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# Animal Spirits and Credit Spreads in a Model with a Cost Channel

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Preliminary draft

Shocks in the financial sector caused the "Great Recession" of 2008. Thereby a lively debate was ignited if Taylor rules should be augmented by financial sector variables (Christiano et al. (2008), McCulley and Toloui (2008), Taylor (2008)). We address this issue in a stylized DSGE-framework enhanced with behavioral elements in expectations to produce waves of bull–bear cycles in the financial intermediation process, that have repercussions on business cycle dynamics. Our main findings suggest that a loan- or spread-augmented Taylor-rule as well as countercyclical equity regulation can well prevent severe recessions. Additionally we flesh out the difference in business cycle dynamics and policy recommendations compared to the counterpart rational expectations DSGE approach.

*Keywords:* Animal spirits, bank regulation, financial intermediation, monetary policy.

*JEL code:* E32 , E52 , G21.

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# 1. Introduction

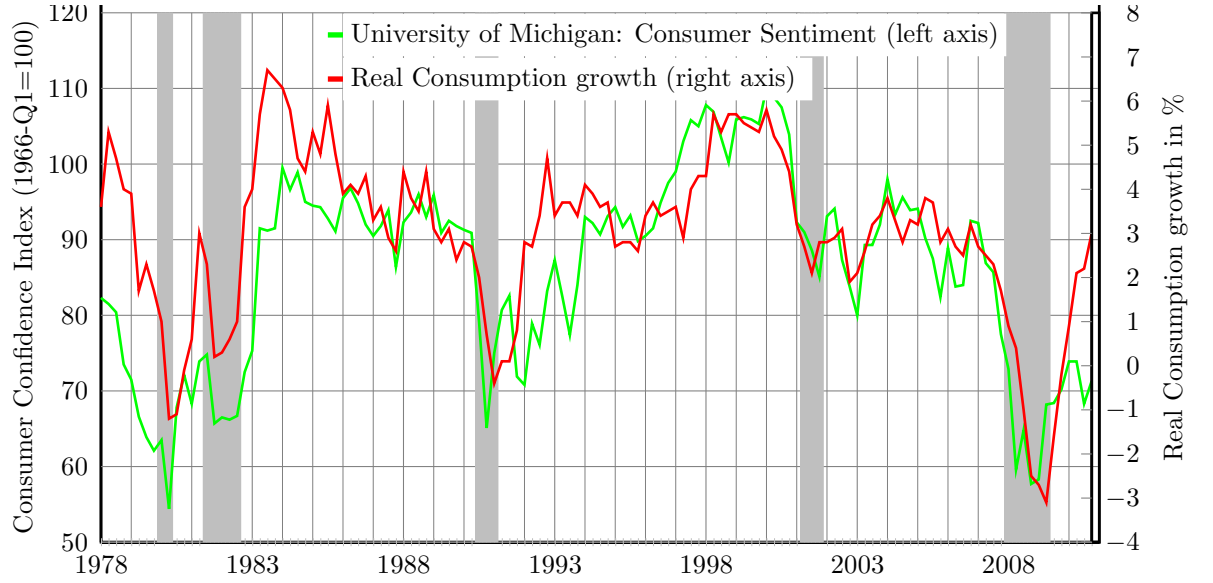
In this paper we address the question whether non-fundamental shocks to credit spreads can systematically interact with agents expectations formation and lead to self sustaining boom-bust cycles. In particular during the financial crises of 2008 credit spreads soared to record highs and thus were an additional factor that aggravated the "Great Recession". Following Tillmann (2010) this might be interpreted as an evil planer in the sense of Sargent that drives a wedge between the policy administered rate and loan rates undermining the ability of monetary policy to steer the economy. In particular Taylor (2008), McCulley and Toloui (2008) argued that monetary policy would be well advised to augment the Taylor rule and systematically adjust Federal Funds Rate to the spread between loan rates and policy administered rates. In a different contribution Christiano et al. (2008) suggested that monetary policy can be improved if monetary authorities respond to the evolution of aggregate credit. Cúrdia and Woodford (2009) challenge this view by illustrating that the optimal response of monetary policy can vary substantially with respect to the shock that hits the economy. Therefore to focus unilaterally on financial friction shocks might impair welfare in an environment where other shocks also play a prominent role. In contrast to the above cited approaches we departure from the standard DSGE route and allow for biased expectations into an otherwise standard DSGE framework. In doing so we develop an alternative financial accelerator mechanism. Bernanke et al. (1999) introduced a "financial accelerator", where the amplifying effects of the financial sector have been pointed out due to problems of asymmetric information. Gerali et al. (2010) and Aguiar and Drumond (2007) argue in the same direction but with heterogeneous groups of households to implement saver-borrower relations where the existence of binding collateral constraints amplifies the cycle. In our approach we succeed to generate a financial accelerator mechanism, by allowing financial friction shocks to trigger swings in consumer sentiments. By formulating their expectations, agents use simple decision rules, which are prone to errors and mood swings. This prepares the ground for waves of optimism and pessimism driving the cycle. The idea of "animal spirits" formulated by Keynes found its impact in behavioral models as De Grauwe (2010), De Grauwe and Grimaldi (2007) and Barberis and Thaler (2003). We pick up this con-

cept and implement it in our model. As illustrated in Figure 1 there exists for the US a tight relationship between consumer sentiment and consumption growth. Therefore we follow De Grauwe (2010) and assume that consumer confidence is intimately related to planned consumption expenditures and thus to waves of optimism and pessimism that drive consumer confidence. Note in particular that around the NBER recession dates swings in consumer sentiment are pronounced and abrupt.

To give a meaningful role to a banking sector we assume as in the cost channel literature tradition that firms have to pay factors of production in advance (Ravenna and Walsh (2006), Christiano et al. (2005)). In contrast to Ravenna and Walsh (2006) we do not assume that the banking industry operates costless but that extending loans to the intermediate firm sector absorbs resources. This gives rise to a spread between the loan rate and the risk free rate. We use the approach proposed by Cúrdia and Woodford (2009) and model the spread as a convex function of banks lending activity in the process of financial intermediation. Key to motivate this spread specification are two arguments. Firstly, the convex technology nests the idea that at each point in time there is only a finite lending capacity. Secondly, the specification is consistent with VAR-evidence according to which a monetary policy shock goes alongside with a counter cyclical movement in spreads. Shocks arise only in the intermediation process because of the mispricing of loan risk. As changing refinancing conditions influence marginal cost they impact on the inflation rate, interest rates and consumption and are thus a source of business cycles. Obviously, as these shocks are not grounded out of technological innovations or taste shocks they impair welfare in a sticky price environment as consumption and labor supply become more volatile. Our findings suggest that the impact of financial friction shocks on the economy are in particular important in an environment where (i) agents only evaluate a limited amount of past data, (ii) are willing to learn from past data, (iii) the financial sector responds smoothly to credit demand from the firm sector and (iv) the Phillips curve is flat. From a policy perspective we can give clear advice that Taylor rules should systematically respond to the spread. Additionally we provide evidence from a welfare perspective that the DSGE counterpart model underestimates the welfare improvements from augmenting the rule.

The paper is structured as follow: in section 2 we outline the model and the expectation

Figure 1: Correlation of Consumer Confidence and Consumption



heuristics. A discussion on the business cycle dynamics is conducted in section 4. Section 5 applies different macroeconomic policy approaches to the model and generates applicable policy recommendations to dampen the shock triggered by the financial sector.

## 2. A behavioral macroeconomic model

In this section we outline the behavioral model, which consists of a consumption–Euler equation, a Phillips curve and a Taylor rule as monetary policy reaction function in conjunction with behavioral mechanisms that determine expectations. The basic model extends Ravenna and Walsh (2006) by a banking industry.

### 2.1. The basic model

We specify aggregate demand in a standard way. The consumption Euler-equation reads:

$$\hat{c}_t = \tilde{E}_t \hat{c}_{t+1} - (\sigma_c)^{-1} \left( \hat{R}_t^M - \tilde{E}_t \hat{\pi}_{t+1} \right) + (\sigma_c)^{-1} \hat{\zeta}_t, \quad (1)$$

where hatted variables  $\hat{X}_t$  denote percentage deviations from steady state  $\log \left( \frac{X_t}{\bar{X}} \right)$ .  $\hat{c}_t$  defines consumption and  $\tilde{E}_t \hat{c}_{t+1}$  is the expectation on the consumption gap in period  $t+1$  and  $\hat{\zeta}_t$  denotes a taste shock. Monetary authorities influence aggregate demand via the

real interest rate lever ( $\widehat{R}_t^M - \widetilde{E}_t \widehat{\pi}_{t+1}$ ), where  $(1/\sigma_c)$  denotes the intertemporal elasticity of substitution.

The aggregate supply equation is derived from the profit maximization problem of the production sector and builds on Calvo-pricing. This implies, that every firm adjusts prices with probability  $(1 - \theta)$ . The remaining fraction  $\theta$  of firms keeps prices fixed. The linearized New-Keynesian Phillips curve reads:

$$\widehat{\pi}_t = \beta \widetilde{E}_t \widehat{\pi}_{t+1} + \kappa_p (\widehat{\varphi}_t + \epsilon_t). \quad (2)$$

Inflation ( $\widehat{\pi}_t$ ) is driven by shifts in expected inflation rates  $\widetilde{E}_t \widehat{\pi}_{t+1}$  and movements in real marginal costs ( $\widehat{\varphi}_t$ ). Marginal cost consist of real wages ( $\widehat{w}_t$ ) and financing conditions as reflected by the loan rate ( $\kappa \widehat{R}_t^L$ ) as we assume that all firms in the intermediate good sector have to pay wages in advance. Households labor supply schedule is derived by assuming a Walrasian labor market:

$$\widehat{w}_t = \varphi \widehat{n}_t + \sigma_c \widehat{c}_t, \quad (3)$$

where  $\varphi$  denotes the inverse of the Frisch elasticity of labor supply. The banking industry sells credits to the firm sector with a markup over the Taylor rate:

$$R_t^L = R_t^M (1 + \omega_t). \quad (4)$$

In line with Cúrdia and Woodford (2009) we assume that the steady state spread is equal to 2 percentage points with  $\bar{\omega} = 0.02$ . In defining the spread we fall back to the method of Cúrdia and Woodford (2009):

$$\omega_t = \Xi_t'(b_t) + \nu_t. \quad (5)$$

The spread  $\omega_t$  is a convex function of the loan amount ( $b_t$ ). The key driver for loans demand is the firms' need to finance their wage bill in advance. Banks produce loans by using a costly intermediation technology. Concretely we apply the following functional form:

$$\Xi(b) = \Xi_t b_t^\eta, \text{ with } \eta \geq 1, \quad (6)$$

where  $\eta$  determines the degree of convexity and  $\Xi_t$  allows to model exogenous shocks to the intermediation technology which can be interpreted in line with Cúrdia and Woodford

(2009) as purely financial disturbances. Thus these shocks accommodate the notion that the financial sector may misprice credit risk. The linearized version of the loan function reads:

$$\widehat{R}_t^L = \widehat{R}_t^M + \left[ \frac{\bar{\omega}}{1 + \bar{\omega}} (\eta - 1) \widehat{b}_t + \widehat{\Xi}_t + \widehat{\tau}_t \right] \quad (7)$$

where the spread is defined as:  $\widehat{\omega}_t = \frac{\bar{\omega}}{1 + \bar{\omega}} (\eta - 1) \widehat{b}_t + \widehat{\Xi}_t + \widehat{\tau}_t$ . Besides the variation of granted loans ( $\widehat{b}_t$ ), the spread function consists of purely financial disturbances in the intermediation process ( $\widehat{\Xi}_t$ ) and the countercyclical equity regulation term ( $\widehat{\tau}_t$ ).

The aggregate resource constraint is composed of consumption and the real resource costs of financial intermediation:

$$\widehat{y}_t = \frac{\bar{c}}{\bar{y}} \widehat{c}_t + \frac{\bar{\omega} \cdot \bar{b}}{\eta \cdot \bar{y}} (\eta \widehat{b}_t + \widehat{\Xi}_t). \quad (8)$$

Finally, monetary policy follows a standard Taylor rule:

$$\widehat{R}_t^M = \phi_r \widehat{R}_{t-1}^M + (1 - \phi_r) (\phi_\pi \widehat{\pi}_t + \phi_y \widehat{y}_t) + r_t. \quad (9)$$

Monetary authorities respond with its instrument to deviations of output and inflation from their steady state value. The intensity of the interest rate reaction is determined by the coefficients for inflation ( $\phi_\pi$ ) and output ( $\phi_y$ ). The degree of interest rate smoothing is defined by:  $\phi_r$ .

## 2.2. Expectation formation

We assume that households only have limited cognitive capacities while forming expectations on the future course of inflation and consumption. Therefore, they use rule of thumb strategies to estimate the value the two forward-looking variables (following De Grauwe (2010)). Cause of the lack of information, agents tend to miscalculate the future consumption gap. We split them into two different groups, whereby the first group has a positive view further evolution of consumption:

$$\widetilde{E}_t^{opt} \widehat{c}_{t+1} = g_t, \quad (10)$$

with the second group consistently underestimates consumption and therefore negatively appraises the future evolution.

$$\widetilde{E}_t^{pes} \widehat{c}_{t+1} = -g_t. \quad (11)$$

As in De Grauwe (2010) the distance between optimistic and pessimistic agents can be defined as divergence in beliefs:  $d_t = 2g_t$ , where  $d_t$  depends on the volatility of consumption:

$$d_t = \beta_d + \delta_d \sigma(\hat{c}_t). \quad (12)$$

If output volatility broadens, divergence in beliefs widens, because of the heterogeneous beliefs in both groups. The volatility  $\sigma(\hat{c}_t)$  is computed based on a rolling data window. The divergence is constant, when  $\delta_d = 0$  and can be calculated as  $|g_t = \beta_d/2|$ . The aggregate forecast of consumption ( $\tilde{E}_t \hat{c}_{t+1}$ ) thus consists of the weighted average of positive and negative assessments:

$$\tilde{E}_t \hat{c}_{t+1} = \alpha_{opt,t} g_t - \alpha_{pes,t} g_t, \quad (13)$$

with  $\alpha_{opt,t} + \alpha_{pes,t} = 1$ . The weights of optimistic and pessimistic households are time-dependent. Although agents use simple decision rules they learn by statistically assessing the performance of the heuristic they apply (Evans and Honkapohja (2001)). Thus agents indeed have a positive or negative bias, but they evaluate their decision every period. Therefore the probability to be optimistic or pessimistic depends on the performance of the last projections with:

$$\alpha_{opt,t} = \frac{\exp(\gamma U_{opt,t})}{\exp(\gamma U_{opt,t}) + \exp(\gamma U_{pes,t})} \quad (14)$$

The forecast performance can be computed via the following "utility"-function, which consists of mean squared forecasting errors (MSFE):

$$U_{opt,t} = - \sum_{k=1}^T \omega_k \left[ \hat{c}_{t-k} - \tilde{E}_{opt,t-k-1} \hat{c}_{t-k} \right]^2 \quad (15)$$

$$U_{pes,t} = - \sum_{k=1}^T \omega_k \left[ \hat{c}_{t-k} - \tilde{E}_{pes,t-k-1} \hat{c}_{t-k} \right]^2. \quad (16)$$

$U_{opt,t}$  represents the utility function of the optimistic agents and  $U_{pes,t}$  the utility function of the pessimistic agents. The variable  $\omega_k$  assesses the MSFE with a geometrical declining weight:  $\omega_k = (1 - \rho)\rho^k$ . Agents memory is described by  $\rho$  and can vary over a range from  $\rho = 0$ , when agents have no memory to  $\rho = 1$ , when agents have infinite memory.

In analogy to consumption, we use the same technique for modeling inflation expectation: the economy is composed out of two groups using different rules of thumbs for forecasting



inflation. The first group ("inflation targeter"), which accounts for a fraction of  $\beta_{tar,t}$  of the population uses the official inflation target of the central bank as its projection:

$$\tilde{E}_t^{tar} \hat{\pi}_{t+1} = \hat{\pi}^* = 0, \quad (17)$$

while the second group ("extrapolators"), which accounts for a fraction of  $\beta_{ext,t}$  is more skeptical on the ability of the central bank to target inflation at the optimal level and falls back to last period's inflation rate:

$$\tilde{E}_t^{ext} \hat{\pi}_{t+1} = \hat{\pi}_{t-1}. \quad (18)$$

The realized inflation expectation are given by the weighted average over both groups:

$$\tilde{E}_t \hat{\pi}_{t+1} = \beta_{tar,t} \tilde{E}_t^{tar} \hat{\pi}_{t+1} + \beta_{ext,t} \tilde{E}_t^{ext} \hat{\pi}_{t+1} \quad (19)$$

wit  $\beta_{tar,t} + \beta_{ext,t} = 1$ . To calculate the share of extrapolators and inflation targeter, we use the well-known utility-function, depending on MSFE:

$$U_{tar,t} = - \sum_{k=1}^w \omega_k [\hat{\pi}_{t-k} - \hat{\pi}^*]^2 \quad (20)$$

$$U_{ext,t} = - \sum_{k=1}^w \omega_k [\hat{\pi}_{t-k} - \hat{\pi}_{t-k-1}]^2, \quad (21)$$

where the weights are defined accordingly:

$$\beta_{tar,t} = \frac{\exp(\gamma U_{tar,t})}{\exp(\gamma U_{tar,t}) + \exp(\gamma U_{ext,t})} \quad (22)$$

and

$$1 - \beta_{tar,t} = \beta_{ext,t} = \frac{\exp(\gamma U_{ext,t})}{\exp(\gamma U_{tar,t}) + \exp(\gamma U_{ext,t})} \quad (23)$$

### 2.3. Matrix solution

To solve the model, we use equation (1), (2), (3), (7), (8) and (9) and rewrite it in the following matrix notation (De Grauwe (2010)):

$$\mathbf{A}\mathbf{Z}_t = \mathbf{B}\tilde{\mathbf{E}}_t\mathbf{Z}_{t+1} + \mathbf{C}\mathbf{Z}_{t-1} + \mathbf{V}_t \quad (24)$$

$$\rightarrow \mathbf{Z}_t = \mathbf{A}^{-1} \left[ \mathbf{B}\tilde{\mathbf{E}}_t\mathbf{Z}_{t+1} + \mathbf{C}\mathbf{Z}_{t-1} + \mathbf{V}_t \right]. \quad (25)$$

The matrices  $\mathbf{A}$ ,  $\mathbf{B}$  and  $\mathbf{C}$  contain the deep parameters of the economy, while  $\mathbf{Z}_t$  covers the state variables. The last vector  $\mathbf{V}_t$  comprises the remaining parameters and the shocks.

### 3. Calibration

We calibrate the model to quarterly values. Starting with the household sector, we set the intertemporal elasticity of substitution ( $\sigma_c$ ) and the marginal disutility of labor ( $\varphi$ ) equal to one. The discount factor  $\beta_\pi$  is set to 0.99, which implies a year on year steady state interest rate of 4%. The elasticity of substitution in the firm sector  $\epsilon$  is 11, implying a steady state markup of 10%. To introduce price stickiness, we use the Calvo approach and set the parameter, which reflects the probability to change prices to  $\omega = 0.66$ , implying that the average price duration is 3 quarters. With respect to the Taylor rule we set  $\phi_\pi = 1.5$ ,  $\phi_y = 0.50$  and the smoothing parameter  $\phi_r = 0.75$ . Later on we introduce countercyclical equity restrictions to cushion excess loan supply during booms and we set the macroprudential variable  $\tau$  to 0.50. For the parameters governing the expectations formation process we assume the following. Following De Grauwe (2010) the divergence of beliefs function is set to  $\beta_d = 1$ , the variable term  $\delta_d$  is set to 2.0. The intensity of choice  $\gamma$ , is set to two. The memory parameter is calibrated to 0.5. As evaluation period we follow De Grauwe (2010) and assume that agents account for 50 periods while forming expectations. Finally, the standard deviation of the loan rate shock ( $\sigma_L$ ) amounts to 0.25. With respect to the intermediation technology we follow Cúrdia and Woodford (2009) and assume that the convexity of the intermediation function is  $\eta = 5$  in the baseline. The steady state spread is set to ( $\bar{\omega} = 0.02$ ) and the loan-to-output-ratio is equal to ( $\bar{b}/\bar{y} = 3.2$ ).

### 4. Financial shocks and their effect on the business cycles

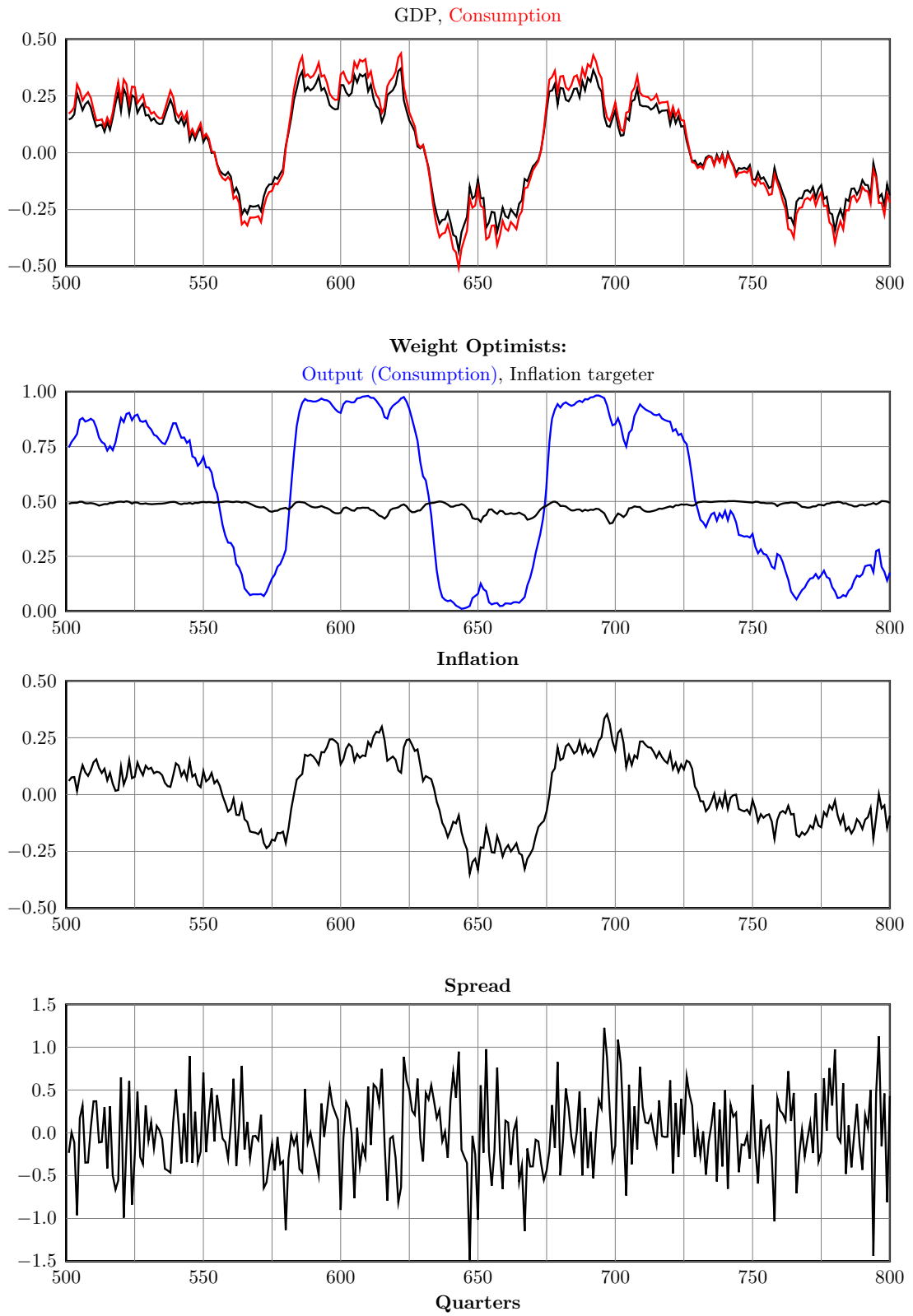
In this section we evaluate if financial sector shocks can ignite endogenous business cycles through its repercussions on private sector expectations formation.

#### 4.1. Animal spirits and defective interest rate transmission

To kick off the analysis we simulate the model under financial friction shocks. It is our prime interest to investigate whether non-fundamental shocks to the spread function can ignite endogenous self sustaining boom-bust cycles. Thus concretely we analyze if

financial friction shocks can trigger waves of animal spirits that endogenously drive the business cycle. As this shock is not grounded out of the utility function or technological innovations it is obvious in a sticky price environment that volatility in output and labor supply will give rise to welfare losses and thus call for adequate policy responses to be discussed later. We simulate the model for 1000 periods and present a realization in figure 2, where we discard the first 500 realizations such that the economy has converged to its ergodic distribution. It is important to notice that our model is only driven by i.i.d. shocks. In the upper panel we illustrate GDP and consumption. As the intermediation process generates real costs, real resources are not fully available to consumption. This drives a minor wedge between the two time series. Starting at the quarters following 580 the intermediation process is hit by a sequence of negative shocks, which leads to a drop in the spread between the loan rate and the policy rate. Thus the financial industry extends loan supply although policy administered rates remain constant. The banking sector misprices the risk of granted loans and lowers the credit barrier for firms, which have now access to cheaper loans. Marginal costs to the intermediate good sector decline which puts downward pressure on inflation. Hereupon, the central bank loosens its monetary policy stance, which improves the overall refinancing conditions. In the wake of negative shock series those agents that were pessimistic on the further course of aggregate consumption loose on ground as their forecasting rule deteriorates in performance as the central bank lowers the real rate of interest. At this stage the non-fundamental shocks originating in the financial sector have macroeconomic importance as an increasing fraction of households change in the bull camp which further fuels the economic cycle. As the financial sector extricates the economy from depression, a swing from negative to positive assessments on output expectation begins. A long lasting economic boom (bull cycle) starts. The bust cycle is initiated by several positive shocks in the intermediation process around period 625. Therefore, banks flee from risky assets and cut down lending. The appearing credit crunch rises marginal cost, which drives inflation rates up by the cost channel effect. The central bank amplifies the turndown (bear cycle) by increasing the policy rate. At the same time agents get a negative view on future output, which slumps the economy to depression. Thus we conclude that non-fundamental shocks in the financial sector can trigger self-sustaining boom-bust cycles in the real economy. Intriguingly it prevails

Figure 2: Animal spirits in the intermediation process and the macroeconomy



that in an environment with sticky prices pronounced boom-bust cycles in output are not translated into inflation cycles. Therefore, if monetary authorities are guided by a conventional Taylor rule they are not sufficiently hawkish to shut down the repercussions from financial sector shocks on the real economy. Additionally, as the shocks impact on inflation the procyclical policy of the central bank to the credit boom is a destabilizing and necessary condition for the evolution of the business cycle. A look at the fraction of the inflation targeter shows no relevant movement in shares and the weight remains round about 0.5, which reflects basically the flat slope of the Phillips curve.

Table 1: Correlations of DSGE and behavioral model

	$\hat{\pi}$		$\hat{y}$		$\hat{c}$		$\hat{R}^L$	
	DSGE	Behavioral	DSGE	Behavioral	DSGE	Behavioral	DSGE	Behavioral
$\hat{\pi}$	1	1	-0.7310	0.8213	-0.7835	0.8085	0.9811	0.7765
$\hat{y}$	-0.7310	0.8213	1	1	0.9968	0.9996	-0.8492	0.3926
$\hat{c}$	-0.7835	0.8085	0.9968	0.9996	1	1	-0.8889	0.3659
$\hat{R}^L$	0.9811	0.7765	-0.8492	0.3926	-0.8889	0.3659	1	1

Table 1 reveals in comparison with the DSGE-counterpart model, which is solved under the standard assumption of rational expectations the interesting feature that the correlation between output  $\hat{y}_t$  and inflation  $\hat{\pi}_t$  can be reversed. In a standard DSGE model the correlation is always negative as a supply shock in conjunction with the Taylor-Principle builds in a counter cyclical movement. In the behavioral model the correlation can be time-varying conditioned on the occurrence of an animal spirit cycle. If the supply shock, e.g a drop in credit spreads initiates a wave of optimism, then inflation and output will be above their mean value which implies that they are positively correlated. The same holds true for the correlation between inflation  $\hat{\pi}_t$  and consumption  $\hat{c}_t$ .

## 4.2. Animal spirits and the business cycle

In this section we shed some additional light on the forces that endow persistence to the business cycle. As illustrated below we can report evidence that animal spirits are likely

to emerge in a habitat where agents have limited memory, are willing to learn from past mistakes, the cost channel plays an important role, prices are sticky and the central bank is hawkish on inflation. In a first step we illustrate that the counterpart DSGE model where expectations are formed according to the standard rational expectations hypothesis does not display endogenous persistence. Solving the equations (1), (2), (6) and (8) under rational expectations we compute the AR(1) coefficients as reported in table 2. It prevails that the standard model is not able to generate high endogenous persistence. Put differently the persistence is not enshrined into the basic equations of the model but can be traced back to the way expectations interact with financial friction shocks.

Table 2: Persistence in DSGE and behavioral setting

	DSGE	Behavioral
$\hat{\pi}$	-0.1407	0.9477
$\hat{y}$	0.5343	0.9765
$\hat{c}$	0.4668	0.9697
$\hat{R}^L$	0.0112	0.3766

In our baseline model the AR(1)-coefficient of output is equal to 0.97, while in the DSGE-framework it is much lower (0.53). The same holds true for the inflation process with 0.94 in the behavioral model and negative correlation of -0.14 in the DSGE-framework. Only for the case of interest rate smoothing the DSGE-reference model is able to generate some persistence.

To dig somewhat deeper we further analyze the factors shaping expectations. First we focus on the memory of agents, which is described by the parameter  $\rho$ .  $\rho$  determines the amount and weight attached to past data.

When agents take all available past data under consideration the fraction of optimists and pessimists is 0.5 as both rules converge in forecasting performance. For this corner solution animal spirits disappear. Therefore we conclude that only when agents focus on a limited time span animal spirits can arise and shape the business cycle. In our baseline calibration the degree of correlation between the output gap and the share of output

optimists is  $\rho_{xy} = 0.86$ .

Divergence in belief  $\delta_d$  determines the rift of negative and positive assessment on the further evolution of consumption. As in De Grauwe (2010) we find that constant divergence of belief is sufficient for the existence of animal spirits. Nevertheless the divergence of beliefs, somewhat reinforces cycles driven by animal spirits.

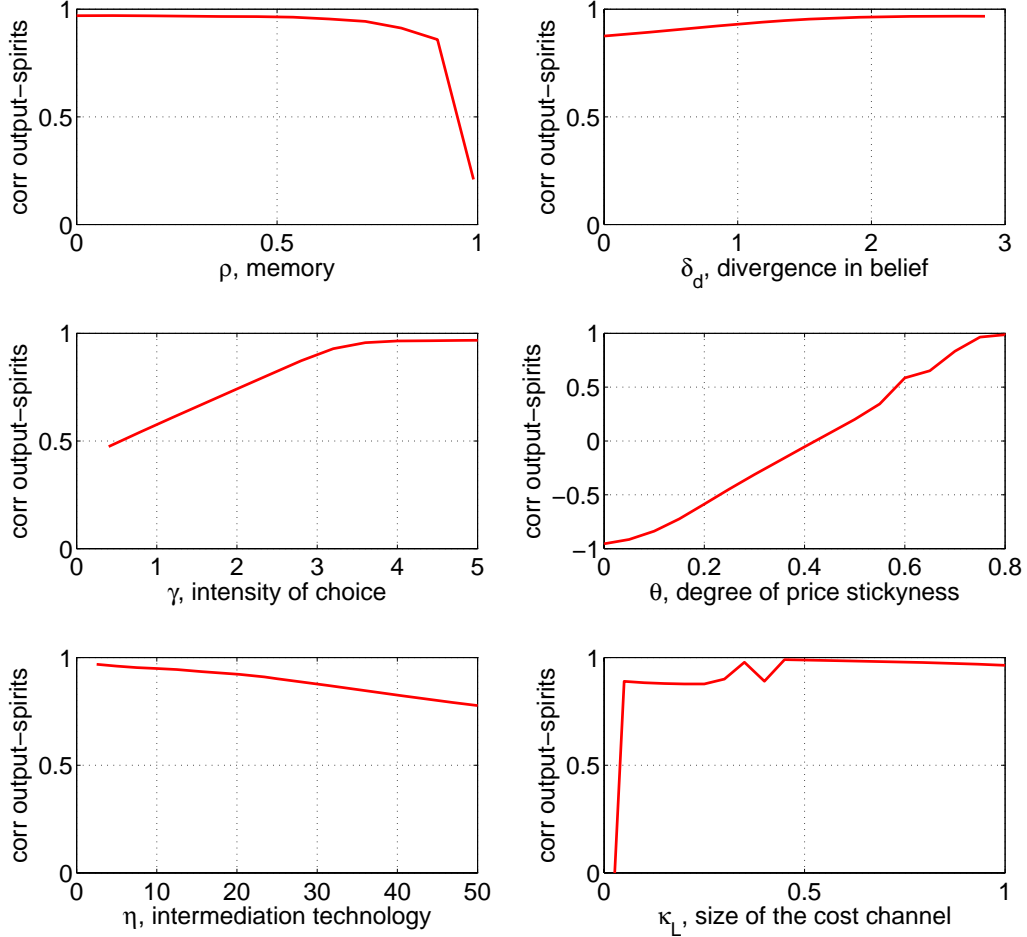
The intensity of choice  $\gamma$  determines the willingness of agents to change from negative to positive assessments and vice versa. It describes to what extend agents are willing to change their attitude on the state of the cycle in the light of the past forecasting performance of their applied heuristics. For  $\gamma = 0$  agents randomly switch between heuristics.

An increasing relationship can be observed from values from 0 to 4 and a plateau with high correlation values are maintained. When  $\gamma$  exceeds 7 we observe a sharp drop in correlation. For an increasing value of  $\gamma$  agents decision which heuristic to choose strongly depends upon the past forecasting performance. Put differently, when agents learn that their rule performs poorly they switch. This lays the ground for the existence of animal spirits and reinforces the results of De De Grauwe (2010). When  $\gamma$  increases the willingness of agents to switch camps from bear to bull gradually decreases. Thus  $\gamma$  increases the length of bear-bull cycles.

Now we turn our attention to the structural parameters of the model. We start with  $\eta$ , which determines the degree of convexity of the intermediation technology. In line with Cúrdia and Woodford (2009) we vary  $\eta$  up to a value of 50. For low values  $\eta$  purely financial shocks are swiftly transformed into additional credit for the firm sector as the banking sector operates smoothly. This strengthens the link between financial sector shocks and animal spirits. When the intermediation technology gets increasingly convex the loan supply becomes more sticky which somewhat attenuates the link between financial sector shocks and additional loans provided and thus erodes the link between business cycle correlation between output and animal spirits. Starting with a correlation coefficient  $\rho_{yx}$  well above 0.9 it gradually declines to values of  $\rho_{xy} = 0.70$  when  $\eta$  increase to 50.

The single most important parameter for the existence of animal spirits is the slope of the Phillips-curve. Price stickiness amplifies the cycle as firms by definition only gradually

Figure 3: Sensitivity analysis of expectation variables, the cost channel and the intermediation technology



adjust prices downward. Thereby, as monetary authority's act timely a large drop in the real rate of interest is engendered by the Taylor-Principle. Thus, the real rate of interest is the necessary link in the chain to make it happen! Paradoxical a hawkish stance on inflation on behalf of the central bank increase the propensity that purely financial friction shocks initiate cycles.

This point is somewhat neglected in related research. The reason for this neglect is straightforward. In Cúrdia and Woodford (2009) the shock occurs in the IS-equation as the creditors in the economy are identified as credit constraint households. In our setup we somewhat more naturally identify the firm sector as single most important net



creditor in the economy. Therefore purely financial disturbances to the loan rate have supply side implications which will be important later on when we evaluate the policy recommendations.

We now turn our attention to the fraction of firms that is credit constraint. If the channel is broadened we observe that already a minor fraction of firms is sufficient round about  $\kappa_L = 0.10$  to ignite a correlation between the business cycle and animal spirits.

The analysis has revealed that the slope of the Phillips-curve and the intensity of choice parameter are the single most important factors. Therefore we report some additional joint sensitivity analysis in table 3.

Table 3: Analysis of standard deviations

Situation	$\hat{\pi}_t$	$\hat{y}_t$	$\hat{R}_t^L$	$\hat{R}_t^M$	$\alpha_{opt,t}$	$\beta_{tar,t}$	$\hat{\omega}_t$
$\gamma = 0$ and $\kappa = 0$	0	0	0.4707	0	0	0	0.4707
$\gamma = 4$ and $\kappa = 0$	0.0019	0.0049	0.4709	0.0052	0.0084	0	0.4707
$\gamma = 0$ and $\kappa = 1$	0.0648	0.0801	0.5302	0.0849	0	0	0.4500
$\gamma = 4$ and $\kappa = 1$	0.1477	0.1971	0.6353	0.3246	0.3369	0.0162	0.4515

Table 3 shows the standard deviation of central variables, when the "animal spirit" parameter  $\gamma$  and the size of the cost channel  $\kappa$  are switched on and off. Disabling both leads to no variance in output and inflation, just as in the share of the agents. Only the shock in the intermediation process has its impact to the variance of the loan rate and the spread. When we allow for switching ( $\gamma = 4$ ), all variances increase slightly, but the loan rate shock is not transmitted to the economy due to a disabled cost channel. When the financial shock has importance for inflation ( $\kappa = 1$ ) we observe a higher standard deviation, but, considering both effects, we get the highest fluctuation in all relevant variables. This reflects the importance of the cost channel and in particular the animal-spirit-component for the economy. As a direct effect, the loan rate is twice volatile than the policy rate.

## 5. Implications for Monetary Policy

The last sections provided evidence that financial friction shocks in conjunction with animal spirits can give rise to boom-bust cycles. In a sticky price environment, this non-fundamental shock obviously impairs welfare as the volatility in labor and consumption increases. Therefore, we discuss the effectiveness of different macroeconomic policy instruments to dampen the self-sustaining boom-bust cycles. In our model two macroeconomic leverages exist to influence the economy: As a first alternative, the central bank can modify its Taylor rule, so we alter the Taylor parameters of output, inflation and interest rate smoothing and augment it by the loan volume and the credit spread itself (section 5.1). The second alternative is regulatory in nature. By introducing countercyclical equity restrictions as provided in the Basle III accord, banks have to build up additional equity buffers in a boom, which melt down in a bust due to losses on granted loans.

### 5.1. Altering Taylor rule coefficients

Two prime candidates for augmenting Taylor-rules in the light of financial friction shocks are either to adjust rates to the evolution of credit volumes (see Christiano et al. (2008)) or alternatively to movements in the interest-rate spread itself.

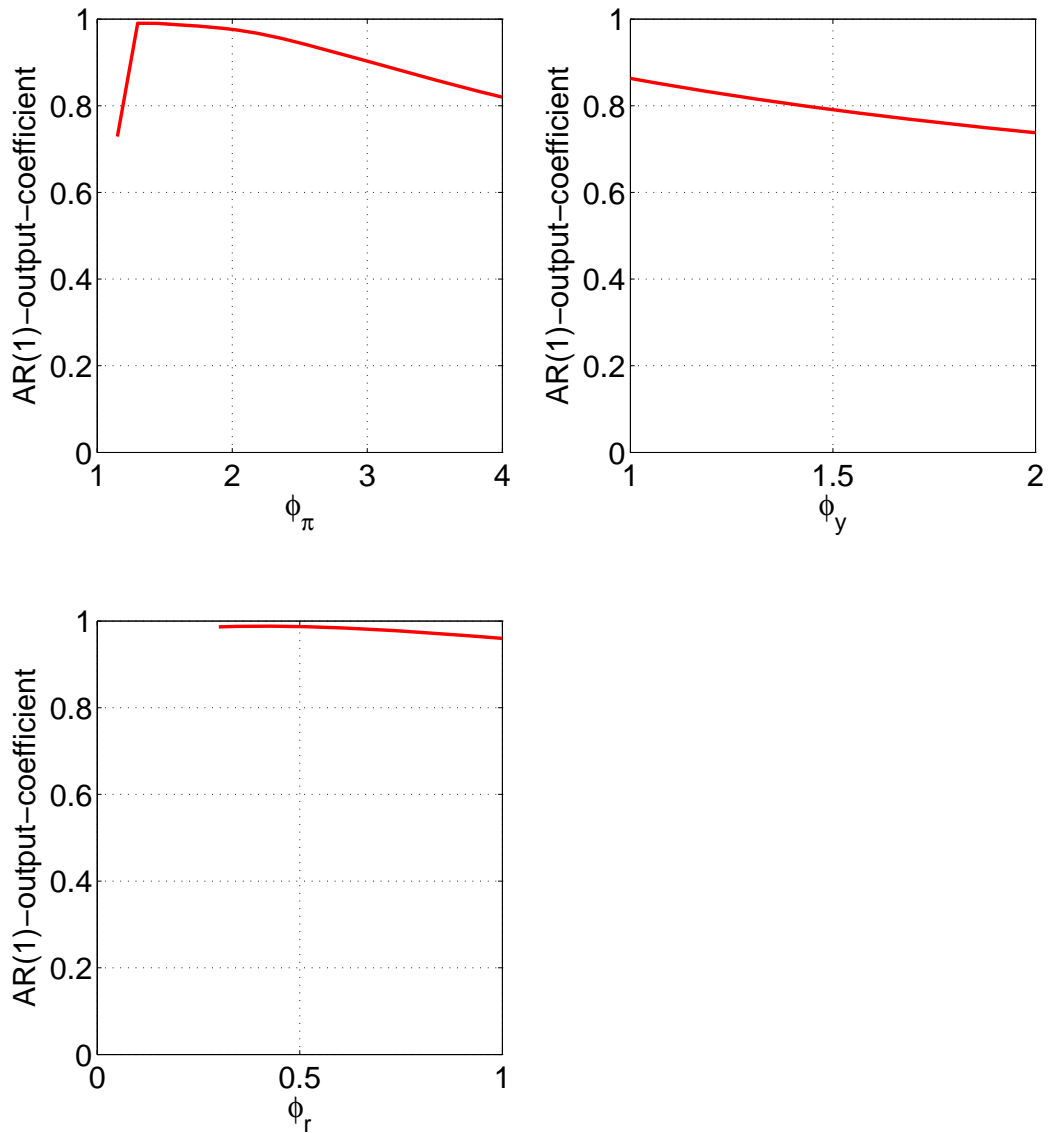
$$\widehat{R}_t^M = \phi_r \widehat{R}_{t-1}^M + (1 - \phi_r) \left( \phi_\pi \widehat{\pi}_t + \phi_y \widehat{y}_t + \phi_b \widehat{b}_t + \widehat{\Xi}_t \phi_\omega \widehat{\omega}_t \right) + r_t, \quad (26)$$

To have a benchmark against which we can evaluate the augmented Taylor-rule we first illustrate that the standard rule can not well deal with purely financial friction shocks. To do so we proceed as follows. Figure 4 reports the impact of changing the coefficients  $\phi_\pi$ ,  $\phi_y$ , and  $\phi_r$  on the AR(1)-coefficient of output  $y_t$  when altering these coefficients within plausible ranges. As a general finding the figure highlights that recalibrating the Taylor-rule does not substantially help to smooth the business cycle. With respect to the inflation-coefficient we see that even coefficients well above those reported within the empirical studies only mildly lower the degree of persistence in output. The same holds true for  $\phi_y$  and  $\phi_r$ . Thus as a first cautious conclusion we state that standard Taylor rules are vulnerable in the light of financial friction shocks and even worth, they are part of

the propagation mechanism.

A first prime candidate to attenuate the adverse effects of financial frictions shocks is to augment the Taylor rule by a credit component (see Christiano et al. (2008)). To analyze the impact of augmenting the Taylor rule on the AR(1)-coefficient we conduct the following experiment.

Figure 4: Variation of Taylor-Rule coefficients

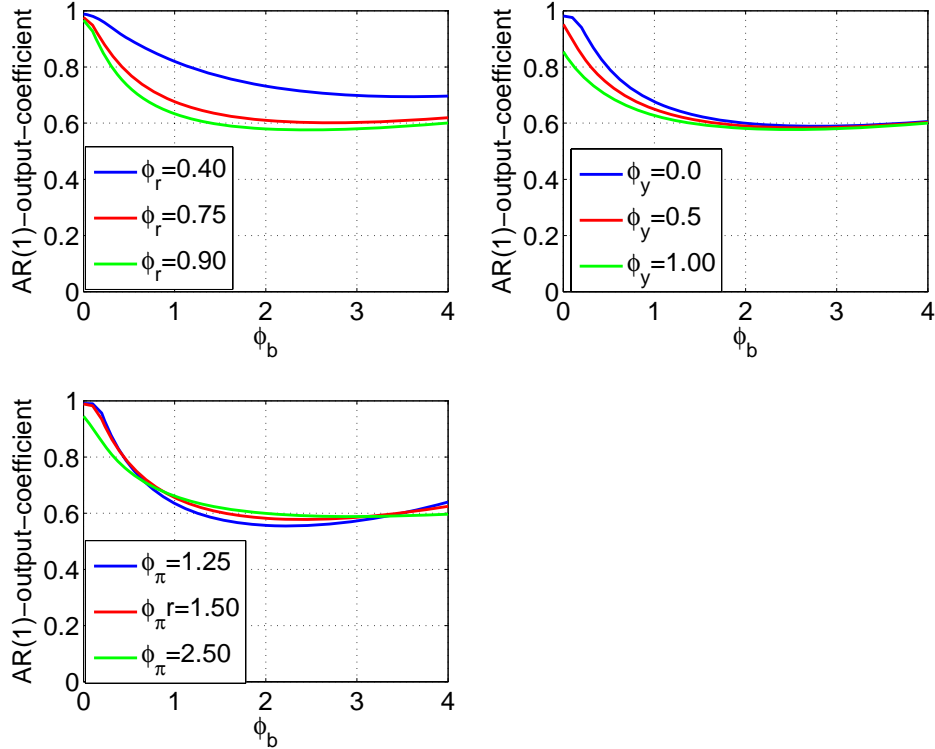


While setting all parameters to their baseline value we alter the response of interest rates to debt volume  $\phi_b$  in a range between 0 to 4. To judge the impact of augmenting the Taylor rule we have to keep in mind that an AR(1)-coefficient in an economy, where weights of

optimists and pessimists are equal to 0.5, is equal to 0.4. Thus by preventing the built-up of waves of optimism and pessimism during the business cycle the AR(1)-coefficient drops from 0.97 in the baseline to 0.4.

The figure 5 reveals that an interest rate response to debt volume is well suited to stabilize business cycles in the light of financial friction shocks. For the baseline scenario, the

Figure 5: Variation of credit-augmented-Taylor-Rule coefficients



AR(1)-coefficient sharply drops from 0.89 to 0.6, when the Taylor-rule coefficient to debt is set equal to  $\phi_b = 2$ . Not surprisingly we find that simultaneously altering one of the other Taylor-rule coefficients  $\phi_\pi$ ,  $\phi_y$ ,  $\phi_r$  at the time does not substantially change any conclusions, which is consistent with our previous results as illustrated in Figure 4.

To somewhat better understand why responding to debt volume  $\hat{b}_t$  stabilizes the economy we can substitute the equations (3) and (8) into:

$$\hat{b}_t = \hat{w}_t + \hat{n}_t, \quad (27)$$

which simply states that the credit volume is equal to the wage bill that has to be paid

in advance of receiving revenues. The expression reads:

$$\widehat{b}_t = \frac{(1 + \phi) + \sigma_c \frac{\bar{Y}}{C}}{1 + \sigma_c \frac{\bar{Y} \omega \bar{b}}{C \eta \bar{y}} \eta} \widehat{y}_t - \frac{\sigma_c \frac{\bar{\omega} \bar{b} \bar{Y}}{\eta \bar{Y} C}}{1 + \sigma_c \frac{\bar{Y} \omega \bar{b}}{C \eta \bar{y}} \eta} \widehat{\Xi}_t, \quad (28)$$

with  $\phi_1 = \frac{(1+\phi)+\sigma_c \frac{\bar{Y}}{C}}{1+\sigma_c \frac{\bar{Y} \omega \bar{b}}{C \eta \bar{y}} \eta}$  and  $\phi_2 = \frac{\sigma_c \frac{\bar{\omega} \bar{b} \bar{Y}}{\eta \bar{Y} C}}{1+\sigma_c \frac{\bar{Y} \omega \bar{b}}{C \eta \bar{y}} \eta}$ . Thus responding to credit volume is in our model context equivalent to responding stronger to output by a factor of  $\phi_b \phi_1 = 5.95$  and countercyclical to the financial friction shock with a factor of  $\phi_b \phi_2 = 0.013$ . Setting these coefficients into the Taylor rule it reads:

$$\widehat{R}_t^M = \phi_r \widehat{R}_{t-1}^M + (1 - \phi_r) \left( \phi_\pi \widehat{\pi}_t + (\phi_y \phi_b) \widehat{y}_t - \phi_2 \phi_b \widehat{\Xi}_t \right) + r_t, \quad (29)$$

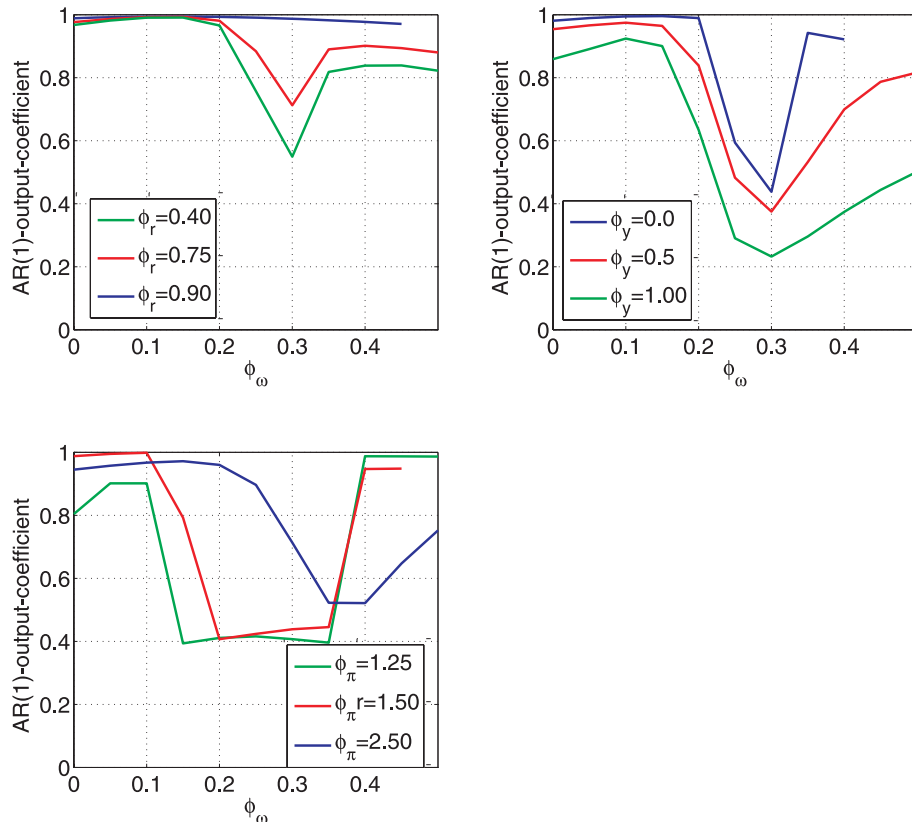
and substitution the Taylor-Rule into the loan rate equation yields:

$$\frac{d\widehat{R}_t^L}{d\widehat{\Xi}_t} = (\phi_3 - (1 - \phi_r) \phi_2 \phi_b), \quad (30)$$

with  $\phi_3 = 1 - \frac{\bar{\omega}}{1+\bar{\omega}}(\eta-1)\phi_2$ . Thus the equations nicely reveal that reacting to debt volumes implicitly builds in a countercyclical response to financial friction shocks. Additionally the countercyclical stance to the state of the cycle is more hawkish. De Grauwe (2010) has already pointed out in a related model that the existence of animal periods, driven by consumer sentiment calls for a higher coefficient on output in the Taylor rule. By responding to credit we implicitly scale up the response to *GDP* by a factor of 40, compared to a standard Taylor rule with  $\phi_y = 0.15$ . So basically one could argue that there is no need to augment the Taylor rule by a credit component as scaling up the output coefficient and responding countercyclical to financial frictions shocks yields equivalent results. We would like to drop two notes of caution on this point of view. First, the idea of simple rules is to give robust policy guidance and respond to a small set of observable variables (McCallum (1988), McCallum (1999)). Therefore it is not in the spirit of Taylor rules to respond to shocks, which are from a practical perspective somewhat unobservable and have to be identified first. Second, there exists a large strand of literature that provides overwhelming evidence that the so called Great Moderation was partly driven by a more moderate response of the FED to the state of the business cycle. In particular Orphanides (2008) has provided evidence that real-time data is flawed by substantial measurement error. Therefore, if the FED responds with a high coefficient on output it

will become a source of destabilization as the Federal Funds Rate is adjusted in response to non-existing changes in the output gap which can be contributed to measurement error. Mayer and Scharler (2011) illustrate, based on the real-time data set of the Federal

Figure 6: Variation of spread-augmented-Taylor-Rule coefficients



Reserve Bank of Philadelphia, that till the present the persistence of measurement error is still as high as in the 70's, although the variance of the noise components seems to have declined considerably. Therefore we conclude that a response coefficient on output equal to 5.95 is not feasible in an environment where the FED responds to noisy estimates of *GDP* in real-time. Credit volumes on contrary are measured in real-time with great accuracy, therefore the central bank seems to be well advised to respond to credit and not to *GDP*. Thereby it directly attenuates the affect of the financial friction shock on the loan rate itself and indirectly prevents the built up of waves of optimism and pessimism on the business cycle.

The same string of arguments holds true for the case when the central bank reacts to credit spreads. Figure 6 reveals that responding to spreads is well suited to prevent waves

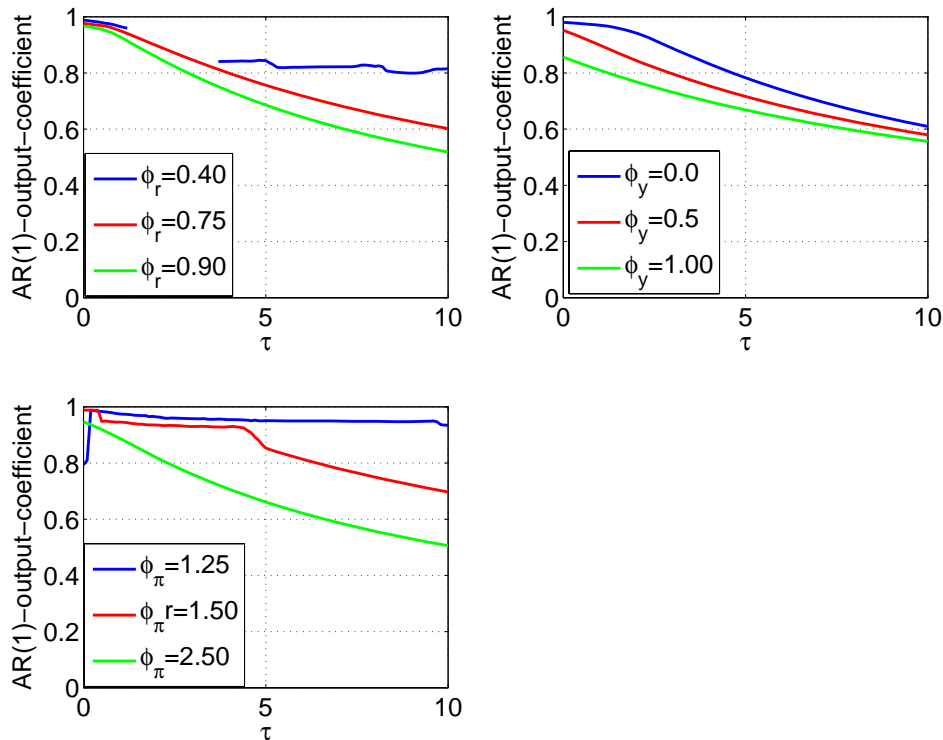
of optimism and pessimism to drive the business cycle. As for the case of credit volumes we can report that the correlation drops from 0.89 in the baseline to 0.60, when the coefficient takes a value of  $\phi_\omega = 0.30$ . The figure 6 illustrates a hump shaped relationship. This can be explained by two opposing effects. On the one hand the response to credit spreads directly attenuates the adverse effect of the financial friction shock on the loan rate. Thereby the effects of the shock are dampened from the outset. On the other the basic shock is supply side in nature. Put differently, when the shock hits inflation is likely to increase while output is likely to decrease. When the central bank reacts strongly to credits, the response of consumption, which is the main component of *GDP* will become more persistent, which acts as a countervailing effect.

## 5.2. Countercyclical equity regulation

In this section we present a regulation-based approach to dampen frictions in the intermediation process. Changes in the equity restriction leads in general to a variation in the loan rate as shown in Bofinger and Debes (2010), so the policy-maker circumvents situations with excessive lending in an economic boom or a credit crunch in a recession. Rising equity strengthens buffers in the financial sector, which improves social welfare due to a reduced shock transmission from the financial to the real sector as figured out in Admati et al. (2010). Having this fact in mind, the Basle III accord consists of additional equity buffer, which raises the required equity ratio from 10.5 up to 13.0 %. The additional buffer moves countercyclical with the business cycle (a discussion of different arrangements of countercyclical capital buffer can be found at Drehmann et al. (2010)). The regulation patterns are introduced in the loan rate equation (7), so we rewrite the term  $\hat{\tau}_t = \tau * \hat{y}_t$ , where  $\tau$  determines the regulation effect to the loan rate. A sluggish economic development lowers the equity requirement, which eases credit supply, vice versa in an economic boom. When choosing a possible value range for  $\tau$  one have to consider, that the spread is third volatile than the output gap as shown in table 3, so we analyze the behavior of the economic system for values from 0 to 10 (figure 7). Therefore, it is not surprisingly that the AR(1)-coefficient drops significantly at values greater than 5 for  $\tau$ . The regulation authority has to set its instrument carefully due of the misspecification

of the output gap as discussed in the previous section. High values for  $\tau$  lead to a further reduction of the intermediation shock up to 0.6 in the baseline calibration, but are prone to measurement errors in the output gap, which have a destabilizing effect for the economy. In combination with augmented Taylor-rules, the results get more promising due to the reduced “financial accelerator” of the monetary policy.

Figure 7: Sensitivity analysis: Regulation case



### 5.3. Impulse response analysis

Another dimension along which we can motivate the use of alternative policy tools is to provide evidence that augmenting Taylor-rules as well as implementing countercyclical equity regulation change the dynamic response of the economy in terms of impulse responses. Computing impulse responses in a non-linear model is not a straight forward exercise. If the financial sector increases the loan rate by a standard deviation shock the impact on the economy will depend on the history of the economic cycle. This is not true for a linearized model with orthogonal shocks where the same shock always has the same impact on the economy. We follow De Grauwe (2010) in dealing with this issue.



In the case of a non-linear context the dynamic of the economic system essentially depends on the share of optimistic and pessimistic agents, which are driven by past realizations of consumption. We start simulating the model for 1070 periods and introduce a standard deviation shock in the intermediation process of 25 basis points for only one period. To get a similar starting point we hold the stochastic draw fixed and generate an alternative reality by eliminating the shock in period 1070 ( $\widehat{\Xi}_t = 0$ ). The impulse responses are computed by taking the difference between the shock scenario from the neutral scenario. We repeat the same exercise of identical draw of shocks under the suggested policy instruments (augmented Taylor-Rules and equity regulation). To take care for the non-linearity in the model we rerun the procedure for 200 different shock scenarios and provide the mean reaction and a confidence band of two standard deviation around the mean.

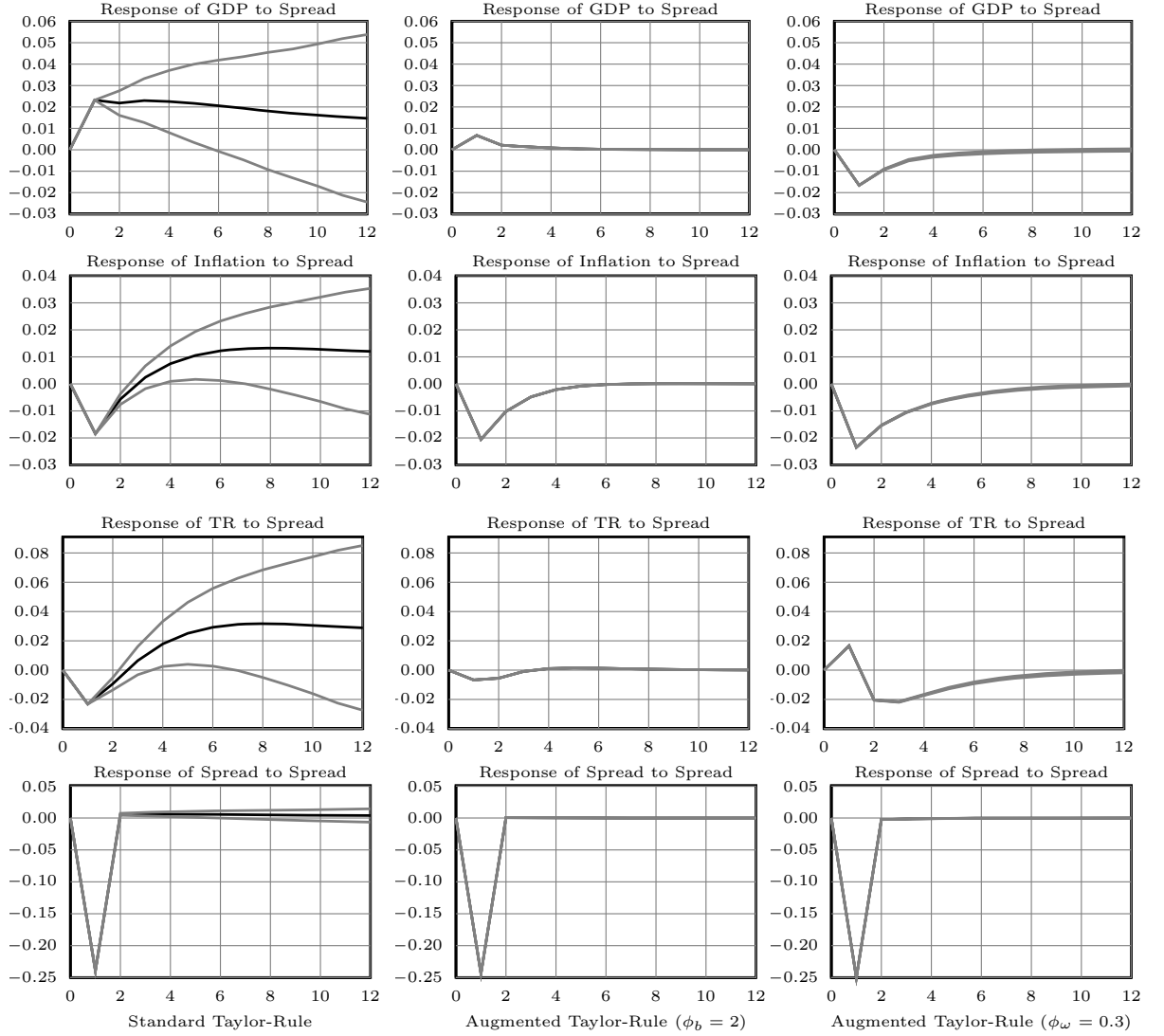
### **Augmented Taylor-rules**

In figure 8 we compare two augmented Taylor-Rules with the standard policy reaction. We set  $\phi_b = 2$  for the credit-augmented rule and  $\phi_\omega = 0.3$  for the spread-augmented rule according to the sensitivity analysis. The results are clear-cut:

At the left panel the standard deviation shock of 25 basis points in the intermediation process is fully transmitted to the economy and has the typical patterns of a supply shock: due to reduced financing costs inflation declines, which leads to lower interest rates in the Taylor-rule and causes an economic boom. Without a modified Taylor-rule the economic system deviates from its steady state with high variance for more than 12 periods as shown in the left panel of figure 8.

We show the outcome under a credit-augmented and spread-augmented Taylor-rule in the middle respectively the right panel. Both policies reduces the amplitude as well as the uncertainty of the shock in a significant way. Another common pattern is the drop in inflation due to the shock, but the two policy rules prevent the decline in interest rates and therefore a transmission to the economy. The rules differ in the behavior of interest rate setting: The credit rule lowers interest rates slightly while the spread rule is leaning against the wind and tightens monetary policy conditions. The same difference consequently appears in the GDP development. The results are in line with the sensitivity analysis: a hawkish monetary policy triggered by deviations in credit aggregate or in the interest rate spread prevent a boom-bust-cycle.

Figure 8: Impulse response functions: Two augmented Taylor-Rules

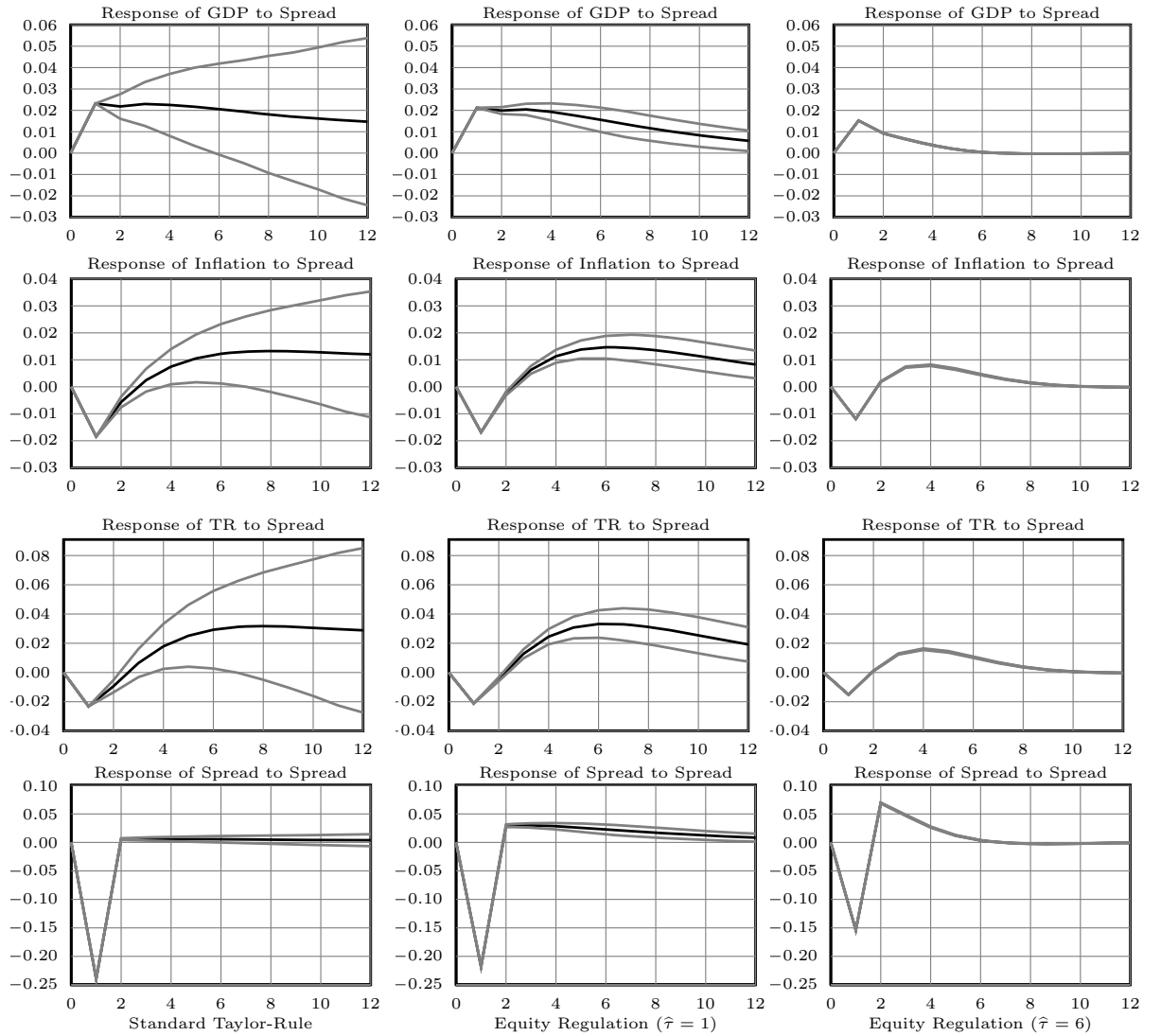


*Notes:* Figure 8 shows the responses of output (GDP,  $\hat{y}_t$ ), inflation rate ( $\hat{\pi}_t$ ), monetary policy rule (TR,  $\hat{R}_t^M$ ) and the interest rate spread ( $\hat{\omega}_t$ ) to shocks to the  $\hat{\omega}_t$  for a standard Taylor rule (left panel), a credit-augmented Taylor rule ( $\phi_b = 2$ ) and a spread-augmented Taylor rule (right panel,  $\phi_\omega = 0.3$ ). We provide informations on the mean (black line) and a likelihood confidence band of two standard deviations around the mean.

## Equity regulation

We confront the countercyclical regulation approach with the same problem as the Taylor-rules and present the result in figure 9. The outcome depends on the different degrees of equity regulation respectively the impact of regulation to the loan rate (values of  $\tau$ ), but the main movement corresponds with the baseline situation on the left panel. One possible explanation is lead back to the fact, that regulation influences only the loan rate and cannot prevent the amplifying effect of monetary policy. Setting the regulation term

Figure 9: Impulse response function: Regulation case



*Notes:* Figure 9 shows the responses of output (GDP,  $\hat{y}_t$ ), inflation rate ( $\hat{\pi}_t$ ), monetary policy rule (TR,  $\hat{R}_t^M$ ) and the interest rate spread ( $\hat{\omega}_t$ ) to shocks to  $\hat{\omega}_t$  for a standard Taylor rule (left panel), and different degrees of equity regulations ( $\hat{\tau} = 1$  middle panel and  $\hat{\tau} = 6$  right panel). We provide informations on the mean (black line) and a likelihood confidence band of two standard deviations around the mean.

to one (middle panel) reduces only the uncertainty of the shock to the economy.  $\tau = 6$  (right panel) pushes the economy to its steady state within eight quarters with almost no variance. Higher values for  $\tau$  are also possible and reduce the amplitude of the shock as shown in the sensitivity analysis, but are prone to measurement errors in the output gap, so we do not recommend too high values for  $\tau$ .

We have evidence that the introduction of alternative policy tools dampens the effect of an intermediation shock to the economy. The credit-augmented rule seems to be the best of the presented tools to prevent the negative effects of financial shocks, while we suggest an introduction of countercyclical regulation only in combination with an augmented Taylor-rule.

#### **5.4. A Welfare Perspective on augmented Taylor-rules: Are welfare implications different compared to the counterpart DSGE model?**

(To be Done)

## **6. Conclusion**

In this paper we extended a behavioral model based on De Grauwe (2010) by a cost channel. The main differences to standard macroeconomic models are the substitution of rational expectations by rule of thumbs heuristics to predict future developments. Additionally, we introduce a spread function between the loan rate and the monetary policy rate, which moves countercyclical to the business cycle following a monetary shock. By allowing for the existence of animal spirits we succeed to introduce a financial accelerator mechanism. If banks mispriced the default risk of a loan and drive the business cycle by granting loans too generously this operates like a supply shock. If monetary authorities follow a standard Taylor rule they will lower the rate of interest. Thereby the occurrence of a boom cycle driven by animal spirits happens as consumers start to become bullish on future consumption expenditures. Thus a financial friction shock can ignite a boom bust cycle. Ironically the Taylor-Principle, which lowers the real rate of

interest in response to the financial friction shock is a necessary link in the chain. As the financial friction shocks not grounded out of preferences or technology it is obvious that in an environment with sticky prices the additional volatility in consumption and labor supply impairs welfare.

Analyzing the macroeconomic instrument box, we suggest a combination of countercyclical equity regulation and augmenting the Taylor-rule by a credit or spread component. This builds-in a negative correlation between financial friction shock and the Taylor-rate. Thus, in particular augmenting the Taylor-rule by a parameter that responds to the evolution of credit or the spread itself seems to be well suited to attenuate the negative effects of financial friction shocks in the economy.

# Appendix

## A. Calibration

Table 4: Calibration

	Parameter	Calibration
<b>Households</b>		
Inverse of the intertemporal elasticity of substitution	$\sigma_c$	1.00
Inverse of marginal disutility of labor	$\varphi$	1.00
<b>Firms</b>		
Discount factor	$\beta_\pi$	0.99
Calvo parameter	$\omega$	0.75
Elasticity of Substitution	$\epsilon$	11.00
Cost channel	$\kappa^L$	1.00
<b>Rule of thumb parameters</b>		
Fixed term of the divergence in beliefs	$\beta_d$	1.00
Variable term of the divergence in beliefs (output and inflation)	$\delta_d$	2.00
Memory parameter	$\rho$	0.50
Intensity of choice	$\gamma$	4.00
Evaluation window	$w$	50.0
<b>Intermediation technology</b>		
Convexity of the intermediation function	$\eta$	5.00
<b>Monetary policy</b>		
Inflation coefficient	$\phi_\pi$	2.00
Output coefficient	$\phi_y$	0.25
Interest rate smoothing coefficient	$\phi_r$	0.75
Spread coefficient	$\phi_\omega$	0.30
Loan coefficient	$\phi_b$	2.00
<b>Steady state values</b>		
Spread	$\bar{w}$	0.02
Loan-to-Output-Ratio	$\bar{b}/\bar{y}$	3.2
<b>Shock</b>		
Standard deviation of the loan rate	$\sigma_L$	0.25

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