market price define the asset market equilibrium given by the downward sloping AM in the figure. Equilibrium is at E where they both

intersect. Given the saddle point dynamics, the stable path to equilibrium will also slope downwards, see SS in the figure. (The unstable eigen-vector will have a positive slope). Also shown are integral curves that asymptotically approach SS and UU. Although these curves are shown as continuous lines, the outcomes will be discrete points on them, given the structure of the model.

Section 6 The effect of a persistent liquidity shock

(A) An unexpected contraction of liquidity

What of the effects of a negative liquidity shock? Since it tightens the financial constraints on firms who want to invest and since workers are income constrained (and there is no Pigou effect to stimulate consumption of owners), the impact is to shift equilibrium to the left, as shown by the 'initial condition' labelled LS - the dotted line in the figure. The actual impact will depend on how long the shock is expected to last – the lower on LS the more persistence is expected. Figure 5 illustrates the outcome where the liquidity squeeze is expected to shrink at a rate ρ . There is a recession with low stock prices, see R.



Confirmation of the results shown in the phase diagram can be obtained by numerical simulation. For given values of the parameters, the impulse responses of the model to a cut in the liquidity parameter from 0.2 to 0.1, with a gradual return to normal, starting from the stationary state are shown in the appendix below, for the variables ϕ , k and q . (Note that the variable X is the product of k and r .)

Alternatively, to avoid introducing the root ρ into the analysis, one might consider a shock which remains constant for a time T periods and then disappears. In this case there will be two impact effects, an unexpected squeeze and an expected recovery T periods later. The initial outcomes for the economy at point R are much as before, but instead of approaching E smoothly as indicated by RE in Figure 4, there is a jump back to V on the stable manifold at time T . As the expected duration of the shock increases the initial recession gets worse: for an irreversible shock, the outcome will lie on the stable path leading to E' .

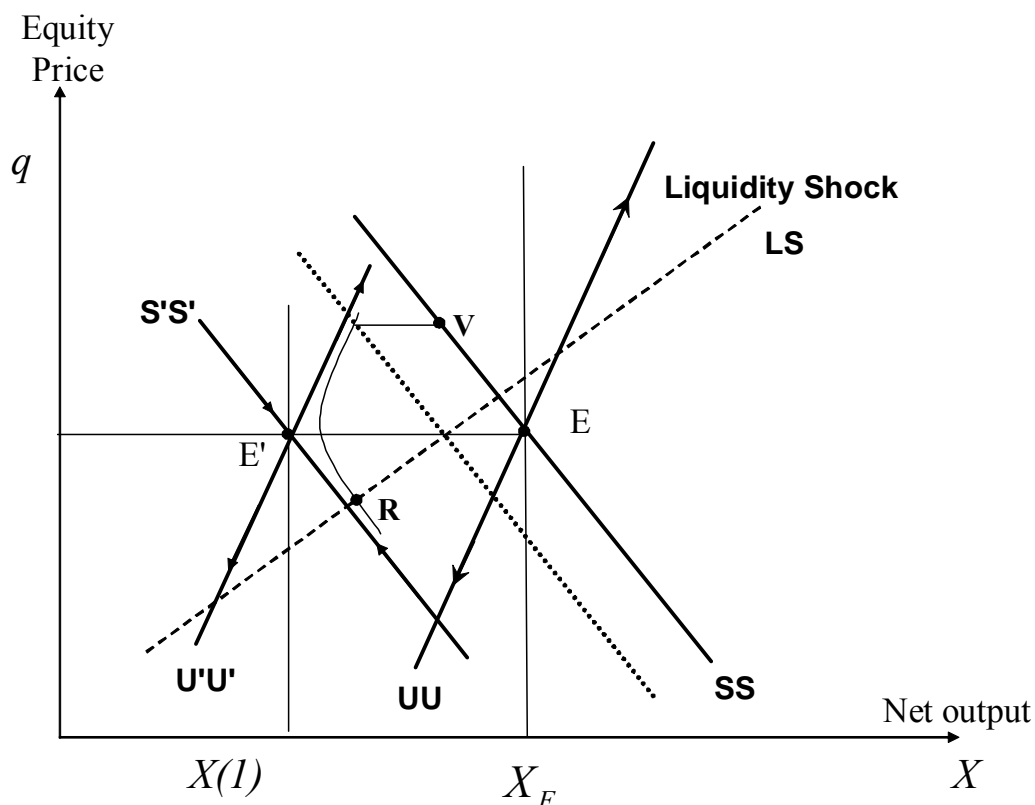


Figure 5. Liquidity shock which last for t periods before disappearing

The antidote discussed by KM should work too: Quantitative Easing in the form of an open market operation where the government supplies liquidity in exchange for corporate securities should ease liquidity conditions. (If this helps to create a market, Tucker 2009, it may help reverse the credit constraint at its source.) Details to be supplied.

(B) Relaxing the Rational Expectations assumption

Another reason for the stock market to fall is that it may be ‘overpriced’ ex ante, in the grip perhaps of ‘Irrational Exuberance’, Shiller (2000)¹², where heterogeneous beliefs may sustain the bubble as analysed in Abreu and Bruinnermeier (2003). For present purposes, following Caballero et al. (2008), we can represent an asset bubble as a movement along an integral curve as shown by II in figure 6, for example.

¹² Behavioural reasons for over-pricing in the housing market are discussed in Laibson (2009) and Shiller (2008)

Assume further that when it bursts, asset prices fall to the stable manifold, SS. If as in the figure, the bubble were to collapse when the real economy is at X_F , there will be no recession simply a correction of asset price from B to E.

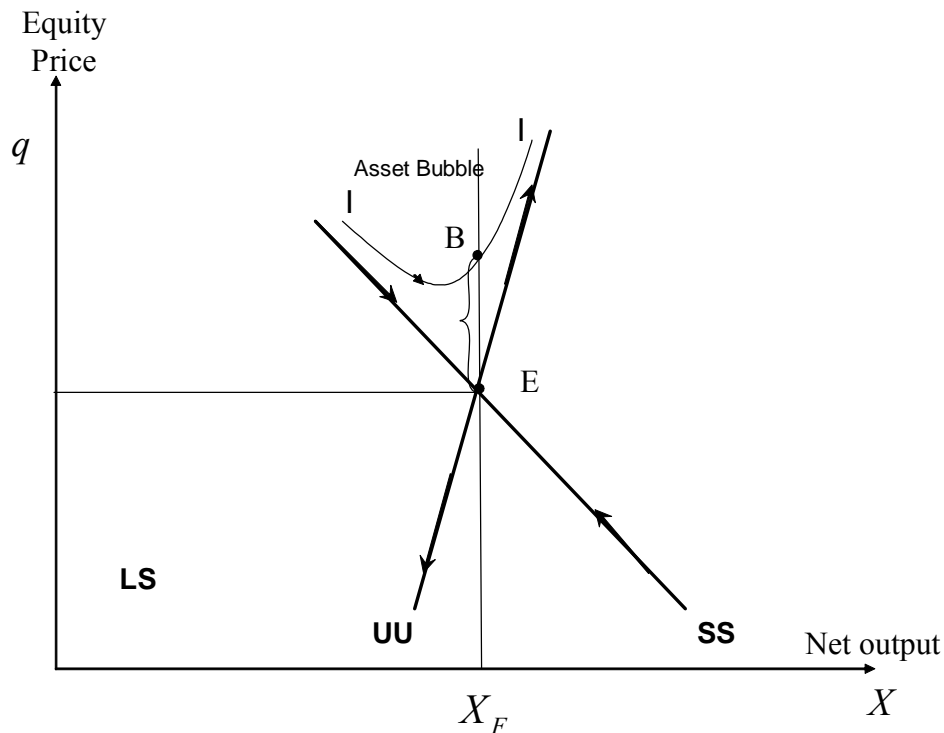


Figure 6. Collapsing asset bubble.

(C) Combining a collapsing asset bubble and a liquidity squeeze.

If the ending of the asset bubble is combined with the loss of liquidity, however, the correction of share prices will be exaggerated and there would be an economic recession, as indicated by the movement from B to R in figure 7, where the liquidity shock is assumed to die away slowly. An economic account of asset price overshooting and resource mis-allocation for highly leveraged firms is given in Miller and Stiglitz (1997). There may of course be good economic reasons why the resale constraint on equities should tighten when stock market crash: but the coincidence of the ending of the bubble and the onset of the liquidity shock in the figure is assumed exogenously.

It is tempting to conclude that the workhorse model developed by KM does in fact supply a micro-founded framework for looking at stabilisation policy – so long as wages and prices are not flexible enough to ensure continuous market clearing. This has been shown by examining a fix-price version of their model, subjected to financial shocks. Aficionados of the writings of Fed economists will see it as an updated version of Bernanke and Blinder (1998)! Pushing things further by adding asset mispricing provides added realism at a time when stock markets have fallen by half.

References

- Abreu, Dilip, and Markus K. Brunnermeier (2003), “Bubbles and Crashes,” *Econometrica* vol. 71(1), 173-204, January
- Akerlof, George, and Robert J. Shiller (2009), *Animal Spirits*, Princeton, NJ: Princeton University Press
- Bank of England, *Financial Stability Report* (2009, June).
- Blanchard O. J. (1981), “Output, the Stock Market, and Interest Rates,” *American Economic Review*, vol. 71 no 1, March, 132-143
- Bénassy, Jean-Pascal (1975), “Neo-Keynesian Disequilibrium Theory in a Monetary Economy”, *The Review of Economic Studies*, vol. 42 no 4 (October), 503-523
- Bernanke, Ben S. and Alan S. Blinder (1988) “Credit , Money and Aggregate Demand” *American Economic Review*,78(May),435-439.
- Bewley, Truman F. (2002), *Why Wages Don't Fall during a Recession*, Cambridge MA: Harvard University Press
- Caballero, R. J., E. Farhi and Pierre-Olivier Gourinchas (2008), “Financial Crash, Commodity Prices and Global Imbalances”, NBER Working Paper
- Chari, V. V., Patrick J. Kehoe and Ellen R. McGrattan (2007), ”Business Cycle Accounting”, *Econometrica*, 75(3) 781-836
- Cúrdia, Vasco, and Michael Woodford (2008). “Credit Market Frictions and Optimal Monetary Policy,” paper presented at the Bank for International Settlements Annual Conference, “Whither Monetary Policy?” Lucerne, Switzerland, 26-27 June
- Debreu, Gerard (1959) *Theory of Value*. NY, NY: J. Wiley
- Del Negro, Marco, Gauti Eggertsson and Andrea Ferrero (2009). ‘The Fed’s Response to the Financial Crisis’. Slides presented to SEDC Conference, Istanbul (July).

- Diamond, David and Philip H. Dybvig (1983), "Bank runs, deposit insurance and liquidity," *Journal of Political Economy*, vol.91, pp.401-19
- Eichengreen, Barry and Kevin O'Rourke (2009), "A Tale of Two Depressions", *voxEu* (Accessed at <http://www.voxeu.org/index.php?q=node/3421> on 13 October 2009)
- Goodhart, Charles A. E. (2008), "Comments on 'Credit Frictions and Optimal Monetary Policy' by Curdia and Woodford," BIS Conference June 2008, accessed at <http://www.bis.org/events/conf080626/goodhart.pdf> on 13 October 2009
- Hahn, Frank (1974) 'On the notion of Equilibrium in Economics' Reprinted in *Equilibrium and Macroeconomics*. Oxford: Blackwell, 1984
- Hahn, Frank (1981) 'General Equilibrium Theory'. Reprinted in *Equilibrium and Macroeconomics*. Oxford: Blackwell, 1984
- Hammond, Peter J, (1977). "The Core and Equilibrium through the Looking-Glass," *Australian Economic Papers*, 16(29), 211-18
- Hicks, John (1937) "Mr Keynes and the Classics: A suggested simplification", *Econometrica*.
- Hicks, John (1939) *Value and Capital: An inquiry into some fundamental principles of economic theory*, Oxford: Clarendon Press.
- Kiyotaki, Nobuhiro (1998), "Credit and Business Cycles," *Japanese Economic Review*, vol. 49, 19-36
- Kiyotaki, Nobuhiro, and John Moore (2009) 'Liquidity, Business Cycles, and Monetary Policy'
- Koo, Richard (2008) *The Holy Grail of Macroeconomics*. Singapore: John Wiley
- Laibson, D. (2009). "Bubble Economics", Frank Hahn Lecture at the Royal Economic Society Annual Meetings, University of Surrey, 20-22 April.
- Layard, Richard and Stephen Nickell (1987). 'The Labour Market'. In R.Dornbusch and R. Layard (eds.) *The Performance of the British Economy*. Oxford: Clarendon Press, pp. 131-179.
- Malinvaud, Edmond (1977) *The Theory of Unemployment Reconsidered*, Oxford: Basil Blackwell
- Manning, Alan (1990) "Imperfect Competition, Multiple Equilibria and Unemployment Policy", *Economic Journal*, Conference Papers, vol. 100, 151-162 *Economic Journal*
- Miller, M. and J. Stiglitz, (2009), "Leverage and asset bubbles: averting Armageddon with Chapter 11?" CEPR DP no. 4679 (forthcoming in *Economic Journal*).

Milne, A (2009) 'Understanding the Current credit crisis: Maturity mismatch and structured credit liquidity'. mimeo, Cass Business School, May

Shiller, R. J. (2000), *Irrational Exuberance*, Princeton NJ: Princeton University Press

Shiller, R. J. (2008). *The Subprime Solution*, Princeton, NJ: Princeton University Press

Tucker, Paul (2009) 'The Repertoire of Official Sector Interventions in the Financial System: Last Resort Lending, Market-Making, and Capital' Bank of Japan's 2009 International Conference, Tokyo [28 May]

Woodford, Michael (2003) *Interest and Prices*. Princeton, NJ: Princeton Univ Press

Appendix 1

Numerical Solutions

We first compute a solution for the steady state of the KM model, assuming a fixed price level and money wage rate. This uses equations (26), (27) and (28) of KM. In them we replace $aK^{\alpha-1}$ by r , the rate of return on capital (which is not necessarily equal to the marginal product of capital when output is constrained by demand below full employment). We have in place of (26):

$$\pi\beta r + \pi\beta \frac{pM}{K} = \left[1 - \lambda + \pi\lambda(1 - \beta) \frac{1 - \phi}{1 - \theta} \right] (1 - \theta q) - \pi\beta\lambda\phi q$$

in which the variables without time subscripts denote the steady state values. The balance between supply and demand for goods, equation (27), can be written as

$$\beta r - (1 - \beta) \frac{pM}{K} = \left[1 - \lambda + \pi\lambda(1 - \beta) \frac{1 - \phi}{1 - \theta} \right] + (1 - \beta) \left(1 - \pi \frac{1 - \phi}{1 - \theta} \right) \lambda q$$

These can be solved to obtain the real return on capital (r) and the real money stock relative to the capital stock (pM/K) as linear functions of the steady-state price of capital q .

The third key relationship is the portfolio balance equation which in non-stochastic stationary state (28) reads:

$$r - (1 - \lambda)q = \pi\lambda \frac{1 - \phi}{1 - \theta} (q - 1) \frac{q + pM/(\chi K)}{r + \lambda \frac{1 - \phi}{1 - \theta} + \lambda \frac{\phi - \theta}{1 - \theta} + \frac{pM}{\chi K}}$$

Since r and pM/K are linear in q , this yields a quadratic in q that can be solved.

This analysis implies that the steady state values of r and q depend on the liquidity parameter ϕ but are independent of real money balances. The capital stock however, depends on the liquidity parameter, but is also proportional to real money balances.

Having found the stationary state, we take linear approximations of the model around the steady state, and reduce it to a system of first order difference equations in K , ϕ , and q . The key equations of the system are KM's (22), the investment equation, (23), the aggregate demand equation, the definition of N_{t+1}^s , (24), the portfolio balance equation, and (25) which describes the evolution of the capital stock. Of the three variables in the state-space system, K is a predetermined variable, ϕ is exogenous, and

q is a non-predetermined 'jump' variable. We look for the number of stable and unstable roots of the system, and examine the quasi phase diagrams to investigate the dynamics. The value of r also emerges as a linear function of q . It is clear from the above that an increase in q causes an increase in K . (The relationship between q and K is also affected in a variety of complex ways by the liquidity constraints.)

Appendix 2 Simulation results

Suppose the parameters of the model are as follows: $\phi = 0.2$ (fraction of existing assets an entrepreneur can sell); discount factor $\beta = 0.96$; fraction of new capital against which an entrepreneur can raise equity, $\theta = 0.4$; probability of an entrepreneur having an idea for an investment, $\pi = 0.2$; the annual survival rate of the capital stock $\lambda = 0.8$. We fix the money supply at $M = 50$ and the price of money $p = 1$.

In steady state, the economy then has a value of $q = 1.12$; $r = 0.252$; $K = 296$; $Mp/K = 0.169$.

What then would be the effect of a 10% cut in the liquidity parameter from 0.2 to 0.18, with a gradual return to normal, starting from the stationary state? To complement the phase diagrams in the text, we attach the impulse responses of the model calibrated as indicated above. The shock occurs in period 1 and the paths over the first twenty periods after the shock are shown in the figures below. Profits and prices fall sharply on impact: while profits recover monotonically, asset prices overshoot before subsiding to equilibrium. The capital stock remains unchanged in period 1, however, then contracts before recovering.

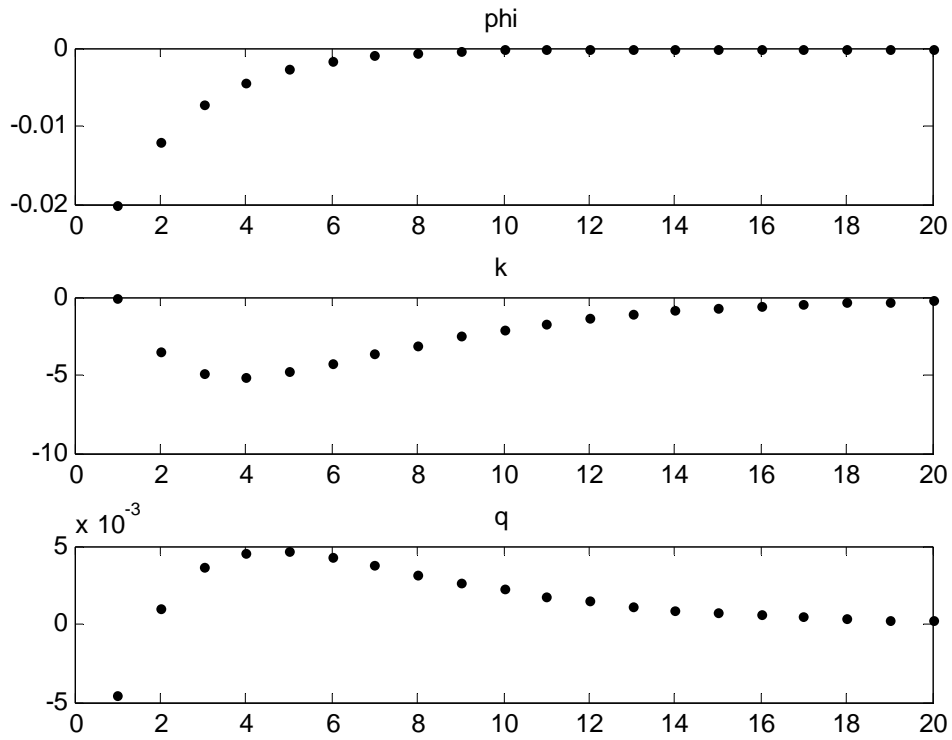


Figure A1: Impulse responses of ϕ (phi), k , and q after a fairly persistent 10% liquidity shock.

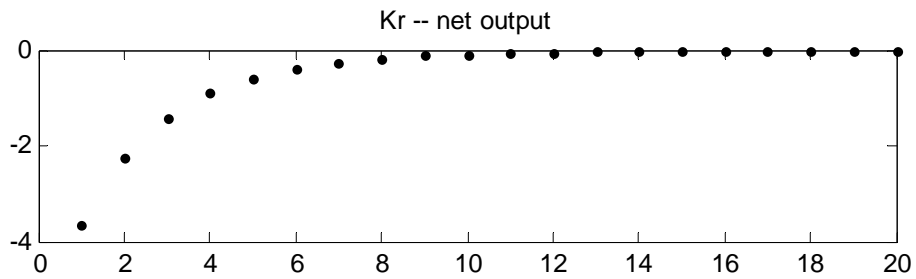


Figure A2: Impulse response of profits (rK) to a fairly persistent 10% liquidity shock.