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Abhandlungen

The Bank Lending Channel with Endogenous Money – A Simple Macro Model

Peter Spahn*

Abstract

The growth and deepening of financial markets entailed the expectation that the bank lending channel of monetary policy transmission would lose its importance. The paper explains why, on the contrary, the banking sector has become a major locus of origination and amplification of macro-financial shocks. Mutual feedback mechanisms between the financial and the real sector are analysed and simulated by using a simple standard macro model with an integrated banking system. A comparison of the efficiency of various Taylor Rule extensions explores whether monetary stabilisation can be improved by additional interest rate reactions to asset prices, bank lending, bank leverage or the spread between the loan and the policy rate.

Der Bankkreditkanal bei endogener Geldmenge – Ein einfaches Makromodel

Zusammenfassung

Wachstum und Vertiefung der Finanzmärkte ließen vermuten, dass der Bankkreditkanal der geldpolitischen Transmission an Bedeutung verlieren würde. Der Beitrag erklärt, aus welchen Gründen jedoch der Banksektor gesamtwirtschaftliche Störungen verstärkt oder sogar verursacht hat. Wechselseitige Rückwirkungseffekte zwischen dem finanziellen und dem realen Sektor der Volkswirtschaft werden anhand eines einfachen Makromodells mit integriertem Banksektor analysiert und simuliert. Vor diesem Hintergrund wird geprüft, ob die monetäre Stabilitätspolitik durch alternative Erweiterungen der Taylor-Regel verbessert werden kann: insbesondere durch zinspolitische Reaktionen auf Vermögenspreise,

* Prof. Dr. Peter Spahn, University of Hohenheim (520A), 70593 Stuttgart, Germany, peter.spahn@uni-hohenheim.de.

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Volumen der Bankkredite, Bankverschuldungsgrad oder den Spread zwischen Kredit- und Geldmarktzins.

Keywords: Monetary policy transmission, credit market, leverage targeting, risk-taking channel, asset market shocks.

JEL Classification: E1, E5, G2

I. Introduction

The awakened interest in the macroeconomic role of the banking sector serves the purpose to gain a better understanding of the mutual feedback mechanisms between the financial and the real sector of the economy, and to explore the operating principles of possible policy tools that might be suitable for stabilisation of goods and asset markets. A widely shared impression is that the banking sector tends to aggravate macroeconomic shocks that emanate in non-financial sectors, but apart from this multiplier effect, also produces disturbances with substantial spill-over to goods market.

The debate on how to merge the financial sector and the goods market in macroeconomic theory is compounded by the analytical complexity of integrated macro-financial models. The dominating New Keynesian approach requires to build all macroeconomic relationships directly on microeconomic decisions. Critics complain 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; *Gertler/Kiyotaki* (2010), e.g., give an example. Others express a basic distrust of this 'fashionable' modern macroeconomic theory: adding just some financial frictions would not repair the shortcomings of a basically non-monetary model (*Borio* (2012)).

However, it is not necessary to take a stand in this fundamental debate on the adequacy of microfoundation in macroeconomics before being able to grasp the analytical essence of the macroeconomic implications of bank behaviour. There are a couple of papers, among them *Woodford* (2010) and *Friedman* (2013), that give a compact treatment of the key relationships. Both focus on the role of the interest rate spread between the money and the credit market and explore potentially destabilising effects of financial intermediation. Other contributions, e.g. *Adrian/Shin* (2010) and *Disyatat* (2010), offer a more detailed image of banking sector operations, but from a more partial-market analysis perspective. The current paper takes up these threads, but aims to maintain a general-equilibrium view and uses a middle-way degree of algebra that is able to yield similar insights and results as more formal treatments as, e.g., *Gerali* et al. (2010) or *Gambacorta/Signoretti* (2013).

After all, it is the respect scientists should pay to the principle of Occam's Razor that justifies the defence of 'small models' (*Krugman* (2000)). A main motivation of the current paper is the aim to develop a medium-scale approach with a limited amount of readily comprehensible algebra. It presents a kind of a workhorse model that can be extended and applied to many related questions; yet it lacks however an empirically realistic calibration of the functional parameters so that policy-relevant conclusions should be taken with care.

The program of the paper is as follows: Section II presents some stages of the debate on the bank lending channel since the 1980s. This has been a period of rapid growth and deepening of financial markets. But, much to the contrary of what the traditional view on monetary policy transmission via bank credits would make believe[1], the message is that bank activities on both sides of their balance sheets gain in their importance for the macroeconomy if banks are embedded in a well developed financial market. Section III, starting from a simple optimisation calculus, derives lending and funding decisions of an integrated banking sector, which then is included in a standard modern macro model where the non-bank sector acquires funds exclusively via the credit market.

Section IV uses the model to explore the consequences of different shocks. First, it is demonstrated that autonomous asset price movements are able to produce credit market reactions and thus macroeconomic effects much the same as discretionary interest rate decisions on the part of the central bank. Second, the focus is on a beneficial supply shock that is amplified by reactions of the banking sector (including the central bank) and thus may lead to an overheating of goods and credit markets. Third, the comparison of alternative policy options in addition to the Taylor Rule yields some arguments in favour of specific interest rate reactions to the spread between credit market and money market rates, to asset prices, or to the volume of bank lending. Section V concludes with a short summary.

[1] "Bank lending channels were likely to have been more important during periods in which financial markets were more heavily regulated. […] In an environment in which interest rates are free to adjust, the bank lending channel of monetary policy is likely to be of lesser importance" (*Walsh* (2003), p. 345).

II. Old and New Aspects of the Credit View

1. *Availability-of-Deposits Doctrine and Central Bank Money Supply*

Banks' balance sheets have expanded rather steadily, relative to nominal GDP, since the end of the Second World War, though with a pronounced peak of that ratio in the recent decade, but the scientific assessment of the banks' importance for macroeconomic activity took place in a few distinctive steps. The Keynesian Revolution had pushed the credit market, which occupied a prominent position in pre-Keynesian macroeconomic thinking (*Trautwein* (2000)), almost into oblivion, following a new modelling architecture, suggested in Keynes's *General Theory*, that focused on the money market instead. Until the early 1980s, the Money View prevailed where bonds and bank loans were treated as perfect substitutes. The convenient conclusion was that the dynamics of macroeconomic activity and the concepts of monetary stabilisation could be analysed without an explicit need to integrate the behaviour of financial intermediaries (*Freixas/Rochet* (2008), p. 195).

Building on *Bernanke's* (1983) work on the Great Depression, the newly developing Credit View took account of market imperfections, mainly arising from asymmetric information. The message was twofold: it became obvious that a large part of prospective debtors had no access to the capital market, which established a kind of market segmentation between bond financing and demanding bank loans; banks provision against the implications of adverse incentives on the part of their debtors, which explains the use of collateral as an additional constraint of bank lending (*Gertler* (1988), *Bernanke/Gertler* (1995)).

Monetary policy transmission thus had to be considered in a somewhat richer framework. The bank lending channel was added to the interest rate channel. However, as central banks still basically were assumed to operate by way of a quantitative reserve management (this was the legacy of the *IS-LM* model), and commercial-bank deposits were regarded as the key source of bank funding and initiating factor of bank lending, the assumption of a stable multiplier relationship between high-powered money and bank deposits promised a reliable control of overall banking activity. Open-market sales of government securities on part of the central bank, e.g., would deprive commercial banks of a proportional amount of deposits and thus would compel a reduction of bank lending (*Bernanke/Blinder* (1988)).

The availability-of-deposits doctrine is still accepted in the circle of central banks[2] although it appears flawed. First, interest rate elasticity of transaction balances is low, and bank accounts nowadays are remunerated near to market rates so that the incentive to modify portfolios is weak. But the key argument is that the doctrine suffers from a fallacy of composition: “For the system as a whole, deposits cannot fall unless banks issue new liabilities to replace them or sell an asset to non-banks (including loan repayment). Individual agents’ attempt to dispose of their deposit holdings by buying assets from other non-bank private sector agents simply redistributes deposits within the system leaving aggregate deposits unchanged” (*Disyatat* (2010), p. 7). This does not mean that non-banks are forced to keep a portfolio of money wealth that is not aligned with their preferences; but if bank clients switch from low-yield deposits to higher-yield savings accounts or bank-issued securities, the volume of bank funding still is unchanged (although there is a cost effect of funding to be discussed below).

The credit channel of monetary policy transmission has a misplaced emphasis on the availability-of-deposits doctrine. A second fundamental objection challenges the associated popular, though mistakable, view that deposits determine bank loans. The dispute on whether ‘deposits make loans’ or ‘loans make deposits’ has a long history.[3] With regard to this topic, there is also a rarely mentioned ‘cultural’ distinction between American and European monetary theory. Students of US textbooks learn that “banks make profits by selling liabilities with one set of characteristics (a particular combination of liquidity, risk, size, and return) and using the proceeds to buy assets with different characteristics”, in short, they practise a kind of asset transformation from saving deposits into loans, i.e. they lend out money previously collected (*Mishkin/Eakins* (2006), p. 429). British textbooks, on the other hand, stress that for “every loan created, someone must receive an addition to his or her deposit” (*Howells/Bain* (2005), p. 236) and demonstrate that the extension of bank

[2] “Bank lending tends to contract after a tightening in monetary policy because an increase in the policy rate is usually followed by a reduction in the availability of bank deposits as deposit holders shift their investments from deposits towards assets offering a higher return. Unless banks can compensate for the decline in deposits via other sources of funding, the downward adjustment acts as a constraint on the asset side of banks’ balance sheets, ultimately inducing a contraction in bank loans” (*ECB* (2010a), p. 63).

[3] It has close connections with the debate on the causality of saving over investment, or vice versa, and thus formed a key topic in the controversy between neoclassical and (post) Keynesian economics (*Lavoie* (1984)).

credit necessarily goes along with a lengthening of bank balance sheets. Recently, the Bank of England emphasised this principle of endogenous creation of bank money in a much-noticed contribution (*McLeay* et al. (2014)).

The controversy has an important implication for the understanding of the relationship between banks and financial markets. According to the American view, both institutions deliver basically an equivalent service of intermediation where banks increase the length and efficiency of transaction chains. This understanding however misses a key point: whereas on financial markets an existing stock of means of payment is transferred between creditors and debtors (in most cases by way of an exchange of bank deposits and newly issued securities), writing credit contracts between banks and new debtors implies the creation of *new* deposits.[4]

For profit-maximising reasons the active, 'primary', business of banks is granting loans, but at the end of the day balance sheet bookkeeping shows that they appear to be 'financed' by deposits (that not necessarily are meant to be 'savings'). The dominance of the 'loans make deposits' business strategy requires that banks rightly expect to obtain additional reserves necessary to cover minimum reserves and cash withdrawals that result from new lending. Also the effect of the above example of a restrictive open-market policy move is not that it draws deposits, but rather that it draws reserves from the commercial banking system; and loan supply might be reduced if banks expect to acquire new reserves only at prohibitive costs. Preserving required liquidity is a key side condition of bank behaviour; the cost effect of non-banks' attempts to shift away from cheap deposits (that emerge as a by-product of credit creation) can only be countered by resorting to central bank refinancing. Therefore the overriding question is whether the market for reserves shows supply side constraints or not.

Here, central bank practice and policy norms have changed over the past decades. In the early days of central banking, quantitative restrictions for the creation of high-powered money were indispensable due to obligations of note convertibility into fixed amounts of precious metal

[4] "Capital market intermediation, like barter and commodity money or cash-based systems, requires that the creditor have on hand the means of payment to deliver to the debtor before the credit is extended. […] Bank lending, on the other hand, involves the creation of bank deposits that are themselves the means of payment" (*Disyatat* (2010), p. 7–8; cf. *Borio* (2012)).

(as in the gold standard). During the 20th century, it was difficult to ascertain whether announcements of base money control were meant to indicate a factual use of that policy tool or merely a way of central bank communication with the public; the period of the Bundesbank's famous strategy of monetary targeting is a case in point (*Bindseil* (2004), *Beyer* et al. (2009)). The policy norm in modern times is unambiguous however: central banks endeavour to avoid any reserve shortages because they produce deviations of the money market interest rate from the policy rate; even if only temporary, these deviations appear as technical imperfections of policy making as they distort the signal of interest setting.[5]

When central bank money is supplied endogenously, both the availability-of-deposits doctrine and the concept of a money multiplier have hardly persuasive power. With regard to bank lending, apart from capital restraints (that also were lowered in recent decades) "there is no quantitative constraint as such. […] While traditional models assume that a monetary tightening leads to a shortage of liquidity for banks, the presumption here is that it leads to a disproportionate rise in the price of funding liquidity, which is readily available" (*Disyatat* (2010), p. 8–9). Thus, an alternative interpretation of monetary policy effects in the bank lending channel points to price-theoretic arguments.

Bernanke and *Blinder* argued already in 1992 that, even if base money supply is elastic in the short run, higher central bank interest rates will also increase yields paid on deposits. The typical maturity mismatch of bank assets and liabilities then produces a profit squeeze if rate adjustment with respect to the stock of credit is precluded. Then the only expedient – pronounced interest rate increases for new lending – is bound to reduce the volume of credit. A price effect also is felt in the impact of interest rate policy on a prospective debtor's pledgeable wealth: changes of capital market interest rates inversely modify the value of bank clients' collateral and thus signal an improved, or worsened, degree of creditworthiness. This balance sheet effect connects the interest rate channel

[5] Contrary to the Bundesbank tradition, the ECB propagates a Separation Principle of interest setting on the one hand, expressing the macroeconomic policy stance, and the provision of high-powered money on the other hand, located on the 'lower', technical level of facilitating payment flows within the banking system and in the macroeconomy at large (*ECB* (2010a), *Fahr* et al. (2011)). For a general survey on the independency of interest rates and monetary aggregates as policy instruments in modern central banking see *Disyatat* (2008). *Friedman* (2014) argues that central banks will continue to use both instruments also after the financial crisis.

and the bank lending channel and magnifies – as 'financial accelerator' – the impact of monetary policy interventions.

2. Risk-Taking and Credit Supply

A more recent step in the growing understanding of the bank lending channel was the realisation that valuation effects also bear on banks' balance sheets, which then might trigger a change of credit supply. In general, risk taking will increase with rising perceived wealth. Variations in the value of bank assets, either brought about by interest policies or by a new assessment of asset risks, modify bank capital and – if banks aim at keeping a constant leverage ratio (i.e. bank assets relative to equity) – induce the purchase of new assets and/or the writing new credit contracts; often even a procyclical variation of leverage has been found (*Adrian/Shin* (2010), *Nuño/Thomas* (2013), *Borio* (2014)).

These credit supply shifts are the key element of the new 'risk-taking channel' of monetary policy. It differs from the well-known impact of risk considerations on the part of debtors/investors by focusing on the behaviour of creditors. A market-driven rise of bank capital "increases the risk-taking capacity of the banking system, which in turn leads to a lower equilibrium risk premium, and an increase in the supply of credit by lowering the hurdle rate at which projects are financed" (*Adrian/Shin* (2010), p. 638). In addition, a successful record of monetary policy in the recent past, high credibility of central banks, a period of low inflation and supply-side innovation, all encourage risk-taking and investment on asset markets (*Borio/Lowe* (2002), *Borio/Zhu* (2008)).

Active acquisition of assets requires additional funding that in recent decades shifted from attracting deposits to tapping domestic and foreign financial markets.[6] A concomitant observation is that bank-issued securities grew large in relation to broad money (*Shin/Shin* (2011)). The more general finding is that bank activity is underrated by looking at any broad money aggregate; bank assets and bank loans, taken as ratios to

[6] In Germany, between 1980 and the early 2000s, the balance sheet share of overall deposits decreased from 50 % to 32 %, while the shares of bond sales and foreign indebtedness rose from 17 % to 24 %, and from 3 % to 10 %, respectively. After the financial crisis however, figures have changed somewhat in direction of earlier values (see Deutsche Bundesbank Homepage, statistical series, nos. BBK01. TUD401, ~ 430, ~ 447, ~ 449). For the US banking sector, a comparison of deposit and non-deposit borrowing growth rates is given by *Adrian/Shin* (2006).

GDP, show an historically unprecedented rise after 1950 (*Schularick/Taylor* (2010)). Bank funding via financial markets, often accompanied by pronounced maturity transformation, rests on the belief that the inclination to provide (mostly short-term) credit on the part of interbank market participants is stable, and that a sufficient number of financial market agents have a secure access to central bank refinancing. Again, the structural change of banking behaviour is based on the expectation of quantitatively unconstrained base money supply.[7]

Because banks advanced to become important debtors, market 'rules' for issuing debt paper increasingly also pertained to banks: due to information costs and risk borne by external investors/lenders, the latter demand an external finance premium that depends inversely on the debtor's economic and financial strength. Shortly before the outbreak of the American banking crisis, *Bernanke* (2007) thus added a further element to the bank lending channel: "The cost and availability of nondeposit funds for any given bank will depend on the perceived creditworthiness of the institution."

For the banking sector as a whole, a higher quality of its assets thus reduces its costs, allowing lower lending rates. As a consequence, changes of policy rates as well as speculative assessments of bank assets' values exert an influence on banks' balance sheets and profitability. Whereas the traditional bank lending channel was built on a separation between the banking sector and financial markets, it now becomes clear that this channel unfolds its strength because also banks are subject to variations of an external finance premium (*Disyatat* (2010)). Banks as the key drivers of the lending channel are themselves subject to waves of changing market sentiment that influence the scope of their business.

The financial industry tends to aggravate macroeconomic shocks that emanate in non-financial sectors, but apart from this multiplier effect, it also produces disturbances with substantial spill-over to goods market.

[7] 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: "Financial crises tend to be preceded by marked increases in leverage. 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), p. 603).

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), p. 602). In the public, banks are considered as the 'villains in the piece'. This state of the debate motivates the following study of the bank lending channel, which attempts to integrate the above mentioned facets into a analysis of bank behaviour, embedded in a simple stylised macroeconomic model.

III. The Banking Sector in a Macroeconomic Framework

1. Banks' Balance Sheets

The economy's commercial banking sector, assumed to work in a competitive fashion, is depicted by its integrated balance sheet (*Table 1*) where all items represent nominal values.

Table 1

Banks' Balance Sheet

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

Bank assets A_t consist of securities and investments (in inelastic supply) that are marketable in principle, but not used for financing purpose in ordinary business. Their base value $\bar{A}$ is modified by various effects, and the ensuing valuation gains and losses alter – for simplification reasons in full amount – the value of bank capital C_t.[8] First, random events might produce a financial market shock ε_t^f, which is modelled as an AR(1) process with persistence, i.e. $\theta_\varepsilon < 1$, and ω_t^f is a 'white noise' term with expected zero mean. In addition, there is a capitalisation effect κ_A[9] that modifies banks' asset values in response to interest rate changes. As

[8] 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.

[9] Throughout small Greek letters void of a time index are semi-positive constant parameters.

the market for A_t is not explicitly modelled, these valuation effects are driven by deviations of the credit market nominal lending rate i_t^L from its equilibrium level (to be derived below). Finally fundamental improvements of macroeconomic conditions in general, proxied by the output gap y_t, also have an impact on assets and capital.[10]

(1) $$A_t = \bar{A} + \varepsilon_t^f - \kappa_A \left(i_t^L - r^*\right) + \sigma y_t$$

(2) $$\varepsilon_t^f = \theta_\varepsilon \, \varepsilon_{t-1}^f + \omega_t^f$$

(3) $$C_t = \bar{C} + A_t - \bar{A}$$

Credit supply L_t^s is the banks' active market tool. It is derived from a simple optimisation calculus of banks' risk-adjusted profits where ρ_t is the credit default rate, i_t the short-term central bank interest rate, and f_t an external finance premium that fluctuates with future bank profits and their leverage ratio $\lambda_t = (A_t + L_t^s)/C_t$; the leverage target is given by λ^*.

(4) $$Q_t = \left(i_t^L - \rho_t\right) L_t^s - \left(i_t + f_t\right) B_t - \frac{\delta}{2}\left(\lambda_t - \lambda^*\right)^2 C_t$$

Profits flow from the lending rate, net of the default rate. The latter follows an AR(1) process around a given basic value $\bar{\rho}$, and is inversely influenced by the output gap: a cyclical improvement of macro conditions translates into lower credit risk.

(5) $$\rho_t = \left(1 - \theta_\rho\right) \bar{\rho} + \theta_\rho \, \rho_{t-1} - \gamma y_t$$

There is second cost element in eq. (4) associated with bond financing that emerges from an external finance premium f_t. It reflects the market result of interbank lenders' risk aversion, therefore it can be assumed being bound to the banks' leverage ratio so that the effective cost of external financing varies with banks' indebtedness. On the other hand, lenders might also have an eye on the profitability of bank lending beyond

10 "The dependence of the supply of intermediation on the capital of intermediaries provides a channel for the amplification and propagation of the effects of economic disturbances. An increase in aggregate economic activity will generally increase the value of intermediaries' assets (loans are more likely to be repaid, land prices increase with increases in income, and so on) and hence their net worth. This will allow additional borrowing by the intermediaries, and hence a larger volume of credit for any given credit spread" (*Woodford* (2010), p. 32).

the short run, which will depend (among other factors) on the expected future output gap (as usual, the operator E_t throughout indicates rational, i.e. model-consistent expectations).

(6) $$f_t = \psi \lambda_t - \gamma E_t y_{t+1}$$

Only a part of funding results from non-bank deposits. They bear no interest and are kept by the public, following its transaction needs that are represented by the output gap.[11]

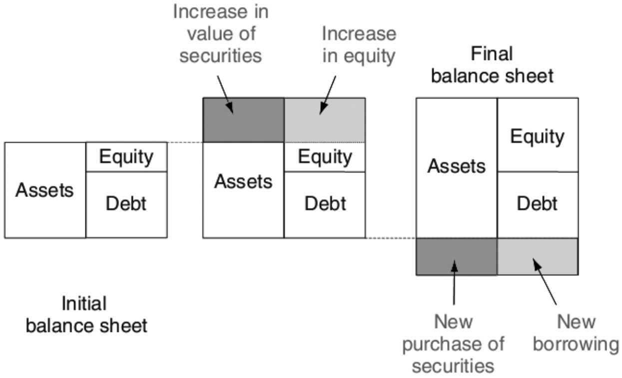
(7) $$D_t = \bar{D} + \mu y_t$$

Besides the modifying effects in eq. (3), bank capital is fixed, thus any funding gap that emerges if deposits prove to be insufficient (or excessive) has to be closed by selling (or buying) short-term bonds B_t. This 'non-core' funding nowadays is obtained from the interbank market and, particularly in small open countries, from capital import (*Shin* and *Shin* 2011). As the model however describes bank sector behaviour in a closed economy bond sales are defined as net quantities. Accordingly the central bank is assumed to be the key counterparty agent who adjusts base money supply endogenously to the banks' demand, by standing ready for (short-term) open-market operations where bond prices are fixed to preserve the central bank policy rate i_t.

The final item in the profit function (4), as in *Gambacorta* and *Signoretti* (2013), represents a kind of penalty, proportional to capital, for deviating from a leverage target λ^*. It can be interpreted in two ways: first, there are microeconomic reasons for aiming at an optimal (in most cases: high) leverage ratio that equalises the profit advantages of indebtedness and the costs associated with the risks of illiquidity and default; second, a regulative authority might impose a prescription of a maximum leverage ratio, again for the sake of maintaining financial market stability.

The leverage target induces further asset purchases or sales if changes of asset prices make actual leverage diverge from target. 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

[11] The term μy_t only shows that part of new transaction balances that are kept in form of deposits. Supply and demand of base money (used for cash holdings and minimum reserves) are not analysed as a further topic.



Source: Adrian/Shin (2010), p. 611

Figure 1: Two-step Balance Sheet Reaction to Positive Asset Valuation Shock

of this market mechanism is obvious. The expansionary adjustment mechanism is demonstrated in *Figure 1* (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. If the stock of newly acquired assets also includes bank loans, valuation shocks on financial markets create a spill-over to goods demand.

Using the balance sheet identity $A_t + L_t^s = C_t + D_t + B_t$ as the constraint, the maximisation of eq. (4) by varying L_t^s and B_t yields as the First Order Condition the banks' credit supply function:

$$L_t^s = \left(\lambda^* + \frac{i_t^L - i_t - \rho_t - f_t}{\delta}\right) C_t - A_t \tag{8}$$

The formula confirms bank capital as the key quantitative constraint of bank lending (*Disyatat* (2010), *Gambacorta/Signoretti* (2013)). Loan supply increases with the credit market interest rate whereas the leverage target, the policy rate, credit default risk and the external finance premium appear as shift factors. Without leverage targeting and external finance premium $(\delta = f_t = 0)$, loan supply (eq. (8) solved for i_t^L) is horizontal at the $(i_t + \rho_t)$ level; with perfect leverage targeting $(\delta \to \infty)$, credit supply is fixed at $(\lambda^* C_t - A_t)$, without any loan rate elasticity.

2. Non-Bank Agents and the Central Bank

The counterpart equation to (8) is the private non-bank sector's credit demand that is given here in a simplified, linear-reduced form; all items though correspond to the results of a standard optimisation framework. Loan demand depends, besides a constant, negatively on the difference between the real credit market interest rate and the steady state, 'normal' real rate r^* that is taken as a constant; there is a positive influence of the expected future income level. The latter can be understood to proxy profit expectations of investors or to reflect the desire of households for consumption smoothing over time, i.e. their "greater willingness to borrow when expected future income is higher" (*Friedman* (2013), p. 18).[12]

$$L_t^d = \bar{L} + \varphi E_t y_{t+1} - \kappa_L \left(i_t^L - r^*\right) - \eta\left(i_t^L - E_t \pi_{t+1} - r^*\right) \tag{9}$$

The inclusion of expected future income in credit demand also shows agents' tendency to take on more risk as their perceived wealth increases (*Borio* (2014a)). Expected income further serves as a proxy for a positive collateral effect in the balance sheet channel of monetary transmission. For the same purpose, a capitalisation effect κ_L, as in eq. (1), is added; it translates interest movements into valuation changes of debtors' wealth, which in turn modifies their collateral.

The intersection of credit supply (8) and credit demand (9) determines the nominal loan rate i_t^L and the nominal volume of lending to non-banks ($L_t^s = L_t^d = L_t$; *Figure 2*). Before turning to the goods demand equation it is instructive to have a cursory view on various shocks that might shift the credit market functions. An increase in the value of collateral and a lower credit risk assessment, e.g., will move both curves to the right, so that, in a special case, there is no effect on the rate of interest. The rise in the volume of credit thus would leave no scare in a stand-

[12] In the earlier literature, a positive effect of current income was a standard element of credit demand; e.g. *Bernanke* and *Blinder* (1988, p. 435) hint to "transaction demand for credit, which might arise […] from working capital or liquidity considerations". On the contrary, *Woodford* (2010, p. 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 eq. (9). This can be explained by the degree of persistence in the model, which was chosen to capture stylised facts.

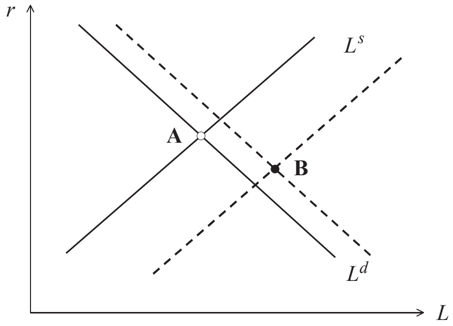


Figure 2: Credit Market Equilibrium Shift After Expansionary Supply and Demand Shocks

ard modelling of goods demand, only the credit-income ratio would change – a not very realistic feature of a banking-macro model.

Therefore, in the following a different set-up is preferred for the design of the goods demand function. Besides the difference between the real credit market and the 'normal' interest rate, deviations from the steady-state volume of credit $\bar{L}$ are added as a further driving force; the $\beta^L(\cdot)$ term thus also captures the impact of access to finance or, inversely, the relevance of credit rationing (note however that the qualitative results of the model do not depend on $\beta^L > 0$). Whereas the basic New Keynesian model assumes that market agents operate on a perfect financial market, the extreme alternative here is that banks alone provide financing.[13] In general, it is a hybrid version of an otherwise rather standard New Keynesian demand function that contains lagged output besides output expectations in order to capture the large dose of persistence observed in actual data; the corresponding microfoundation refers, e.g., to habit persistence in consumption demand. Equilibrium output is normalised to zero.

$$(10)\qquad y_t = \left(1-\theta_y\right) E_t y_{t+1} + \theta_y\, y_{t-1} - \beta\left(i_t^L - E_t \pi_{t+1} - r^*\right) + \beta^L \left(\frac{L_t}{\bar{L}} - 1\right)$$

Also the supply function shows, for reasons of adjustment and information costs, partly forward looking expectations and partly adaptive behaviour; the literature on agents' learning behaviour and sticky infor-

[13] An intermediate modelling strategy would make use of two interest rates in the goods demand equation as, e.g., in: *Cecchetti/Kohler* (2012).

mation provides impressive evidence of the relevance of lags in key macroeconomic relations. It is complemented by an AR(1) disturbance term ε_t^π that symbolises inflation shocks with persistence; its formal pattern conforms to eq. (2).

$$\pi_t = (1-\theta_\pi) E_t \pi_{t+1} + \theta_\pi \pi_{t-1} + \alpha y_t + \varepsilon_t^\pi \tag{11}$$

Monetary policy is represented by a simple Taylor Rule with a zero inflation target and a possible disturbance term ε_t^i, again following the pattern of eq. (2). In accordance with broad evidence, a large dose of interest rate smoothing (denoted by θ_i) is assumed. The central bank's equilibrium interest rate i^* can be found by solving for the equilibrium values of the model's variables. The logic of stabilisation requires the central bank to target r^* in eq. (10), the rate that maintains goods market equilibrium, by controlling the credit market rate i_t^L as an intermediate variable. This in turn is achieved via shifting the credit supply function (8) by means of central bank interest rate changes. In equilibrium, i^* has to correct r^* for the basic credit default risk, for the cost effect of the external finance premium, and for the implications of a difference between targeted and steady-state leverage $\bar{\lambda} = (\bar{A} + \bar{L})/\bar{C}$. The whole difference $(r^* - i^*)$ constitutes the 'credit spread' that figures prominently in present vintages of New Keynesian macroeconomics (*Woodford* 2010).

$$i_t = (1-\theta_i)(i^* + \tau_\pi \pi_t + \tau_y y_t) + \theta_i i_{t-1} + \varepsilon_t^i \tag{12}$$

$$i^* = r^* - \bar{\rho} - \psi \bar{\lambda} + \delta(\lambda^* - \bar{\lambda}) \tag{13}$$

IV. Multiple Market Shocks and Policy Responses

1. Interest and Valuation Shocks

The working of the model is now demonstrated by comparing the effects of two disturbances that originate in the financial sector: a discretionary reduction of the central bank interest rate and an exogenous increase of asset prices (*Figure 3*).[14] In both scenarios asset prices are driv-

[14] The IRFs show the adjustment path of selected endogenous variables after a one-off change of the chosen exogenous shock variables ε_t^i and ε_t^f that however maintain a diminishing part of their impact due to persistence; see eq. (2). For that exercise, a first-order approximation of the model was calculated by the

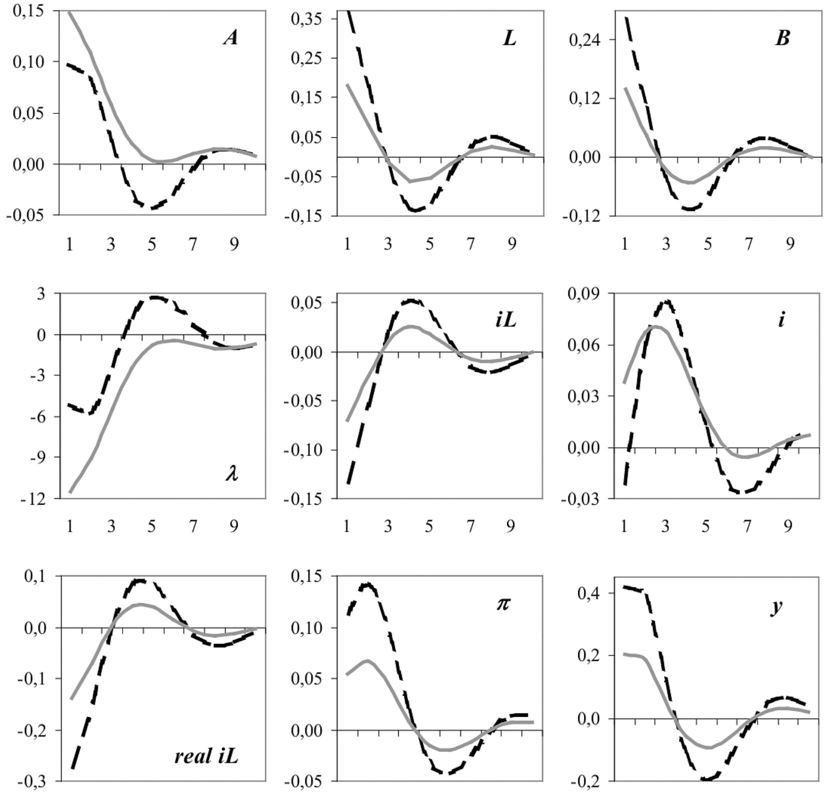


Figure 3: Impulse Response Functions (IRFs) After Negative Interest Shock (Dashed Line) and Positive Financial Market Valuation Shock (Grey Line)

en upwards, either via lower interest rates or via valuation shocks. Loan supply shifts to the right, in the case of a monetary policy move mainly brought about by the lowered Taylor rate, and reflecting a change of asset prices in the second case: the actual leverage ratio falls, which also lowers the cost of external financing, and banks wish to return to the

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Dynare software so that a linear system of difference equations evolves. The initial shock sign was chosen as negative in the case of an interest rate impulse, and positive in case of asset prices. The size of both shocks was set to 0.01; the persistence of ε_t^f is 0.7, and 0.1 in case of ε_t^i, taking into account that the path of interest already entails persistence. Values displayed in the graphs indicate percentage point (leverage: absolute) deviations from steady state. Model parameters were set as follows: $\psi = 0.001$, $r^* = 0.03$, $\lambda^* = 12$, $\bar{\rho} = 0.01$, $\tau_\pi = 1.2$, $\delta = 0.005$, $\eta = 1$, $\beta = \tau_y = 0.3$, $\beta^L = \mu = \sigma = \varphi = 0.2$, $\alpha = \gamma = \kappa_A = \kappa_L = \bar{C} = 0.1$, $\theta_y = \theta_\pi = \bar{A} = \bar{L} = \bar{D} = 0.5$.

target level by writing more credit contracts. The increase of bank lending, which is largely financed via bond sales, lets the real loan rate drop so that goods demand expands.

Note that, in the monetary policy shock scenario, the first period's value of the central bank interest rate reflects the discretionary easing impulse as well as the rule-bound increase of the Taylor rate, although cushioned by the practice of interest rate smoothing. The graphs show that the short-term policy rate affects the macroeconomy not only by means of its influence on the costs of bank refinancing; movements of i_t have a grip on the loan rate and thus the interest spread, i.e. bank profits.[15] Via its influence on the loan rate, i_t also triggers wealth effects on the part of creditors and debtors, shifting both credit market functions.

Asset market sentiments perform a transmission mechanism on their own, in their effect similar to monetary policy actions. In the model, the movement of A_t exhibits high correlation with the real interest rate and output (–0.87 and 0.84, respectively). The impulse response functions reveal that the central bank is forced to lean strongly against the expansionary impulse originating from the valuation shock, just to prevent an even more pronounced output growth. A negative valuation shock would produce a scenario of deleveraging where a downgrading of asset prices forces banks to adjust their asset holding in a downward direction in order to restore their leverage target (imagine an inversed course of the grey IRFs in *Figure 3*). This includes a restriction of credit supply. Demand and production shrink on the goods market, and stabilisation requires a lower Taylor interest rate (*Leijonhufvud* (2009), *Borio* (2014b)).[16]

2. *The Case of a Beneficial Supply Shock*

Whereas in previous decades macroeconomic stability often was endangered by inflation shocks that posed a severe trade-off with regard to the

[15] "At each stage of the intermediation chain, the funding interest rate must be lower than the asset interest rate. As the intermediation chain becomes longer, more short-term funding must be used to support the chain, as short-term funding tends to be the cheapest" (*Shin/Shin* (2011), p. 14).

[16] The model is not designed for an adequate analysis of this kind of balance sheet recession because it ignores the zero lower bound of nominal interest rates and the practice of selling capital market assets on a large scale. Such a 'fire sale' in times of liquidity stress contributes to a further fall of asset prices and requires non-banks or the monetary authority to act as buyers, but this issue is not further explored in this paper.

employment issue, a more recent topic is the somewhat paradoxical scenario where an economy suffers in the end from a – taken by itself – beneficial event like, e.g., the discovery of a new technology, because an overly elastic credit system misleads markets onto a bubble path that is bound to crash later. Therefore the model attempts to confirm various findings in the literature saying that a 'leaning against the wind' on the part of the central bank in times of good-news driven credit booms might help to prevent bubbles (*Christiano* et al. (2008), *De Grauwe/Gros* (2009), *Gambacorta/Signoretti* (2013)). This scenario can be reproduced in the above model by following the various implications of a cost-diminishing AR(1) supply shock ε_t^π in eq. (11).[17] In order to refer to the different stages of the bank lending channel discussion, three model variants are distinguished:

(1) The basic case uses only stripped-down versions of the credit market equations where collateral effects on the part of debtors, and leverage effects on the part of creditors are ignored, i.e. $\kappa_L = \varphi = 0$ in eq. (9) and $\kappa_A = \sigma = 0$ in eq. (1). The simulation of the model's key variables is drawn in solid black lines (*Figure 4*). The whole process shows a relatively moderate expansion. Note that the figures of period 1 capture only the net effect of a complicated pattern of interaction. The initial lowering of inflation call for a Taylor rate response that triggers a credit supply shift, and thus a goods market expansion.

(2) The second scenario describes the financial-accelerator effect that originates from an endogenous increase of debtors' wealth. Higher expected income and lower interest rates let the value of collateral grow; $\varphi > 0$ and $\kappa_L > 0$ in eq. (9). The immediate result is a right-shift of the credit demand function (*Figure 2*); the impulse response functions of lending (L) and the loan rate (i^L) accordingly both start from a higher value (dashed lines in *Figure 4*).

(3) Finally also some new features of the bank lending channel are taken into account. The value of bank assets changes with lower interest rates and higher output; $\kappa_A > 0$ and $\sigma > 0$ in eq. (1). Concomitant capital gains reduce the actual leverage ratio and thus induce further lending in order to meet the leverage target. The credit supply function shifts to the right (*Figure 2*), thereby further increasing the volume of loans. Initially this lowers the loan rate, but the stabilising increase of the central bank interest rate acts as a countervailing power during the adjustment process. Output expansion is strongest (grey lines in *Figure 4*).

[17] The size of the ε_t^π shock is 0.01 with 0.7 persistence.

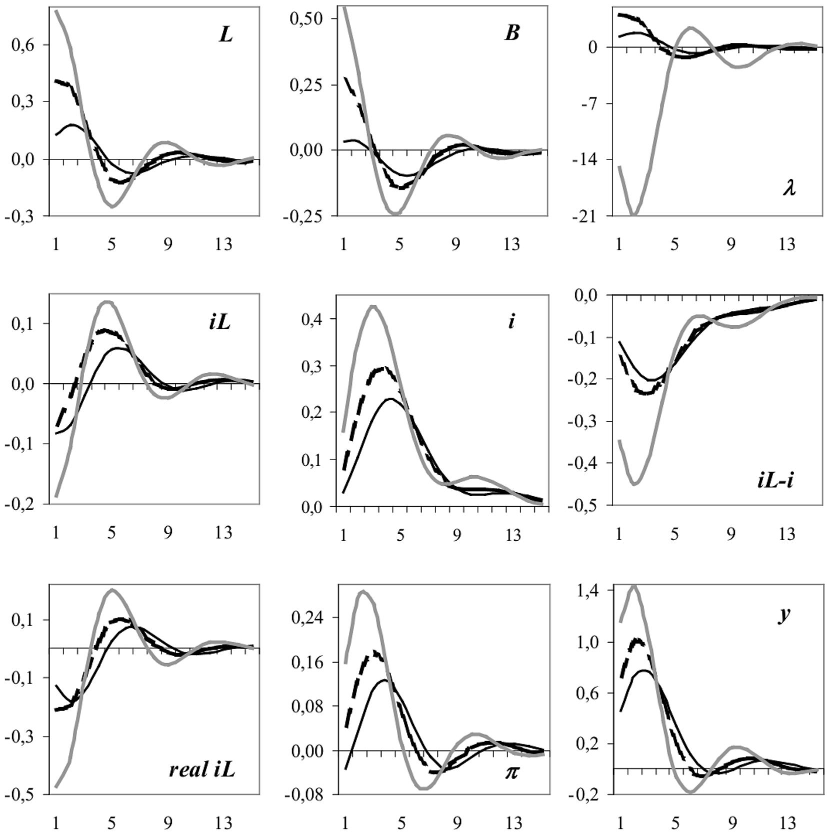

Figure 4: IRFs After Inflation-diminishing Shock in Three Variants of the Bank Lending Channel: Basic Version Without Financial Accelerators (Solid Black Lines), Inclusion of Interest-rate-induced Wealth and Income Effects on the Part of Debtors (Dashed Black Lines), Additional Inclusion of Interest Rate and Income Effects on Creditors Assets Values (Grey Lines)

The credit market spread ($i_t^L - i_t$) is a complex variable, driven by the behaviour on both sides of the credit market, by policy, expectations and shocks. From a macroeconomic point of view, it is like a 'tax on intermediation' (*Woodford* (2010)), at the same time indicating the risk and profitability of bank activity (*Adrian/Shin* (2010)). In all three cases of the model simulation, monetary policy aims to stabilise inflation and output gaps, a task that is impeded by the only indirect (and less than proportional) transmission of the policy rate to the relevant credit market interest rate via the shift of the credit supply function. But money market and credit market rates always move in the same direction (although their correlation is weakened due to the central bank's interest rate smoothing), whereby the interest rate spread is compressed. The spread shows a strong negative correlation with output (–0.92, –0.89 and –0.94, respectively).

3. *Alternative Policy Options*

This opens the discussion on possible policy strategies beyond the simple Taylor Rule in both above scenarios of a positive asset price shock and a beneficial supply side shock.[18] In order to complete the picture, background calculations on three further shocks are also taken into account: a goods demand shock, an exogenous lowering of credit default risk, and an increase of the 'natural' rate of interest.[19] With regard to policy options, six extensions of the simple Taylor Rule can be distinguished:

(1) Following Woodford's recommendation, a term $\tau_S\ (i_t - i_t^L)$ might be added to the Taylor Rule, i.e. inserted into the second bracket of eq. (12). This prescription establishes a negative reaction to the loan rate, and it indirectly augments the weight of inflation and output gap coefficients as long as $\tau_S < (1 - \theta_i)^{-1}$, as can be seen by solving eq. (12) for the central bank rate. Hence, this strategy indirectly supports the case for strengthening the commitment to (flexible) inflation targeting.

(2) Alternatively, an additional interest rate response to the movement of asset prices of the form $\tau_A\ (A_t/\bar{A} - 1)$ can be considered as they act as amplifiers in the bank lending channel (*Gambacorta/Signoretti* (2013)).[20]

(3) The perhaps more obvious policy is to target 'excessive' lending growth, which is simulated in the model by a Taylor Rule add-on $\tau_L\ (L_t/\bar{L} - 1)$. Such a reform can be proposed on account of the impres-

[18] Note that due to the lacking empirical specification of model parameters the following is to be understood as a theoretical exercise, completing the analytical discussion of the model; it offers only a sketchy contribution to the literature on optimal policy making (see, e.g., *De Fiore* and *Tristani* 2012).

[19] Also these disturbances were modelled as AR(1) processes with 0.01 size and 0.7 persistence.

[20] An earlier debate on the question of including asset price stability in the central bank's objective built on the welfare-theoretic argument of a substitutive relationship between goods as assets, and stated that goods market inflation alone is a poor indicator of the value of money.

sive macroeconomic power of bank credits, but also if credits are regarded as the counterparty item to a broad monetary aggregate, i.e. by modifying the traditional monetarist concept of policy making.[21]

(4) The balance-sheet-counterpart approach is to include an external-finance target of the form $\tau_B\,(B_t/\bar{B}-1)$ in the Taylor Rule. It is a possible policy instrument that can be activated in order to constrain negative systemic risk externalities that might result from excessive short-term funding.[22] *Goodhart* (2010) therefore once simply suggested a tax on banking.

(5) Considering the prominent role of the leverage ratio, an obvious idea is to control its level by modifying the effect of the external finance premium f_t. This can be achieved by adding a term $\tau_\lambda\,\lambda_t$ to the Taylor rate.

(6) Finally macroprudential regulation can impose maximum prescriptions for the banks' leverage target, a measure suitable to constrain the growth of bank balance sheets, and of lending in particular (reducing λ^* shifts the credit supply function upwards). The choice of λ^* however has only an impact on the equilibrium position of the credit supply curve and therefore is reflected in the determination of the equilibrium central bank interest rate i^* in eq. (13), but it has no bearing on shock adjustment paths.

Hence, alternative policies (1) to (5) can be evaluated by minimising the simple loss function $\Omega_t = \pi_t^2 + y_t^2$. For each of the coefficients τ_S, τ_A, τ_L, τ_B and τ_λ an optimal value was calculated in a setting where all five shocks (asset prices, supply side, goods demand, credit default, 'natural' rate) occur at the same time. This setup was chosen because the nature of macroeconomic disturbances often cannot easily be understood or distinguished by the policymaker; thus it makes sense to ask for a policy strategy that works best under all circumstances.

The results[23] show that Taylor Rule extensions indeed yield lower welfare losses compared to the baseline policy (*Table 2*). A somewhat irritat-

[21] "The observation that credit growth is high in booms suggests that if credit growth is added to interest rate targeting rules, the resulting modified rule would moderate volatility in the real economy and in asset prices" (*Christiano* et al. (2010), p. 23; cf. *ECB* (2010b)).

[22] "The bank lending channel works through the impact of monetary policy on banks' external finance premium as determined by their perceived balance sheet strength" (*Disyatat* (2010), p. 8; cf. *Shin/Shin* (2011), *Perotti/Suarez* (2011)).

[23] They were calculated by using *Dynare*'s Optimal Simple Rule software procedure. A potential drawback of the algorithm is that it delivers local, but not

Table 2

Loss Levels of Alternative Policy Strategies

Policy / *Results*	Optimal instrument value	Loss level
Simple Taylor Rule		6.35
Additional response to		
– spread	$\tau_S = 1.18$	1.24
– asset prices	1.10	1.74
– lending	$\tau_L = 1.20$	2.24
– external finance	$\tau_B = 0.32$	5.59
– leverage	$\tau_\lambda = -0.006$	3.62

ing finding is that the optimal τ_λ parameter is negative. The reason is that effective leverage initially is below the banks' target level in all cases where positive market or policy impulses impinge on bank assets and capital; this in turn motivates the acquisition of additional assets. Therefore, a monetary policy that responds to low (high) leverage with low (high) interest rates runs the risk of producing pro-cyclical effects. In general, an interest rate response to the credit market spread promises to deliver good results. This finding also followed from *Woodford's* non-formal analysis and motivated him to suggest "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" (2010, p. 39).

With regard to the traditional monetary policy trade-off between output and inflation stabilisation, financial frictions produced and managed by a banking sector call for a modification of policy rules (*Davis/Huang* (2013)). Focusing the beneficial-supply-shock scenario, *Gambacorta* and *Signoretti* (2013) find that employing an extended Taylor Rule that reacts to assets prices (strategy τ_A) improves the trade-off on the frontier of in-

necessarily global optima. This poses hardly a problem in the present context. The iterations in all cases start at the zero value of the additional instruments. This also marks the institutional status quo. Economic policy reforms mostly come in gradual steps. Therefore very large values, even if they would allow the movement to a global optimum, are not that relevant. Moreover, case by case runs by using larger starting values did not yield different results.

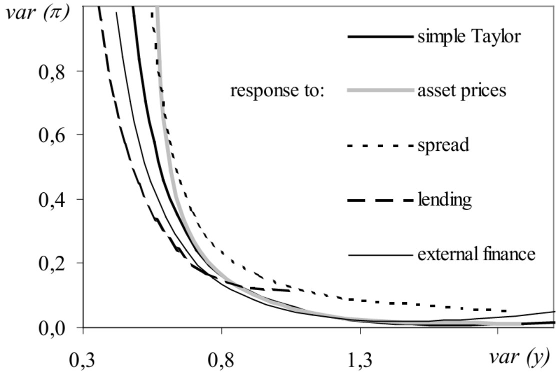

Figure 5: Taylor Curves in Beneficial-supply-shock Scenario, Taylor Output Gap Coefficient τ_y Increasing in 0.1 Steps from Right to Left (While τ_π Held Constant)

flation and output variability.[24] This result is not confirmed by the above model, as other policies, particularly a control on lending, provide better results (*Figure 5*).

Also *De Grauwe/Gros* (2009) propose a monetary tightening in the above case of a beneficial supply shock, but focus on measures constraining bank liquidity as, e.g., higher minimum reserve requirements. This appears to be a reasonable idea, particularly because weaker liquidity constraints "can support higher risk-taking. […] The link between liquidity and risk-taking can add to the strength of the monetary policy transmission mechanism – a sort of 'liquidity multiplier'" (*Borio/Zhu* (2008), p. 12). Unfortunately, in an institutional setting where banks' base money demand is always met without quantity constraints (and where interest payments are granted on minimum reserves) the proposal hardly makes any sense.

Blocking the quantitatively unlimited access to central bank finance (the flexible use of the variable B_t in the model) would indicate a major institutional U-turn in the banking industry. Such a reform would substantially shrink the manoeuvring room for bank business on both sides of their balance sheets. For any single bank, the provision of liquidity

[24] This frontier is called the Taylor Curve and the graphs show equilibrium positions that can be chosen by the policymaker. Thus there is an exploitable trade-off between inflation and output variability (*Taylor* (1994)), in contrast to the no-trade-off message of the standard Phillips Curve.

would be burdened with higher costs and uncertainty: a severe impediment for investment. For the banks as a group, credit expansion becomes dependent on the simultaneous increase of deposits the famous Wicksellian process that once initiated the search for stabilising interest rate policies.

The idea of subordinating bank behaviour to the straightjacket of a tight quantitative control of base money supply cannot promise the end of financial crises – the era of the gold standard where central bank money was strictly limited proves otherwise.[25] Then it took decades to overcome the 'old' principle of maintaining the scarcity of central bank money (*Bindseil* (2004)), and now after a not particularly successful period of monetarist policy making any attempt to return to some kind of (base) money supply targeting is considered an outdated idea by the majority of observers.

V. Summary and Conclusions

For a long time the bank lending channel has been regarded as a minor important part of the transmission mechanism of monetary policy. It was seen to base on a market segmentation between two routes of financing where only a part of non-bank agents had an access to the capital market, forcing other prospective debtors to apply for bank credit. This view no doubt featured practical importance, but from a theoretical point of view it could be argued that the enlargement and deepening of financial markets, and the creation of more innovative and sophisticated financial instruments would solve a growing part of those information, incentive and risk problems that once could only handled in bank-customer relationships.

However, just this before mentioned development in the sphere of financial markets even strengthened the banks' power. Credit supply for goods and asset market investment projects was enlarged, whereby funding shifted more and more from deposits to external sources. Thus banks themselves became large debtors in financial markets where their bor-

[25] In case of exogenously given central bank money, bank sector activity will produce large fluctuations of the famous money multiplier. Bank investments still will be financed via the interbank market where changing sentiments on the part of creditors give rise to boom-and-bust cycles. Expansion dynamics might be more contained, compared to the current regime, but the collapse hits even harder due to a missing flexibility in the provision of base money supply.

rowing power relies on their balance sheet wealth pledgeable as collateral, just like in the case of their own clients. Hence, from this arises a full circle of positive feedback reactions between asset valuation and credit extension, which then again leads to demand-driven higher asset prices.

The banking sector thus contributes to a two-way shock amplification system where "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". This calls for additional facilities of stabilisation policy, but "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" (*Woodford* (2012), p. 5).

The simple model presented in this paper unfolds key functional relations between the banking sector's credit and funding decisions, on the one hand, and a standard set of goods market equations, on the other. It was shown that asset price shocks exert a similar influence on goods market dynamics as central bank interest policy. Conversely, a goods market shock is able to trigger repercussions in the financial sector that – via banks' credit supply reactions – reinforce the initial disturbance.

The key question whether there are easy-to-handle and robust policy measures that can be recommended as add-on measures besides the standard Taylor Rule can only be answered with some reservation. There is evidence that special interest rate responses to the spread between credit market and money market rates, to asset prices or to the volume of bank lending provides good results in most shock scenarios explored in this paper. This is in line with widespread recommendations in the journals and the public at large. But one may doubt whether model-based strategies, no matter how deeply micro-founded, will make policymakers convert to any new rigid behavioural rule.

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