Asymmetric Information in Credit Markets, Bank Leverage Cycles and Macroeconomic Dynamics

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Abstract

I add a moral hazard problem between banks and depositors as in Gertler and Karadi (2009) to a DSGE model with a costly state verification problem between entrepreneurs and banks as in Bernanke et al. (1999) (BGG). This modification amplifies the response of the external finance premium and the overall economy to monetary policy and productivity shocks. It allows my model to match the volatility of the external finance premium and other variables in US data better than a BGG-type model. A reasonably calibrated combination of balance sheet shocks produces a downturn of a magnitude similar to the "Great Recession".

1 Introduction

The ongoing financial crisis has drawn renewed attention to the relationship between bank capital and economic activity. In its Global Financial Stability report, the IMF argues that the losses incurred by banks caused a contraction in credit supply which in turn contributed to the economic downturn in the United States and beyond. Several empirical studies find that negative shocks to the capital of banks reduce lending and economic activity.[1] At the same time, there is a long line of evidence saying that investment spending is positively related to firm net worth.[2]

Therefore, I develop a model where both bank and firm leverage matter for the cost of external funds of firms and aggregate demand. I combine a costly state verification (CSV) problem between borrowing entrepreneurs (the firms accumulating the capital stock) as in the well known Bernanke et al. (1999) financial accelerator model with a moral hazard problem between banks and depositors as in the more recent contribution of Gertler and Karadi (2010). I assume that after collecting household deposits, banks can divert a fraction of its assets and declare bankruptcy. Therefore the bank will only be able to attract household deposits if its' expected value is sufficiently high such that it has no incentive to divert assets. This implies that the banks ability to attract deposits and thus to make loans today is positively related to its current net worth and its expected future earnings. If a shock lowers current bank net worth or future loan demand and thus future earnings, individual banks will have to cut loan supply today. Thus an expected banking sector de-leveraging increases the cost of external finance today.

[1] See Peek and Rosengreen (1997,2000), Ciccarelli et al. (2011) and Fornari and Stracca (2011).

[2] See Hubbard (1998) for a survey.

My main results can be summarized as follows. First, as compared to a BGG-type model, the response of the economy both to a monetary tightening and an adverse productivity shock is amplified in my model, the former more so than the latter. Both shocks trigger a deleveraging process in the banking sector, implying that banks cut loan supply when the shocks occur, thus amplifying the increase in the cost of external finance relative to the BGG model.

Second, in a world with three standard shocks (productivity, monetary policy and government spending), the amplification provided by the moral hazard problem in the banking-depositor relationship allows my model to match the volatility of the external finance premium, investment and other variables relative to output in US data better than the BGG model. My model also performs well at matching the second moments of the bank capital ratio.

Thirdly, in my model, an adverse shock to entrepreneurial net worth causes an output contraction more than twice as big as in a BGG-type model. In line with the existing empirical evidence, an adverse shock to bank net worth of causes a persistent decline of both GDP and inflation. The shock decreases loan supply by individual banks and thus increases the cost of external finance. For a reasonably calibrated combination of both net worth shocks, the model economy enters a downturn of a persistence and magnitude similar to the ongoing "Great Recession".

My model has a number of desirable features not present in some recently proposed DSGE models with leverage constraints both in the firm *and* in the banking sector. First, firms and banks are subject to microfounded leverage constraints, unlike in the models of Gerali et al. (2010) and Dib (2010). Furthermore, the capital stock in my model is owned by entrepreneurs who fund it using their own net worth and bank loans. Thus the leverage constraints banks and entrepreneurs have to obey apply to the whole capital stock. By contrast, in Meh and Moran (2010), households accumulate the capital stock and merely the production of new capital needs to be funded by entrepreneurial net worth and bank loans. Moreover, in my model households save in the form of an ordinary safe saving account and withdraw funds immediately when possibility of bank misbehavior arises. By contrast, in the models of Hirakata et al. (2009) and Meh and Moran (2010), households deliberately take a default risk and price it into the deposit rate, thus behaving like sophisticated investors rather than ordinary savers.[3] Furthermore, in my model entrepreneurs may default with a cyclically varying probability, a feature absent in Meh and Moran (2010) and Gerali et al. (2010). Finally, the model can easily be extended to analyse the merits of the unconventional monetary policy responses to financial crises considered by Gertler and Karadi (2010) and Gertler and Kiyotaki (2009) and of the macroprudential policies considered in Gertler and Kiyotaki (2010), as well as the effect of frictions in the interbank market considered in Gertler and Kiyotaki (2009).

The remainder of the paper is organized as follows. Section 2 develops the model. Section 3 discusses the calibration while section 4 compares the response of my model and a BGG type model to three standard shocks. Section 5 performs a moment comparison while section 6 summarizes the result from a series of robustness checks performed in the appendix. Section 7 discusses the response of the economy to financial shocks.

[3] In Meh and Moran (2010), they even fund a specific entrepreneurial investment project jointly with the bank.

2 The model

Sections 2.1 to 2.3 discuss the real side of the economy, while sections 2.5 and 2.4 discuss the banking and entrepreneurial sector. The first order conditions of households, investment good producers and retailers have been relegated to the appendix since these aspects of the model are standard. Section D of the appendix summarizes the linearized equations of the three model variants considered here.

2.1 Households

Thee economy features a large representative household whose preferences are described by the utility function

$$E_t \left\{ \sum_{i=0}^{\infty} \beta^i \left[\ln \left(C_{t+i} - hC_{t+i-1} \right) - \frac{\chi}{1+\varphi} \left(l_{t+i}^s \right)^{1+\varphi} \right] \right\}$$

where C_t and l_t^s denote a CES basket of consumption good varieties and labour effort, respectively, and h denotes the degree of external habit formation. The household saves by depositing funds in banks and by buying government bonds. Both of these assets have a maturity of one quarter, yield a nominal return and, in the equilibrium considered here, are perfectly riskless in nominal terms. Hence they are perfect substitutes and thus earn the same interest rate. I denote the total financial assets of households at the end of period t-1 as B_{t-1}^T and the interest rate paid on these assets in period t as R_{t-1}.

Following Schmitt-Grohe and Uribe (2005), I assume that a central authority inside the household, a union, supplies labour to a continuum of labour markets indexed by $j = [0, 1]$, with $l_t(j)$ denoting the labour supplied to market j and

$$l_t^s = \int_0^1 l_t(j)\, dj. \tag{1}$$

Labour packers operating under perfect competition buy these varieties at a wage $W_t(j)$ and aggregate them into a CES basket. Cost minimization by the labour packer implies a demand curve for variety j given by $l_t(j) = \left(\frac{W_t(j)}{W_t}\right)^{-\varepsilon_w} l_t$, where W_t and ε_w denote the price index of the labour basket and the elasticity of substitution between varieties, respectively. W_t is given by

$$W_t = \left[\left[\int_0^1 W_t^{1-\varepsilon_w}(j)\, dj\right]^{1/(1-\varepsilon_w)}\right] \tag{2}$$

The union takes W_t and l_t as given and sets $W_t(j)$ such that the households utility is maximized. I assume that in doing so, it is subject to nominal rigidities in the form of Calvo contracts. Each period, the union can not reset the wage optimally in a fraction ξ^w of randomly chosen labour markets. In these markets, wages are indexed to lagged and average inflation according to the rule $W_t(j) = W_{t-1}(j)\, \Pi^{1-\gamma_w}\Pi_{t-1}^{\gamma_w}$, where $\Pi_t = \frac{P_t}{P_{t-1}}$ and P_t denotes the price of the CES basket underlying consumption. Using (2), the law of motion of the aggregate nominal wage is given by

$$W_t = \left[(1-\xi)\left(\widetilde{W}_t\right)^{1-\varepsilon} + \xi^w\left(W_{t-1}\Pi^{1-\gamma_P}\left(\Pi_{t-1}\right)^{\gamma_P}\right)^{1-\varepsilon_w}\right]^{\frac{1}{1-\varepsilon_w}}$$

where $\widetilde{W}_t$ denotes the wage in markets where wages are optimally reset.

Households also derive profit income from their ownership of retail firms and capital good's producers. Hence their budget constraint is given by

$$P_tC_t = P_tl_t \int_0^1 w_t(j) \left(\frac{w_t(j)}{w_t}\right)^{-\varepsilon_w} dj + P_t prof_t + P_tT_t + R_{t-1}B_{t-1}^T - B_t^T \tag{3}$$

where C_t, w_t, Π_t and T_t denote consumption, the real wage, real profits and real lump sum taxes, respectively.

2.2 Capital goods producers

Capital goods producers are owned by households. They produce new capital goods using a technology which yields $1 - \frac{\eta_i}{2}\left(\frac{I_t}{I_{t-1}} - 1\right)^2$ capital goods for each unit of investment expenditures I_t. Capital goods are sold to entrepreneurs at currency price P_tQ_t. Real expected profits of the capital goods producer are then given by

$$E_t\left\{\sum_{i=0}^{\infty} \frac{\varrho_{t+i}}{\varrho_t}\beta^i I_{t+i}\left[Q_{t+i}\left(1 - \frac{\eta_i}{2}\left(\frac{I_{t+i}}{I_{t+i-1}} - 1\right)^2\right) - 1\right]\right\}$$

2.3 Retailers

The varieties of goods forming the CES basket are produced by a continuum of retail firms indexed by i. Each retailer operates under monopolistic competition and is owned by households, with the demand for it's product given by

$$Y_t(i) = \left(\frac{p_t(i)}{P_t}\right)^{-\varepsilon} Y_t$$

where $\varepsilon > 1$ denotes the elasticity of substitution between varieties. Retailers hire labour $l_t(i)$ at real wage w_t from labour packers and capital services $K_t^s(i)$ at renal rate r_t^k from entrepreneurs in economy wide factor markets. Hence the output of firm i is given by

$$Y_t(i) = (K_t^s(i))^{\alpha} (\exp(a_t) l_t(i))^{1-\alpha}$$

where a_t denotes a transitory technology shock with mean zero following an AR(1) process. I assume that retail firms have to pay fractions ψ_L and ψ_K, respectively, of their expenditures on labour and capital services in advance and borrow from banks to do so. I show in section 2.4 that the interest rate on these loans equals the risk free rate R_t. The loans are paid back at the end of period t. Hence total working capital loans to retailers L_t^r are given by

$$L_t^r = \psi_L w_t l_t + \psi_K r_t^k K_t^s \tag{4}$$

Retailers are subject to nominal rigidities in the form of Calvo (1983) contracts: Only a fraction $1 - \xi^P$ is allowed to optimize its price in a given period. Those firms not allowed to optimize its price index it to past inflation at a rate γ_P and to the steady state inflation rate Π at rate $1 - \gamma_P$. Denoting the price chosen by those firms allowed to optimize in period t as p_t^*, the aggregate price index evolves according to

$$P_t = \left[\left(1 - \xi^P\right)(p_t^*)^{1-\varepsilon} + \xi^P \left(P_{t-1}\Pi^{1-\gamma_P}(\Pi_{t-1})^{\gamma_P}\right)^{1-\varepsilon}\right]^{\frac{1}{1-\varepsilon}}$$

2.4 Banks

Following Gertler and Karadi (2010), some households in the economy are bankers. They are risk neutral and die with a fixed probability $1-\theta$ after earning interest income on the loans they made in the previous period. This assumption ensures that banks never become fully self-financing. The fraction $1-\theta$ of bankers who die are replaced by newly born bankers.[4] If banker q dies, he consumes his accumulated end-of-period t real net worth $N_t^b(q)$. Dying bankers are replaced by new ones who receive a transfer N_n^b from households.

Banks derive income from making loans to firms. This is a key difference with respect to Gertler and Karadi (2010), where banks channel funds to firms by buying equity stakes. A banker makes two types of loans. The first type are risky inter-period loans $L_t^e(q)$ to entrepreneurs who need to buy their period t+1 capital stock. These loans are due at beginning of period t+1. The second type are riskless intraperiod working capital loans L_t^r to retailers who need to pay for the labour and capital services used in production and are due at end of period t.

Following Gertler and Karadi (2010), I assume that after collecting deposits, a banker can choose to divert some of his assets for his own consumption. Specifically, a banker can divert fraction $0 \leq \lambda \leq 1$ of loans to entrepreneurs. In this case, the banker declares bankruptcy and households recover the remaining assets. This implies that households will only make deposits if the banker has no incentive to default, i.e. if $V_t^b(q) \geq \lambda L_t^e(q)$, where $V_t^b(q)$

[4] I differ from Gertler and Karadi (2010) in assuming that banks are separate risk neutral agents. Gertler and Karadi (2010) assume that banks are owned by households and transfer their terminal wealth to their household. I adopt the assumption of risk neutral bankers because a risk averse bank would complicate the problem of the entrepreneur.

denotes present value of banker q's expected real terminal wealth:

$$V_t^b(q) = E_t \left\{ \sum_{i=0}^{\infty} (1-\theta)\,\theta^i \left(\frac{1}{\prod_{j=0}^{i} R_{t+1+j}^r} \right) N_{t+1+i}^b(q) \right\}, \; R_{t+1}^r = \frac{R_t}{\Pi_{t+1}}$$

The fact that household only make deposits if the banker has no incentive to divert assets implies the bank never defaults and thus household deposits are riskless in equilibrium.

By contrast, in the management of intraperiod loans, there is no moral hazard problem between bankers and depositors and also no friction in bank-retailer relationship. Hence the loan rate is driven down to the deposit rate, implying that banks earn zero profits on these loans. Thus the intraperiod loan business does not affect $N_t^b(q)$ and $V_t^b(q)$, and thus has no impact on lending to entrepreneurs.

Let $B_t(q)$ be the amount of nominal deposits collected by the entrepreneur in order to fund interperiod loans. It follows that $P_t L_t^e(q) = P_t N_t^b(q) + B_t(q)$ and that the law of motion of banker q's net worth is given by

$$P_t N_t^b(q) = \left[R_t^b P_{t-1} L_{t-1}^e(q) - R_{t-1} B_{t-1}(q) \right] \exp(e_t^z) \quad (5)$$

$$= P_{t-1} \left[\left(R_t^b - R_{t-1} \right) L_{t-1}^e(q) + R_{t-1} N_{t-1}^b(q) \right] \exp(e_t^z) \quad (6)$$

where R_t^b denotes the average return the bank earns on the portfolio of loans to entrepreneurs made in period t-1 net of any costs associated with entrepreneurial bankruptcy. e_t^z denotes an exogenous i.i.d. shock to the capital of existing banks, which I will use below to simulate the effect of a banking crisis on the macroeconomy.

Like Gertler and Karadi (2010) I will calibrate λ such that the incentive compatibility constraint locally binds in equilibrium, hence $V_t^b(q) = \lambda L_t^e(q)$. Appendix A.4, shows that in equilibrium, all banks chose the same ratio between loans to entrepreneurs and their own net worth. Hence we have $L_t^e = \phi_t^b N_t^b$, where L_t^e and N_t^b denote total loans to entrepreneurs and total bank net worth, respectively. ϕ_t^b is determined by a complicated non-linear expression, which however reduces to one equation as we discuss below. In much of the discussion, I will refer to ϕ_t^b as bank leverage since its dynamics are both crucial for my results and are the main driver of "true" leverage, the ratio of total loans to bank net worth $\frac{L_t}{N_t^b}$.

N_t^b consists of the net worth of bankers already in business in period t-1 who did not die at the beginning of period t N_{et}^b and the net worth of new bankers N_n^b, i.e.

$$N_t^b = N_{et}^b + N_n^b$$

N_{et}^b is given by

$$N_{et}^b = \theta z_{t-1,t} N_{t-1}^b \tag{7}$$

$$z_{t-1,t} = \frac{\left[\left(R_t^b - R_{t-1}\right)\phi_{t-1}^b + R_{t-1}\right]}{\Pi_t}\exp\left(e_t^z\right) \tag{8}$$

where $z_{t-1,t}$ denotes the growth rate of real net worth of bankers already in business in period t-1 who did not die at the beginning of period t. The consumption of dying bankers is given by

$$C_t^b = (1-\theta)\, z_{t-1,t} N_{t-1}^b \tag{9}$$

For future reference, it will be useful to divide both sides of the incentive constraint $\lambda L_t^e(q) =$

$V_t^b(q)$ by $N_t^b(q)$, which yields $\lambda\phi_t^b = \frac{V_t^b}{N_t^b}$. $\frac{V_t^b}{N_t^b}$ can be interpreted as a measure of profitability, as it is the ratio of the expected value of being a banker to the own funds of the bank as of period t which generate this value. In appendix B, I show that up to first order, this constraint can be expressed as

$$\widehat{\phi}_t^b = \widehat{\left(\frac{V_t^b}{N_t^b}\right)} = \sum_{i=0}^{\infty} \left(\theta\beta^2 z^2\right)^i \phi^b \frac{R^b}{R} \left(E_t \widehat{R}_{t+1+i}^b - \widehat{R}_{t+i}\right) \tag{10}$$

with $\widehat{\phi}_t^b = \widehat{L}_t^e - \widehat{N}_t^b$. Hence bank leverage depends positively on the expected weighted sum of profit margins on loans made in period t and after $\widehat{R}_{t+1+i}^b - \widehat{R}_{t+i}$. Loosely speaking, the intuition behind this relation is as follows. If the profit margin on loans made in period t and/ or after increases, this raises the profitability of the bank $\widehat{\left(\frac{V_t^b}{N_t^b}\right)}$. This in turn reassures depositors that the bank has no incentive to default and thus they are willing to buy more deposits. Hence the bank can expand its lending to entrepreneurs and its leverage $\widehat{\phi}_t^b$.Therefore equation (10) may be interpreted as a "credit supply curve". The difference with respect to a more conventional supply curve is that it relates the supply of loans in period t not simply to the expected profit margin on loans made in period t but to the profitability of the bank and thus to the expected profit margins on both period t and future loans.

The forward looking nature of loan supply implies that future loan market equilibria have a direct effect on period t loan supply. Imagine that in some future period t+i loan demand is low relative to the own funds of the bank and thus $\widehat{\phi}_{t+i}^b$ is low, moving the bank down its supply curve. This implies that bank profitability as of period t+i $\widehat{\left(\frac{V_{t+i}^b}{N_{t+i}^b}\right)}$ declines. As a consequence, period t profitability $\widehat{\left(\frac{V_t^b}{N_t^b}\right)}$ thus the amount of deposits households are willing to make decline. The loss of funds lower $\widehat{\phi}_t^b$ and thus period t loan supply. As we will see below, this mechanism has important ramifications for the response of the economy to shocks.

2.5 Entrepreneurs

Investment decisions in the economy are made by risk neutral entrepreneurs. My assumptions regarding this sector follows Christiano et al. (2010), unless otherwise noted. At the end of period t, entrepreneur j buy capital K_t^j for price $P_t Q_t$. In period t+1, they rent part of their capital stock to retailers at a rental rate $P_{t+1} r_{t+1}^k$ and then sell the non-depreciated capital stock at price $P_{t+1} Q_{t+1}$. They are subject to capacity utilization costs $a(U_{t+1})$, where $a'(.) > 0$, $a''(.) > 0$, $a'(1) = r^k$ and $a''(1) = c^U r^k$. The average return to capital across entrepreneurs is given by

$$R_{t+1}^K = \Pi_{t+1} \frac{r_{t+1}^k U_{t+1} - a(U_{t+1}) + Q_{t+1}(1-\delta)}{Q_t} \tag{11}$$

where the optimal choice of U_t implies that

$$r_t^k = a'(U_t) \tag{12}$$

The gross nominal return of entrepreneur j is given by $\omega_{t+1}^j R_{t+1}^K$, where ω_{t+1}^j is an idiosyncratic shock creating ex-post heterogeneity among entrepreneurs with density $f(\omega^j)$, mean 1 and variance σ^2.

To fund the acquisition of the capital stock, the entrepreneur uses his own net worth $P_t N_t^j$ and a loan $P_t L_t^j = P_t \left(Q_t K_t^j - N_t^j\right)$, which is granted by the bank at a gross nominal loan rate R_t^L. Loan and interest are paid back in period t+1.

In case of default, i.e. if the realisation of $\omega_{t+1}^{j} R_{t+1}^{K}$ is so low that the entrepreneurs can not repay the loan, the bank seizes the entrepreneurs assets $\omega_{t+1}^{j} R_{t+1}^{K} K_t^j P_t Q_t$ but has to pay a fraction μ thereoff as bankruptcy cost. Hence one can define a cut-off value $\overline{\omega}_{t+1}^{j}$ for ω_{t+1}^{j} such that for values of ω_{t+1}^{j} greater or equal to $\overline{\omega}_{t+1}^{j}$, the entrepreneur is able to repay the loan: $\overline{\omega}_{t+1}^{j} R_{t+1}^{K} P_t Q_t K_t^j = R_t^L P_t L_t^j$. Furthermore, after the realisation of $\omega_{t+1}^{j} R_{t+1}^{K}$ entrepreneurs die with a fixed probability $1-\gamma$. Dying entrepreneurs consume their equity V_t. The fraction $1-\gamma$ of entrepreneurs who died are replaced by new entrepreneurs each period. This assumption ensures that entrepreneurs never become fully self-financing.

At the very beginning of period t+1, after the realization of aggregate uncertainty and in particular R_{t+1}^{K} but *before* the realization of ω^j, the expected revenue to the bank associated with loan L_t^j is given by

$$Loanrev_{t+1}^{j} = R_t^L P_t L_t^j \int_{\overline{\omega}_{t+1}^{j}}^{\infty} f\left(\omega^j\right) d\omega^j + (1-\mu) R_{t+1}^{K} P_t Q_t K_t^j \int_0^{\overline{\omega}_{t+1}^{j}} \omega^j f\left(\omega^j\right) d\omega^j \qquad (13)$$

, where the first term refers to the bank's revenue in case of non-default and the second term refers to the case of default. The expected revenue associated with loan L_t^j as of period t, on the other hand, is given by $E_t\left\{R_t^L P_t L_t^j \int_{\overline{\omega}_{t+1}^{j}}^{\infty} f\left(\omega^j\right) d\omega^j + (1-\mu) R_{t+1}^{K} P_t Q_t K_t^j \int_0^{\overline{\omega}_{t+1}^{j}} \omega^j f\left(\omega^j\right) d\omega^j\right\}$ where expectations are taken over R_{t+1}^{K} and $\overline{\omega}_{t+1}^{j}$.

In the previous section I showed that given current and expected future leverage, the incentive compatibility constraint on the banker pins down the required expected return on loans made to entrepreneurs $E_t R_{t+1}^b$ (see equation (10)). Any debt contract between the entrepreneur and the bank $\left(L_t^j, R_t^L\right)$ has to yield an expected revenue to the bank such that its expected return on these loans equals $E_t R_{t+1}^b$. Hence the participation constraint of banks in the market for loans to entrepreneurs is given by

$$E_t \left\{ R_t^L P_t L_t^j \int_{\overline{\omega}_{t+1}^j}^{\infty} f\left(\omega^j\right) d\omega^j + (1-\mu) R_{t+1}^K P_t Q_t K_t^j \int_0^{\overline{\omega}_{t+1}^j} \omega^j f\left(\omega^j\right) d\omega^j \right\} = P_t L_t^j E_t R_{t+1}^b \quad (14)$$

Note that unlike in Christiano et al.'s version of the BGG model, the loan rate is not state contingent but fixed, i.e. it does not vary with the realisation of R_{t+1}^K. Hence unexpected aggregate shocks will affect the return on bank loans via the implied unexpected losses which where not priced into the loan rate when the debt contract was made. Here I follow Zhang (2009). By contrast, in Christiano et al. (2010), the loan rate varies depending on the realisation of R_{t+1}^K in order to guarantee the bank a nominal return equal to the risk free rate. Hence their model, the following constraint has to hold in ever t+1 aggregate state:

$$P_t L_t^j R_t = R_{t+1}^L P_t L_t^j \int_{\overline{\omega}_{t+1}^j}^{\infty} f\left(\omega^j\right) d\omega^j + (1-\mu) R_{t+1}^K P_t Q_t K_t^j \int_0^{\overline{\omega}_{t+1}^j} \omega^j f\left(\omega^j\right) d\omega^j$$

However, while adding realism to the setup, the introduction of non-statecontingent contracts has only minor effects on the quantitative results.

The entrepreneurs chooses the level of K_t^j and thus implicitly a pair $\left(L_t^j, R_t^L\right)$ to maximize his expected return, which is given by

$$E_t \left\{ \int_{\overline{\omega}_{t+1}^j}^{\infty} f\left(\omega^j\right) \left(\omega^j R_{t+1}^K P_t Q_t K_t^j - R_t^L P_t L_t^j\right) d\omega^j \right\}$$

In appendix A.5, I show that all entrepreneurs choose the same leverage $\phi_t^e = \frac{Q_t K_t}{N_t}$ and derive the first order conditions. Up to first order, these equations give rise to a relationship between $E_t R_{t+1}^K / E_t R_{t+1}^b$ and the entrepreneurial leverage ratio identical to the relationship between the risk premium $E_t R^K_{t+1}/R_t$ and the leverage ratio in BGG:

$$E_t \widehat{R}^K_{t+1} - E_t \widehat{R}^b_{t+1} = \chi^l \left(\widehat{K}_t + \widehat{Q}_t - \widehat{N}_t \right) \tag{15}$$

where $\chi^l \geq 0$. Hence in the presence of both a CSV problem between firms and banks and the moral hazard problem between banks and depositors assumed here, $E_t \widehat{R}^K_{t+1} - \widehat{R}_t$ consists of two spreads, $E_t \widehat{R}^b_{t+1} - \widehat{R}_t$ and $E_t \widehat{R}^K_{t+1} - E_t \widehat{R}^b_{t+1}$. $E_t \widehat{R}^b_{t+1} - \widehat{R}_t$ is driven by bank leverage as detailed in the previous subsection. $E_t \widehat{R}^K_{t+1} - E_t \widehat{R}^b_{t+1}$ is driven by entrepreneurial leverage.

Total entrepreneurial net worth at the end of period t consists of the part of entrepreneurial equity V_t not consumed by dying entrepreneurs and a transfer from households to entrepreneurs W^e :

$$N_t = \gamma V_t + W^e \tag{16}$$

Entrepreneurial equity and consumption are given by

$$V_t = \left[\int_{\overline{\omega}_t}^{\infty} f\left(\omega^j\right) \left(\omega^j R^K_t Q_{t-1} K_{t-1} - R^L_{t-1} L^e_{t-1}\right) d\omega^j \right] \exp\left(e^N_t\right) \tag{17}$$

$$C^e_t = (1-\gamma) V_t \tag{18}$$

where e^N_t denotes an exogenous i.i.d. shock to aggregate entrepreneurial net worth.

The period t cut off value of ω dividing the population of firms into bankrupt and solvent firms $\overline{\omega}_t$ is given by

$$\overline{\omega}_t = \frac{R^L_{t-1}\left(Q_{t-1}K_{t-1} - N_{t-1}\right)}{R^K_t Q_{t-1} K_{t-1}} \tag{19}$$

Note that the lending rate is predetermined, implying that only R^K_t has a contemporaneous effect on $\overline{\omega}_t$. Finally, dividing both sides of 13 by $P_t L_t^j$, iterating one period back and using the fact that entrepreneurial leverage and the cut-off value $\overline{\omega}_t^j$ are the same across entrepreneurs as well as the law of large numbers, we have

$$R_t^b = \frac{Loanrev_t^j}{P_{t-1} L_{t-1}^j} = \left[R_{t-1}^L \int_{\overline{\omega}_t}^{\infty} f\left(\omega^j\right) d\omega^j + (1-\mu) R_t^K \frac{\phi_{t-1}^e}{\phi_{t-1}^e - 1} \int_0^{\overline{\omega}_t} \omega^j f\left(\omega^j\right) d\omega^j \right] \tag{20}$$

for the average return on on loans to entrepreneurs made in period t-1.

2.6 Monetary policy and equilibrium

Monetary policy sets the risk free interest rate, and thus the deposit rate, following an interest feedback rule of the form

$$R_t - 1 = (1-\rho_i) \left[\begin{array}{c} R - 1 + \psi_\pi E_t \left(\log\left(\Pi_{t+1}\right) - \log\left(\Pi\right)\right) \\ +\psi_{\Delta\pi}\left(\log\left(\Pi_t\right) - \log\left(\Pi_{t-1}\right)\right) + \psi_y \left(\log\left(GDP_t\right) - \log\left(GDP_{t-1}\right)\right) \end{array} \right] \tag{21}$$

$$+\rho_i \left(R_{t-1} - 1\right) + e\_i \tag{22}$$

where e_i denotes an i.i.d. monetary policy shock. This rule is taken from Christiano et al. (2010). I will draw on this paper to calibrate many of the model's parameters, including the monetary policy rule.

The resource constraint is given by

$$S_t = (1-\xi^P)\left(\frac{\Pi_t}{\Pi_t^*}\right)^{\varepsilon} + \xi^P\left(\frac{\Pi_t}{\Pi_{t-1}^{\gamma_P}\Pi^{1-\gamma_P}}\right)^{\varepsilon} S_{t-1} \tag{23}$$

$$C_t^P = C_t + C_t^e + C_t^b \tag{24}$$

$$Y_t = S_t \left(\begin{array}{c} I_t + C_t^P + Gov_t \\ +a(U_t)K_{t-1} + \frac{R_t^K}{\Pi_t} Q_{t-1}K_{t-1}\mu \int_0^{\overline{\omega}_t} \omega f(\omega)\, d\omega \end{array} \right) \tag{25}$$

$$Y_t = (K_{t-1}U_t)^{\alpha}(A_t l_t)^{1-\alpha} \tag{26}$$

$$GDP_t = I_t + C_t + Gov_t \tag{27}$$

where S_t denotes the efficiency loss arising from price dispersion and Gov_t denotes government expenditure. The law of motion of capital is given by

$$K_t = (1-\delta)K_{t-1} + I_t\left(1 - \frac{\eta_i}{2}\left(\frac{I_t}{I_{t-1}} - 1\right)^2\right) \tag{28}$$

2.7 Two simplifications of the full model

Below I will compare the response of the model developed in this paper to two simplified versions. The first is a BGG model with a passive banking sector. Specifically, I assume that there is no moral hazard problem between bankers and depositors ($\lambda = 0$) and assume that the loan rate on loans made in period t adjusts after period t+1 shocks are realized in order to ensure that the bank receives a risk free nominal return, which, with $\lambda = 0$, equals the risk free rate R_t. Hence this model features a financial accelerator as in Christiano (2010). The presence of the passive banking sector has no impact on dynamics of the real economy. However, it will be helpful to understand why the economy responds differently to shocks once $\lambda > 0$. The second version is a model where households accumulate the capital stock K_t in order to rent it to retailers in period t+1. Hence apart from the working capital constraint on retailers, there are no financial frictions.

3 Calibration

I calibrate the model to US data over the period from 1990Q1-2010Q1 All data sources are described in appendix G. After setting Π equal to the average percentage change in the GDP deflator, β set such that R equals the average federal funds rate. Some of the parameters pertaining to the various financial frictions in the banking and entrepreneurial sector are calibrated such that the steady state values of important financial variables in the model equal averages of certain financial data time series for the financial and non-farm business sector. This route is also followed by Christiano et al. (2010), Meh and Moran (2010), Nolan and Thoenissen (2009) and Bernanke et al. (1999). Each of the targets is displayed in table 3.

The parameters pertaining to the entrepreneurial sector are σ, μ, γ and W^e. μ is set to lie in the range of estimates of bankruptcy costs cited by Carlstrom and Fuerst (1997). σ is calibrated such that firm leverage ϕ^e and the default rate F meet target values. The target for the probability of default is taken from Bernanke et al. (1999). The target for firm leverage is the average ratio between total liabilities and total net worth of the nonfarm nonfinancial business sector, taken from the Flow of Funds account (FFA) of the Federal Reserve Board.[5] γ is calibrated close to values used by Christiano et al. (2010) and Bernanke

[5]Both net worth and total liabilities are summed up across the non-farm business sector. The resulting leverage ratio is 1.85. A more restrictive measure of net worth suggested by Fuentes (2009) substracts total

et al. (1999), which backs out W^e.

The parameters pertaining to the banking sector are λ, θ and W^b. They are calibrated to meet targets for the cost of external finance of entrepreneurs $R^L - R$, the bank capital ratio $\frac{N^b}{L}$ and probability of bank death $1-\theta$. The target for $R^L - R$ is an estimate of Levin et al. (2007), estimate the cost of external finance of 796 publicly traded nonfinancial companies over the period 1997Q1 to 2004Q4. They match the daily effective yield on each individual security issued by the firm to the estimated yield on a treasury coupon security of the same maturity. [6] The target for $\frac{N^b}{L}$ is average ratio between tangible common equity (TCE) and risk weighted assets (RWA) of Federal Deposit Insurance Corporation (FDIC) insured institutions. Among available empirical measures of bank net worth, TCE comes closes to the definition of bank net worth in my model. The calculation of RWA attaches weights between 0 and 1 to individual assets according to their risk and liquidity as specified by the Basel I agreement. The probability of bank death is $1-\theta$ is set close to the median probability of bank default as estimated by Carlson et al. (2008) over the sample period.

I assume that retailers have to pay the all of their capital and labour costs in advance by taking up working capital loans, i.e. $\psi_L = \psi_K = 1$.

Most parameters not pertaining to the financial frictions in the model are calibrated according to choices and estimates of Christiano et al. (2010), who estimate a model with a financial accelerator. Exceptions are the cost of changing capacity utilization, c^U, and the cost of adjusting investment, η_i, where Christiano et al.'s estimates are unusually high.

credit market instruments from total tangible (as opposed to financial) assets. This measure implies a leverage ratio of 1.7, which is still close to the target under the baseline calibration. Setting the target for ϕ^e to 1.7 has small effects on the numerical results reported below, which however all go in the direction of somewhat strengthening my conclusions, in particular regarding the performance of the two models relative to the data.

[6] They also correspond for the differential tax treatment of government and corporate bonds.

In the moment comparison I will consider three stochastic processes, a monetary policy shock, a transitory productivity shock and a government spending shock. The later both follow AR(1) processes. All stochastic processes are calibrated to the estimates of Christiano et al. (2010). I consider only these three standard shocks in order to let the amplification and propagation mechanisms of the model speak for themselves.

Table 1: Calibration of non-policy parameters			
Parameter	**Description**	Full model	BGG model
β	Household discount factor	0.9938	0.9938
φ	Inverse Frisch elasticity	1	1
h	External habit formation	0.63	0.63
α	Capital Elasticity of Output	0.33	0.33
δ	Depreciation rate	0.025	0.025
η_i	Investment adjustment cost	4	4
c^U	Capital utilization cost	1.5	1.5
ε	Elasticity of substitution between varieties	11	11
ξ^P	Probability of non-reoptimisation of prices	0.7	0.7
ι^P	Degree of indexing with respect to past inflation	0.841	0.841
ε^W	Elasticity of substitution between labour varieties	21	21
ξ^W	Probability of non-reoptimisation of wages[7]	0.947	0.947
ι^W	Wage indexing with respect to past inflation	0.715	0.715
θ	Survival probability of bankers	0.9915	0.9915
ψ_L	Share of retailer's labour costs paid in advance	1	1
ψ_K	Share of retailer's capital rental paid in advance	1	1
λ	fraction of bank assets the banker can divert	0.2351	0
σ	Standard deviation of the idiosyncratic shock	0.3 (backed out)	0.3
μ	Bankruptcy costs	0.2981	0.2981
γ	Survival probability of entrepreneurs	0.972	0.972

[7] Here the calibration exceeds Christiano et al.'s (2010) estimate because my assumption about wage

Table 2: Policy parameters and shocks		
ψ_π	Coefficient on inflation in the Taylor rule	1.82
$\psi_{\Delta\pi}$	Coefficient on inflation change in the Taylor rule	0.18
ψ_y	Coefficient on GDP growth in the Taylor rule	0.31/4
ρ_i	Coefficient on the lagged interest rate in the Taylor rule	0.88
ρ_a	Persistence productivity shock	0.816
ρ_g	Persistence Gov. spending shock	0.93
σ_i	Sd. monetary policy shock	0.0013
σ_a	Sd. productivity shock	0.008
σ_g	Sd. government spending shock	0.021

Table 3: Important steady-state values		
Variable	**Description**	**Value**
R	Risk free rate, APR	3.97%
Π	Inflation target, APR	2.23%
$R^L - R$	Spread of the loan rate over the risk free rate, APR	1.35%
ϕ^1	Leverage in firm sector	1.87
$F(\overline{\omega})$	Quarterly bankruptcy rate, percent	0.75% (calibrated)
$\frac{N^b}{L}$	Bank capital ratio, percent	9.81%

setting differ from their's. They follow Erceg et al. (2000) in assuming that each household monopolistically supplies one labour variety from the labour basket, implying that with wage stickiness, labour supply will vary across households. By contrast, I follow Schmitt-Grohe and Uribe (2005) and assume that one representative household supplies all varieties. This implies that an important source of strategic complementary is abesent from my model. Specifically, the coefficient on the wage markup in the equation determining the real wage will be $\frac{(1-\xi^W)(1-\beta\xi^W)}{(1+\beta)\xi^W}$ in my model while it will be $\frac{(1-\xi^W)(1-\beta\xi^W)}{(1+\beta)\xi^W(1+\varepsilon^W\varphi)}$ in the Christiano et al.'s (2010) framework, implying that given ξ^W, the coefficient on the wage markup in their model will be lower than in mine. Therefore I adjust ξ^W upwards in order to ensure that the mark up coefficent in my model is the same as in Christiano et al. (2010). This procedure was suggested by Schmitt-Grohe and Uribe (2005).

4 Impulse responses

I now discuss the response of the model economy to the three standard shocks. The response of the three economies to a contractionary one standard deviation monetary policy shock is displayed in Figure 1. All charts display log-deviations of the respective variables from their respective steady states, unless the variables are in percentage terms in the first place. Throughout this section I will compare impulse responses of the model I develop in this paper, which I refer to as "full model" with the impulse responses of the two simpler models sketched in section 2.7. The response of GDP is the strongest in the full model (labelled "Full") with a through of -0.89%, reached in quarter 3, while it is the weakest in the model without financial frictions (labelled "nofr", henceforth referred to as "nofriction model"), where the through of GDP equals -0.44%. The response of GDP in the BGG model (labelled "BGG") is in between the full model and the no friction model, with a through of -0.62%. Note that the path of GDP in the nofriction model remains persistently above the path of GDP in the two models with financial frictions. The differences in the GDP declines across the three models is mainly caused by differences in the decline of investment. The through of investment is -2.59% in the full model, -1.67% in the BGG model and -0.88% in the nofriction model, while the path of consumption is much more similar across the three models.

The reason why the response of output to a monetary policy shock is stronger in the BGG model than in the nofriction model is well understood. The increase in the interest rate reduces the price of capital goods $\widehat{Q}_t$ since future rental income to capital is discounted more heavily. This directly reduces investment in both models but in the BGG model also reduces entrepreneurial net worth $\widehat{N}_t$ and increases entrepreneurial leverage. The increase in leverage requires an increase in $E_t\widehat{R}^K_{t+1} - \widehat{R}_t$ via (15) since it increased expected bankruptcy costs. Hence $\widehat{Q}_t$ and thus investment decline even more. The drop in $\widehat{N}_t$ also reduces entrepreneurial consumption.

To understand why GDP responds more strongly to a monetary policy shock in the full model than in the BGG model, it is useful to examine the response of bank and entrepreneurial net worth, entrepreneurial loans and bank leverage in the passive banking sector of the BGG model. Bank net worth $\widehat{N}^b_t$ persistently increases until it peaks in quarter 9. The reason for the increase in $\widehat{N}^b_t$ is the increase in the riskless rate. A higher $\widehat{R}_t$ increases the (accounting) profits banks earn on loans they fund using their own net worth. At the same time loans to entrepreneurs $\widehat{L}^e_t$ first increase until quarter 6 since the drop in entrepreneurial net worth increases their demand for funds, but then persistently decrease since the erosion of the capital stock caused by the persistent decline in investment ultimately reduces it. As a result of the dynamics of $\widehat{L}^e_t$ and $\widehat{N}^b_t$, bank leverage $\widehat{\phi}^b_t$ decreases very persistently until it is about 0.9% below its steady state in period 23.

Now imagine the consequences such a declining path of bank leverage would have in the presence of a moral hazard problem in the banking sector like in the full model, i.e. in a situation where the "loan supply curve" (10) holds. The below steady state loan demand relative to the own funds of the bank implies that profitability as of period 23 is also below normal since $\widehat{\left(\frac{V^b_{23}}{N^b_{23}}\right)} = \widehat{\phi}^b_{23} < 0$. The market for loans in period 23 has a lot of slack and thus profit margins on loans made in period 23 and/ or after $E_1\widehat{R}^b_{24+i} - \widehat{R}_{23+i}$ are driven down by competition among banks. However, the below-steady-state profitability in period 23 also reduces profitability in period one since there is a high probability that existing banks are still in business period 23. Hence in period one, households are worried that the bank might decide to default. Therefore they withdraw deposits, thus forcing individual banks to restrict their supply of loans. The tightened loan supply increases the profit margins on loans made in period one and/or after, which tends to increase bank profitability and thus to reassure depositors.

Figure 1 shows that $E_t\widehat{R}^b_{t+1} - \widehat{R}_t$ indeed increases on impact by about 0.81% at an annualized rate in the full model and remains positive until quarter 9. The persistent increase in $E_t\widehat{R}^b_{t+1} - \widehat{R}_t$ accelerates the financial accelerator by adding to the increase of the spread between the expected return on capital $E_t\widehat{R}^K_{t+1}$ and the risk free rate $\widehat{R}_t$. $E_t\widehat{R}^K_{t+1} - \widehat{R}_t$ increases by 1.5% and 0.37% in the full model and in the BGG model, respectively. Hence more than two thirds of the difference in $E_t\widehat{R}^K_{t+1} - \widehat{R}_t$ between the two models is explained by the increase in $E_t\widehat{R}^b_{t+1} - \widehat{R}_t$ in the full model. The higher path of $E_t\widehat{R}^K_{t+1}$ in the full model in turn causes a stronger drop in $\widehat{Q}_t$ and entrepreneurial net worth $\widehat{N}_t$. The stronger drop in $\widehat{N}_t$ itself contributes to the stronger increase in $E_t\widehat{R}^K_{t+1} - \widehat{R}_t$ in the full model since it implies a stronger increase in entrepreneurial leverage, which increases $E_t\widehat{R}^K_{t+1} - E_t\widehat{R}^b_{t+1}$. The stronger decline in $\widehat{Q}_t$ causes the stronger contraction of investment observed in the full model. Farther, the stronger decline entrepreneurial net worth also means that entrepreneurial consumption declines more strongly in the full model than in the BGG model.

The increase in $E_t\widehat{R}^b_{t+1} - \widehat{R}_t$ is to a large extent driven by an internal acceleration mechanism in the banking sector. The increase in $\widehat{R}^b_{t+1} - \widehat{R}_t$ magnifies the growth of bank net worth relative to the BGG model. As a consequence, the decline in bank leverage $\widehat{\phi}^b_t$ is much steeper than in the BGG model.

The lower response of output to a monetary policy shock in the BGG model as compared to our full model is in line with Euro area evidence by Ciccarelli et al. (2011). They estimate a VAR featuring a survey based measures of the change in the tightness of credit supply of banks with a separate variables for changes in credit supply due to reasons related to the banks own balance sheet. Ciccarelli et al. (2011) find that when they conduct a counterfactual analysis where the impact of the monetary policy shock on changes in credit supply related to bank balance sheet reasons is neutralized, the response of GDP to a monetary policy shock is reduced by 50%.

Note also that, following an on-impact-decline, the full model predicts a persistent increase of loans in response to a monetary tightening while the BGG model predicts a persistent decline. Two recently proposed DSGE models featuring leverage constraints in both the banking and business sector proposed by Meh and Moran (2010) and Gerali et al. (2010), respectively, also find a persistent decline of loans to businesses following a monetary tightening. However, the increase of loans observed in the full model is in line with evidence provided by den Haan et al. (2007), who estimate a VAR featuring loans to businesses and bank net worth. On the other hand, den Haan et al. (2007) also find that bank net worth decreases in response to a monetary policy shock, a feature captured by Meh and Moran (2010) but neither by our model nor the model of Gerali et al. (2010). The failure of my model to produce a decline in bank net worth might be related to two simplifying assumptions, namely the one quarter maturity of contracts and the absence of any traded assets from the banks portfolio. The re-negotiation of debt contracts after one quarter implies that unexpected entrepreneurial defaults not yet priced into the loan rate can occur only on impact but not afterwards. The absence of traded assets imply that banks profits will be unaffected by the loss in value such assets typically suffer in response to a monetary tightening.

Figure 2 displays the response of the three economies to a contractionary transitory technology shock. The on-impact response is twice as big in the full model as in the BGG model. Over time, as GDP declines further in both models the difference between the two models diminishes and the path of GDP. The stronger decline in the full model than in the BGG model is caused both by a stronger drop in consumption and investment, with the latter becoming more important with each passing quarter. The response of GDP in the no friction model is close to the full model during the first couple of quarters but then becomes visibly stronger than in both models.

The reason for the weaker output response of the BGG model than the nofriction model is that in the presence of a nominal debt contract, the unexpected increase in inflation caused by the technology shock reduces the debt burden of entrepreneurs and thus increases their net worth. At the same time the technology shock persistently lowers investment and thus the capital stock and loans to entrepreneurs. Hence entrepreneurial leverage and thus $E_t\widehat{R}^K_{t+1}-\widehat{R}_t$ persistently decline and therefore the decline in investment, entrepreneurial consumption and GDP is attenuated relative to the nofriction model. Christiano et al. (2010) also find that with a nominal debt contract, a CSV problem between entrepreneurs and banks attenuates the effect of transitory technology shocks.

The response of bank net worth $\widehat{N}^b_t$, loans to entrepreneurs $\widehat{L}^e_t$ and bank leverage $\widehat{\phi}^b_t$ in the BGG model is again instructive to understand how the bank leverage cycle amplifies the response of the full relative to the BGG model. We have already noted that $\widehat{L}^e_t$ persistently decreases. $\widehat{N}^b_t$ decreases until quarter four since monetary policy is slow to increase the nominal interest rate in response to the uptick in inflation following the technology shock, but then starts recovering. The declining path of $\widehat{L}^e_t$ and the hump shape of $\widehat{N}^b_t$ generate a declining path of $\widehat{\phi}^b_t$. In the full model, the low future loan demand relative to the net worth of banks causes a cut in loan supply in period one and after. The banking sector profit margin $E_t\widehat{R}^b_{t+1} - \widehat{R}_t$ increases, implying that $E_t\widehat{R}^K_{t+1} - \widehat{R}_t$ is positive in the full model and much higher than in BGG model. The higher path of $E_t\widehat{R}^K_{t+1} - \widehat{R}_t$ lowers the capital good's price $\widehat{Q}_t$, entrepreneurial net worth $\widehat{N}_t$ and thus investment and entrepreneurial consumption relative to the BGG model.

I now check whether and how the BGG model is able to generate the same response of output to monetary policy and productivity shocks if the financial accelerator χ^l is increased.[8] I increase χ^l by increasing μ, the share of a bankrupt entrepreneurs assets that has to be paid as bankruptcy cost. Setting $\mu = 1$, its maximum and far above available empirical estimates indeed reduces the through of GDP in the BGG model to -0.78%, not too far away from the -0.89% observed in the full model. However, since, as discussed above, the BGG financial accelerator attenuates technology shocks, a higher χ^l further reduces the response of output to a technology shock in the BGG model. What is more, setting $\mu = 1$ would imply an unreasonably high annualized steady-state real return on capital $\frac{R^K}{\Pi} - 1$ of 21.6%.[9]

By contrast, the response of GDP to an expansionary government spending shock is strongest in the BGG model, followed by the nofriction and the full model. The crowding out of investment and consumption is the smallest in the BGG model. Entrepreneurial net worth persistently increases since the real interest rate initially declines in response to the shock, while loans to entrepreneurs persistently decrease since the capital stock declines. Hence entrepreneurial leverage and $E_t\widehat{R}^K_{t+1} - \widehat{R}_t$ fall, thus limiting the decline investment as compared to the nofriction model. The decline in loans to entrepreneurs drives a persistent

[8] I thank Hans Dewachter for raising this issue.

[9] An alternative way to increase χ^l would be to increase the degree of idiosyncratic capital return uncertainty σ.However, this would also lower entrepreneurial leverage, implying that the response of the economy to a monetary policy shock is actually dampened.

decline in bank leverage $\widehat{\phi}_t^b$. In the full model, this decline causes an increases in the banking sector profit margin and hence $E_t\widehat{R}_{t+1}^K - \widehat{R}_t$ rises more in the full model than in the BGG model, implying a stronger crowding out of investment.

5 Moment comparison

I now compare the cyclical properties of some important real and financial variables in the full model and in the BGG model to their counterparts data. The real variables considered are GDP, consumption, non-residential investment and hours worked. For the full model, the financial variables considered are the cost of external finance $R_t^L - R_t$, entrepreneurial leverage ϕ_t^e, the bank capital ratio $\frac{N_t^b}{L_t}$, L_t and N_t^b. In the BGG model, the loan rate on loans made in period t is determined only in period t+1, after the realisation of aggregate shocks in period t+1. Therefore, I choose the spread between the loan rate which borrowers at time t expect to pay in case of non default and the policy rate, $E_tR_{t+1}^L - R_t$ as the BGG models measure of the cost of external finance.[10]

As a measure of the cost of external finance in the data, I use the difference between the BAA composite corporate bond rate and the effective federal funds rate, as suggested by Christiano (2010).[11] For the remaining variables, I use the same measures used as targets when calibrating the model. All data except for $R_t^L - R_t$ and $\frac{N_t^b}{L_t}$ was logged and HP filtered.

[10] Christiano at al. (2010) suggest to use an alternative variable as the model's measure of the cost of external finance: the actual transfer of recources from entrepreneurs to banks per unit of loans made minus the policy rate. Using this variable yields virtually identical results both in the full and in the BGG model.

[11] I also considered the spread between BAA rated bonds and the three month treasury bill rate, between AAA rated bonds and the effective federal funds and between AAA rated bonds and the three month treasury bill rate, used by Nolan and Thoenissen (2009). The cyclical properties of these measures of the cost of external finance differ only slightly from the difference between BAA rated bonds and the federal funds rate.

Table 4: Standard deviations relative to GDP			
Variable	**Data**	**Full model**	**BGG model**
$\widehat{GDP}_t$	1	1	1
$\widehat{C}_t$	0.81	0.91	0.93
$\widehat{I}_t$	4.44	2.81	2.34
$\widehat{l}_t$	1.61	1.29	1.39
$\widehat{R}_t^L - \widehat{R}_t; E_t\widehat{R}_{t+1}^L - \widehat{R}_t$, APR	0.99	0.95	0.11
$\widehat{\phi}_t^e$	1.99	1.37	1.00
$\widehat{N}_t$	4.53	3.03	2.08
$\widehat{\left(\frac{N_t^b}{L_t}\right)}$	0.4	0.53	0.07
$\widehat{L}_t$	2.45	0.66	0.77
$\widehat{N}_t^b$	2.42	5.46	0.89

Table 4 displays the standard deviations of the various variables relative to GDP. Both models match the relative volatility of consumption. The full model generates considerably more volatility than the BGG model for I_t, ϕ_t^e, N_t and thus comes closer to the data, although the relative volatilities of all these variables are still too low. Both models also produce a too low relative volatility of loans. By contrast, the full model very closely matches the relative volatility of the cost of external finance. Here the full model greatly improves upon the BGG model, which generates only one tenth of the relative volatility of this variable observed in the data. This is in line with Christiano et al. (2010), who finds that in his estimated version of the BGG model, shocks directly hitting the entrepreneurial sector, i.e. shocks to entrepreneurial net worth or the degree of idiosyncratic capital return uncertainty, explain about 99% of the variation of the cost of external finance at the business cycle frequency.

Using a different methodology, Nolan and Thoenissen (2009) also carry a BGG type model to the data and find that financial shocks explain a large share of the variation of the cost of external finance. By contrast, my full model explains the relative volatility of cost of external finance relying purely on conventional shocks. The fact that the relative volatility of the cost of external finance is higher in the full model than in the BGG model is due to the dynamics of the banking sector profit margin $E_t\widehat{R}^b_{t+1} - \widehat{R}_t$ in the full model discussed in the previous section.[12]

The full model also performs much better at matching the relative volatility of the capital ratio $\widehat{\left(\frac{N^b_t}{L_t}\right)}$ than the BGG model, where it is far too low. By contrast, the relative volatility of $\widehat{N}^b_t$ in the model is much higher than in the data. Section 4 mentioned two mechanisms absent from the model, namely multi-period debt contracts and securities in the loan portfolio of the bank, which would potentially dampen or reverse the increase in bank net worth in response to a monetary policy shock. The too high volatility of $\widehat{N}^b_t$ might be partly due to the absence of these features.

[12]The attentive reader might notice that while the impulse responses of $E_tR^K_{t+1} - R_t$ discussed in the previous section suggest a higher volatility of the cost of external finance in the full model than in the BGG model, they do not suggest a volatility more than 10 times as high, which is what is table 4 says. However, note that table 4 is based on the standard deviations of $R^L_t - R_t$ and $E_tR^L_{t+1} - R_t$, the spread of the (observable) loan rate over the risk free rate, in the two models, while what I was discussing in the previous section are the responses of $E_tR^K_{t+1} - R_t$, the spread of the (unobservable) expected return to capital over the risk free rate, in the two models. The impulse responses of the cost of external finance are qualitatively very similar to the responses of $E_tR^K_{t+1} - R_t$ in both models but differ quantitatively. For instance, the on impact response of the cost of external finance to a monetary policy shock is indeed more than 10 times as high in the full model as in the BGG model, even though the response of $E_tR^K_{t+1} - R_t$ is only a bit more than four times as high.

Table 5: Correlations with GDP			
Variable	**Data**	**Full model**	**BGG model**
$\widehat{GDP}_t$	1	1	1
$\widehat{C}_t$	0.89	0.89	0.85
$\widehat{I}_t$	0.88	0.89	0.87
$\widehat{l}_t$	0.86	0.9	0.86
$\widehat{R}^L_t - \widehat{R}_t$, $E_t\widehat{R}^L_{t+1} - \widehat{R}_t$, APR	-0.62	-0.77	-0.56
$\widehat{\phi}^e_t$	-0.61	-0.75	-0.53
$\widehat{N}_t$	0.73	0.79	0.73
$\widehat{\left(\frac{N^b_t}{L_t}\right)}$	-0.44	-0.32	-0.56
$\widehat{L}_t$	0.37	0.60	0.66
$\widehat{N}^b_t$	-0.12	-0.25	0.15

Turning to the cyclicality of the various variables, in the full model all correlations with GDP are correctly signed. Both models perform similarly well at matching the correlations of $\widehat{C}_t$, $\widehat{I}_t$, the cost of external finance, $\widehat{\phi}^e_t$, $\widehat{N}_t$, $\widehat{L}_t$ and $\widehat{\left(\frac{N^b_t}{L_t}\right)}$ with output. The ability of the two models to match the countercyclicality of the bank capital ratio $\widehat{\left(\frac{N^b_t}{L_t}\right)}$ (and thus the procyclicality of bank leverage $\widehat{\left(\frac{L_t}{N^b_t}\right)}$)is apparent from its increases in response to the contractionary monetary policy- and technology shocks in both models as displayed in the panels in the lower right corners of figures 1 and 2. The rise of $\widehat{\left(\frac{N^b_t}{L_t}\right)}$ is driven by the decline of $\widehat{\phi}^b_t$ in response to these shocks, which was discussed in the previous section. Finally, only the full model is able to reproduce the mild countercylcality of bank net worth $\widehat{N}^b_t$ observed in the data, while this variable is mildly procyclical in the BGG model.

Note that in the data, there is an interesting discrepancy between the firm and banking sector as far as the cyclicality of leverage and net worth is concerned. While in the firm sector, leverage is countercyclical and net worth is procyclical, the opposite is true in the banking sector.[13] The full model is able to reproduce this phenomenon.

Table 6 Autocorrelations			
Variable	**Data**	**Full model**	**BGG model**
$\widehat{GDP}_t$	0.85	0.83	0.84
$\widehat{C}_t$	0.88	0.78	0.84
$\widehat{I}_t$	0.91	0.92	0.93
$\widehat{l}_t$	0.93	0.78	0.75
$\widehat{R}_t^L - \widehat{R}_t$ APR	0.91	0.72	0.68
$\widehat{\phi}_t^e$	0.94	0.66	0.68
$\widehat{N}_t$	0.94	0.62	0.62
$\frac{\widehat{N}_t^b}{\widehat{L}_t}$	0.83	0.95	0.92
$\widehat{L}_t$	0.93	0.86	0.91
$\widehat{N}_t^b$	0.81	0.95	0.94

Regarding the models' ability to reproduce the persistence in the data, both models perform well at matching the autocorrelations of GDP_t, C_t, I_t and L_t. The autocorrelations of $R_t^L - R_t$, ϕ_t^e and N_t are very similar but too low in both models. Both the autocorrelations of $\frac{N_t^b}{L_t}$ and N_t^b are somewhat too high in both models.

Overall, it seems that the amplification provided by the informational frictions in the banking-depositor relationship allows my model to perform better than the BGG model at matching the volatility of the external finance premium, investment and other variables

[13]Note that banking sector leverage is simply the inverse of the bank capital ratio $\frac{N_t^b}{L_t}$.

relative to output. Furthermore, the full model performs well at reproducing the statistical properties of the bank capital ratio aka bank leverage, which is instrumental in generating the extra volatility of $R_t^L - R_t$ in the full model.

6 Robustness

In appendix G.1, I investigate the robustness of my key results so far. I redo the exercises of the previous two sections under numerous deviations from the baseline calibration and the baseline assumptions regarding monetary policy, described in detail in section G.1. As in section 4, I find that typically in the full model the response of output and investment both to monetary policy shocks and to technology shocks is amplified, with the amplification typically being more persistent for monetary policy shocks. The relative performance of the two models at matching the second moments of the data is also broadly robust across the various experiments.

7 Financial shocks and crisis experiment

In this section I examine how the model economy responds to shocks to the balance sheets of entrepreneurs and banks, and whether a reasonably calibrated combination of those shocks can produce a downturn of a magnitude comparable to the "Great Recession" currently observed in the United States.

Figure 4 displays the response of the full model and the BGG model to one-off -1% exogenous shock to entrepreneurial net worth $\widehat{N}_t$, which I implement by setting $e_t^N = 0.01$ for one period. This type of shock has been used by numerous authors using BGG type models, including Christiano et al. (2010) and Nolan and Thoenissen (2009). GDP declines in both models but at the through more than twice as much in the full model than in the BGG model, mainly due to a stronger decline in investment. In both models, the reduction in $\widehat{N}_t$ increases entrepreneurial leverage $\widehat{\phi}_t^e$ since entrepreneurs need to borrow more to fund their capital stock. The resulting increase in leverage $\widehat{\phi}_t^e$ causes an increase in the spread between the expected return on capital and the risk free rate $E_t\widehat{R}_{t+1}^K - \widehat{R}_t$ thus a drop in $\widehat{Q}_t$, which enhances the initial drop in $\widehat{N}_t$ and lowers investment and entrepreneurial consumption. Turning to the passive banking of the BGG model, the immediate and persistent increase in entrepreneurial borrowing causes an immediate persistent increase in bank leverage $\widehat{\phi}_t^b$. $\widehat{\phi}_t^b$ then gradually declines as the decline in the capital stock and the recovery of $\widehat{N}_t$ gradually lowers entrepreneurial borrowing. In the full model, depositors will only accommodate such an expansion the banks balance sheet and leverage if bank profitability $\widehat{\left(\frac{V_t^b}{N_t^b}\right)}$ increases as well, which requires an increase of the banking sector profit margin $E_t\widehat{R}_{t+1}^b - \widehat{R}_t$. Hence the increase in $E_t\widehat{R}_{t+1}^K - \widehat{R}_t$, the $\widehat{Q}_t$, investment, $\widehat{N}_t$ and entrepreneurial consumption are all much stronger than in the BGG model.

Figure 5 displays the response of the full model to a negative exogenous one-off shock to bank capital N_t^b of 5%. For that purpose I set $e_t^z = 0.05$ for one period. GDP contracts in response to the shock and reaches a through of -0.28% in quarter 2. The GDP decline mainly driven by a drop in investment, which declines by -0.56% on impact and reaches a through of -1.2% in quarter 4. The GDP decline is very persistent. After 20 quarters, it is still 1.1% below its steady state. Given loan demand, the decline in $\widehat{N}_t^b$ of about 5% increases bank leverage $\widehat{\phi}_t^b$, which requires higher profitability $\widehat{\left(\frac{V_t^b}{N_t^b}\right)}$ and thus a higher banking sector profit margin $E_t\widehat{R}_{t+1}^b - \widehat{R}_t$. The implied $E_t\widehat{R}_{t+1}^K - \widehat{R}_t$ increase in $E_t\widehat{R}_{t+1}^K - \widehat{R}_t$ causes a contraction of

$\widehat{Q}_t$, entrepreneurial net worth and thus the observed decline in investment and consumption.

Loans to entrepreneurs decline on impact, then move somewhat above the steady state from quarter three to eight, and then again move very persistently and substantially below steady state. The decline in their net worth implies that entrepreneurs have to borrow more. As their net worth gradually recovers and the gradual decline of the capital stock lowers their need for external funds, loans to entrepreneurs persistently decline. The non-monotonic path of loans to entrepreneurs results in a qualitatively similar path of total loans.

Note that in my model the shock to bank capital resembles a demand shock in that reduces both output and inflation. By contrast, in the models of Gerali et al. (2010) and Meh and Moran (2010) it appears to resemble a supply shock in that it lowers output but increases inflation. The results of the few studies trying to empirically estimate the macroeconomic effects of a shock to bank capital tend to be more in line with the model developed in this paper. Ciccarelli et al. (2011), for Euro area, find that their proxy for a shock to bank capital moves output and inflation in the same direction. Fornari and Stracca (2011), obtain the same result in a multi country panel unless they exclude the worldwide financial crisis, i.e. 2007-2009, from the sample, which renders the inflation response insignificant.

I now examine to which extent a reasonably calibrated sequence of shocks to the net worth of banks can generate a downturn similar in magnitude to the "Great Recession" experienced by the US economy as a consequence of the financial crisis of. In the April (2010) version of its global financial stability report (GFS), the IMF estimates that US banks had to write off 7% of the total value of the customer loans and securities on their balance sheets over the period 2007Q2-2010Q4. To assess the consequences of this type of event in the full model, I assume that banks loose an amount of their net worth equivalent to 7% of their assets.

The losses spread equally over the first 15 quarters and are implemented by a series of 15 consecutive unexpected shocks to bank net worth e_t^z, where each shock equals -0.0476.

Figure 6 displays the log-deviation of per capita GDP, consumption, non-residential investment and our measure of credit to non-financial businesses in the US economy from a quadratic trend from 2007Q2 to 2010Q2, normalized by their log-deviation from trend in 2007Q1, and the deviation of our measure of the cost of external finance from its value in 2007Q2, all labelled by an "_Data". The declines of US consumption and GDP relative to trend start in 2007Q2 and 2007Q3, respectively, while investment continues to increase relative to trend until 2008Q1. The throughs of GDP, consumption and investment are -7.9%, -8.4% and -22.5 and are reached in 2009Q3, 2010Q2 and 2009Q4, respectively. Our measure of the cost of external finance, the difference between the BAA composite corporate bond rate and the effective federal funds rate, increases continuously until peaking in 2008Q4 at 7.29% and then slowly declines.[14] Furthermore, note that our measure of loans to non-financial firms actually increases relative to trend until peaking in 2008Q1 at 6.7% and by 2008Q4 is still 5.9% above trend, when GDP and investment have already declined -5.1 and -7.7% relative to trend, respectively. The absence of a marked decline in aggregate lending to non-financial firms by the end of 2008, in spite of the financial crisis, is also noted by Chari et al. (2008).

Figure 6 also displays the path of these variables in the model, labelled "_ez". The economic downturn observed in the model has a similar persistence but a much lower magnitude, with the maximum deviation of investment, GDP and consumption relative to trend

[14]The alternative measures of the cost of external finance mentioned in footnote 11 closely track this measure.

equalling about one half (-11%), one third (-2.5%) and one seventh (-1.2%) of what is observed in the data. Similarly, the cost of external finance increases with a similar persistence as in the data but peaks at 3.1% above its steady state, or about two fifths of its peak in the data. Furthermore loans decline, rather than displaying the strong increase observed in the data during the first year. However, the decline in loans is much more gradual than the decline in GDP.

According to the Flow of Funds Accounts, the net worth of non-financial firms in the United States also declined during the crisis. Relative to a quadratic trend, real per-capita net worth declined by about 40% from 2007Q2 to 2009Q4. Figure 6 shows that in response to the series of shocks to bank net worth, entrepreneurial net worth is only 7% below its steady state in 2009Q4 (quarter 11). Therefore I add a series of 11 consecutive unexpected shocks to entrepreneurial net worth e_t^N to the above experiment, where each shock equals -0.0045. These shocks induce a decline of entrepreneurial net worth of 20% by 2009Q4. The result is also reported in Figure 7, labelled "_ez_eN". The magnitude of the contraction of investment, consumption and GDP roughly doubles. The model now closely matches the magnitude of both the downturn in investment and the increase in the cost of external finance. The maximum deviation of GDP and consumption from trend in the model are almost two thirds and one third, respectively, of what is observed in the data. Furthermore, the model now generates a persistent increase in loans alongside the economic downturn, albeit smaller and more gradual than in the data, followed by a persistent decline.

8 Conclusion

I develop a general equilibrium model combining informational frictions between banks and entrepreneurs as well as banks and depositors. I do so by adding a moral hazard problem between banks and depositors along the lines of Gertler and Karadi (2010) to the canonical Bernanke et al. (1999) financial accelerator model. As a result, both entrepreneurial and bank leverage matter for the cost of external funds of firms. Quantitatively, I find that adding this informational friction amplifies the response of the cost of external finance and the overall economy to monetary policy and productivity shocks as compared to the BGG model. The additional amplification provided by this "bank capital channel" allows my model to improve upon the BGG model's ability to match the volatility of the cost of external finance, as well as investment and other variables. The model also performs reasonably well at matching the cyclical properties of the bank capital ratio and bank leverage. A adverse shock to entrepreneurial net worth causes an output contraction more than twice as big as in a BGG-type model. In line with the existing empirical evidence, an adverse shock to bank net worth of causes a persistent decline of both GDP and inflation. Finally, in response to a reasonably calibrated shock to entrepreneurial- and bank balance sheets, the economy enters a downturn of a magnitude similar to the ongoing Great Recession in the United States.

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A First order conditions of households, retailers, capital goods producers, bankers and entrepreneurs

A.1 Households

Denoting the lagrange multiplier on (3) as ϱ_t and on (1) as $\frac{\varrho_t w_t}{\mu_t}$, the first order conditions with respect to consumption, riskless assets (i.e. deposits and bonds) and total labour supply l_t^s are given by

$$\varrho_t = \frac{1}{C_t - hC_{t-1}} \tag{29}$$

$$\varrho_t = \beta E_t \left[\varrho_{t+1} \frac{R_t}{\Pi_{t+1}} \right] \tag{30}$$

$$\frac{\varrho_t w_t}{\mu_t} = \chi \left(l_t^s \right)^{\varphi} \tag{31}$$

where $\Pi_t = \frac{P_t}{P_{t-1}}$.

Since labour demand curve faced by the labour union and the cost of supplying labour are the same across all markets, wage and employment is going to be the same across all those markets where the union is allowed to re-optimise the price. Let $\widetilde{w}_t$ be the real wage prevailing in the labour markets where the union is allowed to optimally reset the wage in period t. In period t+i, the flow utility associated with this wage is given by

$$\varrho_t \frac{\widetilde{w}_t}{\prod_{k=1}^{s} \frac{\Pi_{t+k}}{\Pi^{1-\gamma_w}(\Pi_{t+k-1})^{\gamma_w}}} \left(\frac{\widetilde{w}_t}{w_t \prod_{k=1}^{s} \frac{\Pi_{t+k}}{\Pi^{1-\gamma_w}(\Pi_{t+k-1})^{\gamma_w}}} \right)^{-\varepsilon_w} l_t - \left(\frac{\widetilde{w}_t}{w_t \prod_{k=1}^{s} \frac{\Pi_{t+k}}{\Pi^{1-\gamma_w}(\Pi_{t+k-1})^{\gamma_w}}} \right)^{-\varepsilon_w} l_t \frac{\varrho_t w_t}{\mu_t}$$

Hence the unions objective is given by

$$E_t \left\{ \sum_{i=0}^{\infty} (\beta \xi^w)^i \varrho_{t+i} w_{t+i}^{\varepsilon_w} l_{t+i} \left(\prod_{k=1}^{i} \frac{\Pi_{t+k}}{\Pi^{1-\gamma_w} (\Pi_{t+k-1})^{\gamma_w}} \right)^{\varepsilon_w} \left[\widetilde{w}_t^{1-\varepsilon_w} \left(\prod_{k=1}^{i} \frac{\Pi_{t+k}}{\Pi^{1-\gamma_w} (\Pi_{t+k-1})^{\gamma_w}} \right)^{-1} - \widetilde{w}_t^{-\varepsilon_w} \frac{w_{t+i}}{\mu_{t+i}} \right] \right\}$$

with the first order condition given by

$$0 = E_t \left\{ \sum_{i=0}^{\infty} (\beta \xi^w)^i \varrho_{t+i} w_{t+i}^{\varepsilon_w} l_{t+i} \left(\prod_{k=1}^{i} \frac{\Pi_{t+k}}{\Pi^{1-\gamma_w} (\Pi_{t+k-1})^{\gamma_w}} \right)^{\varepsilon_w} \left[\frac{\varepsilon_w - 1}{\varepsilon_w} \frac{\widetilde{w}_t}{\prod_{k=1}^{i} \frac{\Pi_{t+k}}{\Pi^{1-\gamma_w}(\Pi_{t+k-1})^{\gamma_w}}} - \frac{w_{t+i}}{\mu_{t+i}} \right] \right\} \tag{32}$$

Using (2), the law of motion of the aggregate nominal wage is given by

$$W_t = \left[(1-\xi) \left(\widetilde{W}_t \right)^{1-\varepsilon} + \xi^w \left(W_{t-1} \Pi^{1-\gamma_P} (\Pi_{t-1})^{\gamma_P} \right)^{1-\varepsilon_w} \right]^{\frac{1}{1-\varepsilon_w}} \tag{33}$$

where $\widetilde{W}_t = \widetilde{w}_t P_t$.

In the model without a financial sector, I assume that households buy the capital stock K_t from capital goods producers in order to rent it to retailers in period t+1. Furthermore, they choose the degree of utilization of the capital stock they acquired in period t-1 K_{t-1}. In doing so, they face a capacity utilization cost $a(U_t) K_t$. Hence the budget constraint becomes

$$\begin{aligned} & P_t C_t + Q_t (K_t - K_{t-1}) + a(U_t) K_{t-1} && (34) \\ = \; & P_t l_t \int_0^1 w_t(j) \left(\frac{w_t(j)}{w_t} \right)^{-\varepsilon_w} dj + P_t prof_t + P_t T_t + R_{t-1} B_{t-1}^T - B_t^T + r_t^K U_t K_{t-1} && (35) \end{aligned}$$

This modification leaves the first order conditions derived above unchanged, but adds first order conditions with respect to K_t and U_t, respectively:

$$\begin{aligned} Q_t &= E_t \left\{ \beta \frac{\varrho_{t+1}}{\varrho_t} \left[r_t^K U_t - a(U_t) + Q_{t+1}(1-\delta) \right] \right\} && (36) \\ r_t^k &= a'(U_t) && (37) \end{aligned}$$

A.2 Capital goods producers

The first order condition with respect to I_t is given by

$$Q_t \left(1 - \frac{\eta_i}{2} \left(\frac{I_t}{I_{t-1}} - 1 \right)^2 \right) = 1 + Q_t \eta_i \left(\frac{I_t}{I_{t-1}} - 1 \right) \frac{I_t}{I_{t-1}} - E_t \left\{ \beta \frac{\varrho_{t+1}}{\varrho_t} Q_{t+1} \eta_i \left(\frac{I_{t+1}}{I_t} - 1 \right) \left(\frac{I_{t+1}}{I_t} \right)^2 \right\} \quad (38)$$

The law of motion of capital is given by

$$K_t = (1-\delta) K_{t-1} + I_t \left(1 - \frac{\eta_i}{2} \left(\frac{I_t}{I_{t-1}} - 1 \right)^2 \right) \quad (39)$$

A.3 Retailers

Cost minimization and the assumption of economy wide factor markets imply that

$$w_t \left(1 + \psi_l \left(R_t - 1\right)\right) = \left(1 - \alpha\right) mc_t \frac{Y_t}{l_t} \quad (40)$$

$$r_t^k \left(1 + \psi_K \left(R_t - 1\right)\right) = \alpha mc_t \frac{Y_t}{K_t^s} \quad (41)$$

$$L_t^r = \psi_L w_t l_t + \psi_K r_t^k U_t K_{t-1} \quad (42)$$

where mc_t denotes the real marginal cost of production.

Retail firms are subject to nominal rigidities in the form of Calvo (1983) contracts: Only a fraction $1 - \xi$ is allowed to optimize its price in a given period. Those firms not allowed to optimize its price index it to past inflation at a rate γ_P and to the steady state inflation rate Π at rate $1 - \gamma_P$. The firm's problem is then to choose $p_t(i)$ in order to maximise

$$E_t \left\{ \sum_{i=0}^{\infty} \left(\xi^P \beta\right)^i \frac{\varrho_{t+i}}{\varrho_t} \left[\left(\frac{p_t(i)}{P_{t+i}} \prod_{k=1}^{i} \Pi^{1-\gamma_P} \Pi_{t+k-1}^{\gamma_P} \right)^{1-\varepsilon} - mc_{t+i} \left(\frac{p_t(i)}{P_{t+i}} \prod_{k=1}^{i} \Pi^{1-\gamma_P} \Pi_{t+k-1}^{\gamma_P} \right)^{-\varepsilon} \right] Y_{t+i} \right\}$$

The first order condition is given by

$$\widetilde{p}_t = \frac{\varepsilon}{\varepsilon - 1} \frac{E_t \left\{ \sum_{i=0}^{\infty} \left(\xi^P \beta\right)^i \frac{\varrho_{t+i}}{\varrho_t} \left(\frac{\prod_{k=1}^{i} \Pi^{1-\gamma_P} \Pi_{t+k-1}^{\gamma_P}}{\prod_{k=1}^{i} \Pi_{t+k}} \right)^{-\varepsilon} mc_{t+i} Y_{t+i} \right\}}{E_t \left\{ \sum_{i=0}^{\infty} \left(\xi^P \beta\right)^i \frac{\varrho_{t+i}}{\varrho_t} \left(\frac{\prod_{k=1}^{i} \Pi^{1-\gamma_P} \Pi_{t+k-1}^{\gamma_P}}{\prod_{k=1}^{i} \Pi_{t+k}} \right)^{1-\varepsilon} Y_{t+i} \right\}} \quad (43)$$

with $\widetilde{p}_t = \frac{p_t^*}{P_t}$, where p_t^* denotes the price chosen by those firms allowed to optimize in period

t. The law of motion of the price index is given by

$$P_t = \left[\left(1 - \xi^P\right) \left(p_t^*\right)^{1-\varepsilon} + \xi^P \left(P_{t-1} \Pi^{1-\gamma_P} \left(\Pi_{t-1}\right)^{\gamma_P}\right)^{1-\varepsilon} \right]^{\frac{1}{1-\varepsilon}} \tag{44}$$

A.4 Bankers

Combining (5) with the definition of $V_t^b(q)$ allows to express the later as

$$V_t^b(q) = v_t L_t^e(q) + \eta_t N_t^b(q) \tag{45}$$

with

$$v_t = E_t \left\{ (1-\theta) \frac{\left(R_{t+1}^b - R_t\right)}{R_t} + \frac{\theta x_{t,t+1} v_{t+1} \Pi_{t+1}}{R_t} \right\} \tag{46}$$

$$\eta_t = E_t \left\{ (1-\theta) + \frac{\theta z_{t,t+1} \eta_{t+1} \Pi_{t+1}}{R_t} \right\} \tag{47}$$

$$x_{t,t+1} = \frac{L_{t+1}^e(q)}{L_t^e(q)}, \; z_{t,t+1} = \frac{N_{t+1}^b(q)}{N_t^b(q)} \tag{48}$$

Using $V_t^b(q) = \lambda L_t^e(q)$ yields

$$L_t^e(q) = \phi_t^b N_t^b(q) \tag{49}$$

$$\phi_t^b(q) = \frac{\eta_t}{\lambda - v_t} \tag{50}$$

where $\phi_t^b(q)$ denotes bank q's leverage ratio. Note that for the incentive constraint to bind, a necessary condition is $0 < v_t < \lambda$.[15] Substituting (5) and (49) into (48) allows to write $z_{t,t+1}$

[15] For an interpretation of this condition see Gertler and Karadi (2010).

and $x_{t,t+1}$ as

$$z_{t,t+1} = \frac{\left(R^b_{t+1} - R_t\right)\phi^b_t + R_t}{\Pi_{t+1}} \exp\left(e^z_{t+1}\right) \tag{51}$$

$$x_{t,t+1} = \frac{\phi^b_{t+1}(q)}{\phi^b_t(q)} z_{t,t+1} \tag{52}$$

Equations (50), (46), (47), (51) and (52) imply that that η_t, v_t, $\phi^b_t(q)$, $z_{t,t+1}$ and $x_{t,t+1}$ depend only on economy wide variables and $\phi^b_{t+1}(q)$, implying that they all depend on economy wide variables alone. This allows for easy aggregation across bankers, implying that

$$L^e_t = \phi^b_t N^b_t \tag{53}$$

where N^b_t denotes the total net worth of banks.

A.5 Entrepreneurs: full model and BGG model

Using $\overline{\omega}^j_{t+1} R^K_{t+1} P_t Q_t K^j_t = R^L_t P_t L^j_t$ and $L^j_t = P_t Q_t K^j_t - P_t N^j_t$, rewrite the participation constraint of the bank (14) as

$$\left(P_t Q_t K^j_t - P_t N^j_t\right) E_t R^b_{t+1} = E_t \left\{ R^K_{t+1} P_t Q_t K^j_t \left[\overline{\omega}^j_{t+1} \int_{\overline{\omega}^j_{t+1}}^{\infty} f\left(\omega^j\right) d\omega^j + (1-\mu) \int_0^{\overline{\omega}^j_{t+1}} \omega^j f\left(\omega^j\right) d\omega^j \right] \right\}$$

or

$$\left(\phi^e_t(j) - 1\right) E_t R^b_{t+1} = \phi^{e,j}_t E_t \left\{ R^K_{t+1} \left[\Gamma\left(\overline{\omega}^j_{t+1}\right) - \mu G\left(\overline{\omega}^j_{t+1}\right) \right] \right\} \tag{54}$$

where $\phi^e_t(j) = \frac{Q_t K^j_t}{N^j_t}$, $\Gamma\left(\overline{\omega}^j_{t+1}\right) = \overline{\omega}^j_{t+1} \int_{\overline{\omega}^j_{t+1}}^{\infty} f\left(\omega^j\right) d\omega^j + \int_0^{\overline{\omega}^j_{t+1}} \omega^j f\left(\omega^j\right) d\omega^j$ and $G\left(\overline{\omega}^j_{t+1}\right) = \int_0^{\overline{\omega}^j_{t+1}} \omega^j f\left(\omega^j\right) d\omega^j_{t+1}$. Using $\overline{\omega}^j_{t+1} R^K_{t+1} Q_t K^j_t = R^L_t L^j_t$ and $E\left(\omega_{t+1}\right) = 1 = \int_0^{\overline{\omega}^j_{t+1}} \omega^j f\left(\omega^j\right) d\omega^j_{t+1} +$

$\int_{\overline{\omega}_{t+1}^j}^{\infty} \omega^j f\left(\omega^j\right) d\omega_{t+1}^j$, rewrite the entrepreneur's objective as

$$
\begin{aligned}
& P_t Q_t K_t^j E_t \left\{ \int_{\overline{\omega}_{t+1}^j}^{\infty} R_{t+1}^K f\left(\omega^j\right)\left(\omega^j - \overline{\omega}_{t+1}^j\right) d\omega^j \right\} \\
= \; & P_t Q_t K_t^j E_t \left\{ R_{t+1}^K \left[1 - \int_0^{\overline{\omega}_{t+1}^j} \omega^j f\left(\omega^j\right) d\omega^j - \overline{\omega}_{t+1}^j \int_{\overline{\omega}_{t+1}^j}^{\infty} f\left(\omega^j\right) d\omega^j \right] \right\} \\
= \; & P_t Q_t K_t^j E_t \left\{ R_{t+1}^K \left[1 - \Gamma\left(\overline{\omega}_{t+1}^j\right)\right]\right\} \\
= \; & \phi_t^e(j) E_t \left\{ R_{t+1}^K \left[1 - \Gamma\left(\overline{\omega}_{t+1}^j\right)\right]\right\} N_t^j
\end{aligned}
$$

where $s_{t+1} = \frac{R_{t+1}^K}{E_t R_{t+1}^b}$. Recall that entrepreneurs differ only in their net worth N_t^j. Since $\overline{\omega}_{t+1}^j = \frac{R_t^L\left(1-\frac{1}{\phi_t^e(j)}\right)}{R_{t+1}^K}$, the values of $\phi_t^{e,j}$ and R_t^L maximizing $\phi_t^e(j) E_t \left\{ s_{t+1}\left[1 - \Gamma\left(\overline{\omega}_{t+1}^j\right)\right]\right\} N_t^j E_t R_{t+1}^b$ subject to (64) are going to be the same across entrepreneurs. The same is true for the cut off value $\overline{\omega}_{t+1}^j$. Hence the problem of the entrepreneur is to maximize

$$
\phi_t^e E_t \left\{ R_{t+1}^K \left[1 - \Gamma\left(\overline{\omega}_{t+1}\right)\right]\right\} + \xi_t E_t \left\{ \phi_t^e R_{t+1}^K \left[\Gamma\left(\overline{\omega}_{t+1}\right) - \mu G\left(\overline{\omega}_{t+1}\right)\right] - R_{t+1}^b \left(\phi_t^e - 1\right)\right\}
$$

The first order conditions with respect to ϕ_t^e, R_t^L and ξ_t are given by

$$
E_t \left\{ R_{t+1}^K \left[1 - \Gamma\left(\overline{\omega}_{t+1}\right)\right]\right\} + \xi_t E_t \left\{ R_{t+1}^K \left[\Gamma\left(\overline{\omega}_{t+1}\right) - \mu G\left(\overline{\omega}_{t+1}\right)\right] - R_{t+1}^b \right\} = 0 \quad (55)
$$

$$
E_t \left\{ -\Gamma'\left(\overline{\omega}_{t+1}\right) + \xi_t \left[\Gamma'\left(\overline{\omega}_{t+1}\right) - \mu G'\left(\overline{\omega}_{t+1}\right)\right]\right\} = 0 \quad (56)
$$

$$
E_t \left\{ \phi_t^e R_{t+1}^K \left[\Gamma\left(\overline{\omega}_{t+1}\right) - \mu G\left(\overline{\omega}_{t+1}\right)\right] - R_{t+1}^b \left(\phi_t^e - 1\right)\right\} = 0 \quad (57)
$$

where ξ_t denotes the lagrange multiplier on the banks participation constraint. Given that we can rewrite the entrepreneur's objective as we have, both in the full model and in the

BGG model, total real entrepreneurial equity at the beginning of period t (i.e. before some entrepreneurs die) V_t is given by

$$V_t = Q_{t-1} K_{t-1} \frac{R_t^K}{\Pi_t} \left[1 - \Gamma\left(\overline{\omega}_t\right)\right] \exp\left(e_t^N\right) \tag{58}$$

In the BGG model, the constraint on the return on the portfolio of loans to entrepreneurs holds not just in expectation, but in every t+1 state. Furthermore, due to the absence of a moral hazard problem in the banking sector, the return on bank loans made in period t equals the deposit rate. Hence the bank's participation constraint is given by

$$\phi_t^e R_{t+1}^K \left[\Gamma\left(\overline{\omega}_{t+1}\right) - \mu G\left(\overline{\omega}_{t+1}\right)\right] - R_t\left(\phi_t^e - 1\right) = 0 \tag{59}$$

The optimisation problem then becomes to maximise

$$\phi_t^e E_t \left\{R_{t+1}^K \left[1 - \Gamma\left(\overline{\omega}_{t+1}\right)\right]\right\} + \xi_t \left[\phi_t^e R_{t+1}^K \left[\Gamma\left(\overline{\omega}_{t+1}\right) - \mu G\left(\overline{\omega}_{t+1}\right)\right] - R_t\left(\phi_t^e - 1\right)\right]$$

with respect to ϕ_t^e, $\overline{\omega}_{t+1}$ and ξ_t. The first order conditions are

$$E_t \left\{R_{t+1}^K \left[1 - \Gamma\left(\overline{\omega}_{t+1}\right)\right] + \xi_t \left\{R_{t+1}^K \left[\Gamma\left(\overline{\omega}_{t+1}\right) - \mu G\left(\overline{\omega}_{t+1}\right)\right] - R_t\right\}\right\} = 0 \tag{60}$$

$$\frac{\Gamma'\left(\overline{\omega}_{t+1}\right)}{\left[\Gamma'\left(\overline{\omega}_{t+1}\right) - \mu G'\left(\overline{\omega}_{t+1}\right)\right]} = \xi_t \tag{61}$$

$$R_t^K \left[\Gamma\left(\overline{\omega}_t\right) - \mu G\left(\overline{\omega}_t\right)\right] = R_{t-1} \frac{\left(\phi_{t-1}^e - 1\right)}{\phi_{t-1}^e} \tag{62}$$

The loan rate in this setup is only determined once the loan is paid back, in order to ensure that (59) holds. It is determined by

$$\frac{R_t^L\left(Q_{t-1}K_{t-1}-N_{t-1}\right)}{R_t^K Q_{t-1}K_{t-1}}=\overline{\omega}_t \tag{63}$$

B Derivation of the linearized bank leverage constraint

I linearize equations (46), (47) and (50) – (52) to express leverage in the banking sector as a function of the current and future spread of R_{t+1}^b over R_t. Linearising (50) yields

$$\widehat{\phi}_t^b=\widehat{\eta}_t+\frac{\upsilon}{\lambda-\upsilon}\widehat{\upsilon}_t=\widehat{\eta}_t+\phi^b\frac{\upsilon}{\eta}\widehat{\upsilon}_t \tag{64}$$

where a hat denotes percentage deviation of this variable from its steady state. Linearising (46) , (47), and (52) yields

$$\begin{aligned}
\upsilon\widehat{\upsilon}_t &= E_t\left\{(1-\theta)\frac{R^b}{R}\left(\widehat{R}_{t+1}^b-\widehat{R}_t\right)+\theta\upsilon z\beta\left(\widehat{x}_{t+1}+\widehat{\upsilon}_{t+1}+\widehat{\Pi}_{t+1}-\widehat{R}_t\right)\right\} && (65)\\
\widehat{\eta}_t &= \theta z\beta E_t\left\{\widehat{z}_{t+1}+\widehat{\eta}_{t+1}+\widehat{\Pi}_{t+1}-\widehat{R}_t\right\} && (66)\\
\widehat{x}_t &= \widehat{\phi}_t^b-\widehat{\phi}_{t-1}^b+\widehat{z}_t && (67)
\end{aligned}$$

Rewriting (51) as$\frac{z_{t+1,t}\Pi_t}{R_t}=\frac{\left(R_{t+1}^b-R_t\right)}{R_t}\phi_t^b+1$, we have

$$\begin{aligned}
\widehat{z}_{t+1}+\widehat{\Pi}_{t+1}-\widehat{R}_t &= \frac{\phi^b\frac{R^b}{R}\left(\widehat{R}_{t+1}^b-\widehat{R}_t\right)+\left(\frac{R^b}{R}-1\right)\phi^b\widehat{\phi}_t^b}{\left(\frac{R^b}{R}-1\right)\phi^b+1}+e_{t+1}^z\\
&= \frac{\phi^b\frac{R^b}{R}\left(\widehat{R}_{t+1}^b-\widehat{R}_t\right)+\left(\frac{R^b}{R}-1\right)\phi^b\widehat{\phi}_t^b}{z\beta}+e_{t+1}^z && (68)
\end{aligned}$$

using the fact that $\left(\frac{R^b}{R}-1\right)\phi^b+1=z\beta$. Substituting (68) into (65) yields

$$
\begin{aligned}
v\widehat{v}_t &= E_t\left\{\frac{R^b}{R}\left[(1-\theta)+\theta v\phi^b\right]\left(\widehat{R}^b_{t+1}-\widehat{R}_t\right)+\theta v\left(z\beta\widehat{\phi}^b_{t+1}+\left[\left(\frac{R^b}{R}-1\right)\phi^b-z\beta\right]\widehat{\phi}^b_t+z\beta\widehat{v}_{t+1}\right)\right\} \\
&= E_t\left\{\frac{R^b}{R}\left[(1-\theta)+\theta v\phi^b\right]\left(\widehat{R}^b_{t+1}-\widehat{R}_t\right)+\theta v\left(z\beta\widehat{\phi}^b_{t+1}+-\widehat{\phi}^b_t+z\beta\widehat{v}_{t+1}\right)\right\} \qquad (69)
\end{aligned}
$$

using the fact that $\left(\frac{R^b}{R}-1\right)\phi^b-z\beta=-1$. Similarly, substituting (68) into (65) yields

$$
\widehat{\eta}_t=\theta E_t\left\{\phi^b\frac{R^b}{R}\left(\widehat{R}^b_{t+1}-\widehat{R}_t\right)+\left(\frac{R^b}{R}-1\right)\phi^b\widehat{\phi}^b_t+z\beta\widehat{\eta}_{t+1}\right\} \qquad (70)
$$

Substituting (69) and (70) into (19) yields

$$
\begin{aligned}
\widehat{\phi}^b_t &= \widehat{\eta}_t+\phi^b\frac{v}{\eta}\widehat{v}_t \\
&= \theta E_t\left\{\phi^b\frac{R^b}{R}\left(\widehat{R}^b_{t+1}-\widehat{R}_t\right)+\left(\frac{R^b}{R}-1\right)\phi^b\widehat{\phi}^b_t+z\beta\widehat{\eta}_{t+1}\right\} \\
&\quad +\frac{\phi^b}{\eta}E_t\left\{\frac{R^b}{R}\left[(1-\theta)+\theta v\phi^b\right]\left(\widehat{R}^b_{t+1}-\widehat{R}_t\right)+\theta v\left(z\beta\widehat{\phi}^b_{t+1}+-\widehat{\phi}^b_t+z\beta\widehat{v}_{t+1}\right)\right\}
\end{aligned}
$$

This can be rearranged as

$$
\begin{aligned}
&\widehat{\phi}^b_t\left(1-\theta\phi^b\left(\frac{R^b}{R}-1\right)+\frac{\phi^b}{\eta}\theta v\right) \\
=\;& E_t\left\{\theta\beta z\left(\widehat{\eta}_{t+1}+\frac{\phi^b}{\eta}v\widehat{v}_{t+1}\right)+\phi^b\frac{R^b}{R}\left(\theta+\frac{1}{\eta}\left(1-\theta+\theta v\phi^b\right)\right)\left(\widehat{R}^b_{t+1}-\widehat{R}_t\right)+\frac{\phi^b\theta vz\beta}{\eta}\widehat{\phi}^b_{t+1}\right\}
\end{aligned}
$$

The fact that $\eta = \frac{1-\theta}{1-\beta\theta z}$ and $\frac{v}{\eta} = \frac{R^b}{R} - 1$ implies

$$\begin{aligned} 1 - \theta\phi^b \left(\frac{R^b}{R} - 1\right) + \frac{\phi^b}{\eta}\theta v &= 1 \\ \theta + \frac{1}{\eta}\left(1 - \theta + \theta v \phi^b\right) &= \theta\left(1 - z\beta + \left(\frac{R^b}{R} - 1\right)\phi^b\right) + 1 = 1 \end{aligned}$$

Using these results and the fact that $\widehat{\eta}_{t+1} + \phi^b \frac{v}{\eta}\widehat{v}_{t+1} = \widehat{\phi}^b_{t+1}$ yields

$$\begin{aligned} \widehat{\phi}^b_t &= E_t\left\{\theta\beta z\left(1 + \left(\frac{R^b}{R} - 1\right)\phi^b\right)\widehat{\phi}^b_{t+1} + \phi^b\frac{R^b}{R}\left(\widehat{R}^b_{t+1} - \widehat{R}_t\right)\right\} \\ &= E_t\left\{\theta\beta^2 z^2 \widehat{\phi}^b_{t+1} + \phi^b\frac{R^b}{R}\left(\widehat{R}^b_{t+1} - \widehat{R}_t\right)\right\} \end{aligned} \tag{71}$$

using $\left(\frac{R^b}{R} - 1\right)\phi^b + 1 = z\beta$.

C Derivation of the relationship between firm leverage and $E_t\left\{\widehat{R}^K_{t+1} - \widehat{R}^b_{t+1}\right\}$ in the full model and $E_t\left\{\widehat{R}^K_{t+1} - \widehat{R}_t\right\}$ in the BGG model

This section derives the first order relationship between firm leverage and the spread between the expected return on capital and the expected return on bank loans for the full model. The derivation is however identical for the BGG model: One simply has to replace $E_t R^b_{t+1}$ with R_t wherever it appears.

After defining $\Upsilon(\overline{\omega}) = 1 - \Gamma(\overline{\omega}) + \xi\left[\Gamma(\overline{\omega}) - \mu G(\overline{\omega})\right]$, we can rewrite (55) as

$$E_t\left\{R^K_{t+1}\Upsilon(\overline{\omega}_{t+1}) - \xi_t R^b_{t+1}\right\} = 0 \tag{72}$$

Linearising (57) yields

$$E_t \left\{ \begin{array}{c} \phi^e R^K \left[\left[\Gamma\left(\overline{\omega}\right) - \mu G\left(\overline{\omega}\right) \right] \left[\frac{d\phi_t^e}{\phi^e} + \widehat{R}_{t+1}^K \right] + \left[\Gamma'\left(\overline{\omega}\right) - \mu G'\left(\overline{\omega}\right) \right] d\overline{\omega}_{t+1} \right] \\ -R^b \left(\phi^e - 1\right) \widehat{R}_{t+1}^b - R^b \phi^e \frac{d\phi_t^e}{\phi^e} \end{array} \right\} = 0$$

or

$$\begin{aligned} E_t d\overline{\omega}_{t+1} &= \frac{\partial \overline{\omega}}{\partial \phi^e} d\phi_t^e + \frac{\partial \overline{\omega}}{\partial s} E_t ds1_{t+1} \qquad (73) \\ E_t ds1_{t+1} &= s1 E_t \left\{ \widehat{R}_{t+1}^K - \widehat{R}_{t+1}^b \right\} \\ s1 &= \frac{R^K}{R^b} \qquad (74) \\ \frac{d\overline{\omega}}{\phi^e} &= \frac{1}{\left(\phi^e\right)^2 s1 \left[\Gamma'\left(\overline{\omega}\right) - \mu G'\left(\overline{\omega}\right) \right]} \\ \frac{\partial \overline{\omega}}{\partial s1} &= \frac{-\left[\Gamma\left(\overline{\omega}\right) - \mu G\left(\overline{\omega}\right) \right]}{s1 \left[\Gamma'\left(\overline{\omega}\right) - \mu G'\left(\overline{\omega}\right) \right]} \end{aligned}$$

where we have used the fact that (57) implies that $\phi^e R^K \left[\Gamma\left(\overline{\omega}\right) - \mu G\left(\overline{\omega}\right) \right] - R^b \phi^e = -R^b$. We then solve 56 for ξ_t and totally differentiate, which yields

$$\begin{aligned} d\xi_t &= \xi'\left(\overline{\omega}\right) E_t d\overline{\omega}_{t+1} = \xi'\left(\overline{\omega}\right) \left[\frac{\partial \overline{\omega}}{\partial \phi^e} d\phi_t^e + \frac{\partial \overline{\omega}}{\partial s} E_t ds1_{t+1} \right] \qquad (75) \\ \xi'\left(\overline{\omega}\right) &= \frac{\mu \left[\Gamma'\left(\overline{\omega}\right) G''\left(\overline{\omega}\right) - \Gamma''\left(\overline{\omega}\right) G'\left(\overline{\omega}\right) \right]}{\left[\Gamma'\left(\overline{\omega}\right) - \mu G'\left(\overline{\omega}\right) \right]^2} \end{aligned}$$

Totally differentiating (72) yields

$$E_t \left\{ dR_{t+1}^K \Upsilon\left(\overline{\omega}\right) + R^K \Upsilon'\left(\overline{\omega}\right) d\overline{\omega}_{t+1} - d\xi_t R^b - \xi dR_{t+1}^b \right\} = 0$$

or

$$E_t \left\{ds1_{t+1}\Upsilon\left(\overline{\omega}\right) + s1\Upsilon'\left(\overline{\omega}\right)d\overline{\omega}_{t+1} - d\xi_t\right\} = 0$$

Using (73) and (75) yields

$$E_t \left\{ ds1_{t+1}\Upsilon\left(\overline{\omega}\right) + s1\Upsilon'\left(\overline{\omega}\right)\left[\frac{\partial\overline{\omega}}{\partial\phi^e}d\phi_t^e + \frac{\partial\overline{\omega}}{\partial s}E_t ds1_{t+1}\right] - \xi'\left(\overline{\omega}\right)\left[\frac{\partial\overline{\omega}}{\partial\phi^e}d\phi_t^e + \frac{\partial\overline{\omega}}{\partial s1}E_t ds1_{t+1}\right]\right\} = 0$$

or

$$d\phi_t^e = \frac{d\phi^e}{ds1}E_t ds1_{t+1}$$

Using $E_t ds_{t+1} = s1E_t\left\{\widehat{R}_{t+1}^K - \widehat{R}_{t+1}^b\right\}$, this can be rearranged as

$$\begin{aligned}
E_t\left\{\widehat{R}_{t+1}^K - \widehat{R}_{t+1}^b\right\} &= \chi^{\phi^e}\widehat{\phi}_t^e \\
Expr1 &= \left[\Gamma\left(\overline{\omega}\right) - \mu G\left(\overline{\omega}\right)\right] \\
Expr2 &= \left[\Gamma'\left(\overline{\omega}\right) - \mu G'\left(\overline{\omega}\right)\right] \\
\Upsilon\left(\overline{\omega}\right) &= 1 - \Gamma\left(\overline{\omega}\right) + \xi\left[\Gamma\left(\overline{\omega}\right) - \mu G\left(\overline{\omega}\right)\right] \\
\frac{\partial\overline{\omega}}{\partial s1} &= \frac{-Expr1}{s1Expr2} \\
\frac{d\overline{\omega}}{\phi^e} &= \frac{1}{\left(\phi^e\right)^2 s1Expr2} \\
\xi'\left(\overline{\omega}\right) &= \frac{\mu\left[\Gamma'\left(\overline{\omega}\right)G''\left(\overline{\omega}\right) - \Gamma''\left(\overline{\omega}\right)G'\left(\overline{\omega}\right)\right]}{\left[\Gamma'\left(\overline{\omega}\right) - \mu G'\left(\overline{\omega}\right)\right]^2} \\
\Upsilon'\left(\overline{\omega}\right) &= \xi'\left(\overline{\omega}\right)Expr1 \\
\frac{d\phi^e}{ds1} &= \frac{\Upsilon\left(\overline{\omega}\right) + \frac{\partial\overline{\omega}}{\partial s1}\left[s1\Upsilon'\left(\overline{\omega}\right) - \xi'\left(\overline{\omega}\right)\right]}{\left[\xi'\left(\overline{\omega}\right) - s1\Upsilon'\left(\overline{\omega}\right)\right]\frac{\partial\overline{\omega}}{\partial\phi^e}} \\
\chi^{\phi^e} &= \frac{\phi^e}{s1\frac{d\phi^e}{ds1}}
\end{aligned}$$

D Linearized equations

D.1 Full model

I assume and explicit functional form for the capacity utilization cost function $a(U_t)$, namely $a(U_t) = r^K(U_t - 1) + \frac{c^U r^K}{2}(U_t - 1)^2$. Furthermore, using (19), (20) can be rewritten as

$$R_t^k \left[\Gamma(\overline{\omega}_t) - \mu G(\overline{\omega}_t)\right] \exp\left(e_t^{R^b}\right) = \frac{\left(\phi_{t-1}^e - 1\right)}{\phi_{t-1}^e} R_t^b \tag{76}$$

Furthermore, I define $\varpi_t' = \frac{R_t^L(Q_t K_t - N_t)}{Q_t K_t} = R_t^L \frac{\phi_t^e - 1}{\phi_t^e}$ and use $\overline{\omega}_t = \frac{\varpi_{t-1}'}{R_t^k}$ to eliminate $\overline{\omega}_t$ wherever it appears.

I now linearize the various equations:

$$\begin{aligned}
\widehat{\varrho}_t &= \frac{-\left(\widehat{C}_t - h\widehat{C}_{t-1}\right)}{1-h} \text{ from (29)} \\
\widehat{\varrho}_t &= E_t\left\{\widehat{\varrho}_{t+1} + \widehat{R}_t - \widehat{\Pi}_{t+1}\right\} \text{ from (30)} \\
\widehat{w}_t &= \frac{1}{1+\beta}\left[\begin{array}{c} \beta E_t\widehat{w}_{t+1} + \widehat{w}_{t-1} + \beta E_t\widehat{\Pi}_{t+1} - (1+\beta\gamma_w)\widehat{\Pi}_t \\ +\gamma_w\widehat{\Pi}_{t-1} - \frac{(1-\beta\xi^w)(1-\xi^w)}{\xi^w}\left[\widehat{w}_t + \widehat{\varrho}_t - \varphi\widehat{l}_t\right] \end{array}\right] \text{ from (31)} - (33) \\
\widehat{wm}_t &= \widehat{w}_t + \widehat{\varrho}_t - \varphi\widehat{l}_t \\
\widehat{\Pi}_t &= \frac{1}{1+\beta\gamma_P}\left[\beta E_t\widehat{\Pi}_{t+1} + \gamma_P\widehat{\Pi}_{t-1} + \frac{\left(1-\beta\xi^P\right)\left(1-\xi^P\right)}{\xi^P}\widehat{mc}_t\right] \text{ from (43)} - (44) \\
\widehat{w}_t + \frac{\psi_l R\widehat{R}_t}{1+\psi_l(R-1)} &= \widehat{mc}_t + \widehat{Y}_t - \widehat{l}_t \text{ from (40)} \\
\frac{dr_t^k}{r^k} + \frac{\psi_K R\widehat{R}_t}{1+\psi_K(R-1)} &= \widehat{mc}_t + \widehat{Y}_t - \widehat{K}_{t-1} - \widehat{U}_t \text{ from (41)} \\
L^r\widehat{L}_t^r &= \psi_l wl\left(\widehat{w}_t + \widehat{l}_t\right) + \psi_K r^k K\left(\frac{dr_t^k}{r^k} + \widehat{U}_t + \widehat{K}_{t-1}\right) \text{ from (4)}
\end{aligned}$$

$$
\begin{aligned}
\widehat{K}_t &= (1-\delta)\widehat{K}_{t-1} + \delta \widehat{I}_t \text{ from (38)} \\
\widehat{I}_t &= \frac{1}{1+\beta}\left[\widehat{I}_{t-1} + \beta E_t \widehat{I}_{t+1} + \frac{\widehat{Q}_t}{\eta_i}\right] \text{ from (39)} \\
\widehat{L}^e_t &= \widehat{\phi}^b_t + \widehat{N}^b_t \text{ from (53)} \\
\widehat{\phi}^b_t &= E_t\left\{\theta\beta^2 z^2 \widehat{\phi}^b_{t+1} + \phi^b \beta R^b \left(\widehat{R}^b_{t+1} - \widehat{R}_t\right)\right\} \text{ from (71)} \\
\widehat{z}_t &= \frac{\phi^b\left(R^b \widehat{R}^b_t - R\widehat{R}_{t-1}\right) + \phi^b\left(R^b - R\right)\widehat{\phi}^b_{t-1} + R\widehat{R}_{t-1}}{z\Pi} - \widehat{\Pi}_t + e^z_t \text{from (8)} \\
\widehat{N}^b_t &= z\theta \widehat{z}_t + z\theta \widehat{N}^b_{t-1} \text{ from (7)} \\
\widehat{C}^b_t &= \widehat{z}_t + \widehat{N}^b_{t-1} \text{ from (9)} \\
\widehat{R}^K_t &= \widehat{\Pi}_t + \frac{\Pi\left(dr^k_t + \widehat{Q}_t(1-\delta)\right)}{R^k} - \widehat{Q}_{t-1} \text{ from (11)} \\
dr^k_t &= c^U r^k \widehat{U}_t \text{ from (12)} \\
\widehat{\phi}^e_t &= \widehat{Q}_t + \widehat{K}_t - \widehat{N}_t \text{ from the definition of } \phi^e_t \\
E_t \widehat{R}^K_{t+1} &= E_t \widehat{R}^b_{t+1} + \chi^{\phi^e} \widehat{\phi}^e_t \text{ from section C} \\
\widehat{\varpi}'_t &= \widehat{R}^L_t + \frac{1}{\phi^e - 1}\widehat{\phi}^e_t \text{ from the definition of } \varpi'_t \\
R^b \frac{\widehat{\phi}^e_{t-1}}{\phi^e} &= -R^K Expr1 e^{R^b}_t + \widehat{R}^K_t\left[R^K Expr1 - \varpi' Expr2\right] + \varpi' Expr2 \widehat{\varpi}'_{t-1} - R^b \frac{\phi^e - 1}{\phi^e}\widehat{R}^b_t \text{ from (20)} \\
\widehat{N}_t &= \gamma \frac{V}{N}\widehat{V}_t \text{ from (16)} \\
\widehat{V}_t &= \widehat{N}_{t-1} + \widehat{R}^K_t - \widehat{\Pi}_t + \widehat{\phi}^e_{t-1} - \frac{\Gamma'(\overline{\omega})\overline{\omega}}{1-\Gamma(\overline{\omega})}\left[\widehat{\varpi}'_{t-1} - \widehat{R}^K_t\right] + e^N_t \text{ from (58)} \\
\widehat{L}^e_t &= \widehat{N}_t + \frac{\phi^e}{\phi^e - 1}\widehat{\phi}^e_t \text{ from the definition of } L^e_t, \text{ divided by } N_t \\
\widehat{C}^e_t &= \widehat{V}_t \text{ from (18)} \\
\widehat{R}_t R &= (1-\rho_i)\left[\psi_\pi E_t \widehat{\Pi}_{t+1} + \psi_{\Delta\pi}\left(\widehat{\Pi}_t - \widehat{\Pi}_{t-1}\right) + \psi_y\left(\widehat{GDP}_t - \widehat{GDP}_{t-1}\right)\right] + \rho_i \widehat{R}_{t-1} + e^i_t \text{ from (21)} \\
\widehat{Y}_t &= \alpha\left(\widehat{U}_t + \widehat{K}_{t-1}\right) + (1-\alpha)\left(\widehat{a}_t + \widehat{l}_t\right) \text{ from (26)}
\end{aligned}
$$

$$
\begin{aligned}
\widehat{Y}_t &= \frac{I}{Y}\widehat{I}_t + \frac{C^P}{Y}\widehat{C}_t^P + \frac{G}{Y}\widehat{g}_t \\
&\quad + \frac{R^K}{\Pi}\frac{K}{Y}\mu G(\varpi)\left(\widehat{R}_t^K - \widehat{\Pi}_t + \widehat{Q}_{t-1} + \widehat{K}_{t-1} + \frac{G'(\varpi)}{G(\varpi)}\varpi\left(\widehat{\varpi}'_{t-1} - \widehat{R}_t^K\right)\right) + r^k\frac{K}{Y}\widehat{U}_t \text{ from } (25) \\
\widehat{C}_t^P &= \frac{C}{C^P}\widehat{C}_t + \frac{C^b}{C^P}\widehat{C}_t^b + \frac{C^e}{C^P}\widehat{C}_t^e \text{ from } (24) \\
\widehat{GDP}_t &= \frac{I}{GDP}\widehat{I}_t + \frac{C^P}{GDP}\widehat{C}_t^P + \frac{Gov}{GDP}\widehat{g}_t \text{ from } (27) \\
\widehat{s1\_4} &= 4\left(E_t\widehat{R}_{t+1}^K - E_t\widehat{R}_{t+1}^b\right) \text{ from } s1\_4 = \left(\frac{E_tR_{t+1}^K}{E_tR_{t+1}^b}\right)^4 \\
\widehat{s2\_4} &= 4\left(E_t\widehat{R}_{t+1}^b - \widehat{R}_t\right) \text{ from } s2\_4 = \left(\frac{E_tR_{t+1}^b}{R_t}\right)^4 \\
\widehat{s3\_4} &= 4\left(E_t\widehat{R}_{t+1}^K - \widehat{R}_t\right) \text{ from } s3\_4 = \left(\frac{E_tR_{t+1}^K}{R_t}\right)^4 \\
\widehat{s4\_4} &= 4\left(\widehat{R}_t^L - \widehat{R}_t\right) \text{ from } s4\_4 = \left(\frac{R_t^L}{R_t}\right)^4 \\
\widehat{L}_t &= \frac{L^e}{L}\widehat{L}_t^e + \frac{L^r}{L}\widehat{L}_t^r \text{ from } (4) \\
\frac{dRat_t}{Rat} &= \widehat{N}_t^b - \widehat{L}_t \text{ from } Rat = \frac{N_t}{L_t} \\
\widehat{a}_t &= \rho_a\widehat{a}_{t-1} + e_t^a \\
\widehat{g}_t &= \rho_g\widehat{g}_{t-1} + e_t^g
\end{aligned}
$$

D.2 BGG model

Unlike in the full model, there is no need for the auxiliary variable ϖ'_t. Hence I do not eliminate $\overline{\omega}_t$.

$$
\begin{aligned}
\widehat{\varrho}_t &= \frac{-\left(\widehat{C}_t - h\widehat{C}_{t-1}\right)}{1-h} \text{ from } (29) \\
\widehat{\varrho}_t &= E_t\left\{\widehat{\varrho}_{t+1} + \widehat{R}_t - \widehat{\Pi}_{t+1}\right\} \text{ from } (30) \\
\widehat{w}_t &= \frac{1}{1+\beta}\left[\begin{array}{c} \beta E_t\widehat{w}_{t+1} + \widehat{w}_{t-1} + \beta E_t\widehat{\Pi}_{t+1} - (1+\beta\gamma_w)\widehat{\Pi}_t \\ +\gamma_w\widehat{\Pi}_{t-1} - \frac{(1-\beta\xi^w)(1-\xi^w)}{\xi^w}\left[\widehat{w}_t + \widehat{\varrho}_t - \varphi\widehat{l}_t\right] \end{array}\right] \text{ from } (43)-(44) \\
\widehat{wm}_t &= \widehat{w}_t + \widehat{\varrho}_t - \varphi\widehat{l}_t \\
\widehat{\Pi}_t &= \frac{1}{1+\beta\gamma_P}\left[\beta E_t\widehat{\Pi}_{t+1} + \gamma_P\widehat{\Pi}_{t-1} + \frac{\left(1-\beta\xi^P\right)\left(1-\xi^P\right)}{\xi^P}\widehat{mc}_t\right] \text{ from } (43)-(44) \\
\widehat{w}_t + \frac{\psi_l R\widehat{R}_t}{1+\psi_l(R-1)} &= \widehat{mc}_t + \widehat{Y}_t - \widehat{l}_t \text{ from } (40) \\
\frac{dr_t^k}{r^k} + \frac{\psi_K R\widehat{R}_t}{1+\psi_K(R-1)} &= \widehat{mc}_t + \widehat{Y}_t - \widehat{K}_{t-1} - \widehat{U}_t \text{ from } (41) \\
L^r\widehat{L}_t^r &= \psi_l wl\left(\widehat{w}_t + \widehat{l}_t\right) + \psi_K r^k K\left(\frac{dr_t^k}{r^k} + \widehat{U}_t + \widehat{K}_{t-1}\right) \text{ from } (4) \\
\widehat{K}_t &= (1-\delta)\widehat{K}_{t-1} + \delta\widehat{I}_t \text{ from } (38) \\
\widehat{I}_t &= \frac{1}{1+\beta}\left[\widehat{I}_{t-1} + \beta E_t\widehat{I}_{t+1} + \frac{\widehat{Q}_t}{\eta_i}\right] \text{ from } (39) \\
\widehat{L}_t^e &= \widehat{\phi}_t^b + \widehat{N}_t^b \text{ from } (53) \\
\widehat{z}_t &= \frac{R\widehat{R}_{t-1}}{z\Pi} - \widehat{\Pi}_t \text{ from } (8)\text{, after using the fact that with } \lambda = 0,\ R_t^b = R_{t-1} \\
\widehat{N}_t^b &= z\theta\widehat{z}_t + z\theta\widehat{N}_{t-1}^b \text{ from } (7) \\
\widehat{R}_t^K &= \widehat{\Pi}_t + \frac{\Pi\left(dr_t^k + \widehat{Q}_t(1-\delta)\right)}{R^k} - \widehat{Q}_{t-1} \text{ from } (11) \\
dr_t^k &= c^U r^k\widehat{U}_t \text{ from } (12)
\end{aligned}
$$

$$
\begin{aligned}
\widehat{\phi}_t^e &= \widehat{Q}_t + \widehat{K}_t - \widehat{N}_t \text{ from the definition of } \phi_t^e \\
E_t\widehat{R}_{t+1}^K - \widehat{R}_t &= \chi^{\phi^e}\widehat{\phi}_t^e \text{ from section (C)} \\
\widehat{\varpi}_t + \widehat{R}_t^K &= \widehat{R}_t^L + \frac{1}{\phi^e - 1}\widehat{\phi}_{t-1}^e \text{ from (62)} \\
R\frac{\widehat{\phi}_{t-1}^e}{\phi^e} &= e_t^{R^b} R^K Expr1 + \widehat{R}_t^K R^K Expr1 + R^K Expr2 \varpi \widehat{\varpi}_t - R\frac{\phi^e - 1}{\phi^e}\widehat{R}_{t-1} \text{ from (62)} \\
\widehat{N}_t &= \gamma \frac{V}{N}\widehat{V}_t \text{ from (16)} \\
\widehat{V}_t &= \widehat{N}_{t-1} + \widehat{R}_t^K - \widehat{\Pi}_t + \widehat{\phi}_{t-1}^e - \frac{\Gamma'(\overline{\omega})\,\overline{\omega}}{1-\Gamma(\overline{\omega})}\widehat{\varpi}_t + e_t^N \text{ from (58)} \\
\widehat{L}_t^e &= \widehat{N}_t + \frac{\phi^e}{\phi^e - 1}\widehat{\phi}_t^e \text{ from the definition of } L_t^e, \text{ divided by } N_t \\
\widehat{C}_t^e &= \widehat{V}_t \text{ from (18)} \\
\widehat{R}_t R &= (1-\rho_i)\left[\psi_\pi E_t\widehat{\Pi}_{t+1} + \psi_{\Delta\pi}\left(\widehat{\Pi}_t - \widehat{\Pi}_{t-1}\right) + \psi_y\left(\widehat{GDP}_t - \widehat{GDP}_{t-1}\right)\right] + \rho_i\widehat{R}_{t-1} + e_t^i \text{ from (2} \\
\widehat{Y}_t &= \alpha\left(\widehat{U}_t + \widehat{K}_{t-1}\right) + (1-\alpha)\left(\widehat{a}_t + \widehat{l}_t\right) \text{ from (26)} \\
\widehat{Y}_t &= \frac{I}{Y}\widehat{I}_t + \frac{C^P}{Y}\widehat{C}_t^P + \frac{Gov}{Y}\widehat{g}_t \\
&\quad + \frac{R^K}{\Pi}\frac{K}{Y}\mu G(\varpi)\left(\widehat{R}_t^K - \widehat{\Pi}_t + \widehat{Q}_{t-1} + \widehat{K}_{t-1} + \frac{G'(\varpi)}{G(\varpi)}\varpi\widehat{\varpi}_t\right) + r^k\frac{K}{Y}\widehat{U}_t \text{ from (25)} \\
\widehat{C}_t^P &= \frac{C}{C^P}\widehat{C}_t + \frac{C^e}{C^P}\widehat{C}_t^e \text{ from (24)} \\
\widehat{GDP}_t &= \frac{I}{GDP}\widehat{I}_t + \frac{C^P}{GDP}\widehat{C}_t^P + \frac{Gov}{GDP}\widehat{g}_t \text{ from (27)} \\
\widehat{s3\_4} &= 4\left(E_t\widehat{R}_{t+1}^K - \widehat{R}_t\right) \text{ from } s3\_4 = \left(\frac{E_t R_{t+1}^K}{R_t}\right)^4 \\
\widehat{s4\_4} &= 4\left(\widehat{R}_t^L - \widehat{R}_t\right) \text{ from } s4\_4 = \left(\frac{R_t^L}{R_t}\right)^4 \\
\widehat{L}_t &= \frac{L^e}{L}\widehat{L}_t^e + \frac{L^r}{L}\widehat{L}_t^r \text{ from (4)} \\
\frac{dRat_t}{Rat} &= \widehat{N}_t^b - \widehat{L}_t \text{ from } Rat = \frac{N_t}{L_t} \\
\widehat{a}_t &= \rho_a\widehat{a}_{t-1} + e_t^a \\
\widehat{g}_t &= \rho_g\widehat{g}_{t-1} + e_t^g
\end{aligned}
$$

D.3 Model without financial frictions

$$\widehat{\varrho}_t = \frac{-\left(\widehat{C}_t - h\widehat{C}_{t-1}\right)}{1-h} \text{from (29)}$$

$$\widehat{\varrho}_t = E_t\left\{\widehat{\varrho}_{t+1} + \widehat{R}_t - \widehat{\Pi}_{t+1}\right\} \text{ from (30)}$$

$$\widehat{w}_t = \frac{1}{1+\beta}\left[\begin{array}{c} \beta E_t\widehat{w}_{t+1} + \widehat{w}_{t-1} + \beta E_t\widehat{\Pi}_{t+1} - (1+\beta\gamma_w)\widehat{\Pi}_t \\ +\gamma_w\widehat{\Pi}_{t-1} - \frac{(1-\beta\xi^w)(1-\xi^w)}{\xi^w}\left[\widehat{w}_t + \widehat{\varrho}_t - \varphi\widehat{l}_t\right] \end{array}\right] \text{ from (43) − (44)}$$

$$\widehat{wm}_t = \widehat{w}_t + \widehat{\varrho}_t - \varphi\widehat{l}_t$$

$$\widehat{\Pi}_t = \frac{1}{1+\beta\gamma_P}\left[\beta E_t\widehat{\Pi}_{t+1} + \gamma_P\widehat{\Pi}_{t-1} + \frac{\left(1-\beta\xi^P\right)\left(1-\xi^P\right)}{\xi^P}\widehat{mc}_t\right] \text{ from (43) − (44)}$$

$$\widehat{w}_t = -\frac{\psi_l R\widehat{R}_t}{1+\psi_l(R-1)}\widehat{mc}_t + \widehat{Y}_t - \widehat{l}_t \text{ from (40)}$$

$$\frac{dr_t^k}{r^k} = -\frac{\psi_K R\widehat{R}_t}{1+\psi_K(R-1)}\widehat{mc}_t + \widehat{Y}_t - \widehat{K}_{t-1} - \widehat{U}_t \text{ from (41)}$$

$$\widehat{K}_t = (1-\delta)\widehat{K}_{t-1} + \delta\widehat{I}_t \text{ from (38)}$$

$$\widehat{I}_t = \frac{1}{1+\beta}\left[\widehat{I}_{t-1} + \beta E_t\widehat{I}_{t+1} + \frac{\widehat{Q}_t}{\eta_i}\right] \text{ from (39)}$$

$$\widehat{Q}_t = \beta E_t\left\{\left[\widehat{\varrho}_{t+1} - \widehat{\varrho}_t\right]\left[r^k + (1-\delta)\right] + dr_{t+1}^k + (1-\delta)\widehat{Q}_{t+1}\right\} \text{ from (36)}$$

$$dr_t^k = c^U r^k\widehat{U}_t \text{ from (37)}$$

$$\widehat{R}_t R = (1-\rho_i)\left[\psi_\pi E_t\widehat{\Pi}_{t+1} + \psi_{\Delta\pi}\left(\widehat{\Pi}_t - \widehat{\Pi}_{t-1}\right) + \psi_y\left(\widehat{GDP}_t - \widehat{GDP}_{t-1}\right)\right] + \rho_i\widehat{R}_{t-1} + e_t^i \text{ from (21)}$$

$$\widehat{Y}_t = \alpha\left(\widehat{U}_t + \widehat{K}_{t-1}\right) + (1-\alpha)\left(\widehat{a}_t + \widehat{l}_t\right) \text{ from (26)}$$

$$\widehat{Y}_t = \frac{I}{Y}\widehat{I}_t + \frac{C}{Y}\widehat{C}_t + \frac{Gov}{Y}\widehat{g}_t + r^k\frac{K}{Y}\widehat{U}_t \text{ from (25)}$$

$$\widehat{GDP}_t = \frac{I}{GDP}\widehat{I}_t + \frac{C}{GDP}\widehat{C}_t + \frac{Gov}{GDP}\widehat{g}_t \text{ from (27), noting that now } C_t^P = C_t$$

$$\widehat{a}_t = \rho_a\widehat{a}_{t-1} + e_t^a$$

$$\widehat{g}_t = \rho_g\widehat{g}_{t-1} + e_t^g$$

E Steady state for the full model and the BGG Model

This section shows how the steady state of the full model can be calibrated recursively by assuming targets for some of the real and financial variables. The calculation of the steady state for the BGG model with the passive (frictionless) banking sector is almost identical. It only differs in that in the BGG model, λ equals 0 and $\frac{R^b}{R}$ equals 1 (i.e. banks earn zero profits on loans funded using deposits). Furthermore, I assume that the bankers of the passive banking sector in the BGG model do not consume when they die. This assumption has a negligible effect on my results but ensures that the dynamics of all variables not pertaining to the banking sector are not affected by the existence of the banking sector.

The calibration strategy adopted here implies that the steady state is computed by assuming values for the parameters Π, h, ε, ε_w, ξ^P, ξ^w, α, δ and μ. β, χ, θ, λ, W^b, σ, γ, W^b and Gov are calibrated to to achieve targets for l R, $\frac{N_t^b}{L_t}$, the flow of funds out of bankers equity, $R^L - R$, F, ϕ^e, the flow of funds out of entrepreneurial equity and $\frac{Gov}{Y}$.

I first use

$$\beta = \frac{\Pi}{R}$$

Turning to the entrepreneurial sector and assuming a target value for the bankruptcy rate and setting a trial value for σ, given $\log\omega \sim N\left(-\frac{\sigma^2}{2},\sigma^2\right)$, we can calculate

$$
\begin{aligned}
brate &= F(\overline{\omega}), \text{ gives } \overline{\omega} \\
F(\overline{\omega}) &= Ncdf\left(\frac{\log(\overline{\omega})+\frac{1}{2}\sigma^2}{\sigma}\right) \\
F'(\overline{\omega}) &= \frac{1}{\overline{\omega\sigma}}Npdf\left(\frac{\log(\overline{\omega})+\frac{1}{2}\sigma^2}{\sigma}\right) \\
F''(\overline{\omega}) &= \frac{-F'(\overline{\omega})}{\overline{\omega}}\left[1+\frac{\left(\log(\overline{\omega})+\frac{1}{2}\sigma^2\right)}{\sigma^2}\right] \\
G(\overline{\omega}) &= \int_0^{\overline{\omega}}\omega dF(\omega) = Ncdf\left[v<\frac{\log(\overline{\omega})+\frac{1}{2}\sigma^2}{\sigma}-\sigma\right] \\
G'(\overline{\omega}) &= \overline{\omega}F'(\overline{\omega}) \\
G''(\overline{\omega}) &= F'(\overline{\omega})+\overline{\omega}F''(\overline{\omega}) \\
\Gamma(\overline{\omega}) &= \overline{\omega}\left[1-F(\overline{\omega})\right]+G(\overline{\omega}) \\
\Gamma'(\overline{\omega}) &= 1-F(\overline{\omega}) \\
\Gamma''(\overline{\omega}) &= -F'(\overline{\omega})
\end{aligned}
$$

where $Ncdf$ denotes the cumulative distribution function of the standard normal distribution.

Given μ, I can calculate ξ, $\frac{R^K}{R^b}$, ϕ^e and R^L using the entrepreneur's first order conditions:

$$
\begin{aligned}
\xi &= \frac{\Gamma'(\overline{\omega})}{\Gamma'(\overline{\omega})-\mu G'(\overline{\omega})} \\
\frac{R^K}{R^b} &= \frac{\Gamma'(\overline{\omega})}{\Gamma'(\overline{\omega})-\left[\mu\left[G'(\overline{\omega})\left(1-\Gamma(\overline{\omega})\right)+\Gamma'(\overline{\omega})G(\overline{\omega})\right]\right]} \\
\phi^e &= \frac{1}{1-\frac{R^K}{R^b}\left[\Gamma(\overline{\omega})-\mu G(\overline{\omega})\right]}
\end{aligned}
$$

I adjust σ in order to set ϕ^e to my target.

I then calibrate $\frac{R^b}{R}$ such that, given the calibration of the entrepreneurial sector parameters, $\frac{R^L}{R}$ is close to target. Hence we have

$$
\begin{aligned}
R^b &= \left(\frac{R^b}{R}\right) R \\
R^K &= R^b \left(\frac{R^K}{R^b}\right) \\
R^L &= \frac{\overline{\omega} R^K}{\left(1 - \frac{1}{\phi^e}\right)}
\end{aligned}
$$

Given R^K, it is possible to calculate most of the steady state values for the "real" side of the economy:

$$
\begin{aligned}
X &= \frac{\varepsilon}{\varepsilon - 1} \\
Q &= 1 \\
r^K &= \frac{R^K}{\Pi} - (1 - \delta) \\
\frac{K}{l} &= k = \left(\frac{\alpha}{X\left(1+\psi_K\right)(R-1)\left(\frac{R^K}{\Pi} - 1 + \delta\right)}\right)^{(1/(1-\alpha))} \\
w &= \frac{(1-\alpha)(k)^{\alpha}}{X\left(1+\psi_l\right)(R-1)} \\
\frac{Y}{K} &= \frac{X\left(1+\psi_K\right)(R-1)\left(\frac{R^K}{\Pi} - 1 + \delta\right)}{\alpha} \\
K &= lk \\
Y &= \left(\frac{Y}{K}\right) K \\
Gov &= \frac{Gov}{Y} \cdot Y \\
I &= \delta K \\
l^s &= l
\end{aligned}
$$

Then calculate

$$\begin{aligned}
\varpi' &= \overline{\omega} R^K \\
V &= \frac{K R^K}{\Pi}\left[1 - \Gamma\left(\overline{\omega}\right)\right] \\
N &= \frac{K}{\phi^e} \\
L^e &= K - N \\
L^r &= \psi_L w l + \psi_K r^K K \\
L &= L^e + L^r
\end{aligned}$$

Given γ, this allows to compute W^e as

$$W^e = N - \gamma V$$

If this results in $W^e < 0$, the calibration is not permissible and needs to be modified.

Then I calibrate ϕ^b such that

$$\phi^b = \frac{1}{\left(\frac{N_t^b}{L_t^e}\right)}$$

where $\frac{N_t^b}{L_t^e}$ equals the target for this variable.[16] I can then calculate all steady state values

[16]Since the actual counterpart in the data is for for $\frac{N^b}{L}$, I later adjust $\frac{N^b}{L^e}$ to achieve this target.

pertaining to the banking sector:

$$
\begin{aligned}
z &= \frac{\left(R^b - R\right)\phi^b + R}{\Pi} \\
x &= z \\
\eta &= \frac{1-\theta}{1-\beta\theta z} \\
v &= \frac{(1-\theta)\frac{\left(R^b - R\right)}{R}}{1-\beta\theta z} \\
\lambda &= \frac{\eta + \phi^b v}{\phi^b} \\
N^b &= \frac{L^e}{\phi^b} \\
N_e^b &= \theta z N^b \\
N_n^b &= N^b - N_e^b \\
W^b &= N_n^b
\end{aligned}
$$

If this results in $N_n^b = W^b < 0$, the calibration is not permissible and needs to be modified.

I then calculate the steady state values of the remaining real variables:

$$
\begin{aligned}
C^e &= (1-\gamma)\, V \\
C^b &= (1-\theta)\, z N^b \\
C &= Y - I - C^e - C^b - Gov - \mu G\left(\overline{\omega}\right)\frac{R^K}{\Pi} K \\
C^P &= C + C^e + C^b \\
GDP &= C^P + I + Gov \\
\varrho &= \frac{1}{C\,(1-h)}
\end{aligned}
$$

This allows to back out χ, the weight of labour in the utility function:

$$\chi = \frac{\varepsilon_w - 1}{\varepsilon_w} \frac{\varrho w}{l^{\varphi}}$$

Finally, the auxiliary variables associated with price and wage setting (all only relevant for the nonlinear model) are calculated as

$$\begin{aligned}
F &= \frac{Y}{(1-\beta\xi) X} \\
Z &= \frac{Y}{1-\beta\xi} \\
S &= 1 \\
F^w &= \frac{\chi l^{1+\varphi}}{1-\beta\xi^w} \\
Z^w &= \frac{\varepsilon_w - 1}{\varepsilon_w} \frac{w \varrho l}{1-\beta\xi^w} \\
S^w &= 1
\end{aligned}$$

F Steady state for the nofriction model

In the nofriction model, the steady state is computed by assuming values for Π, h, ε, ε_w, ξ^P, ξ^w, α and δ. β, χ and Gov are calibrated to to achieve targets for l R and $\frac{Gov}{Y}$.This allows to calculate

$$
\begin{aligned}
\beta &= \frac{\Pi}{R} \\
X &= \frac{\varepsilon}{\varepsilon - 1} \\
Q &= 1 \\
r^K &= \frac{R}{\Pi} - (1-\delta) \\
\frac{K}{l} &= k = \left(\frac{\alpha}{X\,(1+\psi_K)\,(R-1)\left(\frac{R}{\Pi} - 1 + \delta\right)} \right)^{(1/(1-\alpha))} \\
w &= \frac{(1-\alpha)\,(k)^{\alpha}}{X\,(1+\psi_l)\,(R-1)} \\
\frac{Y}{K} &= \frac{X\,(1+\psi_K)\,(R-1)\left(\frac{R}{\Pi} - 1 + \delta\right)}{\alpha} \\
K &= lk \\
Y &= \left(\frac{Y}{K}\right) K \\
Gov &= \frac{Gov}{Y} \cdot Y \\
I &= \delta K \\
l^s &= l \\
C &= Y - I - Gov \\
\varrho &= \frac{1}{C\,(1-h)} \\
\chi &= \frac{\varepsilon_w - 1}{\varepsilon_w} \frac{\varrho w}{l^{\varphi}}
\end{aligned}
$$

The calculation of the auxiliary variables pertaining to wage and price setting is exactly the same in both models.

G Data sources

All components of GDP were divided by the labour force. Except the interest rates or interest rate spreads, all data series reported in nominal terms by the respective data provider were deflated using the GDP deflator and divided by the labour force.

- Labour force: Bureau of Labor Statistics (BLS) "Civilian noninstitutional population" series, ID LNS10000000Q. The series was seasonally adjusted.
- GDP Deflator: BEA, NIPA Table 1.1.9. Implicit Price Deflators for Gross Domestic Product
- GDP: Bureau of Economic Analysis (BEA), from NIPA Table 1.1.6. Real Gross Domestic Product, Chained 2005 Dollars, seasonally adjusted
- Consumption: Personal consumption expenditures, BEA, from NIPA Table 1.1.6. Real Gross Domestic Product, Chained 2005 Dollars, seasonally adjusted
- Non-residential Investment: BEA, from NIPA Table 5.3.3. Real Private Fixed Investment by Type, Quantity Indexes, seasonally adjusted
- Net worth of entrepreneurs: Flow of Funds Account (FFA) of the Federal Reserve Board, sum of "Nonfarm nonfinancial corporate business; net worth", series ID FL102090005.Q, and "Nonfarm noncorporate business; proprietors' equity in noncorporate business", series ID FL112090205.Q. The series was seasonally adjusted.
- Leverage of entrepreneurs: FFA. The numerator is the sum of "Nonfarm nonfinancial corporate business; total assets", series ID FL102000005.Q and "Nonfarm noncorporate

business; total assets", series ID FL112000005.Q. The denominator is "Net worth of entrepreneurs" as described above. The resulting series was seasonally adjusted.

- Loans: FFA. Sum of "Nonfarm nonfinancial corporate business; credit market instruments", series ID FL104104005.Q, and "Nonfarm noncorporate business; credit market instruments", series ID FL114104005.Q. "Credit market instruments" consists of six debt instruments: commercial paper, municipal securities and loans, corporate bonds, bank loans not elsewhere classified, other loans and advances and mortgages. The resulting series was seasonally adjusted.

- Net worth of Banks: Federal Deposit Insurance Corporation (FDIC). Tangible Common Equity (TCE), calculated using the FDIC's "Quarterly Banking Profile" (QBP), table "Assets and Liabilities of FDIC-Insured Commercial Banks and Savings Institutions". TCE is calculated as Total equity capital-Perpetual preferred stock- Intangible assets. The resulting series was seasonally adjusted.

- Capital ratio: Loans/TCE. The resulting series was seasonally adjusted.

- Cost of external finance: Federal Reserve Bank of St. Louis, Moody's Seasoned Baa Corporate Bond Yield-Effective Federal Funds Rate. Alternative measures: Moody's Seasoned Baa Corporate Bond Yield-three month treasury bill rate, Moody's Seasoned Aaa Corporate Bond Yield-Effective Federal Funds Rate, Moody's Seasoned Aaa Corporate Bond Yield-three month treasury bill rate.

G.1 Robustness

This section investigates the robustness of my key findings regarding the dynamics of the full model and the BGG model in response to standard shocks as well as their relative performance in matching the second moments of US data. For that purpose, I redo the exercises of the previous two sections, each time considering one of the following deviations from the baseline setup:

- a lower bankruptcy cost parameter μ equal to 0.2 (at the lower end of the values cited by Calrstrom and Fuerst (1997)
- in the interest feedback rule, we replace current with expected inflation. In the table, this rule is referred to as "Rule1".
- no response to the change of inflation in the monetary policy rule
- a monetary policy rule as in Gertler and Karadi et al. (2009), where the interest rate responds positively to current inflation, the deviation of output from it's level in the absence of nominal rigidities, and lagged inflation, with the long run coefficients on inflation and the output gap being 1.5 and 0.5/4 and the coefficient on the lagged interest rate being 0.8, respectively. The deviation of output from its flexible price/ flexible wage level is proxied by the negative of the deviation of the markup of retailers from its steady state.[17] In the table, this rule is referred to as "Rule2".
- a monetary policy rule where the interest rate responds positively to current inflation, the deviation of output from it's steady state, and lagged inflation, with the long run

[17] As in Gertler and Karadi (2009), the coefficients on inflation, the output gap and lagged inflation are 1.5, 0.125 and 0.8, respectively.

coefficients on inflation and the output gap being 1.5 and 0.5/4 and the coefficient on the lagged interest rate being 0.8, respectively. In the table, this rule is referred to as "Rule3".

- flexible prices, $\xi^P = 0$
- flexible wages, $\xi^W = 0$
- no consumption habits, $h = 0$
- no working capital requirement by retailers, $\psi_K = \psi_l = 0$.
- The parameters determining the degree of nominal rigidity, the policy rule parameters and the law of motions of the three shocks are calibrated to Christiano et al.'s (2010) estimate of a model featuring not just a financial accelerator, but also a banking sector providing liquidity services.[18] In the table, this rule is referred to as Chr_altest.

Figure 7 to 9 display the impulse responses of GDP to the three standard shocks in the full and the BGG model. Consistent with my findings in section 4, the peak effect of monetary policy shocks is amplified in the full model relative the BGG model by between a bit less and a third and a half, and the effect of government spending shocks is attenuated somewhat. Furthermore, the on impact decline of GDP in response to a technology shock ranges is between one third and two times stronger (when using the alternative calibration of Christiano (2010) et al.) in the full model than in the BGG model. An exception is the case of flexible prices, where the deterioration of technology persistently increases GDP in the full model, while in the BGG model, GDP first decreases and then increases. However, the

[18]This is Christiano et al.'s (2010) "baseline" model, see table 4, pp. 94-95. The parameters used in our baseline calibration are taken from their "Financial accelerator Model".

output expansion is due to the fact that monetary policy responds to expected as opposed to current inflation and therefore does not respond to the on impact boost to inflation caused by the shock.

The second moments generated by the two models under the various calibrations are displayed in table A.1-A.3 in appendix G.1, where the respective "a" and "b" tables refer to the full model and the BGG model, respectively. EFP_t denotes $R_t^L - R_t$ in the full model and $E_t R_{t+1}^L - R_t$ in the BGG model, both at annualised rates. In table A.1, deteriorations or improvement of a relative standard deviation relative to the data larger than or equal to 0.3 in black or italics, respectively. Similarly, in tables A2 and A3, deteriorations and improvements larger than or equal to 0.1 relative to the data are also marked in black and italics, respectively. For the policy rule with a response to current as opposed to expected future inflation ("rule1"), $\psi_{\Delta\pi} = 0$ and Christiano et al.'s (2010) alternative estimates, the moments generated by the two models are virtually the same. With $\mu = 0.2$, one moment worsens in both models. With $\psi_K = \psi_l = 0$, one moment worsens in the full model while three moments somewhat improve in the BGG model. With the Gertler/ Karadi type policy rule ("rule 2"), 4 two moments worsen in the full model while four moments worsen in the BGG model. For the remaining experiments (rule 3, $\xi^P = 0$, $\xi^W = 0$ and $h = 0$) several moments change substantially. However, even for these experiments, the full model still outperforms the BGG model at matching the second moments of the data.

Table A.1a: Full Model, Standard deviations relative to GDP, various deviations from the baseline setup

Variable	**Data**	**Baseline**	$\mu = 0.2$	Rule1	Rule2	Rule3	$\psi_{\Delta\pi} = 0$	$\xi^P = 0$	$\xi^W = 0$	$h = 0$	$\psi_K = \psi_l = 0$	Chr_altest
GDP_t	1	1	1	1	1	1	1	1	1	1	1	1
C_t	0.81	0.91	0.93	0.91	0.9	1.03	0.91	1.06	1.07	1.05	0.89	0.87
I_t	4.44	2.81	2.56	2.82	2.83	2.67	2.8	*3.18*	2.69	2.62	2.8	2.94
l_t	1.61	1.29	1.31	1.22	1.11	1.35	1.29	1.50	1.35	1.23	1.33	1.28
EFP_t	0.99	0.95	0.85	0.94	0.91	0.86	0.95	1.27	1.03	0.88	1.96	0.99
ϕ_t^e	1.99	1.37	1.19	1.27	1.1	**1.07**	1.37	**2.66**	2.32	1.29	1.44	1.46
N_t	4.53	3.03	**2.64**	2.89	**2.59**	**2.36**	3.03	*4.56*	*4.35*	2.83	3.15	3.17
$\frac{N_t^b}{L_t}$	0.4	0.53	0.51	0.53	0.53	0.52	0.53	0.69	0.53	0.49	0.66	0.55
L_t	2.45	0.66	0.69	0.65	0.67	*1.03*	0.67	*1.5*	*1.25*	0.6	0.63	0.52
N_t^b	2.42	5.46	*5.16*	5.41	5.31	*5.03*	5.45	**7.25**	**5.96**	*5.09*	5.53	5.74

Table A.1b: BGG model, standard deviations relative to GDP, various deviations from the baseline setup

Variable	**Data**	**Baseline**	$\mu = 0.2$	Rule1	Rule2	Rule3	$\psi_{\Delta\pi} = 0$	$\xi^P = 0$	$\xi^W = 0$	$h = 0$	$\psi_K = \psi_l = 0$	Chr_altest
GDP_t	1	1	1	1	1	1	1	1	1	1	1	1
C_t	0.81	0.93	0.92	0.93	0.92	0.99	0.93	1.05	1.05	1.11	0.91	0.91
I_t	4.44	2.34	2.24	2.42	2.44	2.32	2.34	2.08	1.96	2.22	2.29	2.36
l_t	1.61	1.39	1.4	1.31	1.21	1.44	1.39	1.48	1.45	1.29	1.44	1.37
EFP_t	0.99	0.11	0.08	0.1	0.08	0.09	0.11	0.24	0.22	0.11	0.12	0.12
ϕ_t^e	1.99	1.00	0.88	0.91	0.73	0.82	1.01	*2.15*	*1.98*	0.97	1.11	1.14
N_t	4.53	2.08	1.83	1.94	**1.65**	**1.55**	2.08	*3.07*	3.36	1.97	2.24	2.27
$\frac{N_t^b}{L_t}$	0.4	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.08	0.06	0.07	0.07
L_t	2.45	0.77	0.8	0.77	0.82	*1.14*	0.79	*1.87*	*1.38*	0.68	0.74	0.63
N_t^b	2.42	0.89	0.88	0.83	0.79	1.08	0.89	*2.19*	*1.59*	0.79	0.88	0.84

Table A.2a:Full model, Correlations with GDP, various deviations from the baseline setup

Variable	**Data**	**Baseline**	$\mu = 0.2$	Rule1	Rule2	Rule3	$\psi_{\Delta\pi} = 0$	$\xi^P = 0$	$\xi^W = 0$	$h = 0$	$\psi_K = \psi_l = 0$	Chr_altest
GDP_t	1	1	1	1	1	1	1	1	1	1	1	1
C_t	0.89	0.89	0.89	0.9	0.90	0.80	0.89	**0.75**	**0.75**	0.89	0.87	0.87
I_t	0.88	0.89	0.89	0.9	0.91	**0.79**	0.89	**0.68**	**0.66**	0.84	0.87	0.89
l_t	0.86	0.9	0.89	0.91	0.89	**0.73**	0.9	0.92	**0.79**	0.92	0.89	0.91
EFP_t	-0.62	-0.77	-0.75	-0.76	-0.71	-0.42	-0.77	-0.71	-0.71	**-0.88**	-0.8	-0.81
ϕ_t^e	-0.61	-0.75	-0.72	-0.74	-0.67	**-0.25**	-0.75	-0.67	-0.78	-0.83	-0.8	-0.82
N_t	0.73	0.79	0.78	0.78	0.74	**0.52**	0.79	0.76	0.83	0.88	0.81	0.81
$\frac{N_t^b}{L_t}$	-0.44	-0.32	-0.35	-0.35	-0.41	*-0.47*	-0.32	**-0.21**	**0.01**	**-0.18**	-0.25	-0.3
L_t	0.37	0.60	0.59	0.68	**0.77**	**0.78**	0.60	**-0.05**	0.22	0.66	**0.11**	0.52
N_t^b	-0.12	-0.25	-0.27	-0.27	-0.32	-0.34	-0.24	-0.22	0.05	*-0.1*	-0.22	-0.24

Table A.2b: BGG model, correlations with GDP, various deviations from the baseline setup

Variable	**Data**	**Baseline**	$\mu = 0.2$	Rule1	Rule2	Rule3	$\psi_{\Delta\pi} = 0$	$\xi^P = 0$	$\xi^W = 0$	$h = 0$	$\psi_K = \psi_l = 0$	Chr_altest
GDP_t	1	1	1	1	1	1	1	1	1	1	1	1
C_t	0.89	0.85	0.85	0.87	0.87	**0.76**	0.85	**0.76**	**0.69**	0.85	0.82	0.81
I_t	0.88	0.87	0.87	0.89	0.90	0.82	0.87	**0.69**	**0.62**	0.8	0.84	0.83
l_t	0.86	0.86	0.86	0.88	0.86	**0.74**	0.87	0.84	**0.72**	0.88	0.85	0.86
EFP_t	-0.62	-0.56	-0.52	-0.54	**-0.44**	**-0.02**	-0.56	**-0.31**	-0.63	-0.67	-0.64	-0.68
ϕ_t^e	-0.61	-0.53	-0.52	-0.54	-0.44	**-0.02**	-0.56	**-0.31**	-0.63	**-0.67**	-0.64	-0.68
N_t	0.73	0.73	0.72	0.73	0.72	**0.52**	0.73	**0.56**	0.74	**0.82**	0.74	0.75
$\frac{N_t^b}{L_t}$	-0.44	-0.56	-0.55	-0.55	-0.53	-0.52	-0.56	-0.48	**-0.69**	*-0.43*	-0.28	-0.59
L_t	0.37	0.66	0.66	0.73	**0.81**	**0.80**	0.66	*0.26*	*0.26*	0.67	*0.18*	*0.48*
N_t^b	-0.12	0.15	0.18	0.22	**0.37**	**0.52**	0.15	0.07	*-0.15*	**0.25**	*-0.03*	*-0.13*

Table A3a: Full model, autocorrelations, various deviations from the baseline setup												
Variable	**Data**	**Baseline**	$\mu = 0.2$	Rule1	Rule2	Rule3	$\psi_{\Delta\pi} = 0$	$\xi^P = 0$	$\xi^W = 0$	$h = 0$	$\psi_K = \psi_l = 0$	Chr_altest
GDP_t	0.85	0.83	0.83	0.84	0.85	0.85	0.83	**0.70**	**0.69**	0.76	0.81	0.82
C_t	0.88	0.78	0.78	0.79	0.82	0.86	0.78	**0.65**	**0.67**	**0.66**	0.75	0.74
I_t	0.91	0.92	0.92	0.92	0.92	0.93	0.92	0.92	0.9	0.92	0.92	0.92
l_t	0.93	0.78	0.78	0.8	0.81	**0.67**	0.78	**0.62**	**0.61**	0.73	0.76	0.78
EFP_t	0.91	0.72	0.72	0.72	0.73	0.74	0.72	0.70	0.73	0.73	0.71	0.72
ϕ_t^e	0.94	0.66	0.66	0.65	0.65	0.67	0.66	0.68	0.68	0.66	0.66	0.66
N_t	0.94	0.62	0.62	0.63	0.64	0.62	0.62	0.56	0.57	0.62	0.61	0.61
$\frac{N_t^b}{L_t}$	0.83	0.95	0.95	0.95	0.95	0.95	0.95	0.96	0.96	0.95	0.95	0.95
L_t	0.93	0.86	0.88	0.87	0.88	0.90	0.86	0.88	0.81	0.83	0.88	0.79
N_t^b	0.81	0.95	0.95	0.95	0.95	0.95	0.94	0.95	0.95	0.95	0.94	0.95

Table A3b: BGG model, autocorrelations, various deviations from the baseline setup

Variable	**Data**	**Baseline**	$\mu = 0.2$	Rule1	Rule2	Rule3	$\psi_{\Delta\pi} = 0$	$\xi^P = 0$	$\xi^W = 0$	$h = 0$	$\psi_K = \psi_l = 0$	Chr_altest
GDP_t	0.85	0.84	0.85	0.85	0.86	0.84	0.84	**0.74**	**0.69**	0.77	0.81	0.81
C_t	0.88	0.84	0.84	0.85	0.88	0.89	0.84	0.75	**0.73**	**0.71**	0.81	0.81
I_t	0.91	0.93	0.93	0.93	0.93	0.94	0.93	0.92	0.9	0.93	0.92	0.92
l_t	0.93	0.75	0.75	0.78	0.78	0.66	0.75	**0.59**	**0.57**	0.71	0.73	0.74
EFP_t	0.91	0.68	0.69	0.68	0.69	0.71	0.68	0.7	0.7	0.68	0.68	0.68
ϕ_t^e	0.94	0.68	0.69	0.68	0.69	0.71	0.68	0.7	0.7	0.68	0.68	0.68
N_t	0.94	0.62	0.63	0.64	0.66	0.6	0.62	0.53	0.55	0.63	0.61	0.61
$\frac{N_t^b}{L_t}$	0.83	0.92	0.92	0.93	0.93	0.9	0.92	0.87	0.7	0.91	0.96	0.91
L_t	0.93	0.91	0.91	0.91	0.91	0.92	0.91	0.87	0.84	0.89	0.93	0.88
N_t^b	0.81	0.94	0.94	0.94	0.94	0.93	0.94	0.86	0.91	0.94	0.93	0.93

Figure 1 - Monetary policy shock

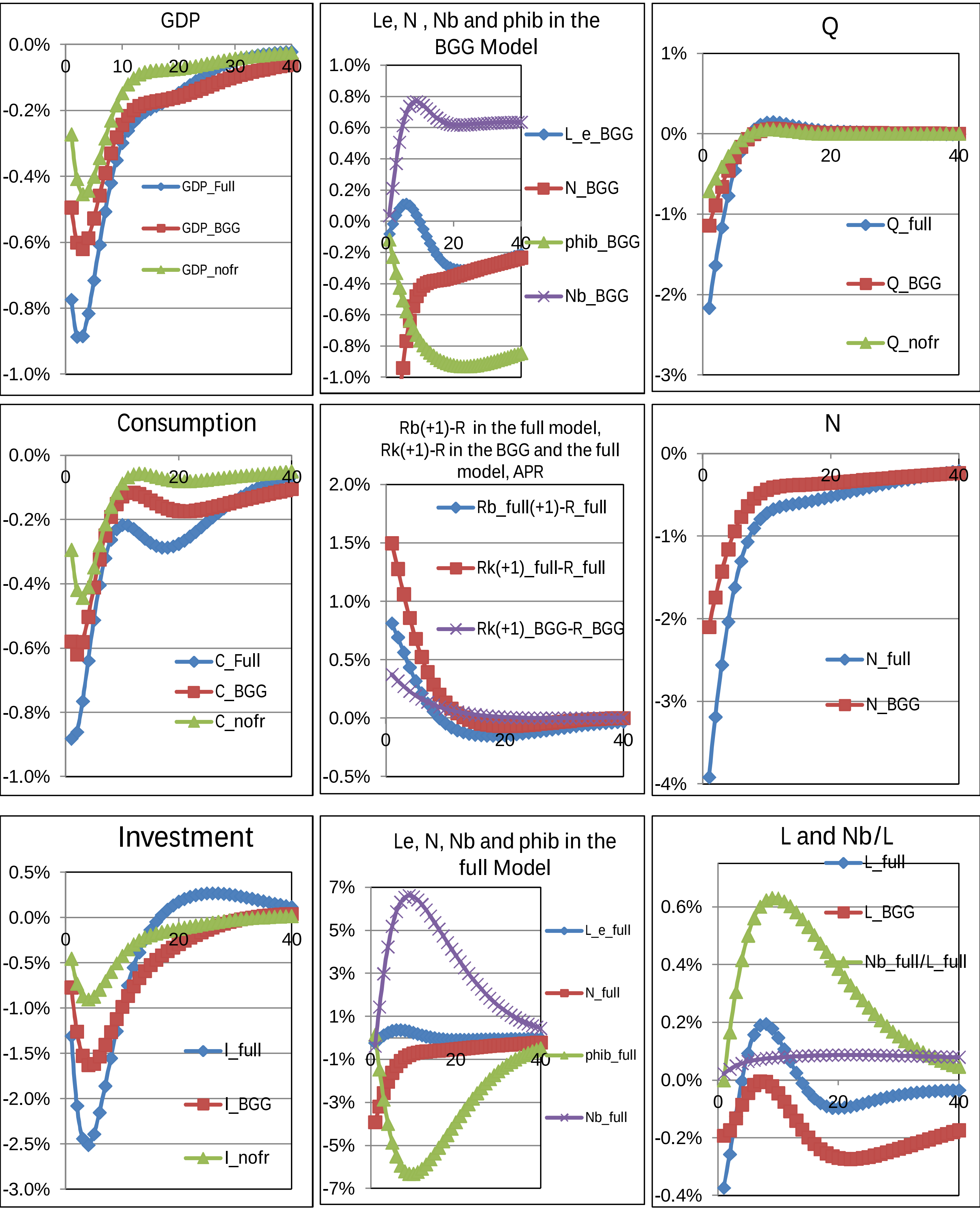


Figure 2 - Technology shock

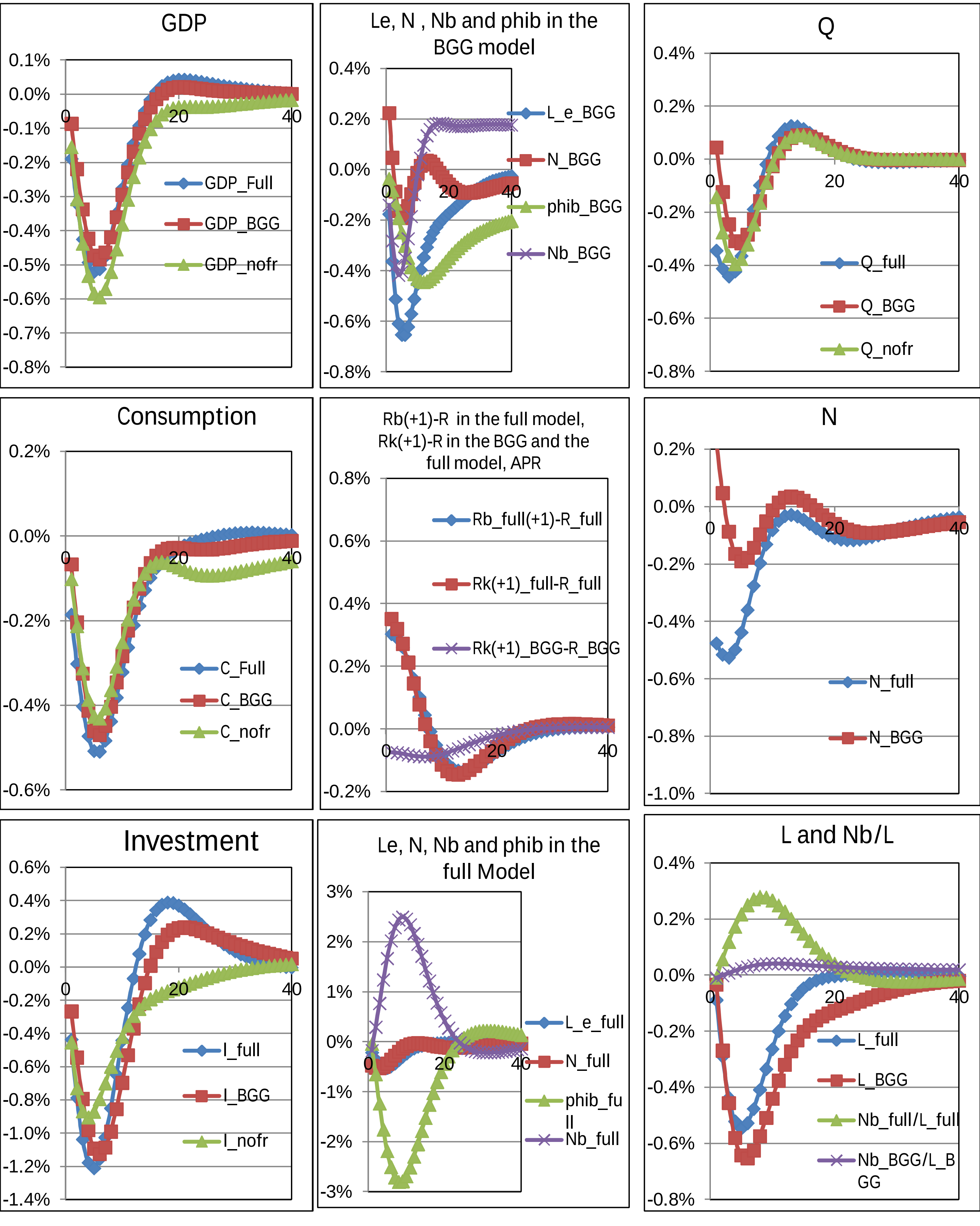


Figure 3 - Government spending shock

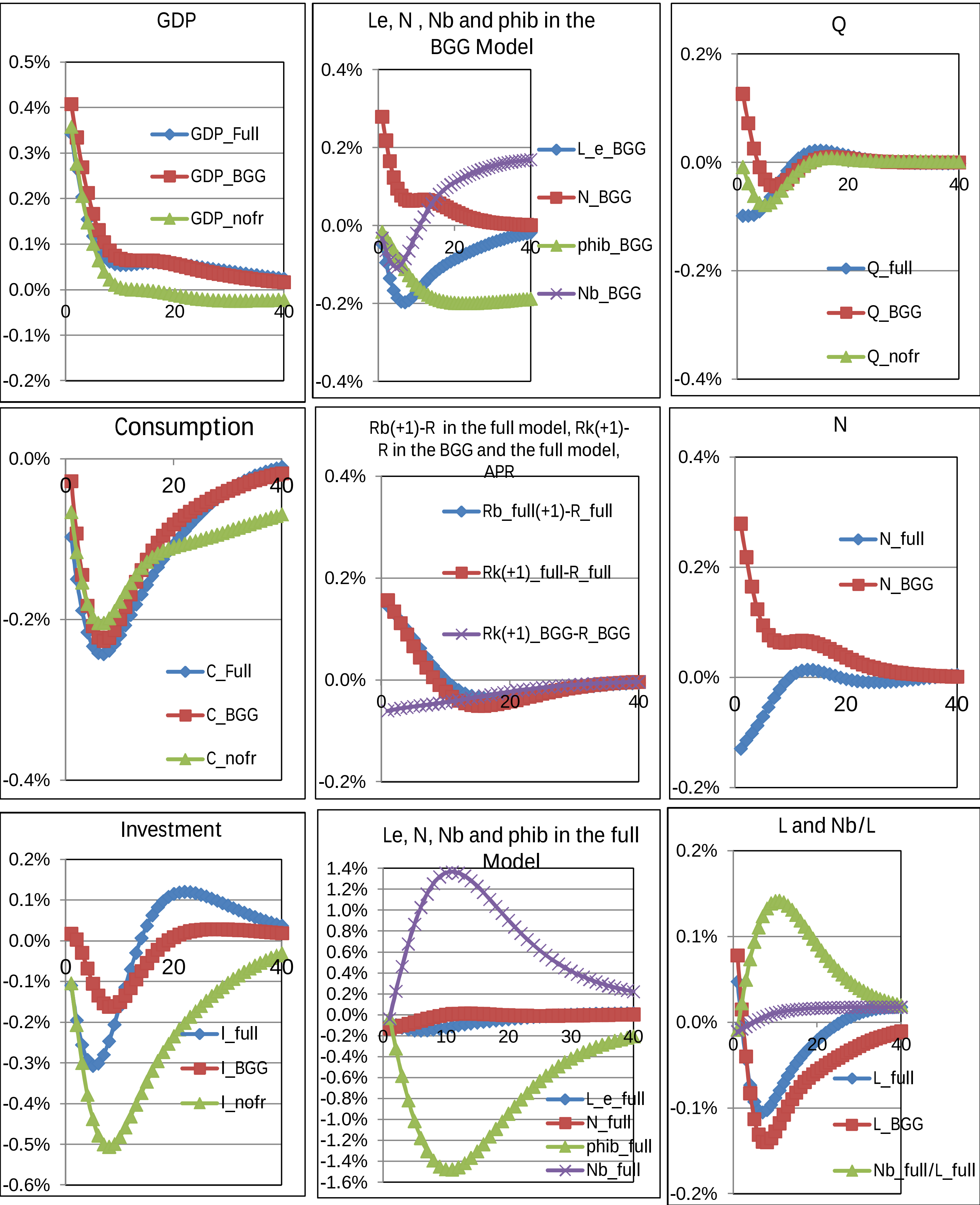


Figure 4 - -1% Shock to entrepreneurial net worth

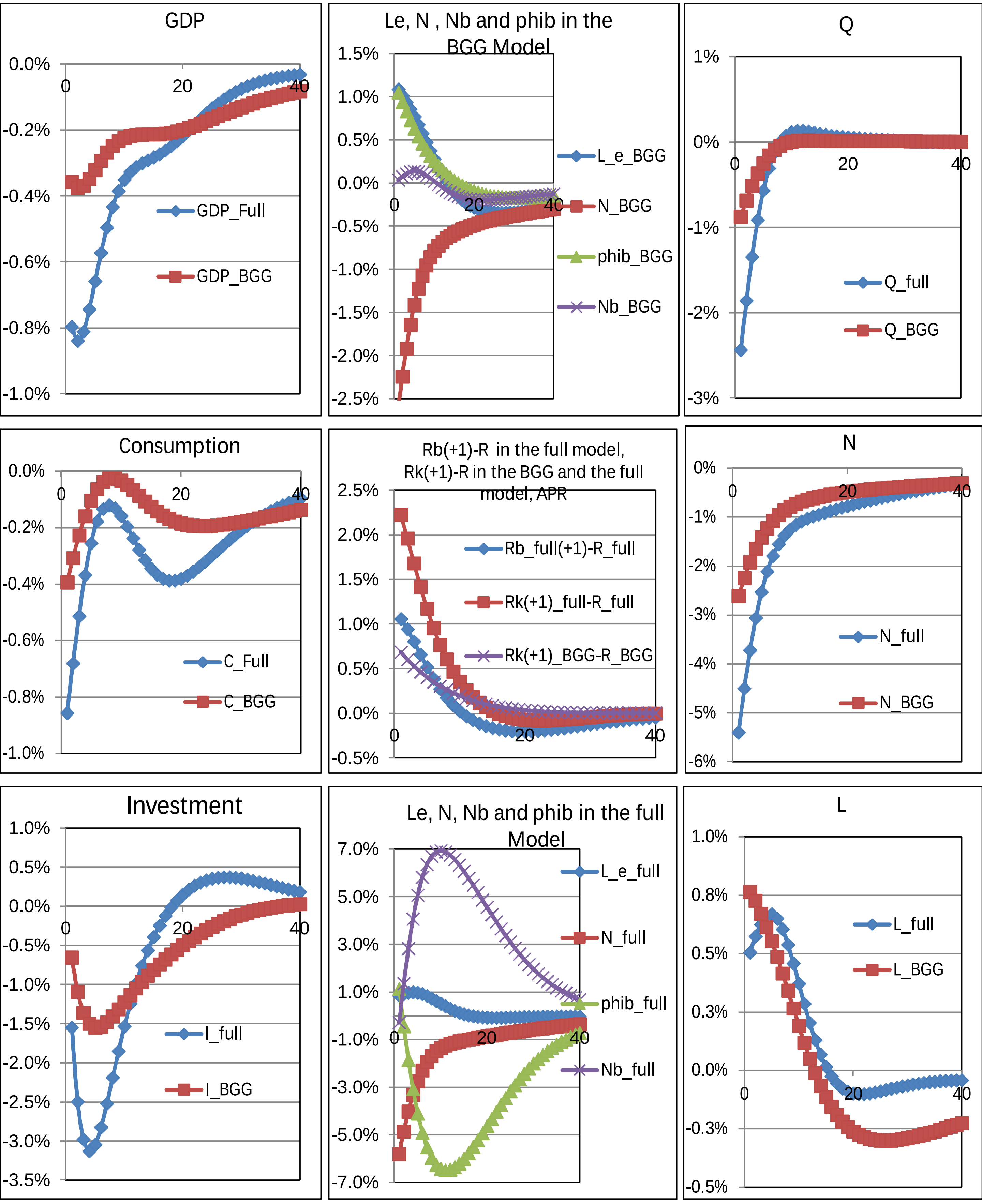


Figure 5 - -5% Shock to bank net worth

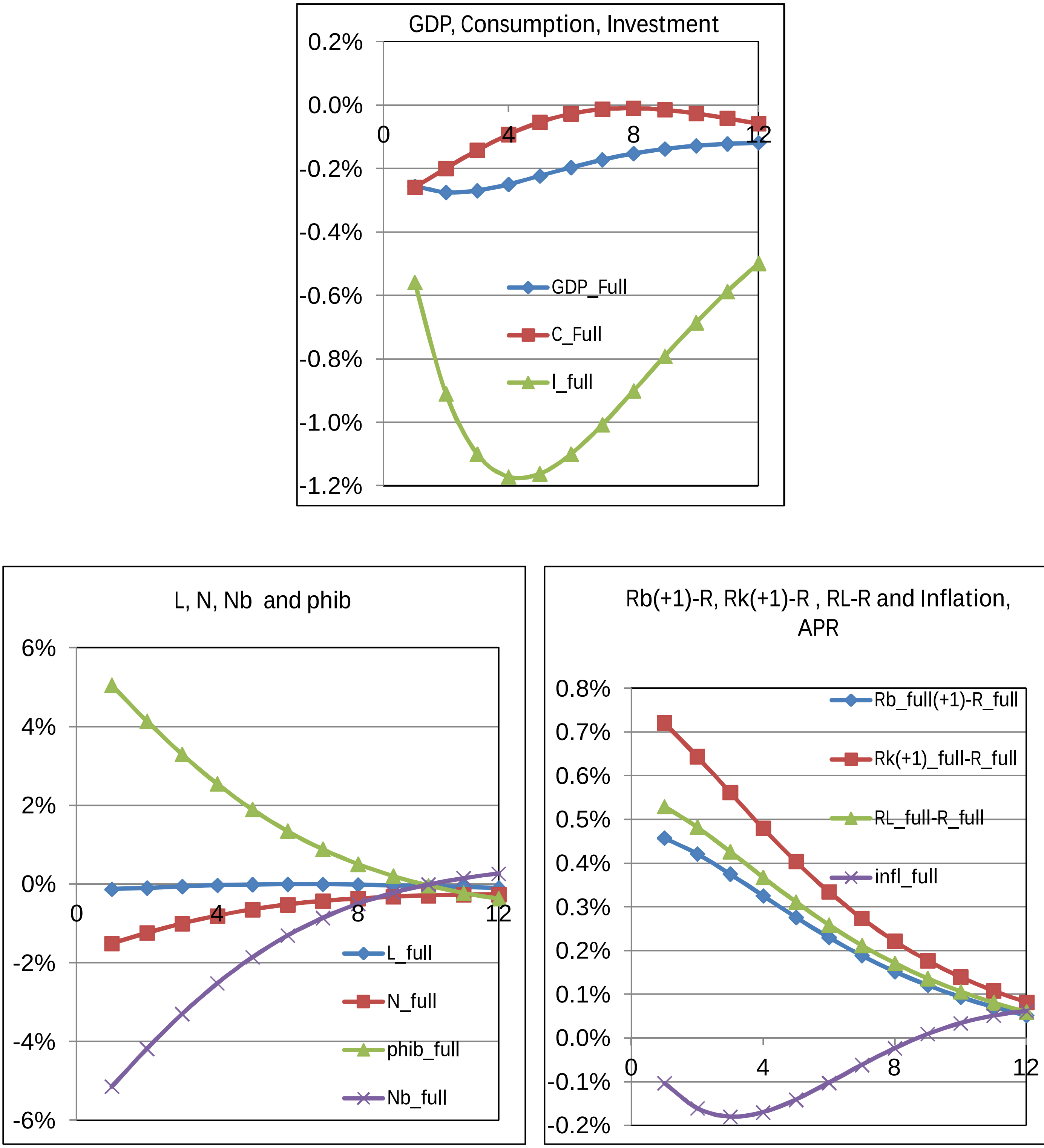


Figure 6 - Crisis experiment

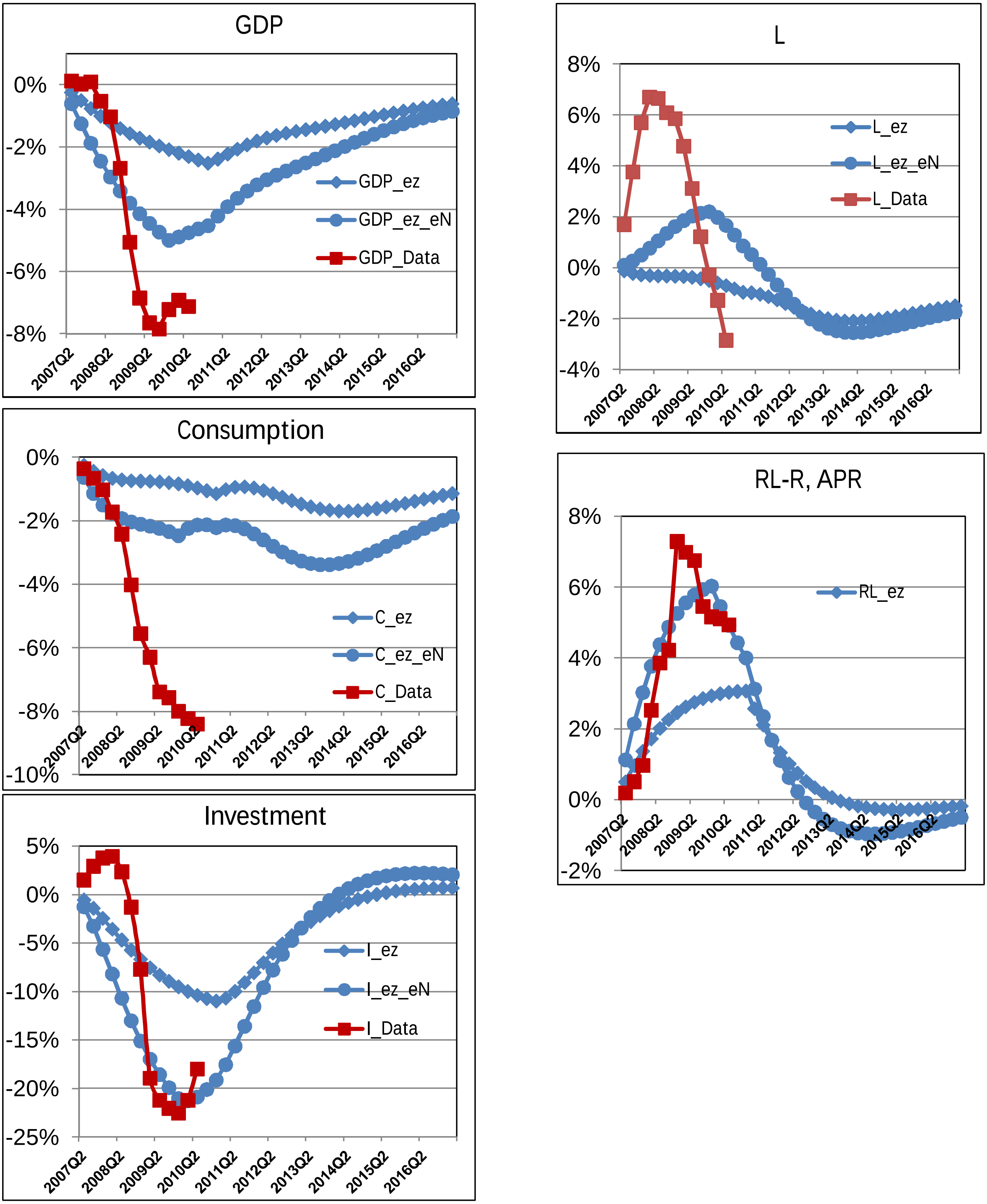


Figure 7a: Monetary Policy Shock - Robustness

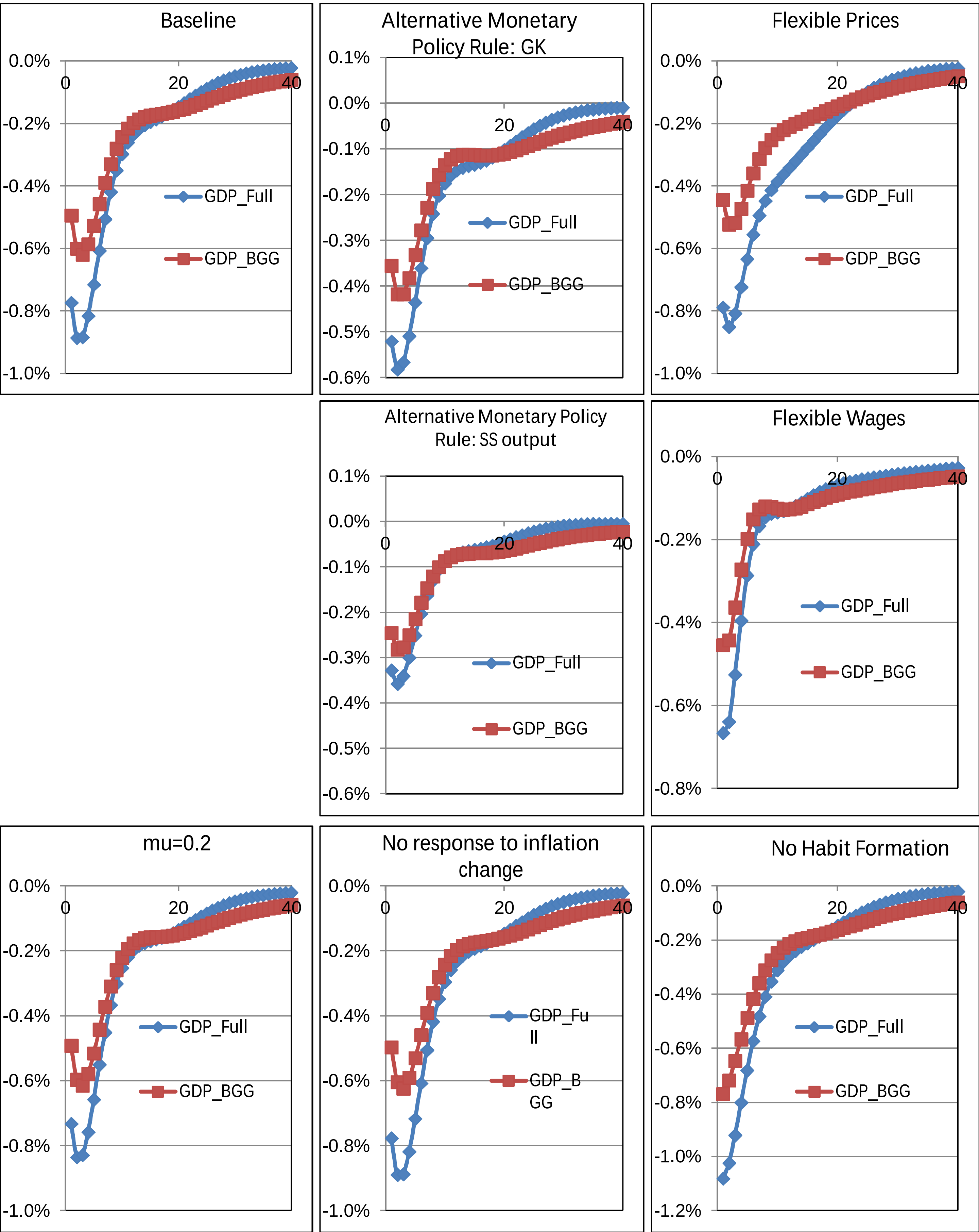
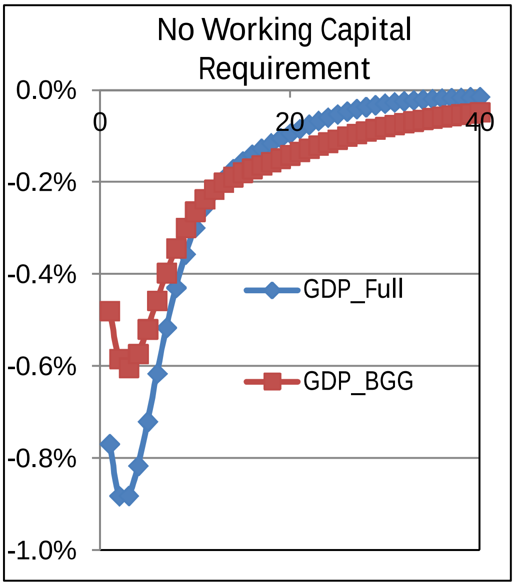


Figure 7b: Monetary Policy Shock - Robustness, continued



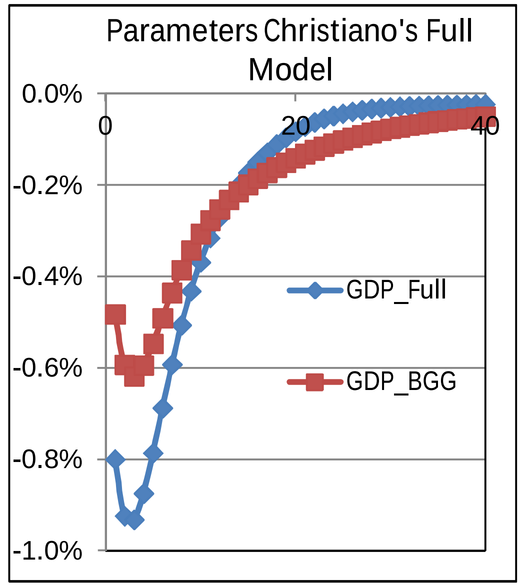


Figure 8a: Technology Shock - Robustness

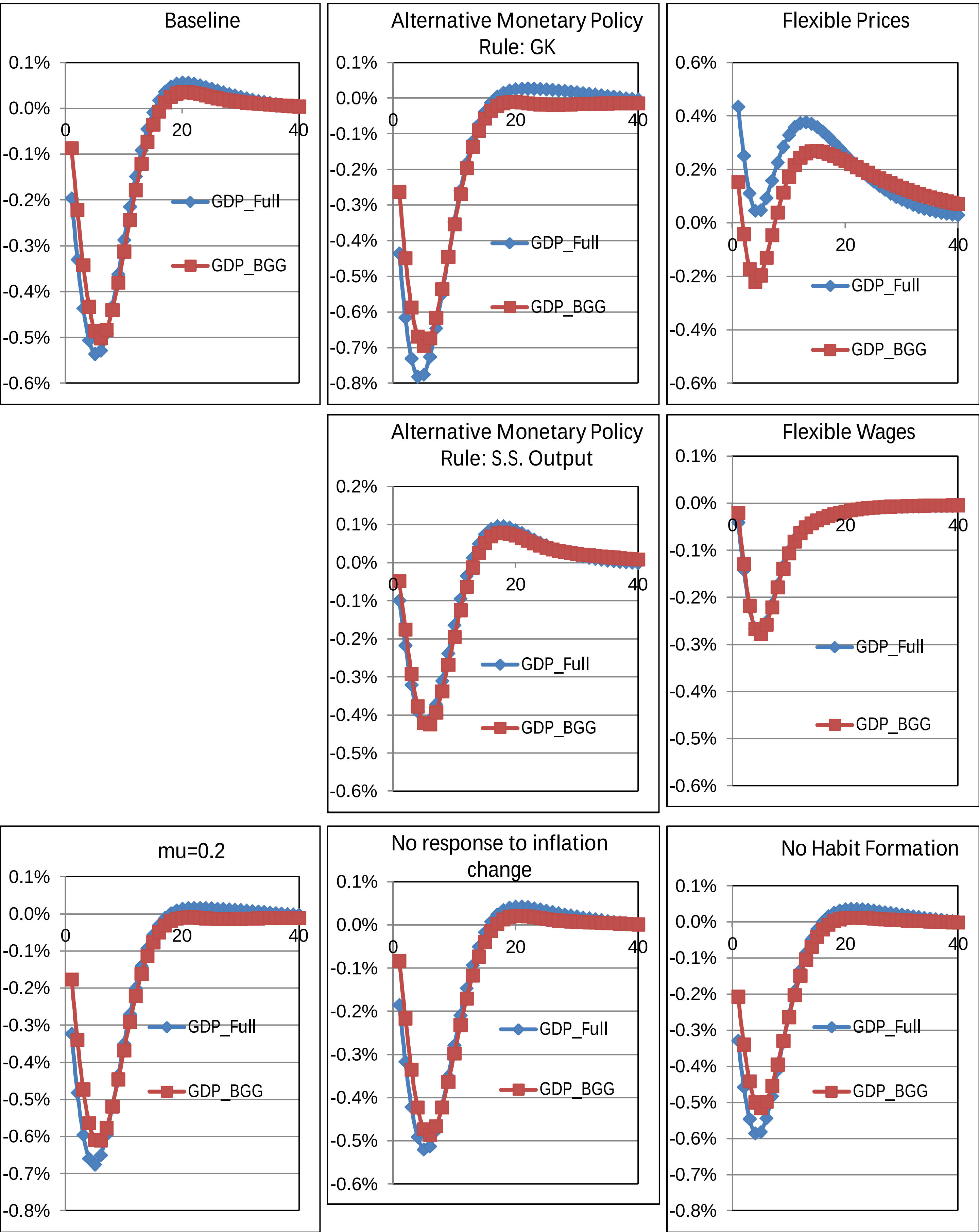


Figure 8b: Technology Shock - Robustness, continued

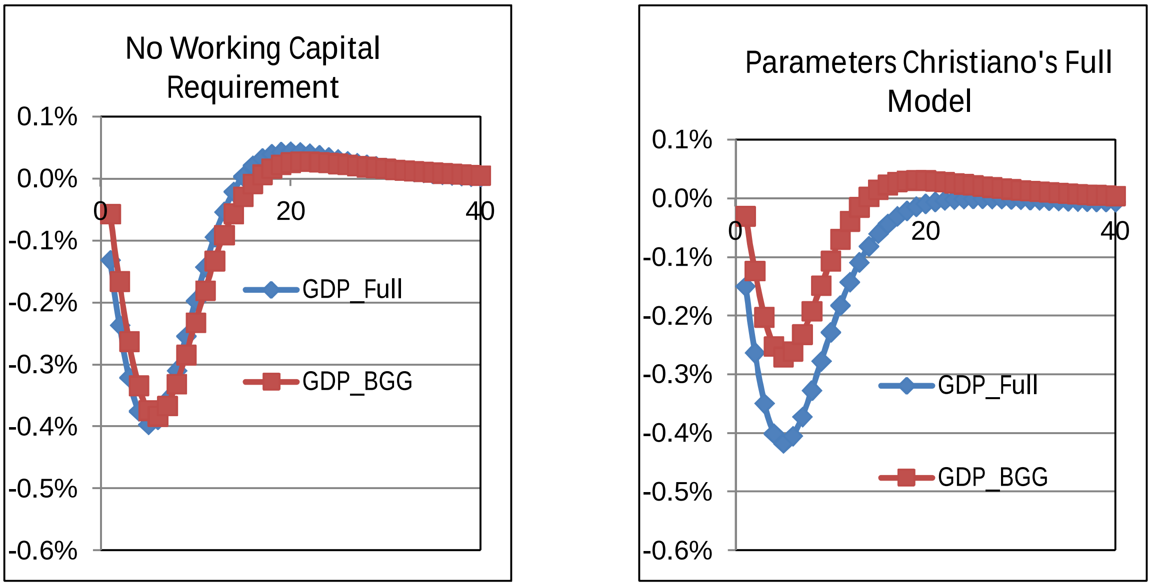


Figure 9a: Government Spending Shock - Robustness

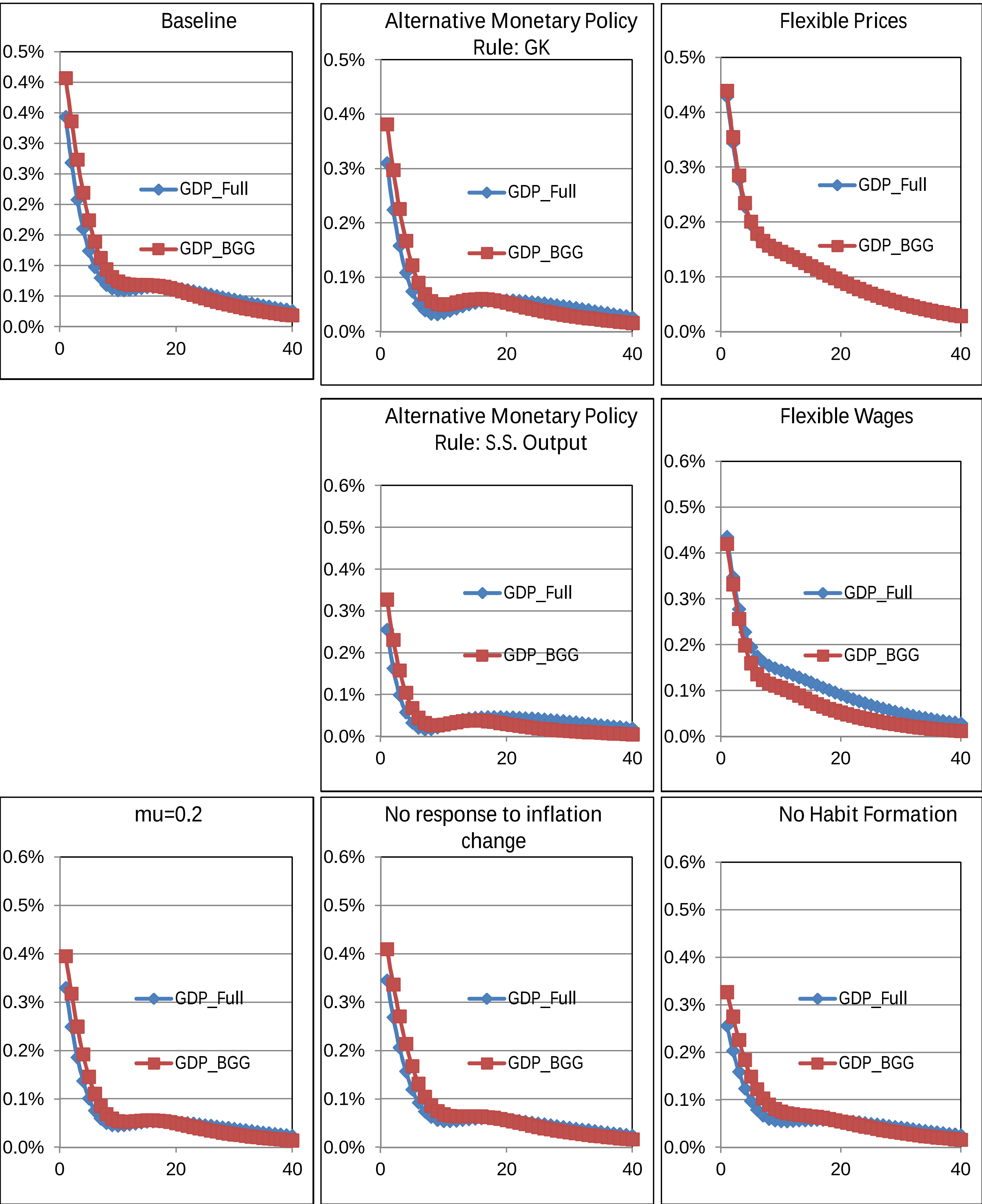


Figure 9 b: Government Spending Shock - Robustness, continued