

Totzek, Alexander

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Christian-Albrechts-Universität zu Kiel

Department of Economics

Economics Working Paper  
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# banks, oligopolistic competition, and the business cycle: a new financial accelerator approach

by Alexander Totzek



# Banks, Oligopolistic Competition, and the Business Cycle: A New Financial Accelerator Approach

Alexander Totzek\*

*Department of Economics, Christian-Albrechts-University of Kiel, Olshausenstr. 40,  
24098 Kiel, Germany*

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## Abstract

In the last two decades a body of literature highlights the role of financial frictions for explaining the development of key macroeconomic variables. Moreover, the financial crisis 2007-2009 again sheds light on the importance of this topic. In this paper, we contribute to the literature by simultaneously explaining two empirical observations. First, mark-ups on the loan market react counter-cyclical. Second, the number of banks operating in the economy significantly co-moves with GDP. Therefore, we develop a DSGE model which incorporates an oligopolistic banking sector with endogenous bank entry. The resulting model generates significant accelerating effects which are even larger than those obtained in the famous financial accelerator model of Bernanke et al. [*Bernanke, B., Gertler, M., Gilchrist, S., 1999. The financial accelerator in a quantitative business cycle framework. In: Handbook of Macroeconomics. North-Holland, Amsterdam*] and performs remarkable well when comparing the generated second moments of real and financial variables with those observed in the data.

*JEL classification:* E44; E32

*Keywords:* Oligopolistic competition; Bank entry; Financial accelerator

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\*Email: totzek@economics.uni-kiel.de

# 1 Introduction

As Gertler (1988) states, there already exists a long-standing tradition in macroeconomic theory that emphasizes a central role to financial markets in the propagation of cyclical movements. Seminal work reaches back to Fisher (1933) and Keynes (1936). In the last two decades a body of literature moreover highlights the role of financial frictions for explaining the development of key macroeconomic variables [see amongst others Carlstrom and Fuerst (1997), Bernanke, Gertler, and Gilchrist (1999), Goodfriend and McCallum (2007), or Gertler and Kiyotaki (2009)].<sup>1</sup> Additionally, the financial crisis 2007-2009 again sheds light on the importance of implementing financial frictions into macro models. In this paper, we contribute to the literature by simultaneously explaining two empirical observations. First, mark-ups on the loan market react counter-cyclical. Second, the number of banks operating in the economy significantly co-moves with GDP.

Figure 1 depicts these observations for US data including the corresponding cross-correlations. As a measure for the mark-up of a commercial bank we choose the spread between the average majority prime rate charged by banks on short-term loans to business and the FED's funds rate.<sup>2</sup> The data is logged and de-trended by application of the Hodrick-Prescott filter. Figure 1 shows that the number of banks significantly co-moves with GDP. The corresponding cross-correlation is 0.49. Moreover, bank mark-ups react counter-cyclical. The corresponding cross-correlation is -0.88. Further empirical support for non-stationary price-cost margins of banks is for instance given by Aliaga-Díaz and Olivero (2010) who highlight the counter-cyclical nature of mark-ups in the banking sector via VAR forecast error-based methodology for US data [see also Santos and Winton (2008)]. Moreover, Olivero (2010) provides further empirical

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<sup>1</sup>See Arend (2010) for an insightful overview of newer contributions. See moreover Gertler (1988) for an excellent overview of "traditional" approaches incorporating financial frictions.

<sup>2</sup>The data for the loan rate and the number of banks is provided by <http://www.federalreserve.gov>

support for OECD data.

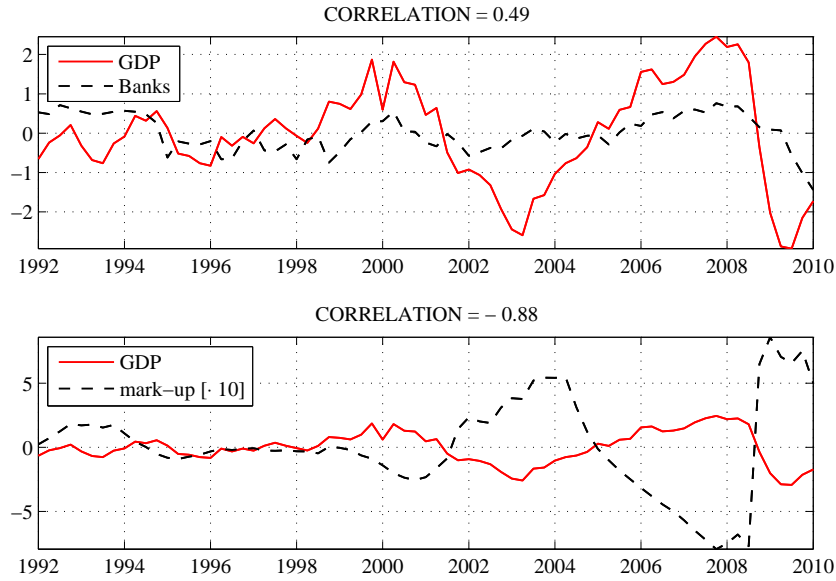


Figure 1: On the counter-cyclical nature of the number of banks and banks' mark-up [US data in logs and HP-filtered]

In the recent literature, the counter-cyclical nature of mark-ups in loan markets is commonly implemented by assuming an information asymmetry between borrowers and lenders as for instance in the famous financial accelerator model of Bernanke, Gertler, and Gilchrist (1999). In this study, the authors integrate the Bernanke, Gertler, and Gilchrist (1996) approach into a New Keynesian model. Hence, they build up an overlapping generations model where firms need physical capital and labor for production. The acquisition of capital is financed either by borrowing or by entrepreneurial net wealth. Competitive financial intermediaries ask for an external finance premium (or: mark-up) over their marginal costs for financing capital. This mark-up is not caused by an imperfectly competitive environment of financial institutions but by the assumption of information asymmetries across borrowers and lenders. Bernanke, Gertler, and Gilchrist (1999) moreover assume that the external finance premium inversely depends on borrowers net wealth. Therefore, an enhancement in wealth of borrowers in boom phases leads to a decline in mark-ups in the loan

market. This in turn increases the net wealth of borrowers and consequently introduces an amplification effect, the famous *financial accelerator*.

By contrast, we do *not* emphasize mark-up movements from the demand side of credits.<sup>3</sup> Instead, our *new* financial accelerator nests from the supply side of credits. More precisely, we develop a New Keynesian model which incorporates an oligopolistic banking sector with endogenous bank entry. This combination enables us to draw the endogenous causality that an increasing mass of banks causes the market share of the single bank and thus the resulting mark-up to decline. As Figure 2 depicts that the latter relation in turn finds support in the data since we found a significant negative correlation (-0.43) between bank mark-ups and the number of operating banks, too.

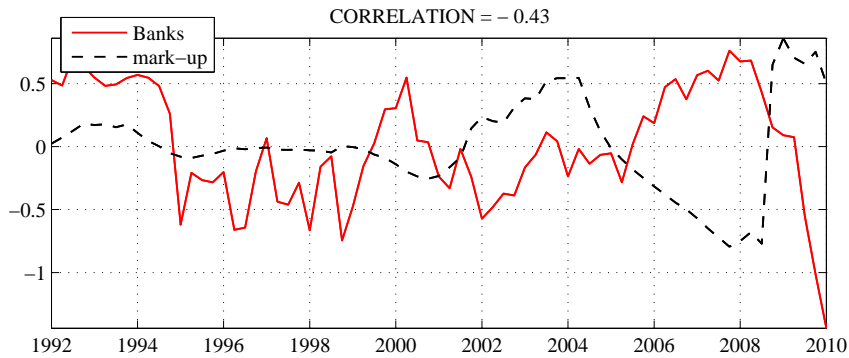


Figure 2: The number of banks and their mark-ups

We follow Christiano, Eichenbaum, and Evans (2005) by assuming that firms have to pre-finance their wage-bill. Therefore, banks provide loans under oligopolistic competition using deposits and money market credits. Thereby, our model generates a financial accelerator which works as follows. Due to increasing profit opportunities for banks in economic upturns, the mass of banks increases in response to expansionary shocks. The market share of the single bank consequently decreases. As a result, banks have to decrease their mark-ups. Since firms have to pre-finance their wage-bill, a decreasing bank mark-up has in turn a positive effect on the marginal costs of firms leading to a further

<sup>3</sup>In the following, we will use the expressions "credit" and "loan" synonymously.

increase in production and thus in loan demand. Consequently, the endogenous mark-up movements resulting from oligopolistic competition<sup>4</sup> induces a multiplier (or: amplification) effect, the *new* financial accelerator.

Thereby, our framework provides a new transmission channel for monetary policy via bank creation which works as follows. A contractionary shock to the instrument of the central bank, the nominal interest rate, results in four expansionary effects. (i) Consumption is shifted into the present leading to a higher loan demand. (ii) The marginal costs of banks decrease. (iii) Bank entry costs decline, too.<sup>5</sup> (iv) The value of a bank which is defined as the discounted sum of future profits increases due to the lower discount rate. The first two effects result in higher bank profits while the latter two effects have moreover an expansionary impact on the profitability of bank start-ups which result in an increase in investment in new banks. All in all, the resulting expansionary reaction of the mass of operating banks leads to a lower market share of a single bank and introduces the new financial accelerator.<sup>6</sup>

The analysis of the resulting impulse responses shows that our framework can indeed depict both the pro-cyclicality of the mass of financial intermediaries as well as the counter-cyclical nature of mark-up movements. Thereby, the resulting endogenous bank entry generates large amplification and persistence effects. In particular, we obtain significantly higher accelerating effects than those generated by the probably most famous study of BGG. It is moreover worth mentioning that in contrast with for instance Meh and Moran (2010) where amplification effects are stronger for supply shocks, we also generate significant amplification effects from demand shocks.<sup>7</sup> Notably, we obtain the

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<sup>4</sup>Remark: In the case of monopolistic competition, the mark-up of a competitor tends to zero. As a result, the mark-ups are constant in such an environment.

<sup>5</sup>Remark: We assume that deposits are needed to build up new banks.

<sup>6</sup>By contrast, the transmission channel for monetary policy in Bernanke, Gertler, and Gilchrist (1999) works as follows. An easing of monetary policy increases the return on capital resulting in an increase in the net wealth of firms. This in turn causes a decrease in firm leverage leading to a reduction of the external finance premium and thus to a further rise in capital demand. This in turn leads to an additional expansionary effect for the production sector.

<sup>7</sup>Meh and Moran (2010) build up a DSGE model in which bank capital mitigates an agency problem between banks and their creditors. In their approach, the resulting propagation effect

largest accelerating effect in the case of a monetary policy shock.

Financial crises have taught us that banks do not only propagate shocks but can also be the source of financial disturbances which have important implications for the real economy. In this context, we investigate the implications of a contractionary shock to bank value. Our analysis shows that the financial shock results in stagflationary effects. The rationale is that the non-stationary bank mark-up acts as an endogenous cost-push shock for the real economy. Note however that the aim of this paper is not to explain the financial crisis of 2007-2009. Our framework is naturally too simple to depict such a complex event. As the famous financial accelerator model of BGG, our framework, instead, represents a further step to solve the puzzle how relatively small shocks can result in large and persistent effects for the real economy [see amongst others Mankiw (2001), Chari, Kehoe, and McGrattan (2000), and Fuhrer and Moore (1995)].

As standard in macroeconomics literature, we finally evaluate our model by comparing the second moments of the generated series with those observed in US data. The analysis shows that the model performs remarkable well with respect to this dimension. In particular, it does not only depict the properties of key macroeconomic variables appropriately but also those of financial variables including the mass of banks, the amount of aggregate loans, and the amount of loans per banks. Moreover, we analyze the macroeconomic implications of a financial activity tax and a financial transaction tax.<sup>8</sup> Our analysis points out that these two taxes are indeed an appropriate tool to stabilize the financial markets and thus to dampen the volatility of key macroeconomic variables. We find that the financial activity tax where banks have to pay a tax on each transaction is significantly more effective than the financial transaction tax

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results from the bank capital channel.

<sup>8</sup>For the partial analysis of Tobin (1978) taxes see amongst others Dieci and Westerhoff (2004). See moreover Lengnick and Wohltmann (2010) who extend a simplified framework à la BGG for a high frequent asset market in the spirit of the latter study. They show that this extension leads to significantly more persistent dynamics.



where the tax base is simply per period profits. The rationale is that the financial transaction tax does not only affect the profitability of bank start-ups but also affects the marginal costs of banks. By contrast, the financial activity tax has not any impact on the marginal costs of banks.

The remainder is structured as follows. In Section 2, we develop the New Keynesian model incorporating an oligopolistic banking sector with endogenous bank entry. Moreover, we present a benchmark model and the calibration. In Section 3, we discuss the impulse responses to a shock to total factor productivity under different assumptions concerning the loan rate stickiness and the survival probability of new banks. We moreover present the new transmission mechanism of monetary policy when considering a shock to the interest rate. Furthermore, we analyze the impulse responses to a fiscal demand stimulus and to a contractionary shock to bank value. The evaluation of the bank entry model is presented in Section 4 by comparing the generated second moments with the data. The last section concludes.

## 2 The Model

Beside the central bank, the model consists of four types of agents, namely households, intermediate good producers (or: firms), retailers, and banks. We assume that firms have to pre-finance their wage bill [see amongst others Christiano, Eichenbaum, and Evans (2005)]. Beside that, firms are totally standard. They produce using labor and sell their differentiated intermediate goods under monopolistic competition to the retailers.

Banks provide loans to firms under oligopolistic competition using deposits and money market credits. Thereby, the mark-up of a single bank endogenously depends on the degree of competition, i.e. on the mass of banks operating in the loan market. Caused by endogenous bank entry and exit, the mass of banks is non-stationary. In our analysis, we will discuss flexible and sticky loan rates.

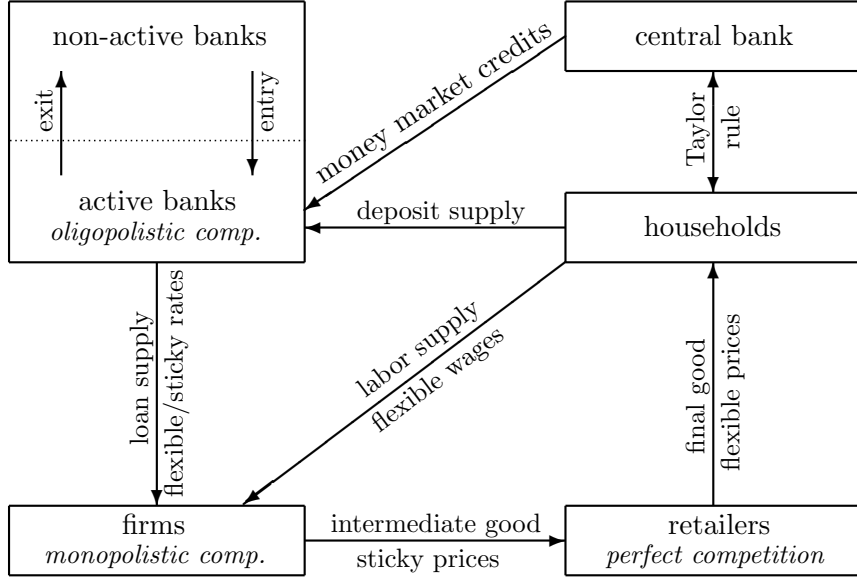


Figure 3: Model structure

Households can invest in interest bearing deposits with a duration of one period at a bank. They moreover supply their working force to firms. The retailers bundle the differentiated intermediate goods to a final good and sell it under perfectly competitive conditions to the households. Monetary policy is simply represented by a standard Taylor rule. The complete model structure is depicted in Figure 3.

## 2.1 Households

The representative household maximizes its life-time utility value

$$E_0 \sum_{t=0}^{\infty} \beta^t \left( \frac{1}{1-\sigma} C_t^{1-\sigma} - \frac{\chi}{1+\eta} L_t^{1+\eta} \right) \quad (1)$$

subjected to its period-by-period budget constraint

$$\frac{B_t}{P_t} + C_t = w_t L_t + R_{t-1}^B \frac{B_{t-1}}{P_t} + \tau_t \quad (2)$$

where  $\sigma > 0$  and  $\eta > 0$  are the inverse of the intertemporal elasticity of substitution and the Frisch elasticity of labor supply, respectively.  $\chi > 0$  is a scaling parameter.  $\beta \in (0, 1)$  represents the private discount factor. According to (2), the household uses its net income for consumption,  $C_t$ , and investment in deposits,  $B_t$ .  $L_t$  is labor supply.  $\tau_t$ ,  $w_t$ ,  $R_t^B$ , and  $P_t$  denote transfers, the real wage, the gross nominal deposit rate, and the price index, respectively.  $E$  denotes the rational expectations operator.

The household's optimization results in the standard Euler consumption equation and the labor supply equation which are respectively given by

$$C_t^{-\sigma} = \beta E_t \left\{ C_{t+1}^{-\sigma} \frac{R_t^B}{\pi_{t+1}} \right\} \quad (3)$$

$$w_t = \chi C_t^\sigma L_t^\eta \quad (4)$$

where  $\pi_t \equiv P_t/P_{t-1}$  is the gross inflation rate.

## 2.2 Retailers

The retailer bundles the intermediate goods,  $y_{j,t}$ , according to the following CES technology

$$Y_t \equiv \left[ \int_0^1 y_{j,t}^{\frac{\theta-1}{\theta}} dj \right]^{\frac{\theta}{\theta-1}} \quad (5)$$

where  $Y_t$  denotes the final good.  $\theta$  is the intratemporal elasticity of substitution between intermediate goods.<sup>9</sup>

Equation (5) implies the price index,  $P_t$ , to follow

$$P_t = \left[ \int_0^1 p_{j,t}^{1-\theta} dj \right]^{\frac{1}{1-\theta}} \quad (6)$$

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<sup>9</sup>Remark: We follow the recent literature by assuming that the mass of firms is normalized to one. This implies that in contrast to the banking sector, the mass of firms is assumed to be constant. See Bilbiie, Ghironi, and Melitz (2007) for a macro model with endogenous firm entry.

where  $p_{j,t}$  is the price of the intermediate good  $j$ .

Cost minimization delivers the optimal goods demand given by

$$y_{j,t} = \left[ \frac{p_{j,t}}{P_t} \right]^{-\theta} Y_t \quad (7)$$

### 2.3 Firm Sector

As in Christiano, Eichenbaum, and Evans (2005), we assume that firms have to pre-finance their wage bill [see also Henzel et al. (2009), Hülsewig, Meyer, and Wollmershäuser (2009), and Christiano, Motto, and Rostagno (2010)]. Beside this assumption, firms are totally standard. For production, they need only labor. Firms act under monopolistic competition and sell their differentiated intermediate good to the retailers being faced with a sticky price setting mechanism.

The production function of a firm  $j$  is given by

$$y_{j,t} = A_t l_{j,t} \quad (8)$$

where  $l_{j,t}$  denotes the labor demand of firm  $j$ .  $A_t$  is a technology shock which follows an AR(1) process:  $A_t/A = (A_{t-1}/A)^{\rho^a} \exp\{\varepsilon_t^a\}$  where  $\varepsilon_t^a$  is white noise.

By cost minimization, we obtain the marginal costs,  $mc_{j,t}$ , of firm  $j$

$$mc_{j,t} = \frac{R_t^L w_t}{A_t} \quad (9)$$

where  $R_t^L$  and  $w_t$  are the gross nominal loan rate and the real wage, respectively. Equation (9) implies symmetry across firms, i.e.  $mc_{j,t} = mc_t$ , since the right-hand side of (9) does not include any firm specific variables depending on  $j$ .

We moreover assume firms to be faced with quadratic price adjustment costs

in the spirit of Rotemberg (1982). Their pricing decision problem is given by

$$\max_{p_{j,t}} E_0 \sum_{t=0}^{\infty} \Delta_{0,t} \left\{ \frac{p_{j,t}}{P_t} y_{j,t} - mc_{j,t} y_{j,t} - \frac{\kappa^f}{2} \left( \frac{p_{j,t}}{p_{j,t-1}} - 1 \right)^2 Y_t \right\} \quad (10)$$

subjected to the optimal goods demand of the retailer given by equation (7).  $\Delta_{0,t}$  denotes the stochastic real discount factor.  $\kappa^f$  can for instance be interpreted as menu costs.  $E$  denotes the rational expectations operator.

The optimization yields a standard Phillips curve

$$\theta - 1 = \theta mc_t - \kappa^f \left[ (\pi_t - 1)\pi_t - \beta E_t \left\{ \left( \frac{C_{t+1}}{C_t} \right)^{-\sigma} (\pi_{t+1} - 1)\pi_{t+1} \frac{Y_{t+1}}{Y_t} \right\} \right] \quad (11)$$

where  $\pi_t \equiv P_t/P_{t-1}$  is the gross inflation rate and the ratio  $E_t \Delta_{0,t+1}/\Delta_{0,t} = \beta(E_t C_{t+1}/C_t)^{-\sigma}$  follows from the Euler consumption equation (3).

As will be shown later, the aggregate loan rate – which is a component of the marginal costs according to (9) – is a function of the central bank’s instrument, the money market rate. As a result, the combination of (9) and (11) indicates that the assumption that firms have to pre-finance their wage bill results in a cost channel. There is empirical support that the direct cost effects of short-run nominal interest rates significantly contribute to inflation dynamics. In particular, Chowdhury, Hoffmann, and Schabert (2006) and Ravenna and Walsh (2006) respectively show the existence of a significant impact of the interest rate on the marginal costs via Phillips curve GMM estimations for the majority of the G7 countries and the US economy. Other studies as for instance Henzel et al. (2009), Hülsewig, Meyer, and Wollmershäuser (2009), and Christiano, Eichenbaum, and Evans (2005) also support the existence of a cost channel by methods of indirect inference for the Euro Area and the US economy. In addition Barth and Ramey (2001) show that based on industry level data the interest rate has a significant effect on the marginal costs of firms.<sup>10</sup>

<sup>10</sup>Remark: The empirical evidence that the cost channel does not seem to be present is restricted

## 2.4 Banking Sector

Banks – indexed with  $i$  – supply loans to firms under oligopolistic competition using deposits and money market credits.<sup>11</sup>

The real loans,  $O_t$ , are aggregated by the following Dixit-Stiglitz aggregator

$$O_t \equiv \left[ \int_0^{N_t} o_{i,t}^{\frac{\zeta-1}{\zeta}} di \right]^{\frac{\zeta}{\zeta-1}} \quad (12)$$

where  $o_{i,t}$  denotes the real loan supply of bank  $i$  and  $\zeta > 1$  is the intratemporal elasticity between loans.  $N_t > 1$  is the non-stationary mass of banks operating in the economy.

Equation (12) implies an aggregate gross loan rate given by

$$R_t^L = \left[ \int_0^{N_t} (r_{i,t}^L)^{1-\zeta} di \right]^{\frac{1}{1-\zeta}} \quad (13)$$

where  $r_{i,t}^L$  represents the gross loan rate set by bank  $i$ .

In a first step, we assume the loan rate to be flexible. Per period profit of a bank  $i$  is then given by

$$d_{i,t} = r_{i,t}^L o_{i,t} - R_t^B b_{i,t} - R_t^M m_{i,t} \quad (14)$$

where  $m_{i,t}$  is the net position on the money market.  $R_t^M$  is the gross money market rate which represents the central bank's tool for monetary policy interventions.  $b_{i,t}$  is the real amount of deposits used for loan supply by bank  $i$  and  $R_t^B$  represents the corresponding nominal gross deposit rate. Following Henzel et al. (2009) and Hülsewig, Meyer, and Wollmershäuser (2009), we assume deposits and money market credits to be perfect substitutes. Consequently, the corresponding rates have to coincide,  $R_t^M = R_t^B$  [see also Freixas and Rochet (1997)]. This assumption implies that banks act under oligopolis-

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to the Bayesian estimation of Rabanal (2007) for US data.

<sup>11</sup>See Henzel et al. (2009) or Hülsewig, Meyer, and Wollmershäuser (2009) for a corresponding approach with monopolistic competition and a constant mass of banks.

tic competition on the loan market while they price deposits competitively. A similar assumption can also be found in amongst others Henzel et al. (2009) and Hülsewig, Meyer, and Wollmershäuser (2009) and finds support in the empirical literature since there exists a vast body of studies providing evidence for market power in the loan market [see amongst others Matthews, Murinde, and Zhao (2007), Claessens and Laeven (2004), DeBandt and Davis (2000), and Molyneux, Lloyd-Williams, and Thornton (1994)]. By contrast and as already pointed out by Olivero (2010), the empirical evidence for the deposit side is very restricted.

The bank maximizes its profit (14) subjected to the loan demand function:

$$o_{i,t} = \left[ \frac{r_{i,t}^L}{R_t^L} \right]^{-\zeta} O_t \quad (15)$$

which results from (12) and (13). Moreover, the bank is faced with the balance sheet constraint:

$$b_{i,t} + m_{i,t} \geq o_{i,t} \quad (16)$$

implying that the amount of loans is restricted by the amount of deposits and money market credits.<sup>12</sup> In the optimum equation (16) holds with equality.<sup>13</sup> Inserting this expression and  $R_t^M = R_t^B$  in (14) yields

$$d_{i,t} = r_{i,t}^L o_{i,t} - R_t^B o_{i,t} \quad (17)$$

Maximizing profits (17) subjected to (15) with respect to  $r_{i,t}^L$  yields

$$\frac{\partial d_{i,t}}{\partial r_{i,t}^L} = o_{i,t} + r_{i,t}^L \frac{\partial o_{i,t}}{\partial r_{i,t}^L} - R_t^B \frac{\partial o_{i,t}}{\partial r_{i,t}^L} = 0 \quad (18)$$

<sup>12</sup>In order to keep the model simple, we abstract from an interbanking market. See for instance Goodfriend and McCallum (2007) for a New Keynesian model incorporating a banking sector with interbank lending.

<sup>13</sup>We abstract from risky credits. As a result, banks do not hold reserves.

where

$$\frac{\partial o_{i,t}}{\partial r_{i,t}^L} = -\zeta \frac{(r_{i,t}^L)^{-\zeta-1}}{(R_t^L)^{-\zeta}} O_t + \zeta \frac{(r_{i,t}^L)^{-\zeta}}{(R_t^L)^{-\zeta+1}} O_t \frac{\partial R_t^L}{\partial r_{i,t}^L} \quad (19)$$

In contrast to the case of monopolistic competition, the individual loan rate,  $r_{i,t}^L$ , has in turn a direct impact on the aggregate loan rate,  $R_t^L$ , and thus on loan demand under oligopolistic competition:<sup>14</sup>

$$\frac{\partial R_t^L}{\partial r_{i,t}^L} = \left( \frac{r_{i,t}^L}{R_t^L} \right)^{-\zeta} = \frac{o_{i,t}}{O_t} \quad (20)$$

Inserting this expression in (19) yields

$$\frac{\partial o_{i,t}}{\partial r_{i,t}^L} = \zeta \frac{o_{i,t}}{r_{i,t}^L} (\lambda_{i,t} - 1) \quad (21)$$

where we define the market share,  $\lambda_{i,t}$ , as

$$\lambda_{i,t} \equiv \frac{r_{i,t}^L o_{i,t}}{R_t^L O_t} \quad (22)$$

Inserting (21) in (18) yields

$$r_{i,t}^L = \frac{(1 - \lambda_{i,t})\zeta}{(1 - \lambda_{i,t})\zeta - 1} R_t^B = \mu_{i,t} R_t^B \quad (23)$$

where the mark-up is given by

$$\mu_{i,t} = \frac{(1 - \lambda_{i,t})\zeta}{(1 - \lambda_{i,t})\zeta - 1} = \frac{\zeta}{\zeta - \frac{1}{1 - \lambda_{i,t}}} \quad (24)$$

Equation (24) implies that if the market share of the single bank tends to zero, we end up with the special case of monopolistic competition where the

<sup>14</sup>Remark: Monopolistic competition was introduced by Chamberlin (1933). The point of monopolistic competition is *not* to study strategic aspects between competitors such as price competition but to abstract from these issues to *simplify* the analysis [see also Blanchard and Kiyotaki (1987)]. By contrast, these aspects are considered under oligopolistic competition.



mark-up,  $\mu_{i,t}$ , is constant since  $\partial R_t^L / \partial r_{i,t}^L \rightarrow 0 \Leftrightarrow \lambda_{i,t} \rightarrow 0$ .<sup>15</sup> Due to the assumption of oligopolistic competition it however follows that even in the case of completely flexible loan rates the mark-up of a bank  $i$  is non-stationary.

Empirical studies have however shown that the loan rate is rigid [see amongst others Henzel et al. (2009) or Gerali et al. (2010)]. We thus extend our framework by assuming quadratic loan rate adjustment costs,  $LAC_t$ , in the spirit of Rotemberg (1982) which are given by:

$$LAC_t \equiv \frac{\kappa^b}{2} \left( \frac{r_{i,t}^L}{r_{i,t-1}^L} - 1 \right)^2 O_t \quad (25)$$

where  $\kappa^b$  can for instance be interpreted as menu costs.<sup>16</sup>

The intertemporal optimization of a bank's profit with respect to the loan rate,  $r_{i,t}^L$ , under sticky loan rates then results in

$$r_{i,t}^L = \frac{(1 - \lambda_{i,t})\zeta}{(1 - \lambda_{i,t})\zeta - 1} R_t^B - \frac{\kappa^b}{(1 - \lambda_{i,t})\zeta - 1} \psi_{i,t} \quad (26)$$

where

$$\psi_{i,t} \equiv \left[ \frac{r_{i,t}^L}{r_{i,t-1}^L} - 1 \right] \frac{r_{i,t}^L}{r_{i,t-1}^L} \frac{O_t}{o_{i,t}} - \beta E_t \left\{ \left( \frac{C_{t+1}}{C_t} \right)^{-\sigma} \left[ \frac{r_{i,t+1}^L}{r_{i,t}^L} - 1 \right] \frac{r_{i,t+1}^L}{r_{i,t}^L} \frac{O_{t+1}}{o_{i,t}} \right\} \quad (27)$$

By setting  $\kappa^b = 0$ , we would end up with (23).

## 2.5 Bank Creation

For modelling bank entry and exit, we apply a mechanism which is analogous to the firm entry model of Ghironi and Melitz (2005) and Bilbiie, Ghironi, and Melitz (2007).<sup>17</sup>

By assumption, there exists an unbounded mass of potential banks which

<sup>15</sup>The mark-up would then be given by  $\zeta/(\zeta - 1) = \text{const}$ .

<sup>16</sup>Naturally, these costs are rather small in the banking sector. Gerali et al. (2010) estimate the menu costs of firms to be more than three times larger than those in the loan markets.

<sup>17</sup>See amongst others Colciago and Etro (2010a,b) and Faia (2009) for firm entry models with oligopolistic competition in the goods market.

want to enter the market if their entry is profitable. Before entry, entrants have to pay a sunk cost. These costs are assumed to be proportional to the real marginal costs, i.e. the real interest rate,  $\tilde{R}_t^B \equiv R_t^B / E_t \pi_{t+1}$ .<sup>18</sup> This implies that new banks are created by using deposits. We further assume a time-to-build lag in new bank creation. This assumption finds support in the data since the correlation between the mass of banks in  $t+1$  and GDP in  $t$  is even larger [0.51] than the contemporaneous cross-correlation. This finding is totally analogous to firm entry data [see amongst others Devereux, Head, and Lapham (1996) or Totzek (2010)].

The following zero-profit condition determines the mass of entrants by aligning bank value,  $v_t$ , with the entry cost,  $f_E$ :

$$v_t = f_E \tilde{R}_t^B \quad (28)$$

where the value of a bank is given by the present value of future profits, i.e. the discounted sum of future profits:

$$v_t = E_t \left\{ \sum_{s=t+1}^{\infty} \Delta_{t,s} (1 - \delta)^{s-t} d_s \right\} \quad (29)$$

or equivalently<sup>19</sup>

$$v_t = (1 - \delta) \beta E_t \left\{ \left( \frac{C_{t+1}}{C_t} \right)^{-\sigma} (v_{t+1} + d_{t+1}) \right\} \exp\{u_t^v\} \quad (30)$$

where  $\delta \in (0, 1)$  denotes the death probability of a bank.

Due to the assumption of a time-to-build lag, banks only consider future profits in their entry decision. In order to analyze exogenous changes in the value of banks, we add an autoregressive shock process,  $u_t^v$ , to (30) which follows:  $u_t^v = \rho^v u_{t-1}^v + \varepsilon_t^v$  where  $\varepsilon_t^v$  is white noise.

<sup>18</sup>In Bilbiie, Ghironi, and Melitz (2007) firms have to pay entry costs proportional to the effective real wage, i.e. their marginal costs.

<sup>19</sup>Equation (29) is the forward solution of (30).

As in the firm entry model of Bilbiie, Ghironi, and Melitz (2007), we assume the recursive law of motion of the mass of banks to be given by

$$N_{t+1} = (1 - \delta)(N_t + N_{E,t}) \quad (31)$$

where  $N_{E,t}$  denotes the mass of new banks. Equation (31) states that a fraction,  $\delta$ , of incumbent and new banks is hit by an exogenous death shock at the very end of each period.<sup>20</sup>

## 2.6 Aggregation

Symmetry across banks implies  $o_{i,t} = o_t$  and  $r_{i,t}^L = r_t^L$ . According to (12) and (13) we then obtain

$$O_t = N_t^{\frac{\zeta}{\zeta-1}} o_t \quad (32)$$

$$R_t^L = N_t^{\frac{1}{1-\zeta}} r_t^L \quad (33)$$

An increasing mass of banks *ceteris paribus* results in a rise in aggregate loans and in a decline in the loan rate.

Inserting (32) and (33) in equation (22) yields

$$\lambda_{i,t} = \lambda_t = \frac{1}{N_t} \quad (34)$$

implying that the market share of the single bank declines if the mass of banks increases. This in turn implies that the mark-up of a bank – also under flexible

<sup>20</sup>Naturally, the assumption of a constant exit rate is a simplification. However, Totzek (2010) shows in a model with simultaneous *firm* entry and exit that the qualitative results do not change when endogenizing the firm exit rate. Instead, he points out that the assumption of simultaneous endogenous entries and exits just results in a marginal amplification effect when compared to the case of endogenous entries but exogenous exits. Further note that we relax the assumption of a constant death rate of banks by introducing an endogenous survival probability of new banks to the model in Section 3.1.3.

loan rates – decreases if the mass of banks rises. Since  $\mu_{i,t} = \mu_t$  and

$$\mu_t = \frac{(N_t - 1)\zeta}{(N_t - 1)\zeta - N_t} \quad (35)$$

we obtain<sup>21</sup>

$$\frac{\partial \mu_t}{\partial N_t} = -\frac{\zeta}{[(N_t - 1)\zeta - N_t]^2} < 0 \quad (36)$$

Our model thus draws an endogenous causality between the mass of operating banks and their mark-up which captures the corresponding negative correlation that we observed in the data [cf. Figure 2].

The real marginal costs of firms are given by equation (9). Inserting (23), (33), and (35) yields

$$mc_t = N_t^{\frac{1}{1-\zeta}} \frac{(N_t - 1)\zeta}{(N_t - 1)\zeta - N_t} \frac{R_t^B w_t}{A_t} \quad (37)$$

implying that beside the pure cost channel, i.e. the direct influence of the nominal interest rate, there exists an *endogenous* cost-push shock resulting from endogenous bank entry and exit of oligopolistic competitors and their non-stationary mark-ups. Consequently, an expansionary reaction of the mass of operating banks leads to a decline in the firms' marginal costs since

$$\begin{aligned} \frac{\partial mc_t}{\partial N_t} &= \left[ \frac{1}{1-\zeta} N_t^{\frac{1}{1-\zeta}-1} \frac{(N_t - 1)\zeta}{(N_t - 1)\zeta - N_t} - N_t^{\frac{1}{1-\zeta}} \frac{\zeta}{[(N_t - 1)\zeta - N_t]^2} \right] \frac{R_t^B w_t}{A_t} \\ &= -N_t^{\frac{1}{1-\zeta}} \left[ \left( \frac{1}{\zeta - 1} \frac{N_t - 1}{N_t} + \frac{1}{(N_t - 1)\zeta - N_t} \right) \frac{\zeta}{(N_t - 1)\zeta - N_t} \right] \frac{R_t^B w_t}{A_t} < 0 \end{aligned} \quad (38)$$

since  $N_t > \zeta/(\zeta - 1) > 1 \Leftrightarrow (N_t - 1)\zeta - N_t > 0$ .

<sup>21</sup>Note that the mark-up,  $\mu_t$ , is larger than one if  $N_t > \zeta/(\zeta - 1)$ . We calibrate  $\zeta$  to 6 implying that  $N_t > 1.2$ . The numerically computed steady state value of  $N_t$  is 1.4.

Aggregate production is given by

$$Y_t = C_t + G_t + \frac{\kappa^f}{2}(\pi_t - 1)^2 Y_t \quad (39)$$

$G_t$  is government spending following an AR(1) process given by:  $G_t/G = (G_{t-1}/G)^{\rho^g} \exp\{\varepsilon_t^g\}$  where  $\varepsilon_t^g$  is white noise. We moreover define GDP as aggregate production plus investment

$$Y_t^{GDP} \equiv Y_t + N_{E,t} v_t \quad (40)$$

where  $N_{E,t} v_t$  is interpreted as investment in new banks.<sup>22</sup>

The loan market clearing condition follows

$$O_t = w_t L_t + N_t \frac{\kappa^b}{2} \left[ \frac{r_t^L}{r_{t-1}^L} - 1 \right]^2 O_t \quad (41)$$

The model is closed by a monetary policy rule of Taylor type

$$\frac{R_t^M}{R^M} = \left( \frac{\pi_t}{\pi} \right)^{\lambda_\pi} \left( \frac{Y_t}{Y} \right)^{\lambda_y} \exp\{u_t^m\} \quad (42)$$

where  $u_t^m$  is a shock to monetary policy which follows an AR(1) process:  $u_t^m = \rho^m u_{t-1}^m + \varepsilon_t^m$  where  $\varepsilon_t^m$  is white noise.

The complete New Keynesian model with endogenous entry of oligopolistic banks can be found in Table 1.

## 2.7 Calibration

As standard in the literature, we set the private discount factor,  $\beta$ , to 0.99 implying a steady state of the annual nominal interest rate of about 4%. We calibrate both the intertemporal elasticity and the Frisch elasticity of labor supply to one which is also standard. In particular, this implies that log con-

<sup>22</sup>An equivalent definition can be found in Bilbiie, Ghironi, and Melitz (2007).

$$\begin{aligned}
\theta - 1 &= \theta m c_t - \kappa^f E_t \left\{ (\pi_t - 1) \pi_t - \beta \frac{C_{t+1}^{-\sigma}}{C_t^{-\sigma}} (\pi_{t+1} - 1) \pi_{t+1} \frac{Y_{t+1}}{Y_t} \right\} \\
m c_t &= R_t^L \frac{w_t}{A_t} \\
C_t^{-\sigma} &= \beta E_t \left\{ C_{t+1}^{-\sigma} \frac{R_t^B}{\pi_{t+1}} \right\} \\
w_t &= \chi C_t^\sigma L_t^\eta \\
Y_t &= A_t L_t \\
Y_t &= C_t + G_t + \frac{\kappa^f}{2} (\pi_t - 1)^2 Y_t \\
Y_t^{GDP} &= Y_t + N_{E,t} v_t \\
\frac{R_t^M}{R^M} &= \left( \frac{\pi_t}{\pi} \right)^{\lambda_\pi} \left( \frac{Y_t}{Y} \right)^{\lambda_y} \exp\{u_t^r\} \\
v_t &= f_E E_t \left\{ \frac{R_t^B}{\pi_{t+1}} \right\} \\
N_t &= (1 - \delta)(N_{t-1} + N_{E,t-1}) \\
O_t &= N_t^{\frac{\zeta}{\zeta-1}} o_t \\
R_t^L &= N_t^{\frac{1}{1-\zeta}} r_t^L \\
r_t^L &= \frac{(1 - \lambda_t) \zeta}{(1 - \lambda_t) \zeta - 1} R_t^B - \frac{\kappa^b}{(1 - \lambda_t) \zeta - 1} \psi_t \\
\psi_t &= \left[ \frac{r_t^L}{r_{t-1}^L} - 1 \right] \frac{r_t^L}{r_{t-1}^L} \frac{O_t}{o_t} - \beta E_t \left\{ \left( \frac{C_{t+1}}{C_t} \right)^{-\sigma} \left[ \frac{r_{t+1}^L}{r_t^L} - 1 \right] \frac{r_{t+1}^L}{r_t^L} \frac{O_{t+1}}{o_t} \right\} \\
\mu_t &= \frac{(N_t - 1) \zeta}{(N_t - 1) \zeta - N_t} \\
O_t &= w_t L_t + N_t \frac{\kappa^b}{2} \left[ \frac{r_t^L}{r_{t-1}^L} - 1 \right]^2 O_t \\
v_t &= (1 - \delta) \beta E_t \left\{ \left( \frac{C_{t+1}}{C_t} \right)^{-\sigma} (v_{t+1} + d_{t+1}) \right\} \\
d_t &= (r_t^L - R_t^B) o_t \\
R_t^M &= R_t^B \\
\lambda_t &= 1/N_t
\end{aligned}$$

Table 1: The complete New Keynesian model with endogenous entry of oligopolistic banks

sumption enters the utility function. As in Smets and Wouters (2007), we set the steady state government spending/GDP ratio to 18% which is moreover the value calculated by Trabandt and Uhlig (2009) for the US economy. The intratemporal elasticity between intermediate goods,  $\theta$ , is set to 11 implying a steady state mark-up of 10% in the goods market. The price stickiness parameter,  $\kappa^f$ , is assumed to be 77 as estimated in Ireland (2001). We moreover

abstract from trend inflation, i.e.  $\bar{\pi} = 1$ .

The elasticity between the loans,  $\zeta$ , is calibrated to 6 in order to obtain an equivalent  $\zeta/\theta$ -ratio as in Gerai et al. (2010). When assuming the loan rates to be sticky, we moreover set the loan rate stickiness parameter,  $\kappa^b$ , to 22.43 in order to obtain the same slope of the loan rate equation,  $(\zeta - 1)/\kappa^b$ , as estimated in Gerlai et al. (2010). When assuming loan rates to be flexible,  $\kappa^b$  is zero. We calibrate the bank death rate,  $\delta$ , to the empirically observed value, 0.013.<sup>23</sup> To match the data appropriately, we set the entry costs,  $f_E$ , to 6. The scaling parameter,  $\chi$ , is endogenously determined by the steady state system to ensure that in steady state total hours worked is  $1/3$ . We moreover apply a standard Taylor rule, with  $\lambda_\pi = 1.5$  and  $\lambda_y = 0.125$ .

Finally, we calibrate the shock processes to the estimated values of Smets and Wouters (2007), i.e. we respectively set the persistence of the shock to technology, to government spending, and to the interest rate to 0.95, 0.97, and 0.15. The corresponding standard errors are 0.45, 0.53, and 0.24, respectively. Without loss of generality, we assume the shock to bank value to occur with a shock persistence of 0.95. The corresponding standard error is normalized to 0.01.

## 2.8 The Benchmark New Keynesian Model

In order to obtain an appropriate benchmark for our analysis, we apply a standard New Keynesian model with a cost channel. The model is characterized by a completely competitive banking sector whose mass is constant and normalized to one. As a result, the banks do not ask for a mark-up such that  $R_t^L = R_t^B$ . The complete benchmark model can be found in Table 2. For the sake of comparability, we apply the same calibration as for the bank entry model.

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<sup>23</sup>The data is provided by the Federal Deposit Insurance Corporation.

$$\begin{aligned}
\theta - 1 &= \theta mc_t - \kappa^f E_t \left\{ (\pi_t - 1)\pi_t - \beta \frac{C_{t+1}^{-\sigma}}{C_t^{-\sigma}} (\pi_{t+1} - 1)\pi_{t+1} \frac{Y_{t+1}}{Y_t} \right\} \\
mc_t &= R_t^B \frac{w_t}{A_t} \\
C_t^{-\sigma} &= \beta E_t \left\{ C_{t+1}^{-\sigma} \frac{R_t^B}{\pi_{t+1}} \right\} \\
w_t &= \chi C_t^\sigma L_t^\eta \\
Y_t &= A_t L_t \\
Y_t &= C_t + G_t + \frac{\kappa^f}{2} (\pi_t - 1)^2 Y_t \\
\frac{R_t^M}{R^M} &= \left( \frac{\pi_t}{\pi} \right)^{\lambda_\pi} \left( \frac{Y_t}{Y} \right)^{\lambda_y} \exp\{u_t^r\} \\
R_t^B &= R_t^M
\end{aligned}$$

Table 2: The complete benchmark New Keynesian model

## 2.9 Stability Analysis

Surico (2008) provides the necessary and sufficient conditions for determinacy for our benchmark model, the New Keynesian model with a cost channel and a standard Taylor rule. Llosa and Tuesta (2009) and Brückner and Schabert (2003) moreover study how different monetary policy rules may affect determinacy. The studies highlight that in contrast to the standard New Keynesian model, there exists an upper bound to the output reaction in the monetary policy rule if the cost channel is existent.

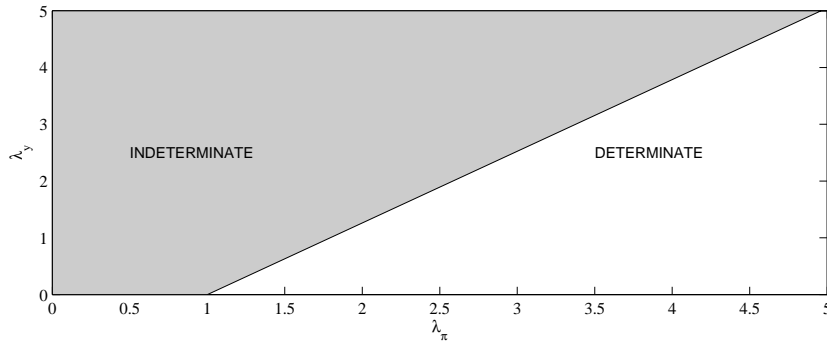


Figure 4: Regions of determinacy

Figure 4 shows the regions of determinacy for the bank entry model. In comparison with the findings of Surico (2008), the figure indicates that the



region of determinacy remains approximately unaffected. In particular, this implies that also in our framework, there exists an upper bound to  $\lambda_y$  which increases if  $\lambda_\pi \geq 1$  is increased.

### 3 Impulse Responses

#### 3.1 The Technology Shock

In this section, we will investigate the impulse responses to an expansionary technology shock. Thereby, we will analyze the impact of the loan rate rigidity and the survival probability of new banks. In the following, we will refer to the model specification with *flexible* loan rates and *exogenous* exits as the *baseline* bank entry model.

##### 3.1.1 The Baseline Bank Entry Model

Figure 5 shows the impulse responses to an aggregate technology shock of the baseline bank entry model.<sup>24</sup>

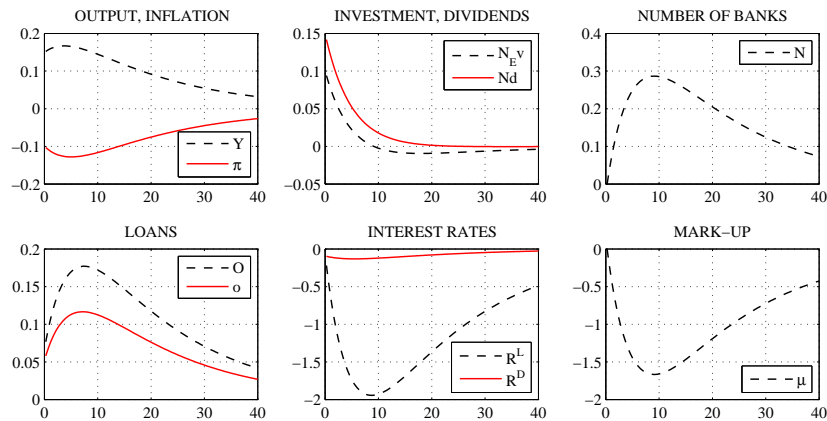


Figure 5: Impulse responses to an expansionary technology shock

In line with empirical evidence of amongst others Smets and Wouters (2003,

<sup>24</sup>The number of years are on the abscissa. However, we interpret periods as quarters. On the ordinate we plot the percentage deviation of a variable from the corresponding steady state value, i.e.  $x_t = (X_t - \bar{X})/\bar{X}$ , where  $\bar{X}$  denotes the steady state value.

2007), the innovation causes inflation to decrease while output increases. Since firms have to pre-finance their wage-bill, the demand for loans reacts expansionary, too. The drop in the nominal interest rate moreover leads to a decline in the marginal costs of banks. All in all, the profit opportunities of banks increase which cause new banks to enter the market and consequently induces a boom in investment in new banks. The latter effect is moreover amplified by the decline in the nominal interest rate which leads to lower entry costs. In Section 3.2, we come to this point into more detail.

The expansionary reaction of the mass of operating banks leads to a drop in the market share of the single banks [cf. equation (34)]. Consequently, banks decrease their mark-ups. As already mentioned, the mark-up of banks acts as an endogenous cost-push shock [cf. equation (37)] which reacts expansionary in this case. The declining mark-up thus results in a drop in firms' marginal costs which leads to a further increase in production and consequently in loan demand. As a result, the endogenous bank mark-up introduces a multiplier effect, the new financial accelerator.

In order to measure the quantitative size of our financial accelerator, Figure 6 shows the impulse responses to an aggregate technology shock of the baseline bank entry model (dashed lines) in comparison with the benchmark New Keynesian model (solid lines).

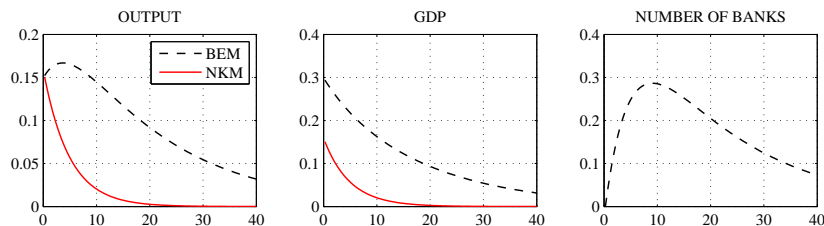


Figure 6: Impulse responses of the baseline bank entry model (BEM) to an expansionary technology shock in comparison with the benchmark New Keynesian model (NKM)

When comparing the quantitative effects of both models, it turns out that the new financial accelerator leads to a significant propagation in the reaction of

output. This effect is even more pronounced in the case of GDP since investment in new banks additionally increases [cf. Figure 5].

The financial accelerator in our model is driven by two effects. First, due to the declining mark-up the contractionary reaction of the loan rate is more pronounced in the bank entry model leading to lower marginal costs for firms. Second, investment in new banks is a component of GDP. All in all, endogenizing the mass of oligopolistic banks leads a significant amplification effect. Moreover, Figure 6 shows that the reactions in the bank entry model turn out to be more persistent, too. Our framework is thus a further step to solve the puzzle how relatively small shocks can result in large and persistent effects for the real economy [see amongst other Mankiw (2001), Chari et al. (2000), and Fuhrer and Moore (1995)].

When comparing the quantitative accelerating effects with BGG, it turns out that our model generates even higher amplification effects than the famous financial accelerator model. BGG conclude that their financial accelerator model generates about 50% amplification of the initial reaction of GDP.<sup>25</sup> Figure 6 however indicates that the assumption of an endogenous mass of oligopolistic banks results in an initial amplification effect of about 100%.

All in all, our model is able to capture the empirical findings that (i) bank mark-ups react counter-cyclical and (ii) the positive co-movement of the mass of banks with GDP and to generate significant amplification and persistence effects.

### 3.1.2 The Bank Entry Model with Sticky Loan Rates

Up to now, we have assumed that loan rates are flexible. However, there exists empirical evidence that loan rates are rigid [see amongst others Henzel et al. (2009) or Gerali et al. (2010)]. Figure 7 shows the impulse responses to an

<sup>25</sup>Note however that Christensen and Dib (2008) estimate a New Keynesian model incorporating the BGG framework for the US. They show that the presence of a financial accelerator mechanism à la BGG significantly amplifies the impact of demand-side shocks but dampens the rise of investment to a shock to technology.

aggregate technology shock under flexible (solid lines) and under sticky loan rates (dashed lines).

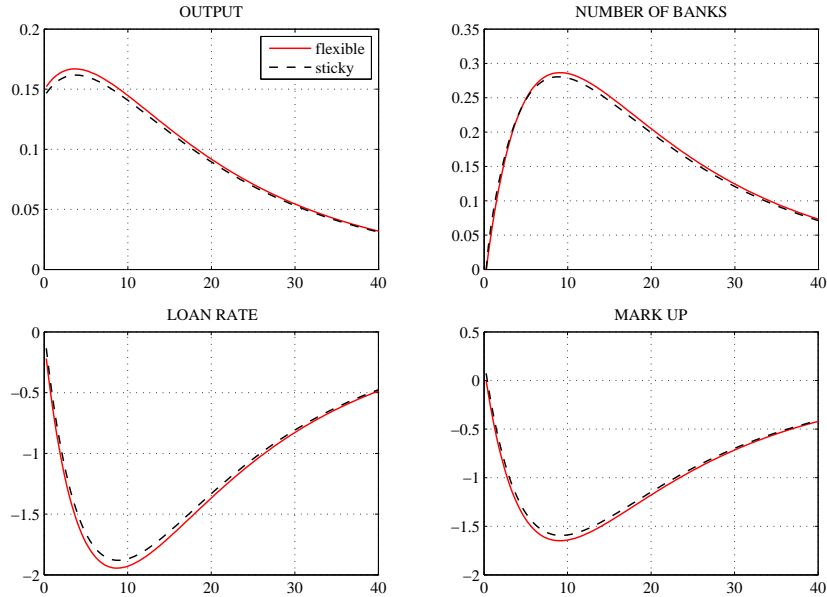


Figure 7: Impulse responses to an expansionary technology shock with sticky loan rates in comparison with the baseline model with flexible loan rates

The figure indicates that the introduction of sticky loan rates as a further nominal rigidity does not make much difference for the resulting dynamics. The reaction of the loan rate becomes naturally somewhat smoother. However, when compared to the case of flexible loan rates the resulting dynamics of the mass of banks and GDP do not differ significantly. The reactions are just slightly less expansionary.

### 3.1.3 The Bank Entry Model with an Endogenous Survival Probability of New Banks

For the sake of simplicity, we have assumed exits to be exogenous as in the firm entry models of amongst others Bilbiie, Ghironi, and Melitz (2007).<sup>26</sup> For the following exercise, we want to abstract from this assumption and alternatively assume that the survival probability for new banks depends negatively on the

<sup>26</sup>See Totzek (2010) for a model with a microfounded incentive-based mechanism of simultaneous endogenous firm entry and exit.

mass of new start ups.<sup>27</sup> Applying this assumption on the mass of banks in the market, results in:

$$N_{t+1} = (1 - \delta)(N_t + F(N_{E,t}/N_{E,t-1})) \quad (43)$$

with  $F(N_{E,t}/N_{E,t-1}) \equiv [1 - S(N_{E,t}/N_{E,t-1})]N_{E,t}$  where  $S(\cdot)$  has the following properties:  $S(1) = S'(1) = 0$  and  $S''(1)$  is constant and strictly positive.<sup>28</sup> Technically, this mechanism is similar to investment adjustment costs as for instance assumed in Christiano, Eichenbaum, and Evans (2005).

We further assume  $S''(1) = 2.48$  which is the value that Christiano, Eichenbaum, and Evans (2005) estimate for capital investment adjustment costs. A function which fulfills these properties is given by

$$F(N_{E,t}, N_{E,t-1}) = \left[ 1 - 1.24 \left( \frac{N_{E,t}}{N_{E,t-1}} - 1 \right)^2 \right] N_{E,t} \quad (44)$$

The impulse responses to an expansionary technology shock are shown in Figure 8 in comparison with the baseline bank entry model and the benchmark New Keynesian model. We assume the loan rate to be flexible again.

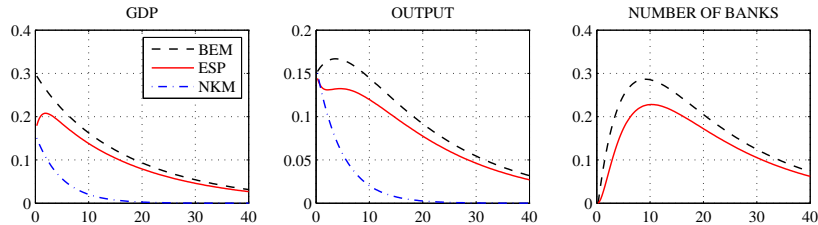


Figure 8: Impulse responses to an expansionary technology shock with an endogenous survival probability (ESP) in comparison with the baseline bank entry model (BEM) and the benchmark New Keynesian Model (NKM)

Figure 8 indicates that the assumption of an endogenous survival probability of new banks has quantitative and qualitative effects for the resulting dynamics. The endogenous survival probability of new banks which increases in the

<sup>27</sup>An equivalent mechanism can be found in the extended firm entry model à la Bilbiie, Ghironi, and Melitz (2007) outlined in Lewis (2009).

<sup>28</sup>When setting  $S(\cdot) = 0 \Leftrightarrow F(\cdot) = N_{E,t}$ , we end up with our baseline model.

mass of start-ups naturally dampens the expansionary reaction of the mass of banks. Moreover, we can now generate a hump-shaped adjustment pattern in GDP which naturally comes at the costs of a lower impact reaction and thus of a smaller initial financial accelerator. Note however that the model still generates a significant amplification and persistence effect in GDP and output when compared to the benchmark New Keynesian model.

### **3.2 The Interest Rate Shock: A New Transmission Channel for Monetary Policy**

In this section, we will describe our new transmission channel for monetary policy. In order to differentiate this concept from that of the traditional financial accelerator model, we start by illustrating the transmission channel in BGG.

BGG integrate the Bernanke, Gertler, and Gilchrist (1996) approach into a New Keynesian model. Hence, they build up an overlapping generations model where firms need physical capital and labor for production. The acquisition of capital is financed either by borrowing or by entrepreneurial net wealth. Financial intermediaries ask for an external finance premium (or: mark-up) over their marginal costs for providing capital. This mark-up is not caused by an imperfectly competitive environment of financial institutions but by the assumption of information asymmetries across borrowers and lenders. BGG moreover assume that the external finance premium inversely depends on borrowers net wealth. The transmission channel for monetary policy in BGG now works as follows. An easing of monetary policy increases the return on capital resulting in an increase in the net wealth of firms. This in turn causes a decrease in firm leverage leading to a reduction of the external finance premium and thus to a further rise in capital demand.

In contrast to BGG, we do not emphasize the mark-up movements from the demand side of credit. Instead, our financial accelerator nests from the supply side. A decrease in the nominal interest rate results in four expansionary effects.

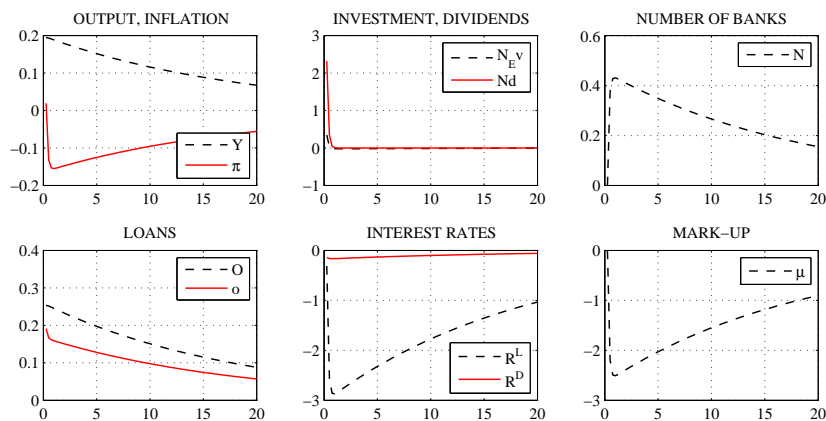


Figure 9: Impulse responses to an expansionary shock to the interest rate

(i) consumption is shifted to the present leading to a higher loan demand. (ii) the marginal costs of banks decrease.<sup>29</sup> (iii) bank entry costs decline, too. (iv) the decrease in the real stochastic discount factor causes the value of a bank to increase. The first two effects result in higher bank profits while the latter two effects have moreover an expansionary impact on the profitability of bank start-ups. This in turn results in an increase in investment in new banks. The resulting expansionary reaction of the mass of operating banks then leads to a declining mark-up in the loan market.<sup>30</sup> Since firms have to pre-finance their wage-bill, a decreasing mark-up has a positive effect on their marginal costs leading to a further increase in production and thus in loan demand.<sup>31</sup> This in turn induces the new financial accelerator. Figure 9 shows the corresponding impulse responses.

Figure 10 shows that the endogenous bank entry mechanism leads to a significant amplification effect when compared to the benchmark New Keynesian model. The effect is again larger than that generated by the financial accelerator in BGG. BGG only generate an amplification effect of about 50%. By

<sup>29</sup>The marginal costs of banks are simply given by the nominal deposit rate,  $R_t^B = R_t^M$ .

<sup>30</sup>Note that the latter effect is absent when assuming monopolistic competition since then the bank mark-up would not decrease when new banks enter the market.

<sup>31</sup>Remark: Under monopolistic competition the bank mark-up would be constant such that this expansionary effect would not occur.

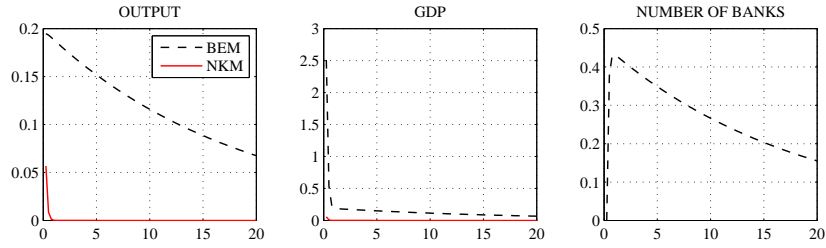


Figure 10: Impulse responses of the baseline bank entry model (BEM) to an expansionary shock to monetary policy in comparison with the benchmark New Keynesian model (NKM)

contrast, the shock results in much larger propagation effects with respect to output and GDP in our framework. As Figure 9 depicts, the easing in monetary policy results in a massive increase in investment in new banks. This in turn amplifies the boom in GDP. Moreover, our bank entry model again generates significantly more persistent dynamics.

### 3.3 The Shock to Government Spending

In this section, we will analyze a shock to government spending. For this exercise, we deviate from our baseline calibration and assume that the monetary authority follows a Taylor rule with the original coefficients of Taylor (1993), i.e.  $\lambda_\pi = 1.5$  and  $\lambda_y = 0.5$ . Figure 11 shows the corresponding impulse responses. At the end of this section, we will investigate how monetary policy affects the results.

Figure 11 shows that output and loan demand increase. The drop in the nominal interest rate lowers the marginal costs of banks. Consequently, the shock generates additional profit opportunities for existing and potential banks. This in turn leads to higher investments and thus to an increasing mass of banks. In comparison with the shock to monetary policy and to total factor productivity, the expansionary reaction of the mass of operating banks is however about ten times smaller.

In comparison with the benchmark model, Figure 12 shows that the bank entry model generates only small amplification effects with respect to output



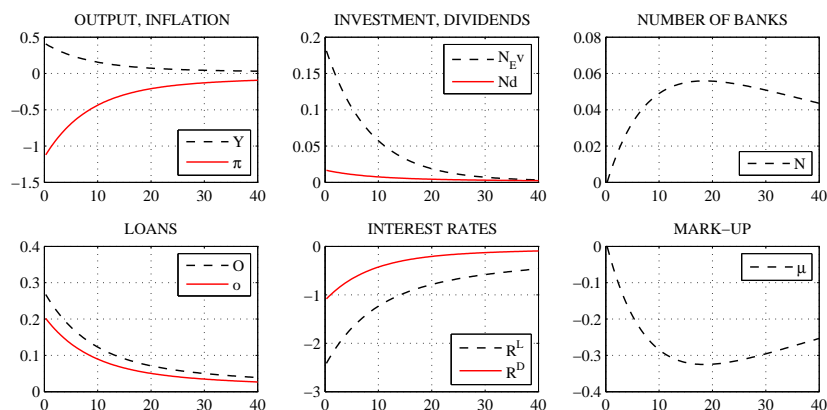


Figure 11: Impulse responses to an expansionary shock to government spending

and GDP. The rationale is the comparatively small expansionary reaction of the mass of banks and consequently that the drop in bank mark-ups turns out to be rather small [cf. Figure 11]. The amplification of output and GDP respectively amount to 36% and 46%. The latter approximately corresponds with the amplification effect in BGG.

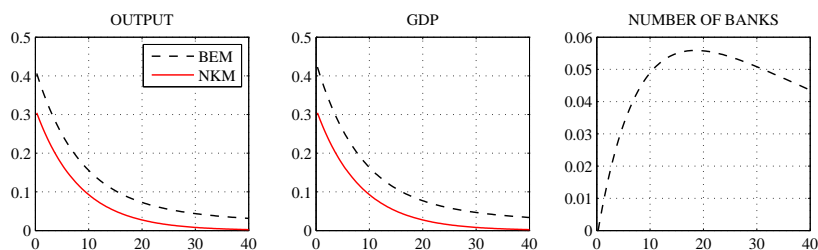


Figure 12: Impulse responses of the baseline bank entry model (BEM) to an expansionary shock to government spending in comparison with the benchmark New Keynesian model (NKM)

Figure 11 shows that the fiscal demand stimulus leads to a decline in inflation which is ad odds with the empirical evidence of amongst others Smets and Wouters (2007, 2003). However, Linnemann and Schabert (2003) show within the baseline New Keynesian model that the qualitative reaction of inflation crucially depends on the design of monetary policy. In particular, the Taylor rule coefficient  $\lambda_y$  is the decisive factor. Linnemann and Schabert (2003) show that inflation only increases if  $\lambda_y = 0$ .

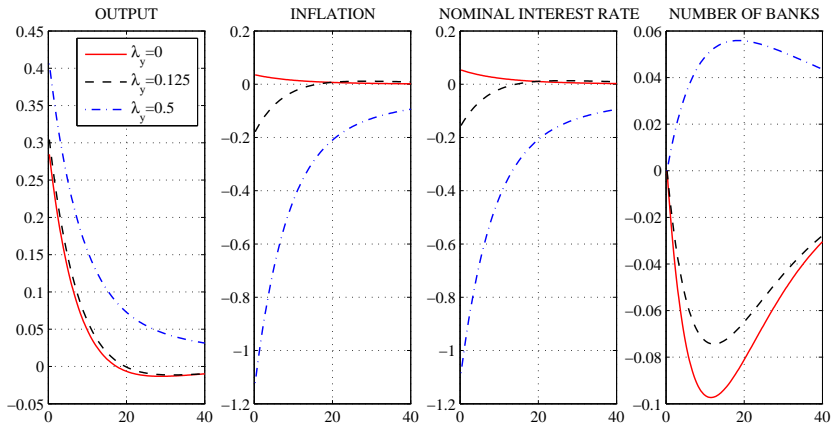


Figure 13: On the impact of monetary policy

Figure 13 indicates that we obtain exactly the same result in our framework. As in the baseline New Keynesian model without a cost channel, inflation and the nominal interest rate only increase if  $\lambda_y = 0$ . However and in contrast to the standard New Keynesian model, the cost channel leads to a more expansionary reaction of output if the monetary authority reacts to output, too, i.e. if  $\lambda_y > 0$ . The rationale is that the reaction of the nominal interest rate causes the marginal costs of firms to decrease. Consequently,  $\lambda_y > 0$  has a positive impact on production via the cost channel. This result holds in both the bank entry model and the benchmark New Keynesian model.

In the bank entry model, a drop in the interest rate moreover leads to a downward pressure on the entry costs. Inversely, an increase in the interest rate leads to an increase in the entry costs. This is the case for  $\lambda_y = 0$  and for  $\lambda_y = 0.125$  in the longer-run. As Figure 13 depicts, the reaction of output moreover turns negative in the longer-run if  $\lambda_y \in \{0, 0.125\}$ . This naturally dampens the profit opportunities of incumbent and new banks. The development of the mass of banks consequently indicates that the additional profit opportunities only cover the entry costs, if  $\lambda_y \geq 0.5$ . Otherwise, the mass of banks declines.<sup>32</sup>

<sup>32</sup>This result is in line with the findings of Totzek and Winkler (2010) who show within an estimated firm entry model that the reaction of the mass of firms is ambiguous in the case of a fiscal demand shock whereas it is unambiguous for other shocks, as for instance a technology

### 3.4 The Shock to Bank Value

As a consequence of the subprime bust in 2007, banks around the globe lost in value. Since we apply a rather simple model, we exogenously add such a value shock to equation (30). Figure 14 shows the corresponding impulse responses. In contrast to the previously analyzed shocks, the shock to bank value does not directly affect the real economy, i.e. the goods market. Instead, it only has a direct impact on the entry decision of new banks. The spill-over to the real economy consequently occurs only via mark-up movements in the banking sector, i.e. the endogenous cost push shock.

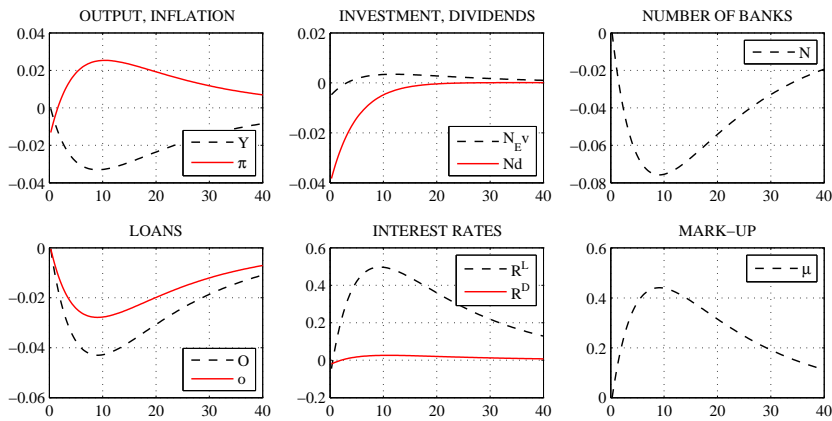


Figure 14: Impulse responses to a contractionary shock to bank value

As entering the market becomes less profitable for new banks, investment in new banks decreases. Since the mass of banks reacts contractionary, the mark-up of banks increases [cf. equation (38)] leading to higher marginal costs for firms. The resulting endogenous cost-push shock consequently reacts contractionary in this case [cf. equation (36)]. The shock to bank value thus leads to stagflation.

Figure 14 however shows that inflation initially declines before the reaction turns positive. However, this result is driven by monetary policy. As the mass of banks decreases, the declining mark-up leads to an upward-pressure on the shock.

loan rate and thus on inflation. By contrast, the expansionary monetary policy reaction decreases the marginal costs of banks leading to a downward-pressure on inflation.

All in all, this exercise shows that in line with the observation in the financial crisis 2007-2009 (and previous financial crisis, too) banks do not only propagate shocks but can also be the source of macroeconomic disturbances.

## 4 Second Moments

Business cycle models are traditionally evaluated by comparing the second moments of the generated series with those observed in the data [see amongst others King and Rebelo (1999)]. In this section, we thus want to report, how the presented model performs along this dimension. Moreover, we analyze the impact of the introduction of a financial transaction tax and a financial activity tax on the generated financial and macroeconomic volatility.

### 4.1 The Baseline Bank Entry Model

For this exercise, we simulate the reaction of the baseline bank entry model to the aggregate productivity shock 500 times for 500 quarters. We then discard the first 411 quarters to obtain the same sample size as in the data set.<sup>33</sup> We use the Hodrick-Prescott filter with a smoothing parameter of  $10^5$ . It is worth mentioning that we do not deviate from our baseline calibration in this exercise.

Table 3 reports the resulting moments of the baseline bank entry model<sup>34</sup> (normal numbers) and the resulting moments of the benchmark New Keynesian model (italic numbers in parenthesis). Moreover, Table 3 shows the values calculated from US data (bold numbers). The data range is 1988:Q1-2010:Q1 due to the restricted availability of the number of banks data. As a measure for

<sup>33</sup>The data set is described below.

<sup>34</sup>In line with the impulse response analysis of Section 3.1, the introduction of loan rate stickiness does not significantly alters the generated second moments. In particular, they are virtually indistinguishable.

loans and for the mark-up of a commercial bank, we respectively choose total loans and investments at all commercial banks and the spread between the average majority prime rate charged by banks on short-term loans to business and the FED's funds rate. The data for the remaining macroeconomic variables is standard.<sup>35</sup>

	Standard deviation			Relative standard deviation $\sigma_X/\sigma_{GDP}$			First-order autocorrelation $E_t(X_t, X_{t-1})$		
	$\sigma_X$								
GDP	<b>1.23</b>	1.25	(0.83)	<b>1.00</b>	1.00	(1.00)	<b>0.89</b>	0.84	(0.82)
$C$	<b>1.04</b>	1.01	(0.82)	<b>0.85</b>	0.81	(0.98)	<b>0.87</b>	0.86	(0.82)
$I$	<b>5.01</b>	2.36	(n.a.)	<b>4.08</b>	1.89	(n.a.)	<b>0.93</b>	0.83	(n.a.)
$w$	<b>1.02</b>	1.43	(1.01)	<b>0.83</b>	1.14	(1.22)	<b>0.79</b>	0.89	(0.82)
$O$	<b>1.89</b>	1.88	(n.a.)	<b>1.54</b>	1.51	(n.a.)	<b>0.82</b>	0.90	(n.a.)
$o$	<b>1.71</b>	1.71	(n.a.)	<b>1.39</b>	1.37	(n.a.)	<b>0.78</b>	0.91	(n.a.)
$N$	<b>0.45</b>	0.25	(n.a.)	<b>0.37</b>	0.20	(n.a.)	<b>0.83</b>	0.96	(n.a.)
$\mu$	<b>0.33</b>	0.85	(n.a.)	<b>0.27</b>	0.67	(n.a.)	<b>0.87</b>	0.96	(n.a.)

Table 3: Business cycle statistics [**data**, bank entry model, (benchmark New Keynesian model)]

Table 3 shows that the introduction of our financial accelerator leads to a significant amplification of the generated standard deviations.<sup>36</sup> This result is in line with Jermann and Quadrini (2009) who show that the introduction of a financial sector leads to an important propagation of macroeconomic volatility.<sup>37</sup> Moreover, the generated standard deviations in both absolute and relative terms are very close to the empirically observed ones. By contrast, the benchmark New Keynesian model does not generate enough volatility in output and consumption.

Naturally, a further advantage of the bank entry model is that we can ad-

<sup>35</sup>The data for loans, the loan rate, and the number of banks is provided by the Board of the Governors of the Federal Reserve System. The data for the standard macroeconomic variables is taken from the US department of Commerce (Bureau of Economic Analysis) and the US Department of Labor.

<sup>36</sup>Remark: The benchmark New Keynesian model does neither include financial variables such as  $O_t$ ,  $o_t$ ,  $N_t$ , or  $\mu_t$  nor investment in new banks,  $I_t$ . Consequently, we cannot calculate the corresponding second moments of these variables. In Table 3 we thus state n.a. (not available).

<sup>37</sup>Remark: Jermann and Quadrini (2009) develop a model with explicit roles for debt and equity financing and analyze shocks that affect the firms' capacity to borrow. They moreover show that the additional introduction of financial shocks lead to a further amplification effect. This also holds true in our framework when for instance considering a shock to loan demand.

ditionally analyze the moments of financial variables. Table 3 reports that the model performs surprisingly well with respect to this dimension, too. The model does not only generate an appropriate volatility of aggregate loans and loans per bank but also depicts the comparatively low volatilities of the mass of operating banks. The generated price-cost margin is however too volatile. With respect to the first-order autocorrelation, the bank entry model even generates too much endogenous persistence of the financial variables under consideration. The generated autocorrelations of GDP, consumption, and the real wage are slightly larger when compared to the benchmark New Keynesian model.

## 4.2 The Financial Activity Tax and the Financial Transaction Tax

As Table 3 depicts, the existence of the financial sector leads to higher volatilities for key macroeconomic variables. In order to extenuate the additional source of economic instability, we will now investigate the effects resulting from the introduction of two financial taxes.<sup>38</sup> The most prominent taxes being discussed by politicians in this context – especially in the Euro Area – are the so-called ‘financial activity tax’ and the ‘financial transaction tax’. The respective tax bases are profits and transactions.

In the case of a financial activity tax, the bank has to pay a tax,  $\tau_t^d$ , on profits. In our framework this implies according to (17):

$$d_{i,t} = (1 - \tau_t^d)(r_{i,t}^L - R_t^B)o_{i,t} \quad (45)$$

The financial activity tax does not affect the optimal loan rate decision. Since the tax however dampens per period profits, it has a negative effect on bank value and thus on bank entry.

<sup>38</sup>Remark: In standard DSGE macro models, profit taxation is lump-sum, i.e. such tax changes do not affect the resulting dynamics, at all. By contrast, taxes on profits are not lump-sum when considering an endogenous mass of oligopolistic banks.

An alternative tax which is especially proposed by German policy makers is the financial transaction tax (or: Tobin (1978) tax) where a bank has to pay a tax,  $\tilde{\tau}_t^d$ , on each transaction. In our simple banking model, a bank makes only a single transaction each period by providing an amount of loans  $o_{i,t}$  to firms. The profit of a bank is then given by

$$d_{i,t} = (r_{i,t}^L - R_t^B)o_{i,t} - \tilde{\tau}_t^d o_{i,t} \quad (46)$$

In contrast to the financial activity tax, the financial transaction tax has an effect on the optimal loan rate decision since it affects the marginal costs of banks. The optimal loan rate is now given by

$$r_{i,t}^L = \frac{(1 - \lambda_{i,t})\zeta}{(1 - \lambda_{i,t})\zeta - 1} (R_t^B + \tilde{\tau}_t^d) \quad (47)$$

Since new banks have to pay entry costs proportional to their marginal costs, the free entry condition must also be modified correspondingly.

As a consequence, the financial transaction tax results in two negative effects on bank entry and thus on the new financial accelerator. First, it dampens per period profits of banks via additional tax costs. Second, the tax raises the marginal costs of banks and consequently entry costs. This implies that in line with the findings of Lengnick and Wohltmann (2010) the financial transaction tax seems to be more effective in decreasing the volatilities on financial markets and the resulting accelerator effects for the real economy.

In order to extenuate the additional source of economic instability, we now want to find the specific level of the financial activity tax rate and the financial transaction tax rate which decreases the macroeconomic volatility to that of our benchmark model where our financial accelerator is not existent. For the sake of comparability, we assume that both tax increases occur with the same degree of persistence as the technology shock.

Figure 15 reports the standard deviation of GDP for different tax levels. The

dashed black lines indicate the standard deviation of GDP which the benchmark New Keynesian model generates, 0.83.

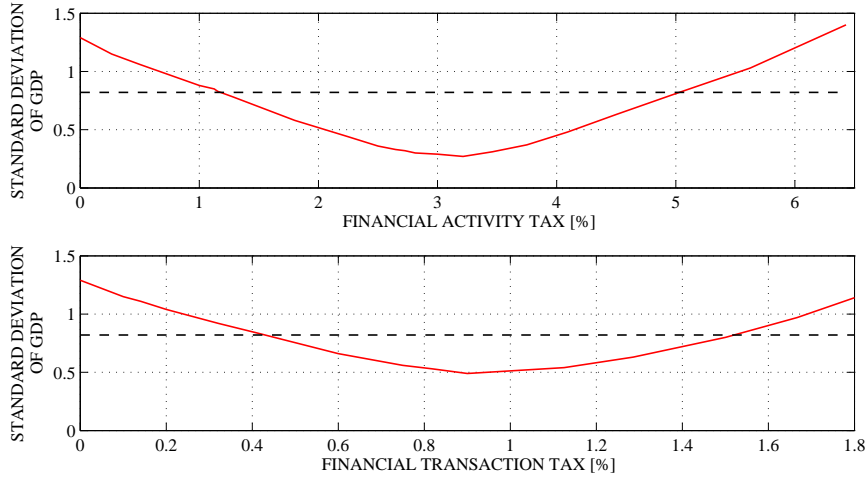


Figure 15: The impact of the financial activity tax and the financial transaction tax on the standard deviation of GDP

Figure 15 shows that both financial taxes perform qualitatively equivalent. Small increases in the tax level lead to a decline in macroeconomic volatility, whereas increases above a certain threshold lead to a rise in macroeconomic volatility. This result is in line with Lengnick and Wohltmann (2010). Figure 15 moreover indicates that the financial transaction tax has significantly larger effects. In the case of the financial activity tax, a tax level of 1.15% is needed to achieve the same volatility level as in the benchmark model without bank entry and oligopolistic competition. By contrast, there is only need for a financial transaction tax of about 0.41% to generate the same volatility of GDP. This implies that the additional effect of the latter tax on banks' marginal costs leads to a three times larger impact on the volatility of GDP.<sup>39</sup>

Table 4 reports the second moments of the baseline bank entry model without a financial tax (bold numbers) in comparison with the case of a financial activity tax [1.15%] (normal number) and a financial transaction tax [0.41%]

<sup>39</sup>Note however that these values seem to be rather large. For instance the Swedish government introduces a financial transaction taxes between 0.003% and 0.5% in the 1980s.



(italic number in parenthesis).

	Standard deviation			Relative standard deviation $\sigma_X/\sigma_{GDP}$			First-order autocorrelation $E_t(X_t, X_{t-1})$		
	$\sigma_X$								
GDP	<b>1.25</b>	0.83	<i>(0.83)</i>	<b>1.00</b>	1.00	<i>(1.00)</i>	<b>0.84</b>	0.82	<i>(0.82)</i>
<i>C</i>	<b>1.01</b>	0.85	<i>(0.83)</i>	<b>0.81</b>	1.02	<i>(1.00)</i>	<b>0.86</b>	0.83	<i>(0.81)</i>
<i>I</i>	<b>2.36</b>	0.75	<i>(0.85)</i>	<b>1.89</b>	0.90	<i>(1.02)</i>	<b>0.83</b>	0.82	<i>(0.82)</i>
<i>w</i>	<b>1.43</b>	1.09	<i>(1.02)</i>	<b>1.14</b>	1.31	<i>(1.22)</i>	<b>0.89</b>	0.83	<i>(0.82)</i>
<i>O</i>	<b>1.88</b>	1.15	<i>(1.04)</i>	<b>1.51</b>	1.39	<i>(1.25)</i>	<b>0.90</b>	0.84	<i>(0.82)</i>
<i>o</i>	<b>1.71</b>	1.12	<i>(1.03)</i>	<b>1.37</b>	1.35	<i>(1.24)</i>	<b>0.91</b>	0.83	<i>(0.82)</i>
<i>N</i>	<b>0.25</b>	0.07	<i>(0.02)</i>	<b>0.20</b>	0.08	<i>(0.02)</i>	<b>0.96</b>	0.96	<i>(0.96)</i>
$\mu$	<b>0.85</b>	0.26	<i>(0.05)</i>	<b>0.67</b>	0.31	<i>(0.06)</i>	<b>0.96</b>	0.96	<i>(0.96)</i>

Table 4: Business cycle statistics of the **baseline bank entry model**, the bank entry model with financial activity tax [1.15%], (*the bank entry model with financial transaction tax [0.41%]*)

Table 4 indicates that both taxes are not only able to reduce the volatility of GDP to the benchmark level but also the volatilities of the other variables under consideration. In fact, the generated moments of the benchmark New Keynesian model and that of the bank entry model with financial taxes are very close to each other. Table 4 moreover shows that both financial taxes are appropriate to dampen the volatilities in the financial markets, too. In particular, the standard deviation of the mass of operating banks significantly declines. This effect is especially pronounced in case of the financial transaction tax where the mass of operating banks and consequently the bank mark-up turns out to be approximately constant.<sup>40</sup>

## 5 Conclusion

In order to capture the empirical findings that the number of banks significantly co-moves with GDP and that bank mark-ups react counter-cyclical, we develop a New Keynesian macro model which incorporates an oligopolistic banking sector with endogenous bank entry.

We find that the resulting model generates counter-cyclical mark-up move-

<sup>40</sup>When assuming lower taxes, the mark-up naturally becomes more volatile again.

ments in the banking sector and large amplification and persistence effects. More precisely, we obtain accelerating effects which are significantly larger than those generated by the famous study of BGG. In particular, we obtain very large accelerating effects in the case of a monetary policy shock. These results are robust with different assumptions concerning the loan rate rigidity and the death rate of new banks.

Moreover, we show that banks do not only propagate shocks but can also be the source of financial disturbances which have important implications for the real economy. Therefore, we analyze the implications of a contractionary shock to bank value which leads to stagflationary effects for the real economy.

We finally evaluate our model by comparing the second moments of the generated series with those observed in US data. The analysis shows that the bank entry model performs remarkable well. More precisely, the model does not only depict the properties of key macroeconomic variables appropriately but also of financial variables including the mass of banks, the amount of aggregate loans, and the amount of loans per banks.

Moreover, we analyze the macroeconomic implications of a financial activity tax and a financial transaction tax. Our analysis points out that these two taxes are indeed an appropriate tool to stabilize the financial markets and thus to dampen the volatility of key macroeconomic variables. We find that the financial activity tax where banks have to pay a tax on each transaction is about three times more effective than the financial transaction tax where the tax base is simply per period profits.

Future work should concern about simultaneous bank and firm entry. This give rise to further amplifications and interesting results with respect to the interdependency between financial and real markets. Moreover, we show that our model generates an endogenous cost-push shock resulting from oligopolistic competition. This implies a non-trivial role for monetary policy also in the case of a technology shock or a shock to the interest rate that – in contrast to a(n

exogenous) cost-push shock – do not generate a trade-off between stabilizing inflation and output in the standard New Keynesian model. Future work could thus concern about optimal monetary policy in such an environment.

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