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Animal Spirits and Credit Cycles

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Abstract

In this paper we extend the behavioral macroeconomic model as proposed by De Grauwe (2012) to include a banking sector. The behavioral model takes the view that agents have limited cognitive limitations. As a result, it is rational to use simple forecasting rules and to subject the use of these rules to a fitness test. Agents then are driven to select the rule that performs best. The behavioral model produces endogenous and self-fulfilling movements of optimism and pessimism (animal spirits). Our main result is that the existence of banks intensifies these movements, creating a greater scope for booms and busts. Thus banks do not create but amplify animal spirits. The policy conclusion we derive from this result is that the central bank has an important responsibility for stabilizing output. Output stabilization is an instrument to "tame the animal spirits". This has the effect of improving the tradeoff between inflation and output volatility.

JEL-Code: E400.

Keywords: animal spirits, credit cycle, interest rate spread, stabilization.

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1 Introduction

Since the start of the financial crisis DSGE modelers have hurriedly attempted to introduce a banking sector into their models. Unfortunately, this has been done in the framework of models that assume rational expectations, i.e. that assume that the representative agent understands the complexity of the underlying model. If there is anything we have learned from the financial crisis it is that this crisis was made possible by the fact that agents do not understand the complexity of the world in which they live. Instead, their cognitive abilities are very limited. Therefore there is a need to introduce a banking sector in models that recognize the cognitive limitations of agents. This is what we attempt to do in this paper.

We will use the behavioral macroeconomic model that was proposed by De Grauwe (2012). This is a model that assumes that agents have cognitive limitations, and therefore use simple forecasting rules that do not take all information into account. Such an assumption is necessary once we take the view that agents are limited in their capacity to collect and process the immense information set that is present in the world. We introduce rationality in this model by allowing agents to learn from their mistakes and to switch to rules that perform better than the one they are currently using. In our opinion, this evolutionary rationality is a better way to describe rationality in a world that is too complex and uncertain for agents to understand.

2 The model

In this section we first present the basic behavioral macro model as proposed by De Grauwe (2012). We then go a step further by decomposing aggregate demand into consumption and investment demand. Finally banks are introduced.

2.1 The baseline behavioral macro model (BMM)

Our baseline behavioral macro model (BMM) consists of three equations, similarly to De Grauwe (2008b; 2008c; 2012).

An aggregate demand (AD) function:

$$y_t = a_1 \tilde{E}_t y_{t+1} + (1 - a_1') y_{t-1} + a_2 (r_t - \tilde{E}_t \pi_{t+1}) + \varepsilon_t, \quad (a_2 < 0) \tag{1}$$

aggregate supply (AS):

$$\pi_t = b_1 \tilde{E}_t \pi_{t+1} + (1 - b_1) \pi_{t-1} + b_2 y_t + \eta_t, \tag{2}$$

and a Taylor rule (TR):

$$r_t = c_1 (\pi_t - \pi_t^*) + c_2 y_t + c_3 r_{t-1} + u_t. \tag{3}$$

As explained in De Grauwe (2008b; 2008c; 2012), there is no direct derivation of the model at the micro level, albeit equations (1) to (3) are consistent with the linearized version of most New Keynesian models (e.g., Smets and Wouters, 2007).

The forecasts of $\tilde{E}_t y_{t+1}$ and $\tilde{E}_t \pi_{t+1}$ in eq. (1) and (2) are governed by a fitness learning selection mechanism.[2]

In this set up, agents are supposed to forecast the output gap (y) and inflation (π) using two alternative forecasting rules. In particular, for $\tilde{E}_t y_{t+1}$, agents are assumed to use the steady-state value of the output gap (*fundamentalist* rule) - y^*, here normalized to zero - against an extrapolation of the gap's past trend (*extrapolative* rule).

Analogously for inflation, agents are assumed to switch between a fundamentalist and an extrapolative rule. Further, in an environment where the central bank explicitly announces its inflation target, inflation fundamentalists are assumed to base their expectations on the central bank's target, π^*. In contrast, inflation extrapolators behave exactly as output extrapolators do: by extrapolating inflation's past trend into the future.

Market forecasts of output gap and inflation are obtained as a weighted average of each respective forecasting rules (for $i = y, \pi$), as:

$$\tilde{E}_t i_{t+1} = \alpha_{f,t} \tilde{E}_t^f i_{t+1} + \alpha_{e,t} \tilde{E}_t^e i_{t+1}, \quad (4)$$

where the fundamentalist rule is generally defined as

$$\tilde{E}_t^f i_{t+1} = i^*,$$

and the extrapolative rule follows

$$\tilde{E}_t^e i_{t+1} = i_{t-1}.$$

We base our forecasting rule mechanism on a dynamic predictor selection, in line with discrete choice theory. This mechanism allows to switch between the two forecasting rules by computing the mean square forecasting error (MSFE)/utility of the two rules and increase (decrease) the relative weight of one rule against the other in each period. Under the formalization that the utilities of the two alternative rules have a deterministic and a random component - assuming the latter to be logistically distributed (see Anderson, De Palma, and Thisse, 1992) - weights can be defined based on each period utility ($U_{.,t}$, see also De Grauwe, 2012) as:

$$\alpha_{f,t}^i = \frac{exp(\gamma U_{f,t}^i)}{exp(\gamma U_{f,t}^i) + exp(\gamma U_{e,t}^i)}$$

and

$$1 - \alpha_{f,t}^i = \frac{exp(\gamma U_{e,t}^i)}{exp(\gamma U_{f,t}^i) + exp(\gamma U_{e,t}^i)},$$

with $(i = y, \pi)$, and where

[2] For sake of brevity, we refrain to report the whole details, which are, anyway, provided in De Grauwe (2008b; 2008c; 2012).

$$U_{f,t}^{i} = -\sum_{k=0}^{\infty} w_k\left[i_{t-k-1} - \tilde{E}_{t-k-2}^{f} i_{t-k-1}\right]^2,$$

and

$$U_{e,t}^{i} = -\sum_{k=0}^{\infty} w_k[i_{t-k-1} - \tilde{E}_{t-k-2}^{e} i_{t-k-1}]^2$$

where w_k are geometrically declining weights, allowing to take into account the degree of forgetfulness in the model (see De Grauwe, 2012).

Agents are thus "boundedly" rational in the sense that they use simple rules but subject these rules to a "fitness test" and switch depending on how well a given rule performs relative to the other rule. In this sense agents learn from their mistakes.

2.2 Decomposing the aggregate demand

The aggregate demand described previously can be decomposed into consumption (c) and investment (i) sides of the economy, plus an error component[3]

$$y_t = c_t + i_t + v_t, \tag{1'}$$

We specify the consumption and investment equations, respectively, as follows:

$$c_t = d_1 y_t + d_2 \tilde{E}_t y_{t+1} + (1 - d_1 - d_2) y_{t-1} + d_3(r_t - \tilde{E}_t \pi_{t+1}), \quad (d_3 < 0) \tag{5}$$

$$i_t = e_1 \tilde{E}_t y_{t+1} + e_2(r_t - \tilde{E}_t \pi_{t+1}). \quad (e_2 < 0) \tag{6}$$

Consumption, c, depends on three factors. First, on current income - according to the parameter d_1 which represents the marginal propensity of consumption. Second, on expected future output gap, $\tilde{E}_t y_{t+1}$. Third, consumption depends on past income, introducing an habit formation mechanism which is assumed to slow down the adjustment of consumption to its optimal level after a shock (see also De Grauwe, 2008b; 2008c; 2012; Smets and Wouters, 2007). Finally, consumption depends negatively on the real interest rate $(r_t - \tilde{E}_t \pi_{t+1})$, for $d_3 < 0$.

Following a standard approach, investment depends first on a forward looking component, the expected future output gap, $\tilde{E}_t y_{t+1}$. Second, it negatively depends on the interest rate, according to the parameter $e_2 < 0$, which measures the sensitivity of investment to changes in the real interest rate.

Substituting (5) and (6) into (1') and comparing with (1) allows us to derive the relationships between the parameters of equations (5) and (6) and equation (1), i.e.:

$a_1 = \frac{d_2 + e_1}{1 - d_1}$, $a_1' = \frac{d_2}{1 - d_1}$, $a_2 = \frac{d_3 + e_2}{1 - d_1}$ and $\frac{1}{1 - d_1} v_t = \varepsilon_t$ where $0 < d_1 < 1$.

[3] For sake of tractability, the usual direct government expenditure term is ignored.

2.3 Introducing banks

Banks are implicitly included in this model, since the interest rate is understood as the price of credit. However, in order to account for banks explicitly, we introduce financial intermediaries which are assumed to collect money from savers (consumers) and lend it to borrowers (firms).

The balance sheet of commercial banks accounts for loan supply (L^S), on the asset side, and deposits (D), on the liability side. Bank equity (n^b) serves as an important cushion against unexpected losses, being defined as the difference between assets and liabilities:

$$L_t^S = n_t^b + D_t. \tag{7}$$

For a commercial bank, the leverage is thus the ratio between its loans and equity. In this respect, banks are subject to an explicit capital-to-asset ratio, i.e.

$$\frac{n_t^b}{L_t^S} = \kappa, \tag{8}$$

with κ is the equity ratio (the inverse of banks' leverage ratio).

When a firm borrows money from a bank, it must pay an interest which normally exceeds the interest rates that savers receive for deposits. Hence, the cost of a loan from banks, ρ, is usually equal to the rate savers receive (here equal to the *risk-free* rate set by the central bank, r) plus a spread, x.

$$\rho_t = r_t + x_t. \tag{9}$$

The investment demand in equation (6) is hence replaced with equation (6'), assuming investment to depend on the cost of bank loans, as:

$$i = i(\rho) = e_1 \tilde{E}_t y_{t+1} + e_2(\rho_t - \tilde{E}_t \pi_{t+1}). \quad (e_2 < 0) \tag{6'}$$

In this way, the spread is assumed to affect the overall investment decisions of firms directly.

Incorporating banks into the aggregate demand - by means of eq. (1'), (5), (9) and (6') - gives:

$$y_t = a_1 \tilde{E}_t y_{t+1} + (1 - a_1')y_{t-1} + a_2(r_t - \tilde{E}_t \pi_{t+1}) + (a_2 + a_3)x_t + \varepsilon_t, \quad ((a_2 + a_3) < 0) \tag{1''}$$

where a_1 and a_2 are defined as before and $a_3 = -d_3/(1 - d_1)$. This new aggregate demand function in (1") subsitutes the one in (1) or (1'), where banks are absent.

Comparisons of eq. (1) and (1") suggest that - while the aggregate demand still depends on future expected and past income and (negatively) on the real interest rate - it also depends on the spread, x_t .

Since the slope coefficient $(a_2 + a_3)$ is negative for $0 < d_1 < 1$ and $e_2 < 0$, i.e. $a_2 + a_3 = \frac{e_2}{1-d_1}$, this new aggregate demand represents a negative relationship between y and x.

Looking at recent credit and money market developments there is a straightforward interpretation for this relationship.

Bank lending further implies (stocks of) consumers' savings to flow into deposits according to:

$$D_t - D_{t-1} = s_t. \tag{10}$$

In the same vein, loan demand (L^D) and investment are related by:

$$L_t^D - L_{t-1}^D = i_t, \tag{11}$$

Thus we assume that savings take the form of an accumulation of bank deposits, and investments by firms are financied by bank loans only.
s is finally being determined as:

$$s_t = y_t - c_t - v_t, \tag{12}$$

as in the standard IS-LM set up.

The next step in the analysis is to determine what the spread between the borrowing and the deposit rate is. We use the *financial accelerator* model of Bernanke, Gertler and Gilchrist (1999) to do so. Defining n^f as firms' equity, we write:

$$x_t = \rho_t - r_t = \varphi n_t^f, \quad (\varphi < 0) \tag{13}$$

Thus, an increase in the firms' equity reduces the spread and *viceversa*.[4] The underlying *financial accelerator* theory is the following. Banks have imperfect knowledge of the credit risk they take when granting a loan to a firm. To cover this credit risk they charge a spread (x_t). When the value of equity of the firm increases this is interpreted by the bank as an improvement in the solvency of the firm. Thus banks will perceive the credit risk to have declined allowing them to reduce the spread. A decline in the value of the firms equity has the opposite effect. Such a decline is interprted as reducing the solvency of the firm and increasing the credit risk. Banks react by raising the spread.

A firm with more debt than equity is leveraged. We define the leverage ratio, τ , as

[4] A further extension could be assuming the spread to depend on banks equity as well, in the vein of Gerali *et al.* (2010). When banks' equity decreases the leverage for a bank would increase and financing new investment opportunities would become riskier. The natural reaction will be for a bank to reduce its assets and stop lending, thus increasing the spread.

$$\tau = \frac{L_t^D}{n_t^f} \tag{14}$$

To keep the model simple, it will be assumed here that firms keep the leverage ratio constant. According to (14) this implies that as the loan demand increases the firm will issue more equity in the same proportion (in Section 6 we will make the leverage ratio endogenous).

By putting together eq. (11) and (14), one realizes that the equity of firms depends on the inverse of firms' leverage ratio (τ), which is the equity ratio, as

$$n_f^t = \frac{1}{\tau}(L_{t-1}^D + i_t);$$

e.g., Bernanke, Gertler and Gilchrist (1999).

The spread clears the lending market determining the total level of loanable funds to firms. Here, loan demand (L^D) is a function of investment, $L_t^D = L^D(i)$. Via eq. (7) loan supply (L^S) is a function of banks' equity and deposits, i.e. $L_t^S = L^S(n^b, D)$, where bank equity is simply the difference between loans and deposits (subject to the contraint in eq. (8)). Via banks' balance sheet the market is cleared for $L^S = L^D$.

3 Solving the model

We obtain a model with five endogenous variables, output gap, inflation, spread, savings and interest rate. The first four are obtained after solving the following set of equations:

$$\begin{bmatrix} 1 & -b_2 & 0 & 0 \\ -a_2c_1 & 1-a_2c_2 & -(a_2+a_3) & 0 \\ -\varphi\tau^{-1}e_2c_1 & -\varphi\tau^{-1}e_2c_2 & (1-\varphi\tau^{-1}e_2) & 0 \\ d_3c_1 & -(1-d_1-d_3c_2) & 0 & 1 \end{bmatrix} \begin{bmatrix} \pi_t \\ y_t \\ x_t \\ s_t \end{bmatrix} =$$

$$= \begin{bmatrix} b_1 & 0 & 0 & 0 \\ -a_2 & a_1 & 0 & 0 \\ -\varphi\tau^{-1}e_2 & \varphi\tau^{-1}e_1 & 0 & 0 \\ d_3 & -d_2 & 0 & 0 \end{bmatrix} \begin{bmatrix} \tilde{E}_t\pi_{t+1} \\ \tilde{E}_t y_{t+1} \\ \tilde{E}_t x_{t+1} \\ \tilde{E}_t s_{t+1} \end{bmatrix} + \begin{bmatrix} 1-b_1 & 0 & 0 & 0 \\ 0 & 1-a_1' & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & -(1-d_1-d_2) & 0 & 0 \end{bmatrix} \begin{bmatrix} \pi_{t-1} \\ y_{t-1} \\ x_{t-1} \\ s_{t-1} \end{bmatrix} +$$

$$\begin{bmatrix} 0 & 0 & 0 \\ a_2c_3 & 0 & 0 \\ \varphi\tau^{-1}e_2c_3 & \varphi\tau^{-1} & \varphi\tau^{-1} \\ d_3c_3 & 0 & 0 \end{bmatrix} \begin{bmatrix} r_{t-1} \\ D_{t-1} \\ n_{t-1}^b \end{bmatrix} + \begin{bmatrix} 1 & 0 & 0 \\ 0 & a_2 & 1 \\ 0 & \varphi^{-1}\tau e_2 & 0 \\ 0 & -d_3 & -(1-d_1) \end{bmatrix} \begin{bmatrix} \eta_t \\ u_t \\ \epsilon_t \end{bmatrix}$$

In compact form, this is written as $\mathbf{AZ_t} = \mathbf{B\tilde{E}_tZ_{t+1}} + \mathbf{CZ_{t-1}} + \mathbf{DX_{t-1}} + \mathbf{Ev_t}$. As in De Grauwe (2008b; 2008c; 2012), a solution for $\mathbf{Z_t}$ is obtained as $\mathbf{Z_t} = \mathbf{A^{-1}}(\mathbf{B\tilde{E}_tZ_{t+1}} + \mathbf{CZ_{t-1}} + \mathbf{DX_{t-1}} + \mathbf{Ev_t})$ for $\mathbf{A}$ being non-singular.

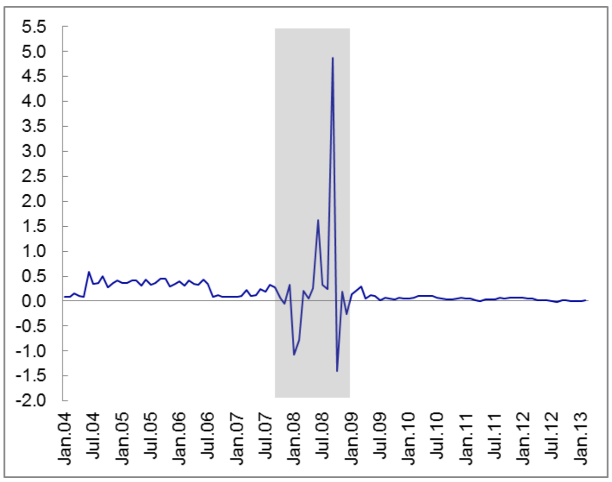
We then obtain the value of the interest rate recursively by substituting output gap and inflation into the Taylor rule. Investments, equities and deposits are determined by the model solutions for inflation, output, the spread and savings.[5]

4 Calibration

For the aggregate demand (AD) function we calibrate the parameters (d_1, d_2, e_1) to match standard macroeconomic simulation results, broadly consistent with De Grauwe (2012). In particular, d_1 is computed to match a marginal propensity to consume out of income equal to 0.5, in line with the empirical literature pointing to a MPC in the range of $0.2 \sim 0.7$.

The remaining parameters are derived consistent with sign restrictions posited, namely a firms' leverage factor of $\tau = 1.43$, following Pesaran and Xu (2013) and $\varphi < 0$.

Figure 1: US LIBOR-FFR spread (end-of-month)



Spread computed as in Taylor and Williams (2009)

Table 1: US LIBOR-FFR spread (end-of-month)

	Average	Max	Min
2004:1 - 2007:7	0.28	0.59	0.08
2007:8 - 2009:3	0.29	4.88	-1.40
2009:4 - 2013:3	0.05	0.12	-0.01

For the latter, corresponding estimates are not available with precision in the literature.[6] Thus, we calibrate φ for the spread to display the desirable propery of being alsways positive, consistent with the historical average of the LIBOR vs. Federal Fund Rate spread before August

[5] As in De Grauwe (2008b; 2008c; 2012), focusing on detrended variables - i.e. the output gap is GDP minus capacity GDP - implies that all our new variables will not show a trend either.

[6] For a discussion on steady state estimates for the spread see also Mehra, Piguillem and Prescott (2008), Curdia and Woodford (2010).

2007 (see Figure and Table 1).[7] Banks' equity ratio (the inverse of the leverage ratio, k) is further set equal to 0.09, as in Gerali *et al.* (2010), being consistent with much of the recent regulatory capital requirements for commercial banks.[8]

5 Results

5.1 Animal spirits drive the business cycles

Figures 2 and 3 show the time pattern of output gap and animal spirits produced by the baseline model with banks in a typical simulation run. We observe a strong cyclical movement in the output gap (Figure 2). The source of these cyclical movements is seen to be the index of animal spirits in the market (Figure 3).

We define animal spirits as the fraction of agents who forecast a positive output gap. When this is 1 all agents forecast such a positive output gap. They are all optimistic. When the index is zero all agents forecast a negative output gap; they are all pessimistic. The model creates endogenous waves of optimism and pessimism. These are highly correlated with movements in the output gap (0.91) (see also De Grauwe, 2008b; 2008c; 2012). During some periods, pessimism dominates and this translates into below average output growth. These pessimistic periods are followed by optimistic periods when optimistic forecasts tend to dominate, with above average growth.

Figure 2

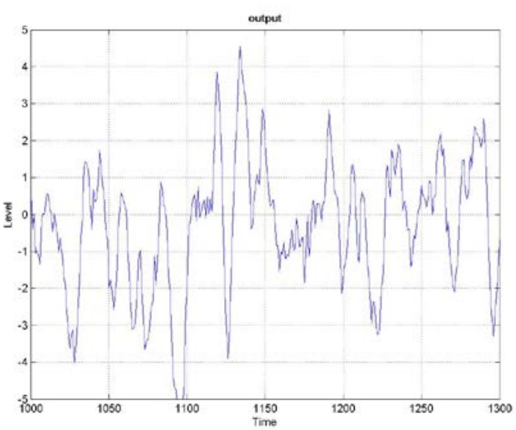
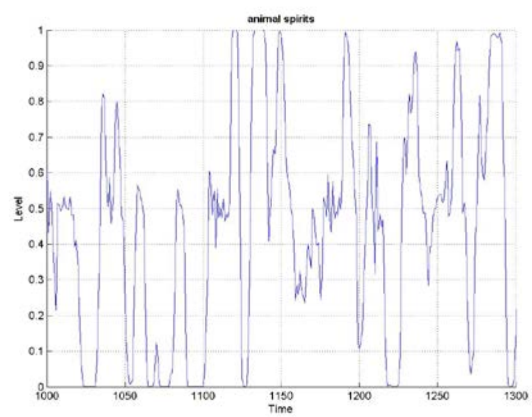


Figure 3



In Figure 4 we present the frequency distribution of the output gap. It turns out that this distribution is not normal. It has fat tails. Note that the stochastic shocks in the model are all *i.i.d*. Thus the non-normality of the distribution of the output gap is generated by the model, and

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[7] Similar pictures are provided when considering the spread between other interest rates at which different classes of borrowers are able to fund their activities (e.g., LIBOR vs. overnight index swap rates; see Taylor and Williams, 2009). Bernanke, Gertler and Gilchrist (1999) refer to the prime lending vs. six-month Treasury bill rate. Our specification, however, takes into account the fact that the prime lending rate is no longer used as actual interest rate, being rather regarded as an index for calculating rate changes to adjustable-rate mortgages and other variable short term loans.

[8] There is consensus that that a 9% equity-to-assets ratio (inverse leverage), corresponding to 18% equity-to-risk-weighted-assets ratio would offer banks enough capacity to absorb asset related shocks.

does not come from outside. This contrasts with standard linear DSGE models that can only produce non-normal movements in output by non-normally distribute shocks. The mechanism in the model that produces the non-normality is the interaction between animal spirits and output. As more and more agents become, say, optimists, output gap changes accelerate, producing large changes. The same happens when the downturn sets in.

We obtain more insight in this mechanism by plotting the frequency distribution of animal spirits in Figure 5. The latter is just a representation of the same animal spirits of Figure 3, but in the frequency domain. We observe that there is a concentration of observations at the extreme values of +1 (everybody is optimist) and 0 (everybody is pessimist). Thus the dynamics of animal spirits is characterized by movements in optimism (pessimism) that reguarly lead to outcomes when everybody is optimist (pessimist). This leads to “market frenzy” and large movements in economic activity.

Figure 4

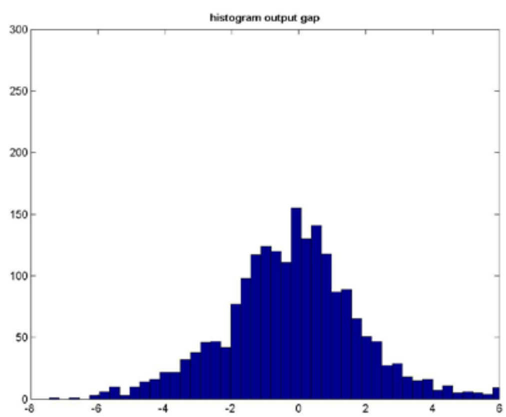


Figure 5

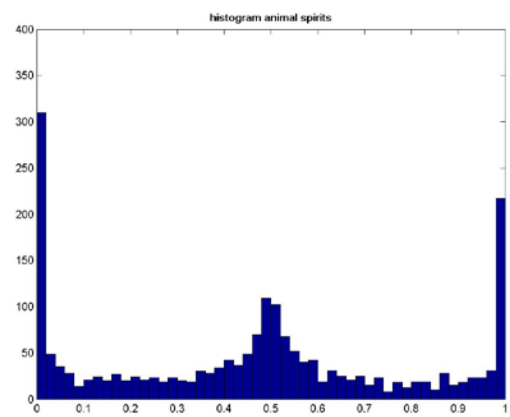


Figure 6 shows the evolution of the spread in the time domain. The spread is negatively correlated with animal spirits (-0.087). The reason is that during an upturn of economic activity when agents are optimistic, the value of equity of firms increases, leading banks to lower the spread. The opposite occurs during a downturn. The correlation coefficient is low, however, suggesting that this effect is weak. The relatively low correlation coefficient has much to do with the fact that the banks cannot easily expand their balance having to obey the balance sheet contraint in eq. (7), subject to an explicit (inverse of) banks’ leverage ratio, as set in eq. (8).

To study the implications of changing regulatory capital requirements, we further vary the equity ratio k (or, the inverse of banks’ leverage ratio) in the interval [0.01,0.9] and simulate the model over the spectrum of different ks. By changing k to values closer to 0.9 (which is ten times the 9% capital requirement normally used) we force banks’ leverage to be smaller and smaller. From Figure 7 we observe that as banks increase their equity ratio the correlation between animal spirits and output gap declines dramattically. This suggests that the equity ratio could be used as a policy intrument: by raising the equity ratio of banks the authorities can singificantly reduce the scope for animals spirits to lead to boom and busts in economic activity.

Figure 6

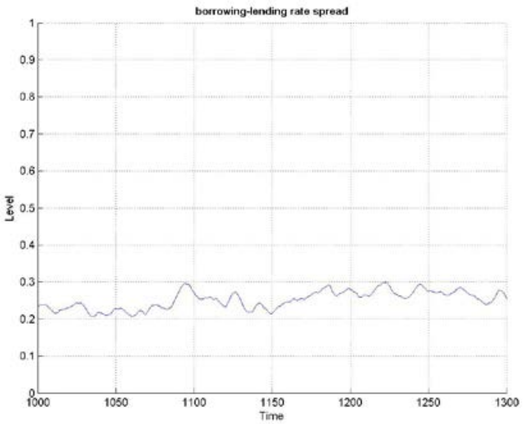
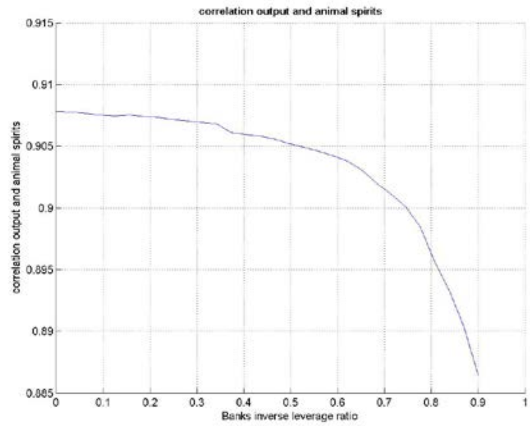


Figure 7



In a later section we discuss ways to make the banks' balance sheets react to the state of the economy.

5.2 Effects of monetary policy shocks

In this section we analyse the impulse responses following an unanticipated increase in the interest rate. We show these in Figures 8 to 11. The monetary policy shock occurs in period 100. We obtain the traditional results, i.e. output, investment and inflation decline. The results also confirm the pro-cyclicality of the spread. The interest rate induced decline in output and investment has the effect of reducing equity of firms. As a result, their creditworthiness declines. This then induces banks to raise the spread. Thus this effect is pro-cyclical, i.e. it tends to enhance the downturn initiated by the central bank's increase in its interest rate.

Figure 8

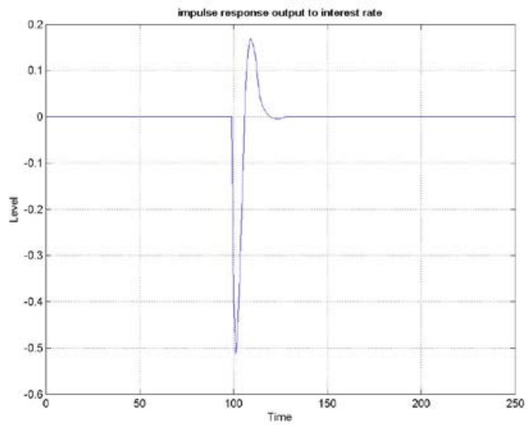


Figure 9

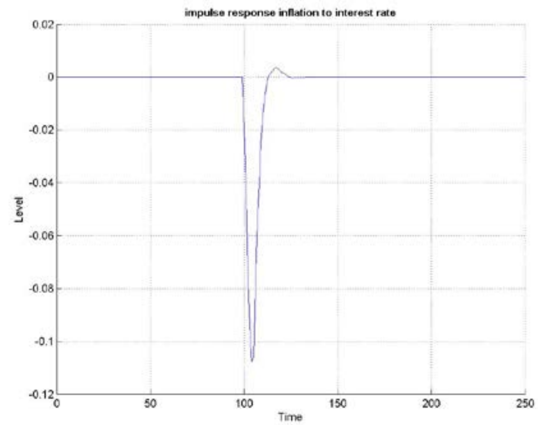


Figure 10

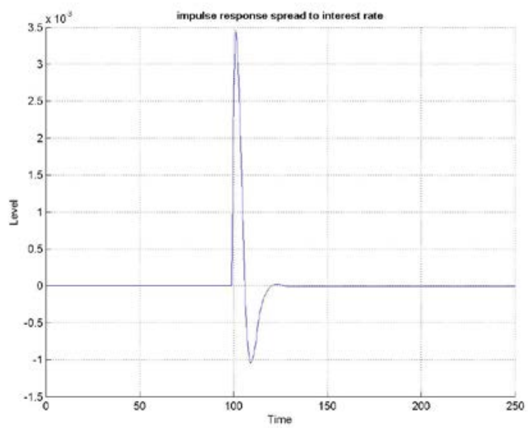
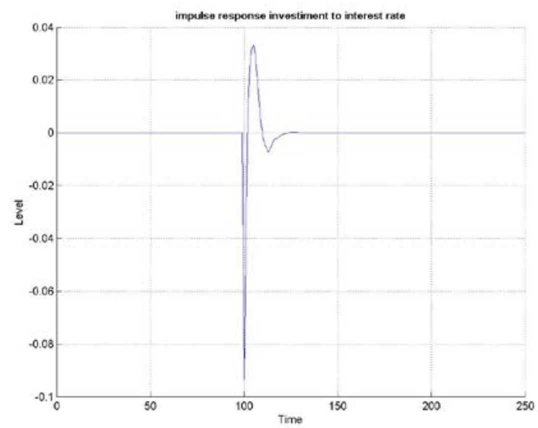


Figure 11



6 Leverage and stock prices

6.1 The extended bank model

In our previous set up we discussed the balance sheet constraint implied banks could not lend much more than they borrowed from households. As discussed in earlier, banks had no alternatives other than over reduce credit availability during a boom, and *viceversa*. This pretty much fixed the banks' balance sheets. In practice, however, there exist mechanisms that can lead banks to expand their balance sheets duing booms and contract them during recessions, thereby amplifying business cycle movements. In this section we analyze one such mechanism. It will be based on the link between the firms' asset values and the banks' balance sheets. This can be called the "risk taking channel" . This exists when incentives for both banks and firms to bear risk related to the provision of loans are affected. Essentially, a boost in asset and collateral values (together with the belief that the increase in asset values is sustainable; ECB, 2011; Mankiw and Ball, 2010) may lead both borrowers and firms to accept higher risk, resulting into an excessive loan provision. This mechanism may easily come into play if admitting banks to hold risky assets on their balance sheets, e.g. firms' shares, and following a positive reevaluation of the profitability of these assets.

In order to have asset price variability to contribute to the volatility in firms' equity, we resort on the idea that firms' market capitalization is equal to the number of (time-varying) shares ($\bar{n}_t$) multiplied by the current share price (S_t), i.e

$$n_t^{f,m} = \bar{n}_t S_t. \tag{15}$$

To derive share prices, we use the standard Gordon discounted dividend model,[9].

$$S_t = \frac{E_t \bar{\Lambda}_{t+1}}{R_t^S}, \tag{16}$$

with

$$R_t^S = r_t + \xi, \tag{17}$$

linking the asset price S_t to expected future dividends ($E_t \bar{\Lambda}_{t+1}$) net of a discount rate R_t. The latter consists of the *risk-free* interest rate plus a constant equity premium (ξ). We calibrate ξ to be 5%, which is in line with the historical average market risk premium.

The standard stable growth (Gordon) model assumes that dividends grow at a constant rate. The forecasts made by agents about future dividends follows the logic of the forecasts they make for the output gap. Agents assume the 1-period ahead forecast of dividends to be a fraction α of nominal GDP one period ahead, whereas dividends are assumed to be constant thereafter (from $t+1$ onwards). This forecast is reevaluated in every period. Since nominal GDP consists of a real and an inflation component, agents make a forecast of future output gap and inflation, in the same way as analyzed in Section 2. Thus, the forecasts are reevaluated each period, and agents are willing to switch to another forecasting rule if this performs better than the one they currently use.

As before (equation 13) we assume that the spread is determined by the value of the firms' equity. We substitute (15) into (13) and obtain

$$x_t = \varphi \bar{n}_t S_t, \quad (\varphi < 0) \tag{13'}$$

As a result, share prices, by affecting the firms' financial positions, influence the spread.

Given these additional dynamics in S, firms' leverage in eq. (14) is no longer exogenous. It is by the new equation (14')

[9] See e.g., Brealy and Myers (1984).

$$\tau_t = \frac{L_t^D}{\bar{n}_t S_t} \quad (14')$$

Finally, the banks balance sheet is modified in a way that allows for asset prices to feed back on banks' balance sheet. In particular, it is assumed that banks own a fixed fraction, $\bar{\bar{n}}$, of firms' shares.

Tot. Assets (A)	Liabilities (B)
Loans (L^S)	Deposits (D)
Risky assets ($\bar{\bar{n}}S$)	Own equity (n^b)

In this way, the sum of total assets, A_t, to be considered in banks' balance sheet identity is simply:

$$A_t = L_t^S + \bar{\bar{n}}S_t, \quad (18)$$

As a result, the new balance sheet constraint of the banks is given by the following,

$$A_t = n_t^b + D_t, \quad (7')$$

substituting equation (7).

The link between asset prices and the banks' balance sheets can now be described as follows. An increase in asset prices increases available collateral, leading to a decrease in leverage on the part of the borrowers, and granting potential access to credit. Financial intermediaries, in turn, see the value of their assets increase and will then have incentives to expand lending. This then tends to bring down the spread. Thus, asset prices affect the aggregate demand indirectly via credit spread dynamics and do not have wealth effects directly as in De Grauwe (2008a; 2012, Chapter 7).

6.2 Results with the extended banking model

We simulated the extended model using the same calibration as in the simple model. The results of the simualtions are shown in the Figures 12 to 16 below.

A comparison with the simulations obtained with the simple model of Section 2 leads to a number of interesting insights. First, in the extended model with endogenous asset prices we obtain longer waves of optimism and pessimism leading to larger movements in the output gap, compared to the model without endogenous asset prices. This can be seen from the time series results of the output gap and animal spirits in Fig. 12 and 13 compared to Fig. 2, (note the different scales in Fig. 12). The frequency distribution of the output gap exhibits fatter tails in the banking model with asset price. Analogously, animal spirits and their frequency distribution (Figure 14 and 15) display more concentration of observations in the extremes of optimism and pessimism in the new model with endogenous asset prices.

Figure 12

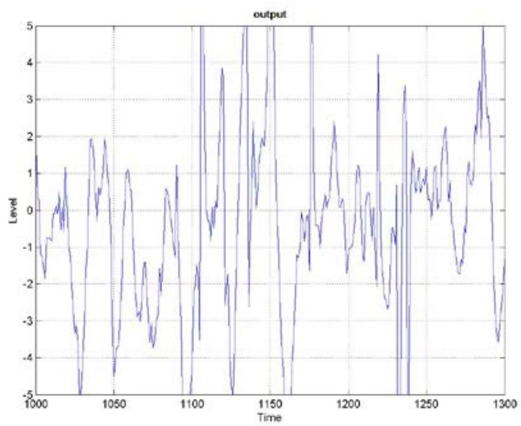


Figure 13

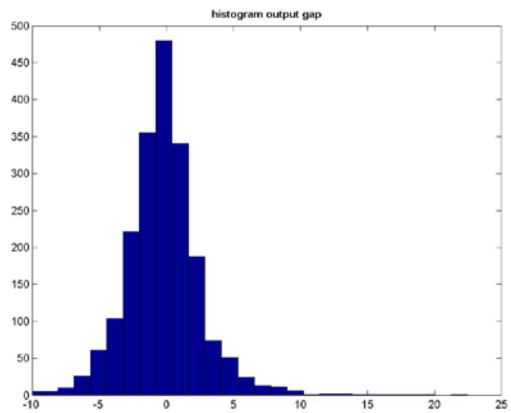


Figure 13

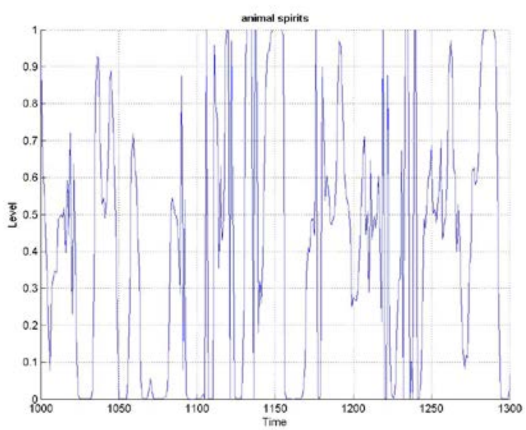
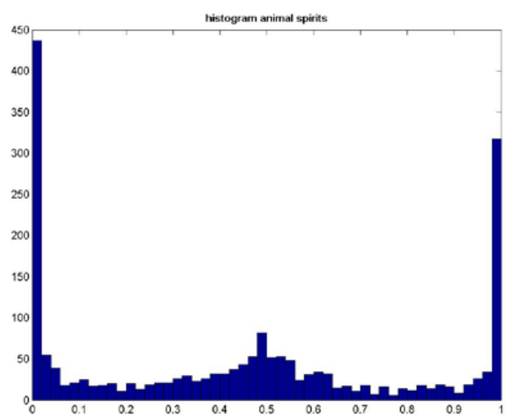


Figure 14

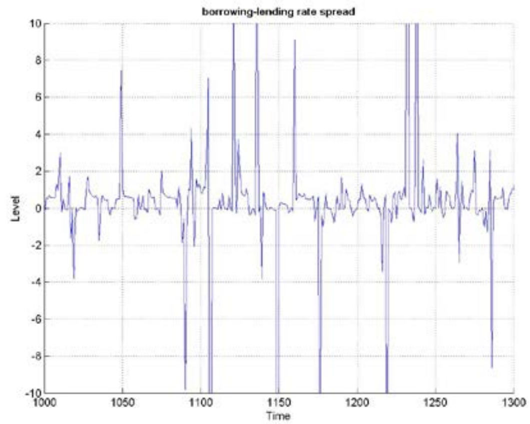


Further, in the extended model the spread dynamics as shown in Fig. 16 seems to more closely match the pattern observed on the US money market between August 2007 and March 2009 (see Fig. 1). Hence, a "risk taking channel", resulting into a larger loan provision, do exist and seem to be well capured by the model.

Consistently, the spread correlation with respect to the economic cycle increases (in absolute value) up to 0.17. This suggests that bullish (bearish) periods affect the relationship between animal spirits and the spread, consistent with a “risk taking channel” hypothesis. However, this relationship remains itself feeble.[10]

[10] The fact that correlation does not increase by much is also explained by the fact that the spread is driven by stock prices, being themselves a function of real expected output growth. In particular, the expected inflation component in eq. (15) is negatively correlated both with expected nominal output growth (-0.51) and with animal spirits (-0.44) for the model with stock prices. The results are not qualitatively different for the model without stock prices, i.e. -0.62 and -0.47, respectively.

Figure 16



7. Monetary Policy implications

The existence of endogenous movements in optimism and pessimism (animal spirits) has important implications for monetary policy. The way we analyze these implications is by constructing tradeoffs between output and inflation variability. In standard DSGE-models these trradeoffs are always downward sloping. This means that in these models, any attempt to reduce output volatility by the use of the interest rate instrument comes at a price, i.e. more inflation volatility. Put differently, if the monetary authorities decide to increase their ambition to stabilize output fluctuations, they may be succesful in reducing output volatility, but this will be achieved by increasing inflation volatility.

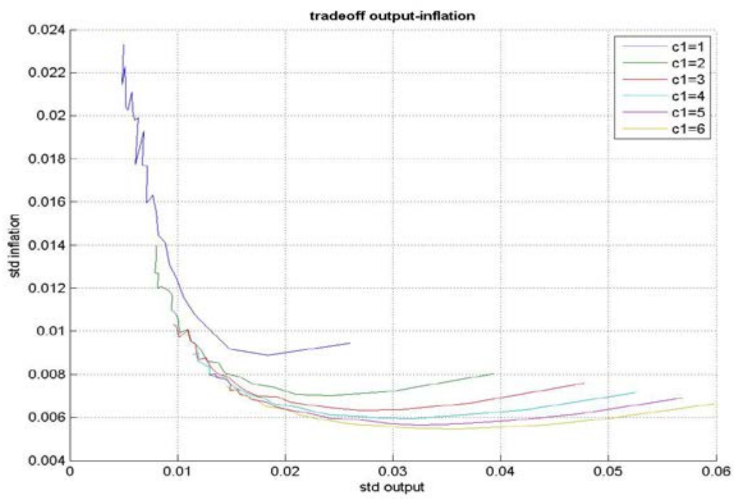
In our behavioral model we obtain a different result. In order to show this we construct the tradeoffs between output and inflation volatility usng the behavioral model with the simple banking sector. We do this by varying the output coefficient in the Taylor rule equation, c_2, from 0 to 1 (keeping the inflation coefficient constant). For each value of c_2 we simulate the model and compute the standard deviations of output and inflation. We plot these numbers in figure with standard deviation of inflation on the vertical axis and the standard deviation of output on the horizontal axis (see Figure 17). We repeat this exercise for different inflation coefficients, so that we obtain one trade-off for every fixed inflation coefficient.

The striking aspect of our results is that the tradeoffs we obtain are non-linear in nature. In order to understand the nature of this on-linear trade-off we start from point A on the tradeoff obtained when $c_1 = 1$. Point A corresponds to the situation where the central bank sets $c_2 = 0$, i.e. it does not attempt to stabilize output at all. If the central bank then starts increasing c_2, we go down the tradeoff. This means that for a given c_1 increasing the output stabilization parameter reduces both output volatility (not surprising) and inflation volatility (surprising). Where does this effect come from? The answer is that by stabilizing output, the central bank helps in stabilizing animal spirits (waves of optimism and pessimism). The latter is a source of volatility not only of output but also of inflation. By "taming the animal spirits" the central banks reduces both inflation and output volatility. It follows that strict inflation targeting can never be optimal.

There are limits to this "win-win" situation. The central bank can overdo its output stabilization effort. This is achieved whereh the tradeoff reaches the minimum point and becomes a negatively sloped line. We reach this point because too much output stabilization undermines the credibiliyt of the inflation target.

Inflation targeting remains important. We observe from Figure that with increasing c_1's the tradeoffs move downwards. This means that as the central banks follows a tighter inflation targeting policy rule, the tradeoffs improve. They remain non-linear, though; which means that even in tighter inflation targetin regimes is pays to stabilize output.

Figure 17



8 Spread dynamics and monetary policy

In this Section we assume the central bank may attempt to stabilize the spread directly - *quantitative* (or, credit) easing - for instance, by buying loans directly from commercial banks. In our set up, the spread between the interest rate controlled by the central bank and the interest rate at which firms can borrow have little dampening effect on the real economy (via investment and output). However, this effect is likely to be amplified when stock prices are included (see Section 6.2).

Over the most recent cycle in the US, this pattern has become particularly clear. In fact, rising credit risks (following assets' re-evaluations) have pushed credit spreads to unprecedented levels, taking a "heavy toll on business and consumer confidence" (Bernanke, 2009). In the previous section we showed, in fact, that the model mimics well this behaviour of the spread over the recent US cycle (Figure 1), when share prices are included. The effect on the real activity is likely to be magnified, as it results from the analysis of correlograms of both output and animal spirits. However, concurrence between the spread and animal spirits remains small, and similarly so for the model without stock prices.

While, at this stage, it is not clear whether spread dynamics may warrant a monetary policy reaction, the US experience (together with our exercise in section 6.2) certainly questions the conventional wisdom that the relation between the short-term risk-free interest rate - controlled by the central bank - and the interest rate at which firms can borrow is by itself stable (McCulley and Toloui, 2008).

The policy question that arises here is whether the central bank can exploit the effect of the spread on economic actitiy and introduce it in its monetary policy reaction. Curdia and Woodford (2008) have suggested that the Fed should do so and should target the spread so as to minimize deviations of expected inflation and output from their benchmark levels..

Therefore we allow the central bank to react to changes in the spread via a modified Taylor rule function, as:

$$r_t = c_1(\pi_t - \pi_t^*) + c_2 y_t + c_3 r_{t-1} + c_4 x_t + u_t, \quad (3')$$

where c_4 is the policy parameter the central bank uses in reacting to the spread. An investigation of this policy rule corresponds to the proposal of authors such as Curdia and Woodford (2008), McCulley and Toloui (2008), Taylor (2008). However, differently from the latter two, and following the former, we do not limit our analysis to the case of $c_4 = 1$. Instead, we consider the possibility of policy adjustment being less than the size of the increase in the credit spread. For those reasons, we choose an interest rate spread reaction parameter to be in the range of $0 \leq c_4 \leq -1$. As discussed in the relevant literature, the reaction parameter must be negative, as an increase in the interest rate spread implies a credit crunch, requiring monetary policy alleviation.

As in the previous section we construct tradeoffs that show how the variability of inflation and output are affected by the stablization of the spread. Put differently, we ask whether targeting the spread enhances the central bank's capacity of stabilizing output and inflation.

Figure 18

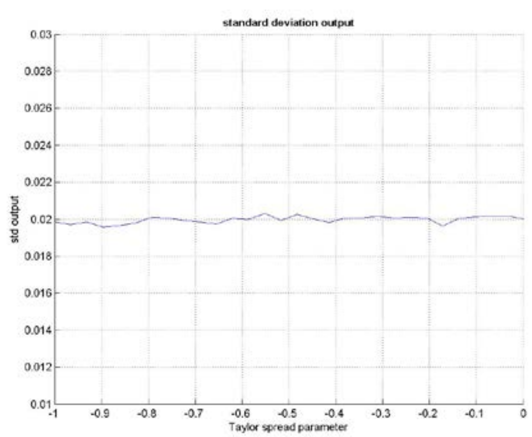
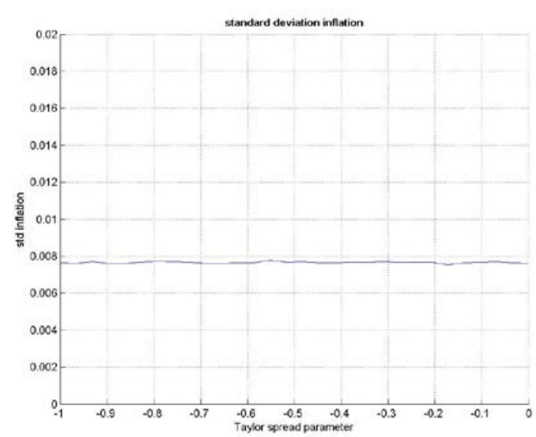


Figure 19



For each value in the parameter space of c_4 we simulated the model over 1000 periods and computed the standard deviations of output, inflation and the spread. The exercise is then repeated 100 times and the mean standard deviations obtained for each value of c_4 are computed. The results are presented in Figures 18 (output variability) and 19 (inflation variability). We find that there is no relation between c_4 and the standard deviations of output and inflation. This implies that targeting the spread does not allow the central bank to reduce the volatiliyt of output or inflation.

These results are consistent with the finding that the spread displays little correlation with animal spirits. Thus, targeting the spread does not do much in "taming the animal spirits". This contrasts a great deal with the results obtained in the previous section, showing that the direct stabilisation of output has the property of stabilizing the animal spirits and in so doing stabilizing output.

8 Conclusion

In this paper we have extended the behavioral macroeconomic model as proposed by De Grauwe (2012) to include a banking sector. The behavioral model takes the view that agents have limited congitive limitations. As a result, it is rational to use simple forecasting rules and to subject the use of these rules to a fitness test. Agents then are driven to select the rule that performs best. We believe that this is the proper way to define rationality in a world were agents are baffled by the complexity of the world. It is also in this framework that the banking sector is introduced.

Our behavioral model produces endogenous and self-fulfilling movements of optimism and pessimism (animal spirits). Our main result is that the existence of banks intensifies these movements, creating a greater scope for booms and busts. Thus banks do not create but amplify animal spirits. The feature that is responsible for this amplification effect is the following. During booms, equity of firms increases in value. This is a signal for the banks that the credit risk of firms declines. As a result, they are willing to lower the interest rate spread they chargen on loans. The opposite occurs during a recession. This the spreads work procyclically and intensify the volatility of output.

The policy conslusion we derive from this is that the central bank has an important responsibility for stabilising output. Output stabilization is an instrument to "tame the animal spirits". This has the effect of improving the tradeoff between inflation and output volatility. We also found that the equity ratio of banks can be used as a policy instrument, i.e. by raising the equity ratio of banks, the amplification effect that is produced by the banking sector is reduced and and as a result the influence of animal spirits on economic activity is weakened, reducing the intensity of booms and busts in economic activity.

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