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How large is the Financial Accelerator? Some Evidence from Firm-level Data*

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25 February, 2016

Very preliminary.

Abstract

This paper analyzes how the size and composition of the balance sheet affects firms financing cost within a large panel of Swiss firms in the non-financial sector from 1998 to 2011. The data includes a large number of small firms, which makes the data representative. We use an instrumental variables approach to identify the investment finance supply curve. Our finding that financing cost increase with exogenous changes in leverage supports the financial accelerator mechanism a la Bernanke, Gertler and Gilchrist. We quantitatively evaluate the implications of our findings for the aggregate business cycle and find that the amplification mechanism of the financial accelerator is economically significant: the volatility of the business cycle is amplified by a factor of 2.25 due to the presence of the financial accelerator channel.

JEL classification: E32, E22, E44.

Keywords: Financing structure, financial accelerator, firm-level data.

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1 Introduction

Models incorporating financial frictions play a prominent role in modern macroeconomic theory, at least since the beginning of the 2007 financial crisis. While a consensus seems to emerge that the financial sector plays an important role for the real economy, the quantitative impact remains unclear, mainly because it is difficult to disentangle the financial accelerator from other propagation mechanisms.

One of the seminal contributions to the literature on financial frictions in DSGE models is the financial-accelerator model developed in Bernanke et al. (1999) (BGG hereafter). The main mechanism is that a firm's net worth determines its creditworthiness. A negative aggregate demand shock, which erodes cash flows or depresses collateral values, squeezes firm's net worth and thereby loan demand, which in turn reduces investment and thereby amplifies the original demand shock.

In this paper, we estimate the size of the financial accelerator from firm-level balance sheet and income statement data for Swiss firms. The data is the main input for the calculation of the Swiss aggregate value-added GDP series. The advantage of the data over more prominent databases, such as Compustat, is that it includes many small and medium-sized firms, which account for a substantial share of aggregate GDP, but are often privately owned and therefore not included in Compustat balance-sheet data.

We estimate the size of the financial accelerator by calculating firms' net-worth-to-investment ratio from the balance sheet data, estimating the return on capital from a production function, and using firms' dividend yield on fixed assets net of write-downs on financial fixed assets and fixed securities as an instrument. Both dividends and write-downs should be exogenous variations in the cash-flow of firms, which affect their net worth, but are not correlated with their investment opportunities.

Our preliminary results show that the size of the key parameter is substantial, in fact even somewhat higher than the parameter assumed in BGG. We evaluate the importance of the financial accelerator in a calibrated version of the BGG model and show that the volatility of the business cycle would be reduced by a factor of 2.25 in the absence of the financial

friction.

Our paper relates to the empirical literature that aims at identifying the role of net worth for firms' investment activity. The key challenge is to find an exogenous variation in net worth, which is uncorrelated with investment opportunities. A good overview of the empirical literature is provided in Sraer (2012). Blanchard et al. (1994), for example, use unexpected cashflow from firms' wins or settled lawsuits as an instrument for cash flows. Even though they have only 13 observations, their data supports the existence of the BGG-type financial friction. More recently, Chaney et al. (2012) use variation in real estate prices as a measure for variation in collateral value. They find that firms invest on average 0.06\$ out of 1\$ of collateral, which suggests that the net-worth channel is substantial. Similarly, Benmelech et al. (2015) use zoning regulation to determine the collateral value of commercial property, because properties in regulated areas are less valuable as collateral. They show that firms owning such properties received less loans and had to pay higher interest, as compared to firms that do not owe property in regulated areas.

Our approach differs from the ones above in the sense that we directly estimate the microeconomic investment supply curve, which yields the key parameter in BGG. We furthermore evaluate the quantitative importance of the financial friction parameter by calibrating the BGG model. According to our findings, the volatility of the business cycle is amplified by a factor of 2.25 due to BGG-type financial frictions.

The remainder of this paper is structured as follows. Section 2 shows the key microeconomic equations in BGG and the log-linearized version of their model. Section 3 describes the balance-sheet and income-statement data, section 4 the empirical strategy and results, section 5 evaluates the empirical estimates quantitatively. Section 6 concludes.

2 Model

We use the model developed in BGG. In this section, we show the equations, which we estimate in the empirical section. The full BGG model is written down in the Appendix.

2.1 The relationship between net worth, investment, and the external finance premium

The main mechanism is that a firms' net worth determines its creditworthiness. A negative aggregate demand shock, which erodes cash flows or depresses collateral values, squeezes firm's net worth and thereby loan demand, which amplifies the original demand shock.

As shown in BGG, the first order conditions for their model yield a link between capital expenditure and the expected discounted return to capital, defined as $s_t = E[\frac{R_{t+1}^k}{R_{t+1}}]$ (s can also be called a wedge between the expected return to capital and the safe return demanded by lenders)

$$Q_t K_{t+1}^j = \psi(s_t) N_{t+1}^j, \quad (1)$$

with $\psi(1) = 1$ and $\psi'(s) > 0$.¹ This equation shows that capital expenditures are proportional to the net worth of the firm, with the proportionality factor increasing in s_t . There is a positive relationship between s_t and $\bar{\omega}$, thus with rising s_t , the probability of default, $F(\bar{\omega})$, declines. However, with falling default probability, the entrepreneur wants to take on more debt. He/she is constrained from raising the debt infinitely by rising expected default costs, because the ratio of borrowing to net worth increases (or, equivalently, capital-to-wealth ratio declines).

Equation (1) can be inverted, giving the expected return as a function of s and the safe return

$$E[R_{t+1}^k] = s \left(\frac{N_{t+1}^j}{Q_t K_{t+1}^j} \right) R_{t+1}, \quad (2)$$

with $s'(\cdot) < 0$. It shows that the external finance premium, s_t depends inversely on the share of the entrepreneurs' investment, that is financed by the entrepreneurs own net worth. The higher is the share of investment, that is financed by own net worth, the smaller is the external finance premium. Equation (2) nicely shows that in equilibrium the expected return

¹This comes from the FOC, which yield a function for $k \equiv \frac{QK}{N}$ ($k = \Psi(\bar{\omega})$ and $k = \psi(s)$). See Bernanke et al. (1999), Appendix A, for details.

to capital (left hand side) is equal to the marginal cost of external finance (right hand side).

Equation (2) can be aggregated over all entrepreneurs, which gives the supply curve for investment finance

$$E[R_{t+1}^k] = s\left(\frac{N_{t+1}}{Q_t K_{t+1}}\right) R_{t+1}, \quad (3)$$

which shows that the external finance premium $s(\cdot)$ depends on the financial condition of entrepreneurs (the ratio $\frac{N_{t+1}}{Q_t K_{t+1}}$).

2.2 Log-linearized version of the BGG model

BGG derive the log-linearized version of their model, where lower case variables are the percent deviations from steady state values. Capital letters denote the steady state level of the respective variable.

The resource constraint is approximated by

$$y_t = \frac{C}{Y} c_t + \frac{I}{Y} i_t + \frac{G}{Y} g_t + \frac{C^e}{Y} c_t^e, \quad (4)$$

the Euler equation is approximated by

$$c_t = E_t[c_{t+1}] - r_{t+1}, \quad (5)$$

consumption of entrepreneurs (the share that goes bankrupt) is simply a share of net worth and thus approximated by

$$c_t^e = n_{t+1}. \quad (6)$$

The supply curve for investment finance is approximated by

$$E_t[r_{t+1}^k] - r_{t+1} = -\nu(n_{t+1} - q_t - k_{t+1}), \quad (7)$$

which would be equal to zero in the absence of financial frictions. The expected gross return

to holding capital is approximated by

$$r_{t+1}^k = (1 - \epsilon)(y_{t+1} - k_{t+1} - x_{t+1}) + \epsilon q_{t+1} - q_t, \quad (8)$$

as in a model without financial frictions.

The same is true for the log-linear version of the equation describing the price-of-capital dynamics

$$q_t = \varphi(i_t - k_t). \quad (9)$$

The aggregate production function, together with the labour aggregation definition and the assumption that entrepreneurial labour is unity yields

$$y_t = a_t + \alpha k_t + (1 - \alpha)\Omega h_t. \quad (10)$$

Combining the two further FOC for labour supply and the first order condition on the marginal product of capital, together with the rental rate of capital equation yields

$$y_t - (1 + \eta)h_t - c_t = x_t, \quad (11)$$

which states that the marginal product of labour, weighted by marginal utility of consumption, varies with the mark-up (=inverse relative price of wholesale goods).

The Phillips curve:

$$\pi_t = E_{t-1}[\kappa(-x_t) + \beta\pi_{t+1}]. \quad (12)$$

Capital stock and net worth of entrepreneurs evolve according to

$$k_{t+1} = \delta i_t + (1 - \delta)k_t, \quad (13)$$

coming from the capital stock equation, and

$$n_{t+1} = \gamma \frac{RK}{N}(r_t^k - r_t) + r_t + n_t, \quad (14)$$

from the difference equation for net worth.

The policy rule is given by

$$r_t^n = \rho r_{t-1}^n + \varsigma \pi_{t-1} + \varepsilon_t^{rn}.$$

and the shock processes by

$$a_t = \rho_a a_{t-1} + \varepsilon_t^a \quad (15)$$

$$g_t = \rho_g g_{t-1} + \varepsilon_t^g. \quad (16)$$

The parameters are related to the structural model parameters by

$$\varphi = \frac{(\Phi(I/K)^{-1})'}{(\Phi(I/K)^{-1})''} \quad (17)$$

$$\nu = \frac{\psi(R^k/R)}{\psi'(R^k/R)} \quad (18)$$

$$\epsilon = \frac{1 - \delta}{1 - \delta + \alpha Y/(XK)} \quad (19)$$

$$\kappa = \frac{1 - \theta}{\theta} (1 - \theta\beta). \quad (20)$$

The key parameter is ν : in the absence of financial frictions, ν is zero and the net worth-to-investment ratio does not have any explanatory power for the spread between the return to capital and the risk-free rate.

3 Data

Our data set comprises balance sheet information for roughly 20,000 firms over the period 1998 to 2011 (Table 1). It is an unbalanced panel, that is, we do not observe every firm for all 13 years. However, the sample is a representative draw from the population of Swiss firms for 12 sectors and it has the advantage over more frequently used data sets, such as Compustat, that it includes both market-listed and privately held firms. The only paper we are aware of,

which uses such a database is Bachmann and Bayer (2014), who show that investment-rate dispersion is procyclical.

The balance sheet data includes detailed information on the financing structure of a firm: external and internal finance, accounting capital stock, number of employees, the net worth of the firm, the value-added, interest payments, and accounting depreciation. From the accounting capital stock and the total write-downs on capital, we calculate investment using a reverse perpetual inventory method: $I_t = K_t - (1 - \delta)K_{t-1}$, where δ is the depreciation rate and thus δK_{t-1} is the total depreciation presented in the balance sheet.

On average, about 60% of a firm's total capital is external capital, which suggests that the credit channel might indeed play an important role. The average and median loan-capital ratio FK_K is at 58% and 61% respectively (fourth and fifth columns in Table 1). There are some sectoral differences. The sectors pharmaceuticals and mining operate with a lower leverage (loan-to-capital ratio around 42-43%), while the sector restaurants and hotels operates with a high share of external finance: more than 70% of the total capital stock is externally financed.²

The average share of interest payments in total costs is very low. On average, only 1.7% of a firm's total costs are interest payments (sixth and seventh columns in Table 1). This suggests that the traditional interest channel plays a minor role in monetary policy transmission, at least the impact of higher interest rates on total costs seems to be rather small.

The loan-capital ratio varies over the business cycle (Figure 1). While the loan-to-capital ratio rose during the boom period up to 2007, it declined during the recession 2009-2010. This might be due to a supply-side effect, where firms have difficulties obtaining external finance during recessions, or a demand-side effect, where firms lower their production and investment during recessions and therefore demand less external finance.

The distribution of loan-to-capital ratios by sector (Figure 2) shows that in particular energy, entertainment and most of the manufacturing sectors are quite heterogeneous, while in construction, restaurants and hotels, and transportation, the largest share of the firms has a loan-to capital ratio of more than 50%. Again, we cannot tell whether the differences are

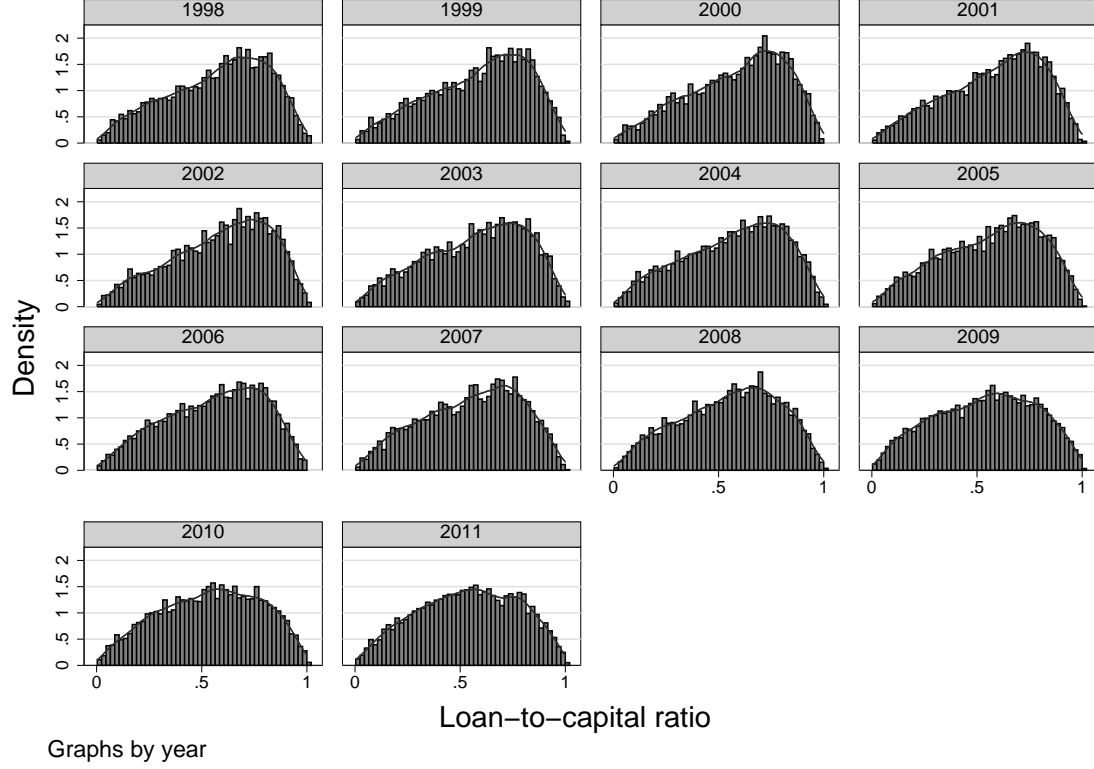
²This relates to the literature, which documents sectoral differences in monetary policy transmission. For example, Dedola and Lippi (2005) show that there are substantial cross-sectoral differences in the response of output to monetary policy shocks. They relate the responses to microeconomic data and find that their responses correlate with durability and investment intensity, which support the credit channel view.

Table 1: *Sample statistics*

	<i>Observ.</i>		<i>FK/K</i>		<i>Int.paym./TotalCosts</i>	
	Total	Firms	Mean	Median	Mean	Median
Aggregate	83299	19846	0.58	0.61	0.017	0.006
<i>Sector</i>						
Business Services 1	5971	1982	0.58	0.60	0.033	0.004
Business Services 2	2227	802	0.61	0.64	0.011	0.003
Construction	7687	1821	0.63	0.67	0.011	0.005
Education	1366	391	0.65	0.70	0.009	0.002
Energy	3408	655	0.49	0.52	0.040	0.013
Entertainment	2236	709	0.57	0.59	0.015	0.005
Health	3290	1022	0.54	0.56	0.013	0.003
IT	3429	983	0.57	0.58	0.012	0.003
Manufacturing Investment Goods	15577	2981	0.54	0.56	0.014	0.008
Manufacturing Pahrma	693	143	0.45	0.43	0.017	0.007
Manufacturiung Watches	3978	768	0.50	0.50	0.013	0.006
Manufacturing Other	10028	1933	0.58	0.62	0.014	0.009
Mining	711	156	0.44	0.42	0.017	0.010
Restaurants Hotels	4237	943	0.71	0.76	0.039	0.021
Trade	14116	3617	0.59	0.62	0.010	0.004
Transport	4345	940	0.64	0.69	0.019	0.008

Note:

Figure 1: *Loan-to-capital ratio 1998–2011*



Note: .

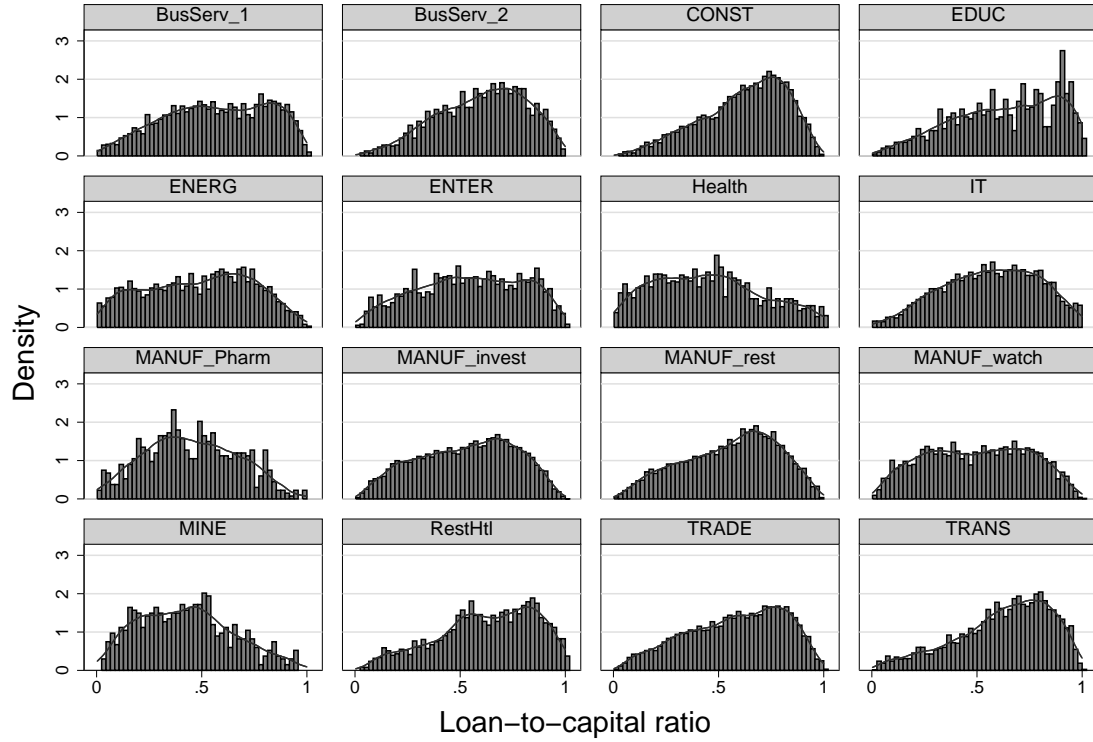
due to supply-or demand-side effects.

Large firms with more than 250 full time equivalents rely most on external finance (Figure 3).

For the estimation sample, we deflate all nominal variables such as the capital stock, the net worth of the firm, the value-added, interest payments and investment by the respective sectoral price indices from the SFSO (Swiss Federal Statistical Office). We use nominal variables whenever we compute ratios, such as the ratio of interest payments to external finance.

To calculate economic capital stocks from the book value of the capital stocks, we use the method proposed in Bachmann and Bayer (2014) (Appendix A.4). In the descriptive statistics, we have used the book value of capital to properly calculate the loan-to-capital ratios. For the estimation, in particular the estimation of the production function and the

Figure 2: *Loan-to-capital ratio by sector*

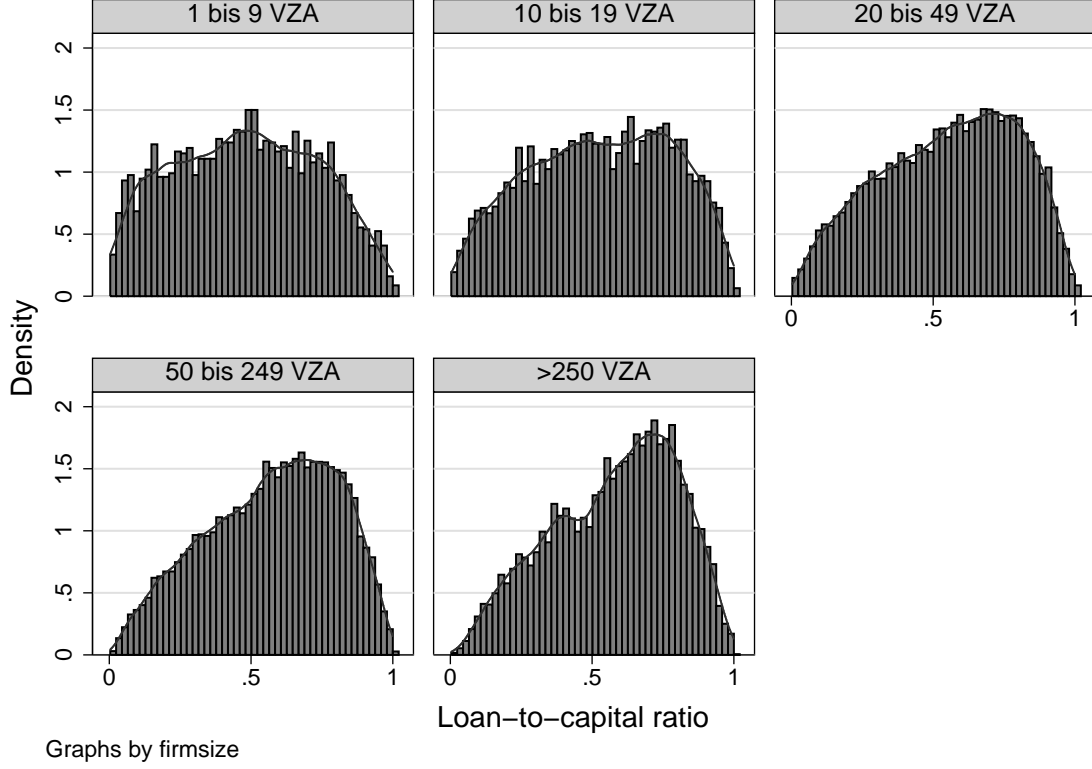


Graphs by sector

Note: .

return to capital, we use economic capital stocks.

Figure 3: *Loan-to-capital ratio by firm size*



Note: .

4 Estimation based on firm-level data

We estimate some of the structural model parameters based on our firm-level data set. In a preliminary step, we fit a micro-level production function for each sector and estimate the equation

$$\Delta y_{i,s,t} = \alpha + \beta_s \Delta k_{i,s,t} + \varepsilon_{i,s,t} \quad (21)$$

in first differences using fixed effects. Here, $y_{i,s,t}$ is the value-added per worker of a firm i in sector s , $k_{i,s,t}$ is the per-worker capital stock, and $\varepsilon_{i,s,t}$ is the *iid* error term.

The supply curve of investment finance in equation (??) requires data on the (expected) return to capital. This can be derived from the estimates of equation (21). We calculate the marginal product of capital and set it equal to the return to capital $R_t^k = \hat{\beta}_s \frac{Y_t}{K_t}$. As shown in Mulligan (2002), this method yields a rental rate of capital, which is a better predictor of

consumption growth than interest rates on financial assets.³

We estimate equation (1) by assuming a functional form for the function ψ , which fulfills the conditions from the FOC, $\psi(1) = 1$ and $\psi'(s) > 0$. $\psi(s_t) = s_t^\phi$. Re-writing equation (2) using this functional form yields $s_t = [\frac{Netw_{i,t-1}}{I_{i,t-1}}]^\frac{1}{\phi}$

and taking logs yields the estimation equation

$$\log(E[R_{i,t}^k] - \log(R_{i,t})) = \frac{1}{\phi} \log[\frac{Netw_{i,t-1}}{I_{i,t-1}}] + D^{time} + D^{sector} + fte_{i,t} + \varepsilon_{i,t} \quad (22)$$

where $R_{i,t}$ denotes the risk-free rate, proxied by the 3M-Libor. We then calculate the main parameter in the log-linearized version of the model, $\nu = \frac{\psi(R^k/R)}{\psi'(R^k/R)}$, which is $\frac{1}{\phi} \frac{R^k}{R}$, thus the estimated coefficient multiplied by the steady-state values for R and R^k , for which we use the sample averages.

Because we want to estimate how an exogenous variation in the net worth affects the external finance premium, we use net financial income (financial income such as dividends or stock returns net of financial asset write-downs) as an instrument for $\log[\frac{Netw_{i,t-1}}{I_{i,t-1}}]$. The idea is that net income on financial assets changes the net worth of a firm but it should be exogenous to a firm's investment opportunities. It is largely determined by stock market movements (which should be uncorrelated with current information). Similar, financial asset write-downs should not be correlated with $\varepsilon_{i,t}$.

Our estimates are summarized in the second column of Table 2, together with the assumptions made by BGG (column 1). We used micro data wherever available, macro data for Switzerland for steady state values, and we left the remaining parameters unchanged from BGG.⁴

³See also Caselli (2007) for an application.

⁴Thanks to Nicolas Viegi for making the dynare code for BGG available on his webpage.

Table 2: Estimates

Values	BGG	BLS	Description	Calculation
Steady-state values				
$\frac{C}{Y}$	0.606	0.56	Share of consumption in output	Macro
$\frac{C^e}{Y}$	0.01	0.01	Share of entrepreneurila consumption	BGG
$\frac{I}{Y}$	0.184	0.05	Share of investment in output	Micro
$\frac{G}{Y}$	0.2	0.11	Share of government expenditure in output	Macro
$\frac{K}{N}$	2.082	1.09	Capital-net-worth ratio (inv. Lerverage ratio)	Micro
$\frac{Y}{N}$	0.282	1.49	Output-net-worth ratio	Micro
X	1.1	1.10	Relative price of retail goods	BGG
R	$= \beta^{-1} = 0.015$	0.011	Riskles rate (quarterly)	Macro
R_k	$= R + 0.02$	0.09	Return to capital (ex post)	Micro estimates
Parameters				
α	0.2	0.07	Capital share of output	Micro estimates
β	0.95	0.99	Discount factor	Macro
η	$= \alpha^{-1}$	15.24	Labour supply elasticity	Micro estimates
ω	0.99	0.99	Share of hh labour in production	BGG
δ	0.025	0.13	Depreciation rate	Micro
ψ	0.25	0.25	Elasticty of price of capital to investm-cpaital ratio	BGG
γ	0.9728	1.00	Survivor rate of entrepreneurs	Micro
μ	0.12	0.12	Fraction of payoffs lost in bankrupcy	BGG
θ	0.75	0.75	Calvo	BGG
ρ	0.96	0.96	Interest rate smoothing	BGG
ς	0.2	0.20	Taylor parameter on lagged inflation	BGG
ν	0.05	0.07	Elasticity of interest rate spread to leverage ratio	Micro estimates
ρ_a	0.99	0.99	Persistence technology shock	BGG
ρ_g	0.95	0.95	Persistence government spending shock	BGG

Note:

5 Quantitative implications in a macro model

In this section, we use the firm-level estimates and evaluate the importance of financial frictions using the macro model from BGG. We first calibrate their model with i) the parameters set by BGG ii) the parameters we obtained in the previous section. In a second step, we estimate the model using Swiss macro data.

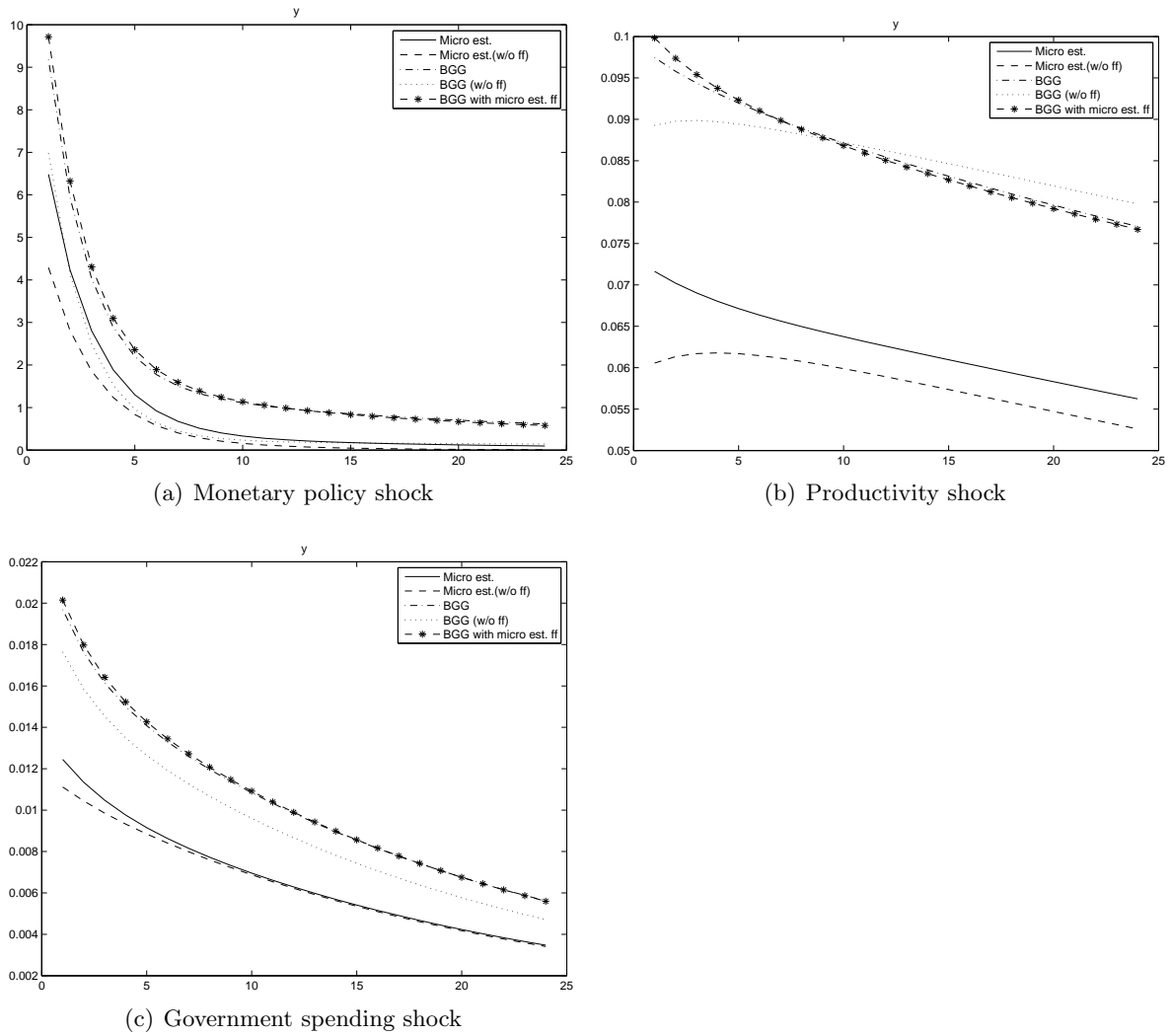
5.1 Calibration

The key parameter we estimate in the model, ν is even a bit higher than the parameter assumed in BGG. This implies that the responses of output or inflation to shocks are stronger in our model than in the BGG model.

Figure 4 shows the responses of output to a) a monetary policy shock, b) a productivity shock and c) a government spending shock. We calibrate five versions of the model: the dashed-dotted line labelled *BGG* shows the impulse responses for the original BGG model with all assumptions identical to the assumptions made by BGG. The dotted line labelled *BGG (w/o) ff* shows the responses for a model, where all assumptions are identical to BGG, we just replaced the parameter ν with zero, thus calibrate a version of the model without financial frictions. The dashed line with asterisks shows the original BGG model, where we replaced only the parameter ν with our estimate of 0.068 (labelled *BGG with micro est. ff*). The solid line shows the responses for the model with all parameters chosen for the Swiss economy as documented in Table 2, labelled *Micro est.*. The dashed line labelled *Micro est. (w/o ff)* is identical to the model *Micro est.* with one difference: we set the financial friction to zero.

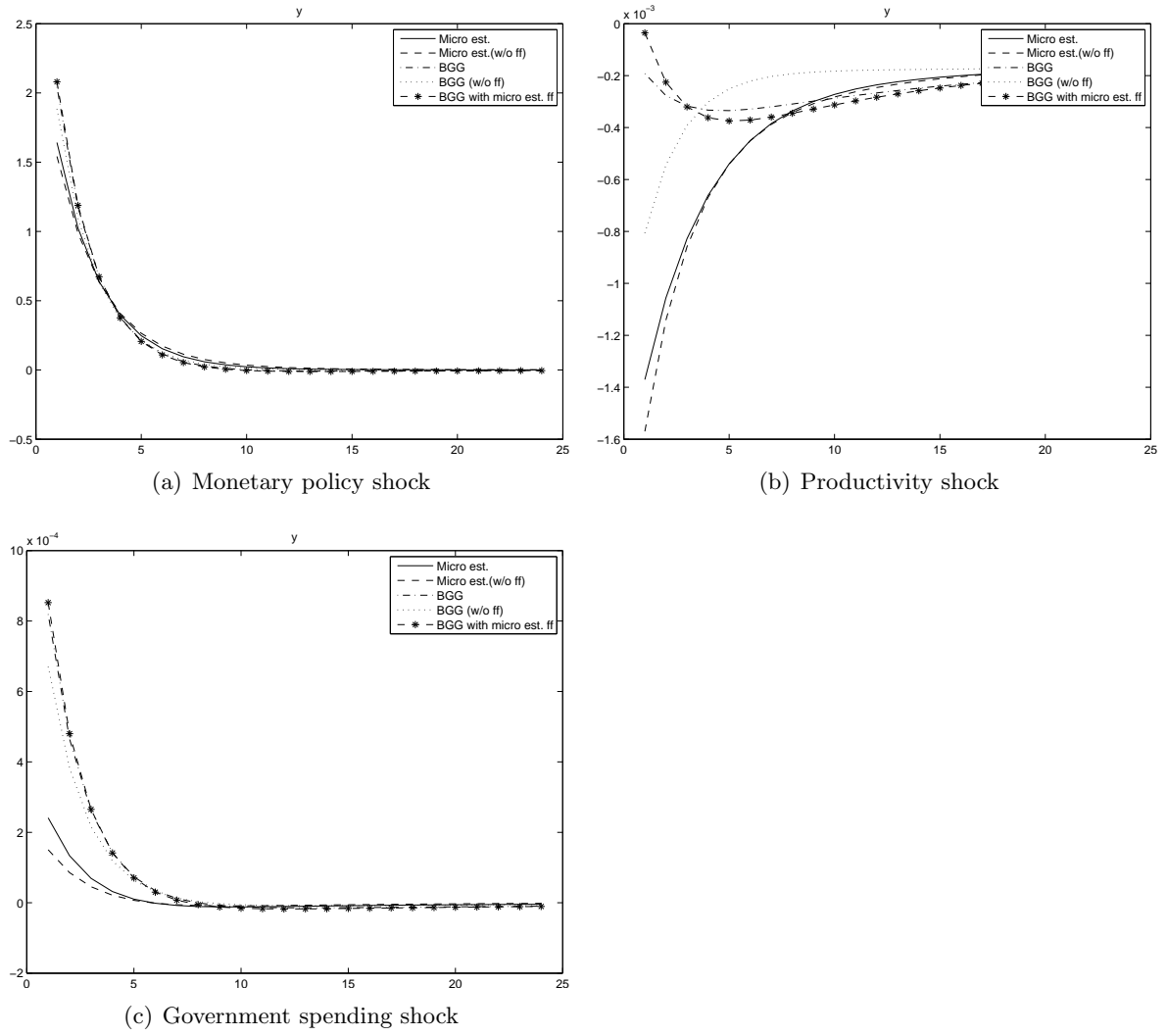
To get an idea of the size of the financial accelerator, we derived cumulated impulse responses for the BGG model including our estimate (*BGG with micro est. ff*) and the BGG model without financial friction (*BGG (w/o) ff*), shown in Figure 6. We then calculate the factor by which the cumulated impulse response differed after 120 quarters, the factor converges to 2.25, which suggests that the business cycle is more than doubled due to financial frictions.

Figure 4: *Impulse responses of output for original BGG and BGG with mirco estimates*



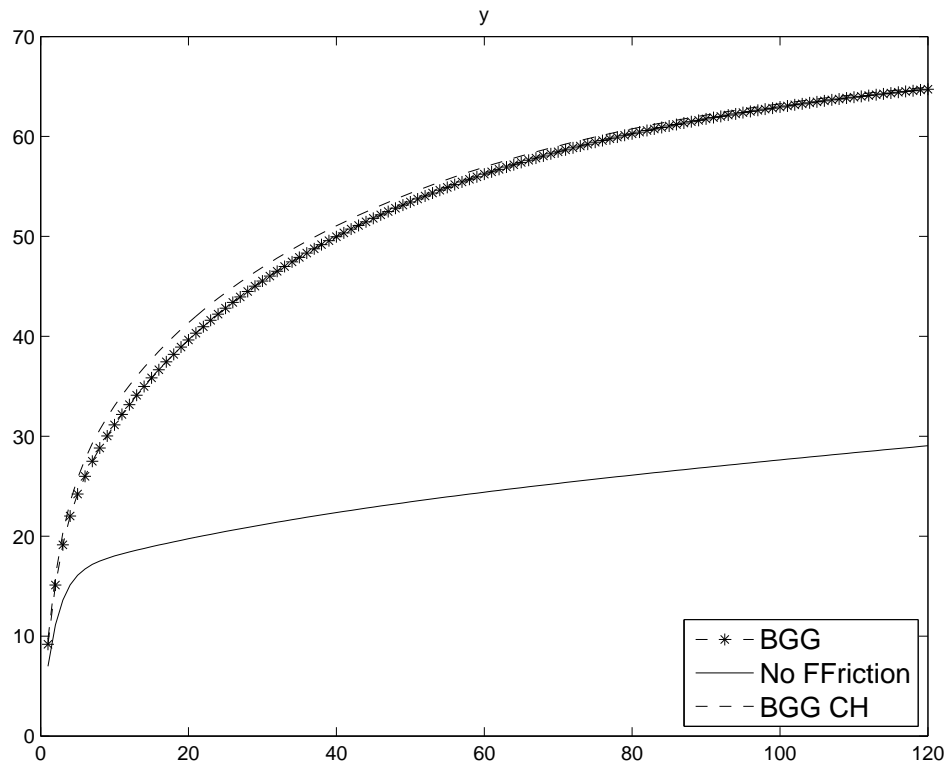
Notes: .

Figure 5: *Impulse responses of inflation for original BGG and BGG with mirco estimates*



Notes: .

Figure 6: *Cumulated impulse responses of output for original BGG with and without financial friction and BGG with mirco estimates*



Notes: .

5.2 Estimation using macro data

TO BE COMPLETED.

6 Conclusions

The balance-sheet channel is one of the most prominent transmission channels of monetary policy. The main mechanism is that a firms' net worth determines its creditworthiness. A negative aggregate demand shock, such as a surprise tightening of monetary policy, which erodes cash flows or depresses collateral values, squeezes firm's net worth and thereby loan demand, which in turn reduces investment and thereby amplifies the original demand shock.

In this paper, we estimate the size of the financial accelerator from firm-level balance sheet and income statement data for Swiss firms, which has the advantage that it includes many small and medium-sized firms, which might be more severely affected by collateral constraints during downturns.

Our findings suggest, that the financial accelerator is substantial and increases the volatility of aggregate GDP by a factor of 2.25.

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