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MACROECONOMIC STABILISATION AND BANK LENDING: A SIMPLE WORKHORSE MODEL

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Abstract
A hybrid standard macro model is supplemented by an explicit analysis of bank lending, based on a five-position aggregative balance sheet. In the model's two versions credit supply is based on a leverage targeting rule or on simple optimisation, taking into account lending risks and funding costs. Model simulations explore consequences of supply and demand disturbances, discretionary interest rate moves, asset valuation and credit risk shocks. Besides standard Taylor policies, the paper compares the relative efficiency of additional stabilisation tools like external-funding taxes and anti-cyclical leverage regulation. Quantitative restrictions for bank activities seem to be useful.

JEL Codes: E1, E5, G2

Key words
Taylor rule; Leverage targeting; Financial market shocks; Funding costs; Endogenous money

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1. Introduction

After the Subprime Crisis, it has become common saying that modern macro models show a severe deficit because financial markets are not analysed directly, and thus their (mal-) functioning remains somewhat hidden in the background. It was cold comfort for modern New Keynesian macroeconomics that this complaint also applies to more traditional theories, starting from *IS-LM*, comprising monetarism, New Classical and Real Business Cycle models. This lacuna is all the more awkward as the pattern of macroeconomic cycles seems to have changed. Boom and bust periods on asset markets appear to dominate, whereas the 'old' scenario of rising output and prices on goods markets, followed by disinflation policies, seems to have vanished after the 1990s.

The 'new' image of macro cycles however is basically not new. It characterised large periods of the gold standard era where trend inflation did not exist and bank panics, preceded by heavy speculation on various investment fields, produced severe disturbances on goods markets.[1] The decades after the Second World War were protected from financial instability due to regulative restraints, on the one hand, and increasing inflationary pressure on goods and labour markets, on the other, that provoked, in a cyclical fashion, stabilisation policies. They aimed at disinflation, but at the same time they also might have choked off market forces that would have led to financial boom and bust later.

For the future the challenge is to design monetary policy strategies that likewise are apt to stabilise goods and financial markets, although in the latter case many experts, as e.g. Svensson (2012), recommend the primary use of macroprudential regulation. For the development of proper monetary policy tools obviously a macrotheoretic framework is needed. The task is not just an integration of the traditional bank lending channel in macroeconomic analysis. This approach was needed to cover borrowing of a class of private agents who for various reasons were excluded from the capital market. But as other bank asset items apart from credit supply played no essential role, and deposits were regarded as indispensable for bank funding, the central bank's direct or indirect control of reserves provided a reliable means of

[1] "It is no coincidence that financial booms and busts of this kind were quite common during the gold standard, all the way up to the 1930s. This was the previous time in history in which a liberalised financial system coincided with a monetary regime that yielded a reasonable degree of price stability over longer horizon" (Borio 2012: 8n). However, due to the structural scarcity of bank reserves, imbedded in the principles of the gold standard, the mechanisms of financial crises at that time cannot easily be compared with the contemporary scenario.

overall banking activity (Bernanke/Blinder 1988).

Since the 1990s however, the banking 'industry' including various types of shadow banks has engaged in a large variety of financial assets, and increasingly has relied on the money market to attract additional funding. Thus the banking sector gained a new dimension of financial flexibility. As a consequence, it tended to aggravate macroeconomic shocks that emanated in non-financial sectors, but apart from this multiplier effect, the financial industry also produced disturbances with substantial spill-over to goods market. Many observers now share the "hypothesis that the financial intermediary sector, far from being passive, is instead the engine that drives the boom-bust cycle" (Adrian/Shin 2010: 602).

The debate on a new concept of central bank behaviour is compounded by the analytical complexity of integrated macro-financial models. It took a quite lengthy and algebra-loaded paper to incorporate just the simple element of bilateral consumption credits into the canonical setup of intertemporal representative-agent optimisation of the New Keynesian macro model (Cúrdia/Woodford 2009), to say nothing of the computational effort necessary to bring together the market behaviour of agents from labour, goods and financial markets if every step ought to be derived from the famous 'First Principles' of micro foundation.[2]

Nevertheless there do exist some papers that aim at a more compact treatment of the key relationships. Woodford (2010) presents an *IS-LM*-like graphical model where financial intermediaries operate on the credit market and earn an interest rate spread rewarding their two-way services for final lenders (savers) and borrowers (investors). Intermediation is limited by capital and leverage of the financial industry, and the spread appears as a kind of tax that society has to pay in order to make good the lack of a 'perfect' credit market with direct saver-investor contracts. Consequently, for keeping these welfare losses low, "the model therefore suggests that changes in credit spreads should be an important indicator in setting the federal funds rate; the funds rate target should be lower than would otherwise be chosen, given other conditions, when credit spreads are larger" (Woodford 2010: 39).

The credit interest rate spread is also a key variable in the partial analysis of the banking industry provided in many papers by Adrian and Shin. They emphasise that by changing short-term interest rates monetary policy executes a strong, inverse effect on the term structure. Lowering the policy rate thus increases expected profits of financial intermediaries. "The NIM [net interest margin] determines the profitability of bank lending and increases the present value of bank income, thereby boosting the forward-looking measures of bank capital"

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[2] Gertler and Kiyotaki (2010) give a first impression.

(Adrian/Shin 2010: 638). This argument helps to enrich the general picture of monetary policy transmission: if for some reason the spill-over from changes of the policy interest rate to the long-term capital market rate should be blocked, there is still an unidirectional effect working through the expected profitability of financial intermediation.

Not least for teaching purposes, Benjamin Friedman (2013) suggests an extension of the simple three-equation New Keynesian macro model in two steps. First, goods demand is taken to be dependent on a long-term interest rate, which in turn is explained by an additional fourth equation. It captures the policy rate, its expected course in the future, and a variable risk factor driven by the relative amount of safe assets held in the system. The alternative of this reduced-form mark-up calculation of the long rate could be a setup of two additional equations capturing each side of the aggregate credit market where the central bank might intervene, enabling quantitative and qualitative easing operations.

The model proposed in this paper takes up central topics from the contributions mentioned above. The aggregated banking sector is integrated in a simple hybrid macro model so that key balance sheet items are linked to goods market activities. Supply and demand equations are given without any microfoundations, but are compatible with the New Keynesian framework. Contrary to Friedman (2013), the direct link from the central bank interest rate to goods demand is retained; bank lending thus appears as a second channel of the monetary transmission process. The key emphasis however is on the analysis of shocks that emanate within the private financial sector. Here, aiming to keep the analysis as simple as possible, no distinction is made between different branches although the presentation of important market mechanisms might require a differentiated view on the banking industry.

Chapter 2 lays out the basic model and analyses shocks emanating from goods and financial markets. Apart from discretionary moves of interest rate policy a special focus is on additional tools of stabilisation strategies beyond the standard Taylor principle, like leverage prescriptions, taxes on external funding etc. The comparison of simulation paths of the macroeconomy after the occurrence of disturbances allows some tentative conclusions on the relative efficiency of alternative stabilisation tools. Banking activities follow a behavioural, somewhat mechanical rule that can be described as leverage targeting: shocks that affect main bank balance relations trigger adjustment moves apt to restore banks' indebtedness; via credit supply these balance sheet operations affect goods demand.

A similar research program is pursued in Chapter 3 where instead of leverage targeting a simple optimisation calculus for deriving bank lending and funding is applied. Chapter 4 concludes with an outlook on the use of quantitative restraints in the refinancing of the banking sector: an old and new view on the role of money in the economy.

2. A Leverage Target Model

2.1 Goods Market and the Banking Sector

Consider a fairly standard hybrid macro model supplemented by an explicit bank lending channel. The goods market part of the model consists of a supply and a demand equation[3], where expectations are only partly forward looking[4], and adjustment and information costs cause an effect of last periods' variables on their current values. Both equations are complemented by a Taylor rule, with the inflation target normalised to zero, and additional AR(1) demand and supply shocks, where ω_t denotes white noise. The model equations are *not* written in terms of deviations from the steady state, thus a constant autonomous demand term g is included in (3); potential output is normalised to zero.

$$\pi_t = \left(1-\theta_\pi\right) E_t\pi_{t+1} + \theta_\pi\, \pi_{t-1} + \alpha\, y_t + \varepsilon_t^s \tag{1}$$

$$y_t = \left(1-\theta_y\right) E_t y_{t+1} + \theta_y\, y_{t-1} + g - \beta\left(i_t - E_t\pi_{t+1}\right) - \beta^L\left(i_t^L - E_t\pi_{t+1}\right) + \varepsilon_t^d \tag{2}$$

$$\varepsilon_t^{s,d} = \theta_\varepsilon\, \varepsilon_{t-1}^{s,d} + \omega_t^{s,d} \tag{3}$$

$$i_t = r_t^* + \left(1+\gamma\right)\pi_t + \varphi\, y_t + \mu\left(A_t + L_t^s - BS^*\right) \tag{4}$$

Contrary to Friedman (2013), but similar to Cecchetti/Kohler (2012), the credit market interest rate i_t^L acts as an *additional* impact factor on goods demand. Thus the model takes into account that a fixed fraction of market agents depends on bank finance. The coefficients β and β^L, respectively, thus each measure the interest rate elasticity of goods demand *and* the relative size of two groups of market agents: spending decisions of the first group depend on the short-term real interest rate, basically controlled by the central bank, and its implications for the whole interest rate channel of monetary transmission; and the second group's goods

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3 Well-educated economists easily will find appropriate microfoundations that yield (1) and (2) as results of a standard optimisation calculus. In that case, output variations show the Representative Agent's response to exogenous shocks, but have not necessarily an implication for the emergence of involuntary unemployment. Of course, the equations also allow a more traditional interpretation; in so far, their algebraic logic is independent of the "stories we tell" (Colander 1995).

4 The operator E indicates that a well defined part of the market population uses rational, i.e. model-consistent expectations, taking into account that other agents rely on adaptive behaviour. The model was solved by applying the MSV solution following McCallum (2003).

demand responds to changes of the credit market rate of interest. Fixing β and β^L implies a market segmentation that remains exogenous to the cyclical path of macro variables (indicating a drawback of these kind of models).

Banks' Balance Sheet

Assets A_t	Capital C_t
Lending L_t^s	Deposits D_t
	Bonds B_t

Table 1: Stylised banking sector

The banking sector's balance sheet, with its items denoted in nominal values[5], is given by *Table 1*. The Taylor interest rate i_t in (4) may or may not respond ($\mu \geq 0$) to deviations of the volume of either balance sheet side from its equilibrium level BS^* (to be explained below). Bank assets A_t are assumed to be illiquid in the short run. Their value reflects financial market shocks ε_t^f, which are also of the AR(1) type. They are mainly driven by random events, but also amplified by (fundamental) macro conditions measured by the path of output. The ensuing valuation gains and losses modify – for simplification reasons in full amount – the value of the banks' capital.[6]

$$A_t = \bar{A} + \varepsilon_t^f \tag{5}$$

$$C_t = \bar{C} + \varepsilon_t^f \tag{6}$$

$$\varepsilon_t^f = \theta_\varepsilon \, \varepsilon_{t-1}^f + \omega_t^f + \sigma \, y_t \tag{7}$$

Deposits, bearing no interest, are accepted passively on demand of the public, following its transaction needs which are represented by the output level.[7] Credit supply is taken to be the banks' active market tool; but in the first model version banks are assumed to fully exploit the restraint given by a leverage prescription λ_t.

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5 In terms of formal dimensions, the model brings together logs of real magnitudes, percentage points and money values. Its equations can only be interpreted to show small deviations from equilibrium values.

6 This of course depends on institutional and legal prescriptions that might differ across countries. The extreme parameterisation is chosen to show the macro impact of financial market shocks more clearly.

7 The transaction demand argument would favour the inclusion of nominal income in (8), but the motive to avoid inflation losses on the part of deposit holders suggests the use of real income only. Switching between both alternatives has no bearing on the model's main results.

$$D_t = \overline{D} + \kappa\, y_t \tag{8}$$

$$A_t + L_t^s = \lambda_t\, C_t \tag{9}$$

As a primary hypothesis, assume that banks will adjust their balance sheets after any valuation shock so that a given value of leverage $\overline{\lambda}$ is restored.[8] As a second step, leverage might take the form of a variable norm imposed on the banks by a regulatory institution that aims to prevent the emergence of financial market bubbles by restricting the growth of balance sheets:[9]

$$\lambda_t = \overline{\lambda} - \delta\left(A_t + L_t^s - BS^*\right) \tag{10}$$

Linking L_t^s to A_t and C_t, and having D_t determined by depositors, implies that financial market funding through selling short-term bonds B_t is endogenously determined via the balance sheet identity. In both cases, with regard to L_t^s and B_t, banks are assumed to accept market prices, i_t^L and i_t respectively, as given, and they are not confronted with quantity constraints.

$$B_t = A_t + L_t^s - C_t - D_t \tag{11}$$

Bond financing is needed to fill a funding gap if deposits prove to be insufficient. Here this paper's model gradually deviates from the Adrian-Shin view. They assume the 'core' funding items (deposits) to be relatively sticky so that the growth of balance sheets is financed mainly through 'non-core' funding, which in small open economies to a large part reflects capital import (Shin/Shin 2011). On the contrary, by linking deposits closely to the path of income, as in equation (8), and thus to credit supply, bond financing appear as a supplementary factor only.

Bond sales B_t are meant to be net quantities as the model describes bank *sector* behaviour (interbank transactions are neglected). Accordingly the central bank is assumed to be the counterparty agent who adjusts base money supply endogenously to the banks' demand, by

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8 For the relation between leverage and the banks' management of 'Value at Risk' see Adrian and Shin (2008).

9 It might appear plausible to assume that balance sheet data are only available with a lag. But similar considerations can be raised with respect to output data, requiring the Taylor rule (4) to be modified accordingly. As these more practical questions concerning the technique of stabilisation are beyond the scope of the paper, the hypothesis of reacting to current period's values in (10) is maintained; the same argument applies to the μ effect in equation (4) above.

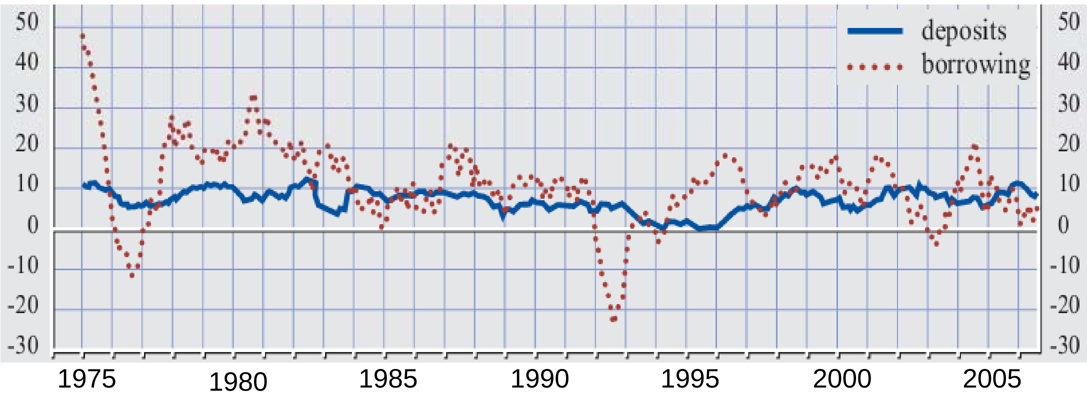

Figure 1: Growth in deposits and borrowing of US commercial banks (Adrian/Shin 2006: 307)

standing ready for (short-term) open-market operations where bond prices are fixed to preserve the central bank policy rate i_t.[10]

Empirically of course, much of the dynamics of financial markets in recent years is to be found in lender-borrower relations *within* the banking industry. Therefore *Figure 1*, which displays the interplay of deposit and external funding in US banking, corresponds nicely to the model simulations below, but underrates the active role of the shadow banking system, consisting of investment banks, broker-dealers of securities and hedge fonds. Within this lengthened chain of financial intermediation, deposits are not the main source of bank finance, but rather short-term credits from other financial agents.

Seen as a whole, funding in the banking industry might be characterised, albeit somewhat loosely, as a system of 'bootstrap finance': every financial agent counts on the possibility to receive sufficient funds from other money market agents – an expectation that comes true in good times, but is shattered in times of distress.[11] Therefore the central bank is urged to keep the money market liquid and to provide additional funds when imbalances between lending and borrowing occur. Thus the variable B_t in the model should be understood to show the 'tip of the iceberg' of market funding, an excess demand that is covered by accommodative monetary policy.

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[10] Note that the items D_t and B_t (besides C_t) are needed to finance the asset balance sheet positions. Supply and demand of base money (used for cash holdings and minimum reserves) are not analysed as a further topic.

[11] "The fluctuations of credit in the context of secured lending expose the fallacy of the 'lump of liquidity' in the financial system. The language of 'liquidity' suggests a stock of available funding in the financial system which is redistributed as needed. However, when liquidity dries up, it disappears altogether rather than being reallocated elsewhere" (Adrian/Shin 2009: 603; cf. ECB 2007; Brunnermeier 2009).

Non-banks' credit demand depends negatively on the expected real lending rate and positively on the expected output level.

$$L_t^d = \overline{L} + \psi \, E_t y_{t+1} - \eta \left(i_t^L - E_t \pi_{t+1} \right) \qquad (12)$$

The positive sign of the expected-income effect on credit demand is compatible with the modern intertemporal-optimisation approach of a representative household who aims for consumption smoothing over time; the sign of ψ "reflects the greater willingness to borrow when expected future income is higher" (Friedman 2013: 18; cf. Cecchetti/Kohler 2012). Further ad-hoc explanations are conceivable: expected income might serve as a proxy for a positive collateral effect in the balance sheet channel of monetary transmission, or for profit expectations of investors.[12]

By equating loan supply and demand, from (9) and (12), respectively, the credit market determines the loan rate i_t^L. Obviously this should be interpreted as a long-term interest rate although there is no assumption on the maturity of loans in the model.[13] The equilibrium level of the loan rate is found by $L_t^s = L_t^d$, disregarding all shocks and using the goods market equilibrium conditions $y_t^* = E_t(\pi_{t+1}) = \pi_t^* = 0$; note that $\overline{L}$, contrary to the other variables in the numerator of (13), does not indicate a steady-state value but a constant term in credit demand.

$$\left(i_t^L \right)^* = \frac{\overline{A} + \overline{L} - \overline{\lambda}\, \overline{C}}{\eta} \qquad (13)$$

The influence of the bank lending channel is also felt in the determination of the equilibrium real interest rate r_t^* in equation (4). The calculation of r_t^* serves to find that level of the Taylor rate that guarantees goods market equilibrium, given a level of potential production. Solving the demand equation (2) for $y_t^* = E_t(\pi_{t+1}) = \pi_t^* = 0$ and then for $i_t = r^*$ (with $\mu = 0$)

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[12] More controversial is the effect of current income on credit demand. In the earlier literature, it is generally seen to be positive; e.g. Bernanke and Blinder (1988: 435) hint to "transaction demand for credit, which might arise [...] from working capital or liquidity considerations". On the contrary, Woodford (2010: 28) argues that higher current output should "reduce the demand for loans, insofar as borrowers have more current income available out of which to finance current spending needs or opportunities". In this paper's model, as long as the impact effect is taken to be positive, there is little difference in the simulation results if current income is substituted by expected next-period's income in equation (12). This can be explained by the heavy dose of persistence in the model, which was chosen to capture empirical stylised facts.

[13] The interest rate spread between i_t^L and the Taylor rate is particularly important in the second version of this model below, but term structure relationships are neglected.

yields

$$r^* = \frac{g}{\beta} - \frac{\beta^L}{\beta}\left(i_t^L\right)^* \tag{14}$$

Finally, by using (11), (12) and (13), the equilibrium balance sheet level is defined as

$$BS^* = \overline{A} + \overline{L} - \eta\left(i_t^L\right)^* = \overline{\lambda}\,\overline{C} \tag{15}$$

2.2 *The Case of Demand and Supply Shocks*

In the following, two examples show the interaction of the model's variables. The Taylor rule is still standard, and the leverage ratio is fixed ($\mu = \delta = 0$).[14] A goods demand shock yields a positive output response which is dampened over the following periods via the Taylor interest rate (*Figure 2*). This stabilisation effect is supported by the increase of the loan rate i_t^L; it follows from the rise of loan demand that is connected to the rise of (expected) income. Note

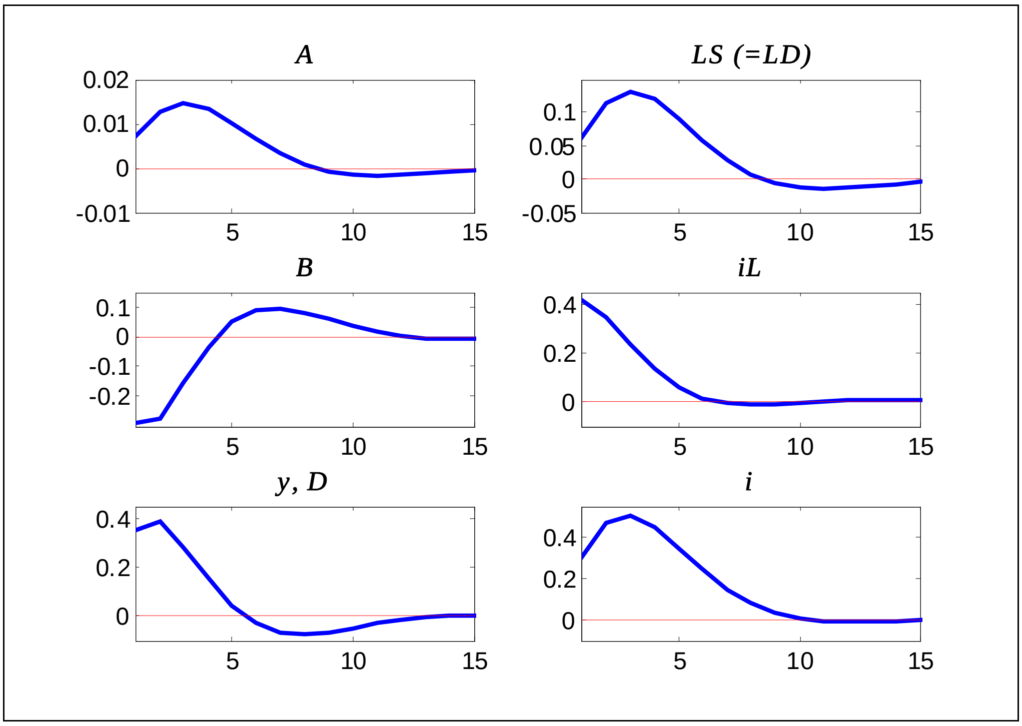

Figure 2: Deviations from equilibrium after goods demand shock ($\varepsilon^d = 0.1$)

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[14] Parameter values were chosen as follows: $g = 3.5$, $\alpha = \varphi = 0.1$, $\overline{A} = \overline{D} = 5$, $\theta_y = \theta_\varepsilon = 0.7$, $\overline{\lambda} = 10$, $\overline{L} = 8$, $\beta = \kappa = \overline{C} = 1$, $\gamma = \beta^L = \eta = \psi = \theta_\pi = 0.5$, $\sigma = 0.02$.

that loan supply nevertheless would basically remain unaffected because it is fixed by the leverage prescription (9); the loan supply curve is vertical. However, changing macro conditions spill over to financial market sentiments according to (7). Thus there is a weak indirect valuation effect upon A_t, which – amplified by the leverage ratio – shifts the loan supply curve to the right.

On the debit side of the banks' balance sheet deposits follow the temporary increase in income so that less external finance is necessary; banks initially can reduce the amount of outstanding bonds. This pattern of 'self-financing' through higher deposits supports the old post-Keynesian view of "lending creates deposits" (Borio 2012) – whereas the old neoclassical view believed otherwise. The contribution of the banking system to the demand shock's stabilisation is mixed: there is some additional lending, but a marked increase of the lending rate, which helps to dampen demand.

In case of an inflation shock the standard Taylor policy reaction yields a temporary output loss, accompanied by a smaller stock of deposits (*Figure 3*). This loss of funding is only partly compensated by an increase of bond financing. The ability to tap external funds helps to avoid liquidity shortages. Nevertheless balance sheets shrink. This is mainly due to a lower volume of credit. The worsening of activity translates into a negative valuation shock so that loan supply is reduced. Loan demand decreases on account of expected lower output, but this is partly neutralised by the shock-driven expected inflation effect, which – depending on the

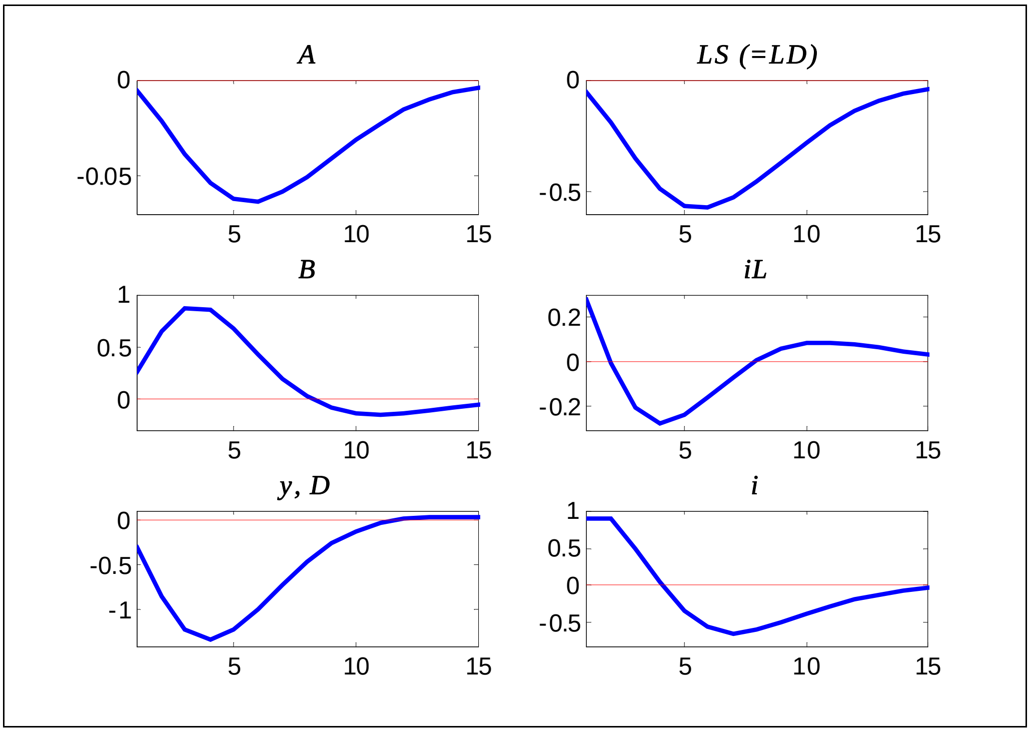

Figure 3: Deviations from equilibrium after supply shock ($\varepsilon^s = 0.1$*)*

strength of the inflation persistence parameter – lowers the real credit market interest rate. The net effect of both credit supply and credit demand shifts increases the nominal loan rate so that both interest rates work to bring down inflation.

2.3 *The Impact of Financial Market Shocks*

Now it is shown that valuation shocks on financial markets spill over to goods demand via a mechanical response of bank lending that follows a simple leverage targeting rule. This is demonstrated with reference to *Figure 4* (which simplifies this paper's model by merging assets and loans, on the one hand, and deposits and bonds, on the other). A rise in the value of the banks' assets is booked as additional equity, and thus creates – just by restoring the initial leverage ratio – scope for the purchase of new assets, funded by external finance.

This behaviour of financial intermediaries leads to 'perverse' asset demand and supply functions as a positive market revaluation of an asset lets agents buy more, while a negative change of its market price forces additional ('fire') sales aiming to restore the target leverage ratio; the destabilising impact of this market mechanism is obvious. It was found that investment banks in particular even pursued a variable, procyclical leverage target so that their indebtedness grew in boom periods. In the downturn, attempts to deleverage cause asset prices to crash and preclude a recovery of investment (Adrian/Shin 2006; Leijonhufvud 2009).

This paper's model modifies the above picture by distinguishing between two types of assets and two types of funding sources. If bank capital allows expansion, the acquiring of financial assets concentrates on lending to the non-bank sector. This of course is a special case

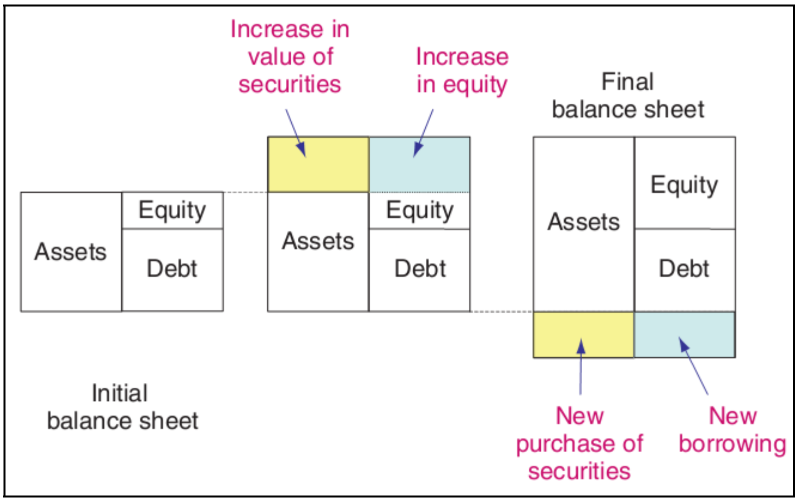

Figure 4: Two-step balance sheet reaction to positive asset valuation shock (Adrian/Shin 2010: 611)

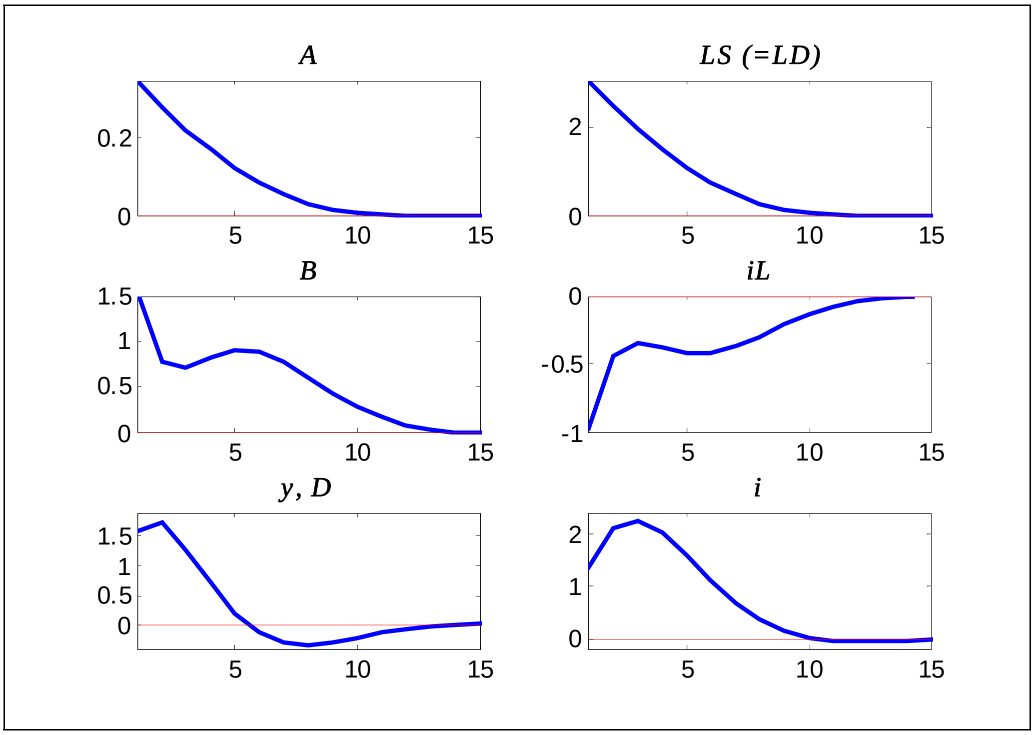

Figure 5: Deviations from equilibrium after valuation shock ($\varepsilon^f = 0.1$)

of a more general approach that helps to trace out the impact of financial market shocks for the activity on goods and labour markets. Contrary to the traditional 'broad' bank credit channel where borrowers' wealth positions limit credit demand via a collateral constraint (Bernanke/Gertler 1995), the valuation effect creates additional 'free' capital on the part of lenders that motivates a credit supply shift.

The simulation shows the dynamics in more detail (*Figure 5*). An improved asset valuation implies a bank capital appreciation and motivates an expansive credit supply shift, which is funded also by selling bonds. The loan rate falls and induces an equivalent increase of loan demand. The bank lending impulse lets goods demand rise which amplifies the ε_t^f shock and calls for a stabilisation response on the part of the central bank. The path of output and bank deposits is thus forced back to zero and below.[15] Credit expansion is basically funded by deposits; but as Taylor policies succeed to dampen output, and thus deposits, whereas credit supply shrinks more slowly, relative strength of supply an demand forces on the credit market changes during the adjustment process. This can be seen in the non-monotonic path of the lending rate and of the amount of bonds that are sold in order to close the funding gap.

A cursory look on the initial periods of output growth might provoke the appraisal that

[15] Background simulations show that with flat supply curves and weaker Taylor coefficients (both observable in the 2000s) valuation shocks are able to produce extended boom and bust cycles.

Taylor interest rate policies are conducted on 'too easy' terms. This is a widely shared assessment of US monetary policy in the mid 2000s. But Woodford (2010) rightly hints to the fact that borrowing costs for firms actually *fell* when the Fed's policy rate was already back to 'normal' levels, obviously driven by credit supply shifts which in turn resulted from a persistent change in the perception of macroeconomic risk.

Tracing out the consequences of a single valuation shock, the model displays a similar course of events. The comparison of both interest rates reveals that the process of stabilisation is accompanied by a severe compression of the spread. Note however that monetary policy tightening has no impact on incentives and quantitative funding capabilities of credit supply.

2.4 Stabilising Financial Market Shocks

There are two obvious strategies of cushioning the impact of financial market volatility on goods markets variables. One is a modification of the Taylor rule so that the policy rate now also reacts (with an ad-hoc chosen parameter of $\mu = 0.1$) to a balance sheet gap: the deviation of the sum of assets and lending from the long-run equilibrium level BS^*. The alternative is a version of activist macroprudential regulation: imposing a variable leverage on the banking business that likewise, in an anti-cyclical way, targets 'normal' balance sheets. In order to enable a comparison between both policy strategies, the strength of macroprudential balance sheet targeting has been set (with $\delta = 0.286$) so that output variances coincide; this outcome is taken as a benchmark that allows an evaluation of the other different results of both policies.

Given the mechanical assumption of bank behaviour, an extended Taylor policy has no direct impact on the financial sector as lending and funding do not depend on short-term interest rates. Therefore the spill-over runs via lower goods demand, which reacts to an initial increase of the real interest rate, brought about by a lower path of inflation (*Figure 6*); note that the nominal Taylor rate remains lower than in the baseline shock case although the balance sheet gap in the Taylor equation (4) is positive throughout the adjustment process.

According to (12), depressed output expectations reduce loan demand, produce an even larger excess supply on the credit market and thus a further lowering of the lending rate, compared to the baseline case. With a vertical loan supply curve, there is hardly any dampening effect of the extended Taylor policy on the amount of credit, apart from the very weak repercussion of output reduction on the time path of the valuation shock, according to (7). An increase of external funding has to compensate the lower stock of deposits.

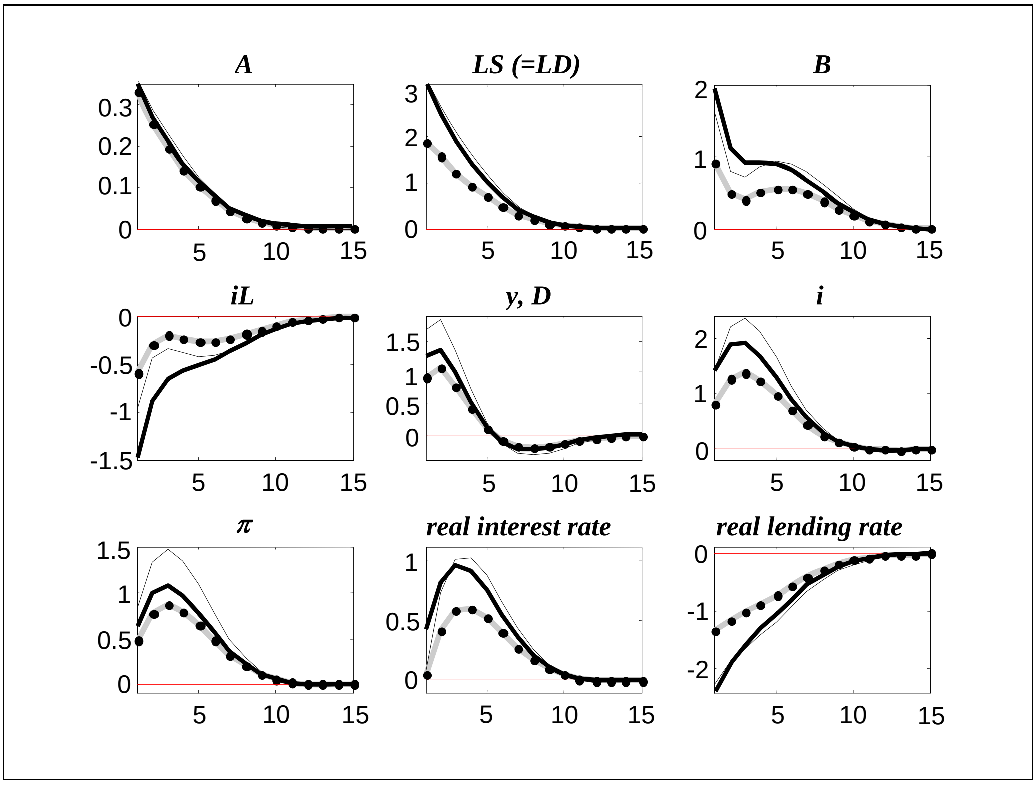

Figure 6: Baseline valuation shock (thin line) and two stabilisation policies compared: extended Taylor rule (bold line) or leverage regulation (dotted line)

Thus the result of the extended Taylor policy is mixed: the path of output and inflation is less exposed to the consequences of valuation shocks in the financial sector, if the central bank not only responds to inflation and output gaps. But balance sheet growth is not tamed, the initial widening of the excess supply gap on the loan market keeps the credit market rate of interest low (and this might drive asset values further in case of a – not modelled – capitalisation effect on A_t).

The inefficiency of this policy strategy is well understood: a countervailing mechanism should be established 'in the neighbourhood' of potential disturbances, if possible on the same level and at the same location of the market process. Therefore a policy of imposing a variable leverage ratio promises better results. From (5), (6), (9), (10) and (15) lending supply follows

$$L_t^s = \frac{\bar{\lambda}\left(1+\delta\bar{C}\right)}{\delta+\left(\bar{C}+\varepsilon_t^f\right)^{-1}} - \bar{A} - \varepsilon_t^f \qquad (16)$$

This reveals that with a sufficiently large basic leverage ratio $\bar{\lambda}$ a positive valuation shock produces an expansive shift of credit supply; but this effect is dampened unambiguously with $\delta > 0$. The simulation (*Figure 6*) shows that lending responds in a weaker fashion compared

	variance		
	standard stabilisation $\mu = \delta = 0$	extended Taylor rule $\mu = 0.1, \delta = 0$	leverage regulation $\mu = 0, \delta = 0.286$
A	0.32	0.29	0.29
B	7.65	9.23	4.13
LS	26.29	23.67	14.40
iL	2.26	4.75	1.38
i	21.44	14.98	11.30
y	8.54	4.70	4.70
π	8.62	4.57	4.54
iR	4.01	3.58	2.13
iLR	17. 94	17.25	9.62

Table 2: Simulation variance of endogenous variables in case of a valuation shock with different policy strategies

to the baseline shock scenario. As a consequence, the decrease of the lending rate – nominal and real – is smaller. Accordingly, goods market variables, output and inflation, appear to be more stable; the calculated simulation variance however shows that the volatility of output and inflation roughly remains unchanged (*Table 2*). But the general impression from looking at all variances is that macroprudential anti-cyclical leverage regulation has a clear advantage compared to an extended Taylor rule.

Inspection of the macro process with a series of (positive and negative) valuation shocks, stabilised by leverage control, gives further insights into the linkages between financial and goods markets (*Figure 7*):

- A series of small bad shocks (e.g. periods 25 to 35) may add up to a catastrophic output crisis, driven by severe contraction of bank lending and a marked increase of the loan rate. Particularly in this case, but also in general, a stabilising feature of the variable leverage ratio is revealed.[16] Nevertheless, additional simulation shows that equity can be wiped out also in the regime of leverage regulation.
- The interest rate spread $i_t^L - i_t$ shows a pronounced anti-cyclical pattern. Output is driven by credit supply (there is a correlation of .91) and the induced lowering of the loan rate whereas the Taylor rate attempts to stabilise output. Thus both interest rates work against each other. Also external funding fluctuates with goods demand (correlation of .63).
- A related observation is that bank lending obviously is not driven by bank profits (in the

[16] A drawback of the model is the neglect of the zero lower bound of interest rates which of course would influence simulation dynamics particularly in large-shock periods.

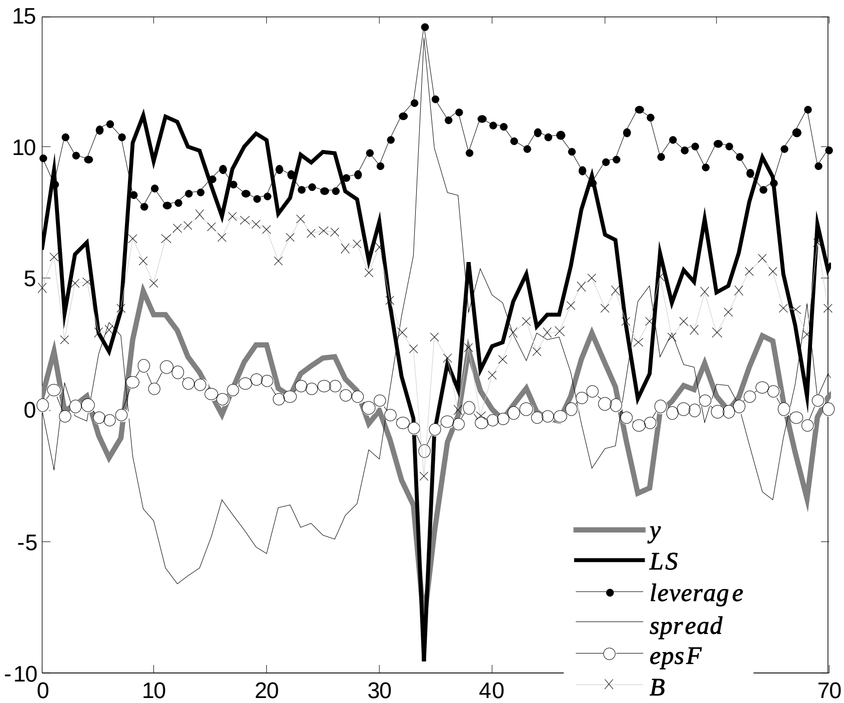

Figure 7: Simulated process with repeated valuation shocks under leverage regulation

literature roughly captured by the interest spread). Hence, the leverage targeting behaviour cannot simply be taken as a short-cut of a comprehensive optimisation approach of banking behaviour.

2.5 Discretionary Interest Rate Moves

Before proceeding to a simple model of optimal bank behaviour, we explore the consequences of discretionary interest-rate policy shocks of the type

$$\varepsilon_t^i = \theta_i \, \varepsilon_{t-1}^i + \omega_t^i \tag{17}$$

where ε_t^i is added to the Taylor rule equation (4) and ω_t indicates white noise. At the same time, all specific stabilisation features are deactivated ($\mu = \delta = 0$). Assume that the central bank wishes to stimulate the economy; then the initial disturbance is a lowering of the Taylor rate, boosting goods demand. After some periods, the rule-based stabilisation feature of Taylor policy gains momentum and brings the macroeconomy back to equilibrium (*Figure 8*).[17]

[17] In order to capture the short-term character of this autonomous change of interest rate policy, persistence has been set at a low level with $\theta_i = 0.1$. The visual separation of discretionary and stabilising

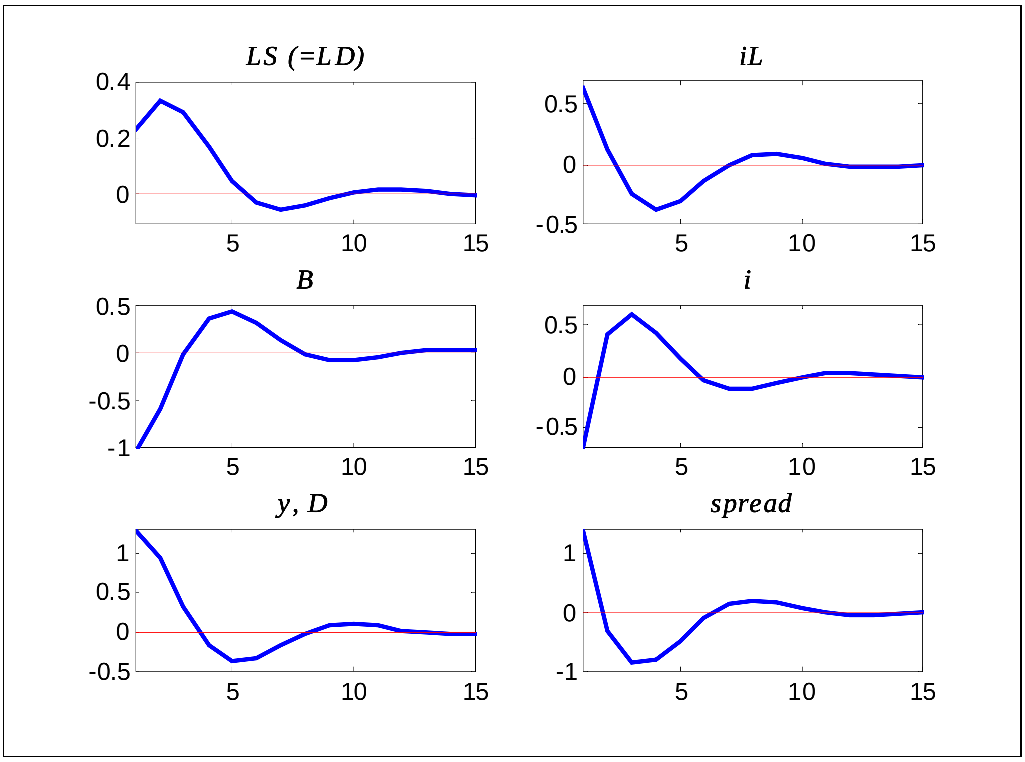

Figure 8: Deviations from equilibrium after negative interest rate shock ($\varepsilon^i = 0.5$)

During the initial expansionary periods two channels affect the credit market. On the one hand, credit demand increases on account of the income effect in equation (12); on the other, positive output experience also modifies asset valuation according to (7). The ensuing variation of leverage translates into a rightward shift of credit supply. The rise in the volume of lending is accompanied (under the given parameter set) by an increase of the lending rate and the interest rate spread. Taking into account that this latter effect improves the banks' profitability (although this is not captured in the above model) the simulation shows that the transmission mechanism of monetary policy also drives an amplifying effect by activating the bank lending channel. Falling policy rates cause banks to increase their holdings of risky (loan) assets through active balance sheet management (Adrian/Shin 2009).

3. Implementing Lending Risk and Funding Costs

3.1 The Stabilisation of Credit Market Shocks

In the following, banks no longer apply a mechanical leverage targeting rule with respect to credit supply as in (9), but take into account profitability with regard to lending and funding.

features of central bank behaviour is emphasised by neglecting the response to the output gap ($\varphi = 0$) and by assuming a lagged reaction to inflation in the Taylor rule.

Banks' risk-adjusted profits Q_t are determined by the lending rate i_t^L, corrected by an estimated risk premium ρ_t, and funding costs that ensue from selling bonds, i.e. the short-term interest rate plus a possible add-on tax rate τ, to be explained below (keep in mind that deposits do not yield interest).

$$Q_t = \left(i_t^L - \rho_t\right) L_t^s - \left[i_t + \tau\left(\cdot\right)\right] B_t \tag{18}$$

The constraint is given by the balance sheet identity (11). Optimisation creates a simple interest rule for the lending rate whereas banks behave as price takers in the funding market:

$$i_t^L = \rho_t + i_t + \tau\left(\cdot\right) \tag{19}$$

This first order condition implies that – in contrast to the first model – the credit supply curve now is flat, and the amount of lending is determined by credit demand ($L_t^s = L_t^d$). As A_t, C_t and D_t are given, B_t then follows endogenously from the balance sheet identity. Valuation shocks have no impact on credit supply and therefore are neglected. Because A_t and C_t stay invariant balance sheets as a whole fluctuate less compared to the first model scenario. As a consequence, with smaller funding gaps, also the quantitative importance and the volatility of bond financing is now lower.

The risk premium follows an AR(1) process (with ω_t indicating white noise) around a given basic value $\bar{\rho}$[18], but is also (inversely) influenced by the output gap; a cyclical improvement of macro conditions translates into lower credit risk.

$$\rho_t = \left(1 - \theta_\rho\right) \bar{\rho} + \theta_\rho \, \rho_{t-1} + \omega_t - \sigma \, y_t \tag{20}$$

The equilibrium lending rate, now given by (19) with $\rho_t = \bar{\rho}$ and $\tau = 0$, again constitutes a part of the Taylor real equilibrium interest rate so that equation (14) applies.

Figure 9 shows the effects of a credit risk shock; to allow a better comparison with the valuation shock in the first model above, the simulation starts with an exogenous *lowering* of the risk premium. At first, there is no stabilisation beyond the simple Taylor rule.[19] An initial

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[18] It can also be interpreted as a kind of monopolistic mark-up on funding costs, representing fixed costs of intermediation services.

[19] Thus we have $\tau = 0$, and $\mu = 0$ in equation (4). Deviating from the former assumptions (see footnote 14) now $\bar{A} = 4.5$, $\bar{L} = 7$ and $\sigma = 0.5$. A new setting is $\bar{\rho} = 1$. In the leverage targeting model, the valuation shock was multiplied in its impact by the leverage ratio. In order to attain similar effects here, and to improve the visual exposition of simulation paths, the dimension of the risk premium shock has been enlarged.

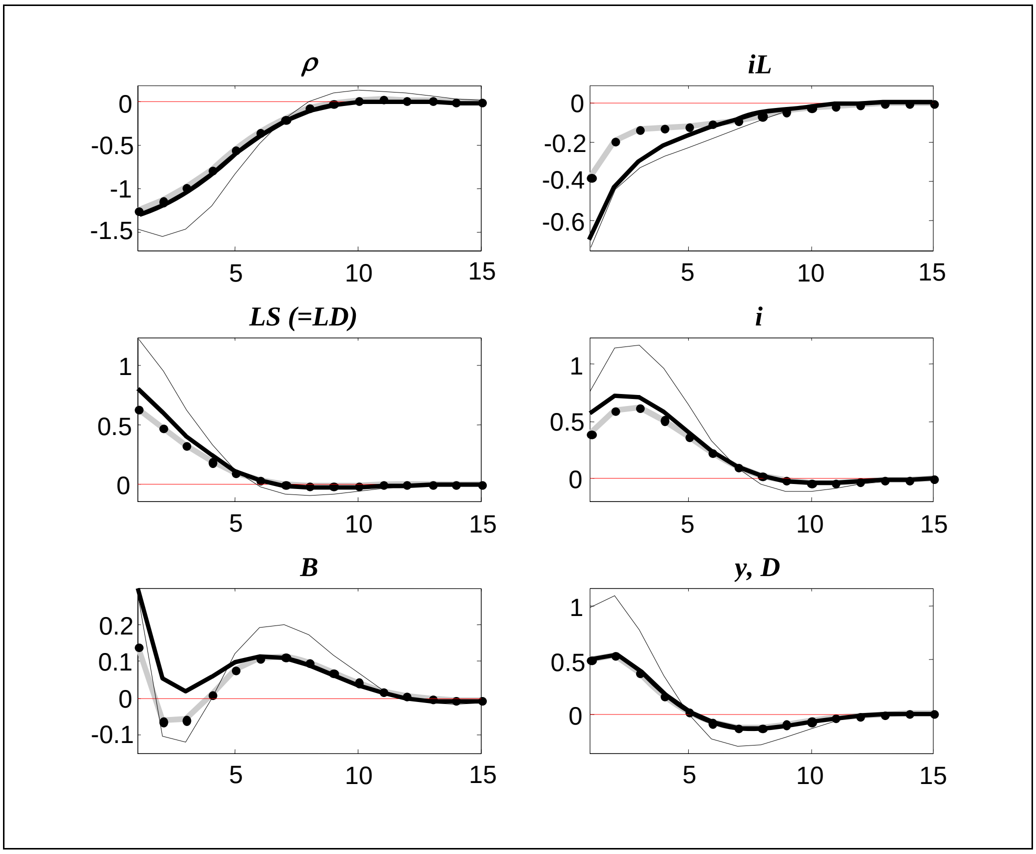

Figure 9: Deviations from equilibrium after negative credit risk shock ($\rho = 1$)
with simple Taylor rule (thin line), extended Taylor rule (bold line) or funding tax (dotted line)

lowering of credit risk assessment decreases the lending rate and thus drives credit and goods demand; the latter reinforces the decline of the risk premium. On the other hand the Taylor interest rate increases, which directly stabilises the demand shock; there is also an indirect effect as the rising Taylor rate is transmitted into the lending rate. Higher output allows easy funding via increased attraction of deposits; banks demand some additional external funds initially, and larger volumes later when income-dependent deposits shrink.

Leverage is increased by the risk shock, and returns to its baseline value during the adjustment process. This is a typical finding in the cyclical behaviour of the banking sector (*Figure 10*). It is reproduced in the model simulation (*Figure 11*) where lending represents the active part of total assets. A series of small risk shocks that are accentuated by feedback mechanism of output changes may well lead to a severe recession where bank variables, credit supply and the lending rate, act procyclically. Leverage now shrinks in the crisis, in contrast to scenario of the first model (*Figure 7*), where the monetary authority pursued a stabilising leverage targeting strategy that allowed higher bank indebtedness, which in turn helped to dampen the macro downturn.

An obvious regulatory intervention would be a prohibition to exceed some given leverage

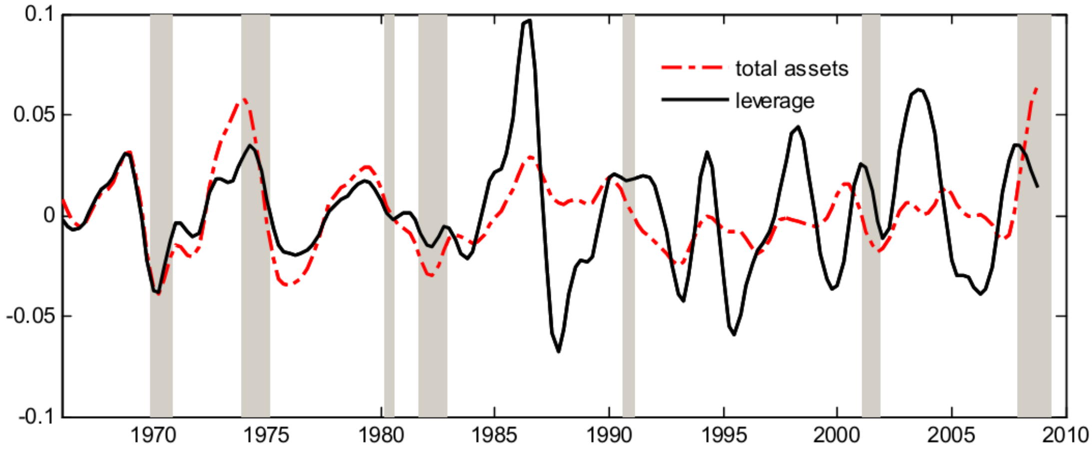

Figure 10: Cyclical components of total assets and leverage in US-chartered commercial banks, shaded areas indicate recession periods (Nuño/Thomas 2013: 33)

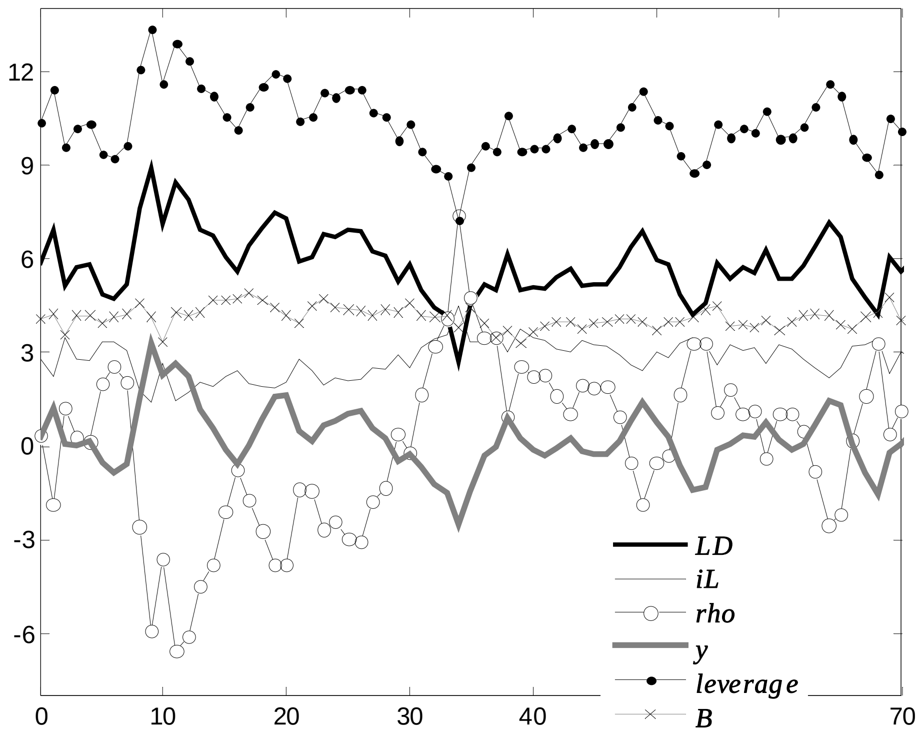

Figure 11: Simulated process of repeated risk shocks with standard Taylor stabilisation

ratio, but there is no price-theoretic lever to implement this restraint in the model's bank behaviour. Instead, monetary policy might resort to the extended Taylor rule and respond to a balance sheet gap.

An alternative policy approach is to impose additional costs on external funding. In a competitive financial market, we might observe rising funding costs for individual banks anyhow; the assumption, made in the above calculus, of unlimited funding at the money market interest rate is hardly realistic. The rise of external funding costs in general will reflect interbank

	variance		
	standard stabilisation $\mu = \tau = 0$	extended Taylor rule $\mu = 0.2, \tau = 0$	funding tax $\mu = 0, \tau = 0.75$
B	0.25	0.16	0.08
LD	3.18	1.31	0.84
iL	1.04	0.90	0.26
i	4.99	2.02	1.49
y	3.14	0.80	0.80

Table 3: Simulation variance of endogenous variables in case of a risk shock with different policy strategies

lenders' risk which in turn might be captured by borrower banks' leverage. In the simple model at hand this market risk premium is substituted by a tax mark-up, imposed by a monetary or fiscal authority where excess balance sheets are taken as the basis of the tax rate: thus we have $\tau\,(A_t + L_t^s - BS^*)$.[20]

Both specific stabilisation strategies, the extended Taylor rule and the funding tax, are also shown in *Figure 9*. As in the leverage target model, output variance is chosen as the benchmark to assess relative efficiency of both strategies; this made the setting of $\tau = 0.75$ endogenous given the arbitrary choice of $\mu = 0.2$. *Figure 9* and *Table 3* reveal that both strategies deliver better results compared with the simple Taylor rule. Nevertheless, as in the leverage target model, the stabilisation approach that is located 'closer' to the banking sector, i.e. the funding tax, yields superior results: the volatility of all variables beyond output is smaller. This might come as a surprise as both the Taylor extension $\mu > 0$ and the tax add-on $\tau > 0$ drive the credit market interest rate in (19). But the former also has a direct impact on goods demand which might cause a tension between the two goals of goods and financial market stabilisation. On the other hand, the tax add-on exclusively works to counter the lending rate decrease brought about by the lowering of the risk premium.

3.2 An Easy-Money Policy

A final question is in what respect monetary policy shocks in a regime of optimal bank behaviour differ from the leverage targeting regime. All specific stabilisation devices are deacti-

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[20] For a more thorough discussion of liquidity regulation when short-term funding enables credit growth but generates negative systemic risk externalities see Shin and Shin (2011) and Perotti and Suarez (2011).

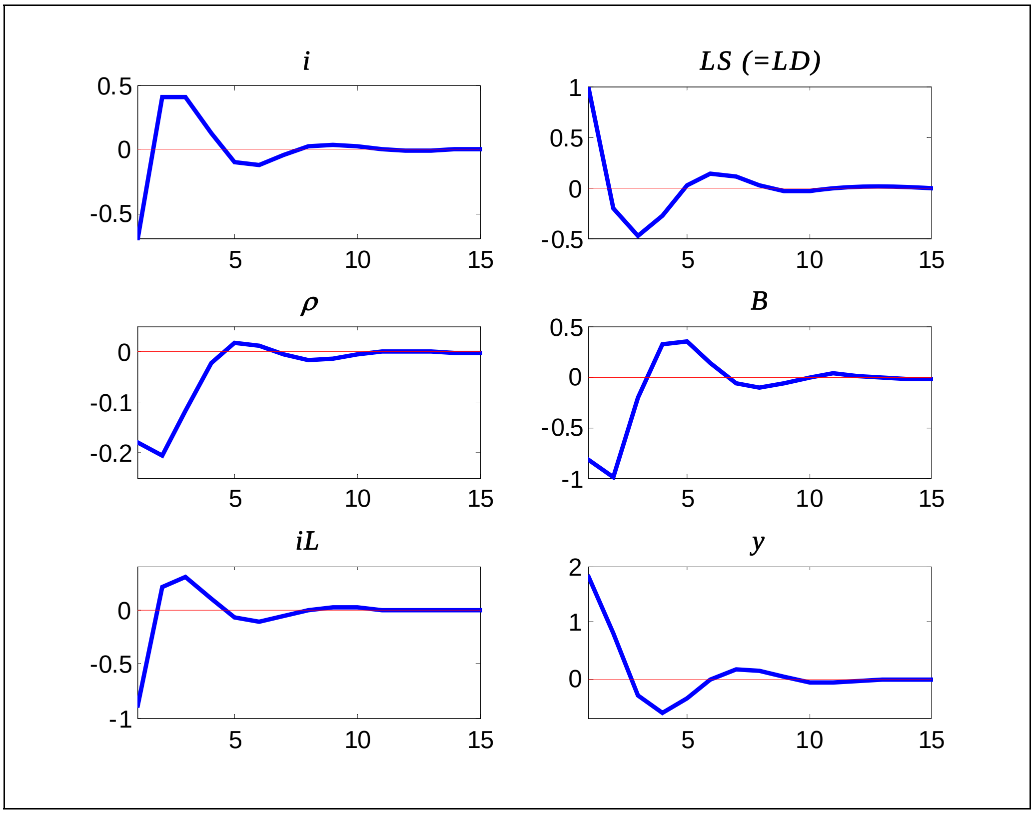

Figure 12: Deviations from equilibrium after negative interest rate shock ($\varepsilon^i = 0.5$)

vated again; the central bank starts a short-term expansionary initiative before its behaviour is more and more dominated by the standard Taylor rule (*Figure 12*).[21] Increased output figures, which helped to improve asset valuation in the leverage targeting regime, now lower the assessment of credit risk. In the first case the restoration of leverage resulted in a credit supply shift that initially was exceeded by an income-driven increase of credit demand so that the lending rate was raised[22] to clear the market. Now, with banks choosing an optimal lending rate, lower funding rates and risk premia let the credit market interest rate decrease, and the volume of lending adjusts to higher credit demand.

The model again confirms that the direct effect of monetary easing on goods demand is amplified by a financial market response where now credit risk assessment plays a key role. Besides, a similar picture emerges in the case of demand shocks emanating in the 'real' sector (no graph shown). Credit supply now follows more flexibly credit demand, compared to the leverage targeting scenario (*Figure 2*), and the increase in the lending rate brought about by the rising Taylor rate is cushioned by the lower risk premium. Higher leverage signals an am-

[21] For technical details of this case see footnote 17.

[22] Note that the sign of the lending rate response depends on the model's parameters.

plifying effect of bank behaviour.

4. Conclusions: a Note on the Elasticity of the Financial System

The topic of this paper has been the question of optimal stabilisation policies with some emphasis given to the final goal of maintaining goods market equilibrium. Preventing, and healing, financial boom and bust cycles as such are not an issue. But the model in its two versions elucidates that portfolio decisions in the banking industry can amplify disturbances that emerge in the field of good and labour markets, or result from a monetary policy impulse. More important, shocks from within the financial sector, like changing market sentiments of the value of financial assets, are shown to produce a substantial spill-over to goods demand. A typical pattern is that positive financial market shocks encourage a credit supply shift, which by lowering the lending rate strengthens investment spending.

In principle all disturbances rooted in this new dimension of the bank lending channel in macroeconomics can be dampened by relying on the standard Taylor rule. However, the explicit analysis of bank behaviour suggests to employ additional tools that have a more direct bearing on the banks' contribution to market disequilibria. A simple advice would be to increase the Taylor rate whenever the volume of bank balance sheets (or the path of single items) grow too fast. But this was proven to be less efficient as this might pose a conflict between goods market and financial market stabilisation. The latter, in the framework of this paper's model, was interpreted as the goal to contain the growth of banks' balance sheets. By using this criterion, imposing a leverage restriction or an external-funding tax on the banking business appeared more useful.[23]

Interbank relations were excluded from this study, but they constitute a major factor of financial market mechanisms. Thus the funding tax substitutes a mark-up on interbank lending rates in a 'perfect' market where creditors account for their lending risk that can be derived from 'excess' bank balances. The multiplier function of the bank sector depends on the elasticity of the financial system, i.e. on the ability of the banks to draw funds from the private sec-

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[23] "The real issue [...] should not be one of controlling the possible mis-pricing of assets in the marketplace – where the central bank has good reason to doubt whether its judgments should be more reliable than those of market participants – but rather, one of seeking to deter extreme levels of leverage and of maturity transformation in the financial sector. [...] Even modest changes in short-term rates can have a significant effect on firms' incentives to seek high degrees of leverage or excessively short-term sources of funding" (Woodford 2012: 5).

tor and the central bank. It is an advantage that banks at times can reduce the amount of bonds outstanding, and that their financial needs in other periods are smoothly satisfied by additional funds drawn from the central bank. Bond sales B_t stand ready to fill any lacuna that is left if deposits should prove insufficient.

At earlier times, losses of banks' reserves could not easily be replenished, but nowadays the high elasticity of the financial system by some observers is held to be the key explanation of the widespread volatility and instability of financial markets, the major root of macroeconomic troubles of the 2000s (Borio/Disyatat 2011). The key point is the perfect endogeneity of central bank money, which has become a guiding principle of monetary policy after the new macro theories, focused on the importance of interest rates, gained acceptance. Keeping money market rates as close as possible to 'optimally' calculated policy rates became the new criterion for 'good' central bank practice. Frictions in base money supply would create interest rate spreads that hamper efficient goods demand control.

This progress in monetary policy making came at a cost. Commercial banks progressively reduced liquid asset holdings, and were led to engage in any investment as long as spreads were estimated to be positive; 'capacity constraints' in the financial industry seemed to be removed.[24] Thus the suggested policy response, leverage regulation, should be understood as a hint to the former strategy of monetary targeting. Of course, Woodford (2010) is right to argue that the new topic of financial intermediation and its macroeconomic impact once again has demonstrated the limits of money supply and money multiplier concepts; liabilities of just the most active agents of the financial industry in no way count as money.

But the rationale of monetary targeting always has been the establishment of quantitative restraints in the financial sector, and the repeated modifications and redefinitions of monetary aggregates show the attempts of monetary policy makers to keep pace with market innovations. Leverage control therefore stands for the acknowledgement that bank assets, and credit supply in particular, can no longer be captured by the path of liquid deposits as a proxy (Schularick/Taylor 2010). The distinction between deposits and other liabilities has been blurred, not least because the criterion of the immediate means-of-payment function for defining a monetary aggregate was downgraded in the first place when the case was made for pro-

[24] "After quantity controls [of base money] were dismantled, the major central banks were left with a single policy tool: the ability to change the short-term policy rate. They lost control over the supply of bank credit and, over time, their influence over the demand for credit also weakened. [...] The build-up in banks' leverage was a direct result of the removal of quantity controls" (D'Arista/Griffith-Jones 2010: 134).

ceeding from *M1* to *M3*.

Financial market instability and its repercussions on the goods market can thus be interpreted as an unwelcome by-product of former 'modernisation' of monetary policy strategies, and the need for new instruments may in part reflect the abandonment of 'old' restraints in the field of banking. However, the cyclical resurgence of old problems in new clothes is not atypical for economic theory and policy.

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Dynare/Matlab files used to produce the simulations in the paper are available upon request from the author.

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