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Firm net worth, external finance premia and monitoring cost – Estimates based on firm-level data*

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Abstract

Based on a large panel of balance sheets and income statements of Swiss nonfinancial firms from 1998 to 2016, we estimate the sensitivity of the cost of external finance to firm net worth using exogenous variation in net worth. We find that firm net worth is inversely related to the external finance premium, consistent with models featuring financial frictions as in Bernanke, Gertler, and Gilchrist (1999). Through the lens of their costly state verification setup, we provide a range for the monitoring cost implied by our estimated sensitivity of the cost of external finance to net worth. Our implied estimate of the monitoring cost ranges between 15 and 20 percent, consistent with an economically significant financial friction.

JEL classification: E32, E22, E44.
Keywords: External finance premium, net worth, firm-level balance sheet data, costly state verification.

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1 Introduction

Do firms' financing structures matter for aggregate fluctuations? In a setting with no financial frictions, whether firms use internal or external funds to finance their projects would be irrelevant, because the costs of the two sources of financing would be the same. This is not necessarily the case in reality, for example, because of asymmetric information between lenders and borrowers in credit markets. Such information asymmetries can lead to firms having to pay a premium for external finance, making external funds more costly. At the same time, firms that have a higher net worth also have a higher collateral, and therefore pay a lower external finance premium than do firms with low net worth. This negative relationship between the external finance premium and firm net worth can generate a financial accelerator mechanism, that amplifies shocks generating aggregate fluctuations (Bernanke, Gertler, and Gilchrist, 1999) (BGG). This mechanism underlies the so-called "balance sheet channel" of monetary policy transmission (Bernanke and Gertler, 1995).

In this paper, we examine the sensitivity of a firm's cost of external finance to variation in its net worth. This sensitivity reflects the key mechanism in financial accelerator models such as the BGG model. We provide empirical estimates of this sensitivity based on firm-level data including detailed information on balance sheets and income statements for Swiss manufacturing firms. Our estimates suggest that this type of financial friction is economically important. Furthermore, we provide a micro-based estimate of parameters that are unobserved in the macro data but that must be included in the calibrations of macroeconomic models featuring financial frictions of this type. Specifically, we derive an estimate of the monitoring cost.

Our paper is related to the literature that shows how financial frictions arise due to information asymmetries, in particular assuming costly state verification as in Townsend (1979). In Bernanke and Gertler (1989) and Carlstrom and Fuerst (1997), costly state verification implies an inverse relation between a firm's net worth and the cost of external finance. This is because, when a firm defaults on its debt, the lender must pay a monitoring cost before it can observe the firm's realised return on the project. This process makes external finance more expensive than internal finance and thereby creates an external finance premium. The external finance premium is decreasing in firm net worth, because a firm with a higher net worth is less likely to declare bankruptcy and therefore financing a project for a high-net-worth firm (vs. a low-net-worth firm) implies a lower likelihood of having to pay the monitoring cost.[1] The main model on which we rely is the BGG model, which includes the costly state verification framework (CSV) in an otherwise standard sticky-price general equilibrium model. The BGG financial accelerator model has been included in various, widely used DSGE models, for example, in Christiano, Motto, and Rostagno (2008), Smets and Wouters (2007), and Christiano, Trabandt, and Walentin (2011).

However, although used in many applications, the quantitative importance of the financial accelerator channel continues to be debated. As an example, Carlstrom, Fuerst, and Paustian (2016) (CFP) relax the BGG model assumption that the lender's contract is not contingent on aggregate fluctuations and argue that this assumption weakens the amplification of aggregate shocks through financing conditions. Further examples are Christensen and Dib (2008) and Meier and Müller (2006), who assess the importance of the channel by estimating DSGE models, with somewhat conflicting results. While the former document that the financial accelerator channel is quantitatively important, the estimates of the latter imply a less prominent role.

One reason the literature has not agreed on the quantitative importance of the financial accelerator channel may be that the external finance premium is unobserved. One way of estimating the aggregate external finance premium relies on DSGE models using aggregate data (Walentin, 2005; De Graeve, 2008). These estimates suggest that the external finance premium is economically sizeable and that it is mostly counter-cyclical, an observation that is consistent with the accelerator mechanism.[2] A second way of estimating the external finance premium is to use firm-level balance sheet data to estimate how firms' financing costs vary with their net worth. To our knowledge, the only paper that does so is Levin, Natalucci, and

[1] The main mechanism in Bernanke and Gertler (1989) is that a shock that reduces the capital return also reduces firm net worth, which increases the cost of external finance, thereby reducing firms' investment and amplifying the initial shock. For this reason, it is referred to as an "accelerator" mechanism.

[2] De Graeve (2008) discusses several cases in which the premium may be procyclical, depending on the shock that is responsible for aggregate fluctuations.

Zakrajsek (2004). They use quarterly data on credit spreads, expected default probabilities, and leverage ratios for 900 publicly listed US nonfinancial firms over the period 1997 to 2003 to back out the cross-sectional and time-series behaviour of the external finance premium. Their estimates suggest that the external finance premium was low on average during the expansion in the late 1990s, and rose substantially in the early 2000s. Their estimates provide support for the macroeconomic significance of the financial accelerator mechanism.

Our paper adds to the literature by using firm-level balance sheet and income statements to estimate the sensitivity of the external finance premium to variation in net worth. The dataset consists of balance sheets and income statements for both large and small firms in Switzerland, including many firms that are not publicly listed, for the period $1998 - 2016$. Since our data include income statements and firms report interest expenses for external capital, we can calculate credit spreads for firms that do not issue corporate bonds, which includes most firms. In addition, the data allow us to estimate the external finance premium under the assumption of a functional form for the production function. We can therefore compare estimates of the sensitivity of the external finance premium to variation in net worth and estimates of the sensitivity of credit spreads to net worth. Both are related to the structural parameter measuring the monitoring cost in the CSV framework. We can therefore provide a range for the monitoring cost that is consistent with these estimates. We address the potential endogeneity issue that firms with a higher net worth may have better investment opportunities with an instrumental variable approach. To isolate the variation in net worth that is exogenous to firms' business opportunities, we use changes in net worth stemming from net financial income and net nonoperating income as an instrument. Our estimates of the sensitivity of credit spreads to variation in net worth and our estimate of the premium-to-net worth sensitivity imply estimates of the monitoring cost ranging between 15 and 20 percent, depending on the empirical specification. These estimates are a bit higher than are those in the BGG model (they assume 12%), largely in line with the range of baseline estimates in Levin, Natalucci, and Zakrajsek (2004) but lower than those in Carlstrom, Fuerst, and Paustian (2016) (assuming 63%).

This paper proceeds as follows. In Section 2, we outline the key equations from the BGG model, and in Section 3 we discuss our data and show how our measures fit into the BGG model. In Section 4, we present the estimates, and in Section 5 we discuss their implications. Section 6 concludes.

2 Theoretical motivation based on costly state verification

In this section, we outline the theoretical framework that motivates our empirical analysis. In general, financial frictions arise due to agency or enforcement frictions. We focus here on demand-side friction due to CSV, because of which financial intermediaries can observe the firm-specific return to a funded project only after paying a cost (Townsend, 1979). This section follows the BGG model, in which a CSV setup is used to introduce an information asymmetry that implies that the external finance premium depends inversely on the borrowing firm's net worth. In the aggregate, if net worth is cyclical, the external finance premium becomes countercyclical and thereby amplifies aggregate shocks.

The model framework assumes a continuum of risk-neutral firms with a constant probability γ of surviving to the next period.[3] Each firm i at period t is hit by an idiosyncratic shock $\omega_{i,t}$ with an expected value of one and variance σ^2. Firms purchase all the capital they need for production $K_{i,t}$ at price Q_{t-1} anew each period. Firms decide upon capital purchases for production in period t at the end of period $t-1$, before observing $\omega_{i,t}$. The ex-post rate of return on a firm's capital project is given by $\omega_{i,t} r_t^k$, where $r_t^k \equiv \frac{r_t+(1+\delta)Q_t}{Q_{t-1}}$ is the aggregate rate of return on capital, which is publicly observed as a function of the risk-free rental rate of capital r_t, the depreciation rate δ, and the price of capital. The expected rate of return on capital exceeds the risk-free real interest rate r_t. The firm may leverage a project and borrow an amount $B_{i,t}$ from risk-neutral financial intermediaries to finance the project. The total project size is thus $Q_{t-1}K_{i,t} = N_{i,t} + B_{i,t}$, where $N_{i,t}$ denotes firm net worth.

Financial intermediaries can observe the size of the shock only after paying a monitoring cost μ (as a fraction of the return on capital $\omega_{i,t} R_t^k K_{i,t}$, where R_t^k is the aggregate gross

[3]This assumption precludes the possibility that the entrepreneurial sector ultimately accumulates sufficient wealth to be fully self-financing. Entrepreneurs receive news at the beginning of the period regarding whether they will die at the end of the period. Dying entrepreneurs thus choose to consume all of their net worth before exiting the economy. The dead firms are then replaced by an equal number of new entrepreneurs.

rate of return on capital). If the shock is too small, below the threshold value $\overline{\omega_{i,t}}$, a firm defaults on its debt and the financial intermediary receives the remaining return on capital after subtracting the monitoring cost. If the firm does not default, the financial intermediary receives a repayment of $Z_{i,t}B_{i,t}$. The debt contract defines this gross nondefault loan rate $Z_{i,t}$, which relates the nondefault loan repayment to the default threshold $Z_{i,t}B_{i,t} = \overline{\omega_{i,t}}R_t^k Q_t K_{i,t}$. As shown in the BGG model, with aggregate risk, the threshold value is contingent on the realised gross aggregate rate of return on capital R_t^k; therefore, Z_t becomes countercyclical: a lower-than-expected value of the aggregate return to capital requires a compensation of increased default probability in terms of a higher loan rate and implies an increase in the threshold value $\overline{\omega_{i,t}}$.

The optimal contracting problem requires that financial intermediaries earn their required rate of return in expectation (which is equal to the risk-free rate r_t, see BGG, Appendix A for the derivation) in the competitive loan market. Firms choose their optimal amount of $K_{i,t}$ and their threshold value $\overline{\omega_{i,t}}$, subject to their capital-to-net-worth ratio and the financial intermediaries' participation constraint: A decrease in net worth leads to an increase in firms' capital-to-net-worth ratio, which leads to an increase in firms' incentive to default. As a result, firms will increase their default threshold $\overline{\omega_{i,t}}$, conditional on the reaction function of the financial intermediaries, which respond to a higher default threshold by increasing the external finance premium, $s_{i,t} \equiv E_{t-1}[\frac{R_{i,t}^k}{R_t}]$. This phenomenon leads to an upward sloping supply- of-funds curve. The marginal cost of external finance increases in the capital-to-net-worth ratio: $\kappa_{i,t} \equiv \frac{Q_t K_{i,t}}{N_{i,t}}$, $\kappa_{i,t} = \psi(s_{i,t})$, with $\psi(1) = 1$ and $\psi'(.) > 0$. Firms choose the size of their capital stock by equating the expected return to capital $E_{t-1}[R_{i,t}^k]$ to their marginal cost of external finance,

$$E_{t-1}[R_{i,t}^k] = \psi^{-1}(\kappa_{i,t})R_t. \tag{1}$$

This equation is key to the financial accelerator as it amplifies the effect of macroeconomic shocks. Imagine a negative demand shock leading to a decline in net worth, which implies that leverage will increase. This will lead to an increase in the marginal cost of external finance, which will lead to lower investment, spending and production. Thus, the link between the marginal cost of external finance and the net worth of firms accelerates the downturn. Consequently, the slope of $\psi^{-1}(\kappa_{i,t})$ is key for the magnitude of the accelerator.

Common practice for quantitative exercises with macroeconomic BGG-type models is to calibrate the parameters of the CSV framework to match some empirical moments in the data. Specifically, the variance of the idiosyncratic shock σ^2 and the monitoring cost μ are set to obtain a certain bond spread and default probability. However, different authors reach quite different conclusions regarding μ and σ and, consequently, those regarding the financial accelerator effect. The BGG model uses $\mu = 0.12$ and $\sigma = 0.28$, implying a slope ν equal to 0.05. The CFP model keeps $\sigma = 0.28$, but sets $\mu = 0.63$, implying a substantially higher slope of 0.19. Our strategy is to estimate directly the log-linearised version of equation (1), assuming a functional form on $\psi^{-1}(\kappa_{i,t}) = \kappa_{i,t}^{\nu}$

$$E_{t-1}[r_{i,t}^k - r_t] = \nu \ ln(\kappa_{i,t}), \tag{2}$$

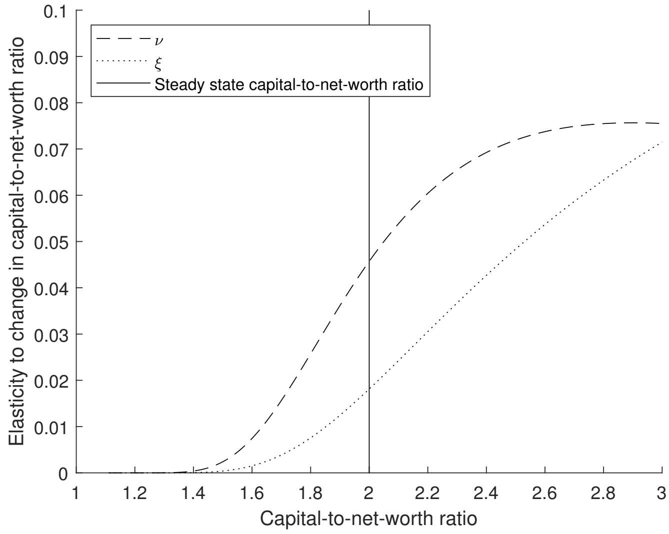
using measures for the return to capital as a spread to the risk-free rate and the leverage ratio that we observe in our dataset, as described in further detail in the subsequent section.

We also estimate an alternative specification replacing the marginal product of capital with the actual interest rate observed on debt. The difference between this actual interest rate on debt and the risk-free rate represents the credit spread that can be observed in the data. Importantly, in the CSV model, the paid gross interest in the no-default case, is not necessarily equal to the gross marginal cost of external financing $Z_{i,t}$. Therefore, in equation (3), the sensitivity ξ is not necessarily equal to ν in equation (2):

$$z_{i,t} - r_t = \xi \ ln(\kappa_{i,t}). \tag{3}$$

Equations (2) and (3) can be mapped to our dataset and used for the estimation of the model parameters. Both the difference of the contractual interest rate $z_{i,t}$ and the marginal cost of external finance $r_{i,t}^k$ to the risk-free rate are functions of the capital-to-net-worth ratio $\kappa_{i,t}$. Figure 1 shows parameters ν and ξ for a given capital-to-net-worth ratio as calibrated in the BGG model. The figure illustrates that, given a certain capital-to-net-worth ratio, a certain value of ν can be mapped onto a corresponding value of ξ and vice versa by determining the respective implications for monitoring cost μ. Therefore, ν is expected to differ from ξ and we can infer a value of μ implied by estimates of ξ or, equivalently, calculate the value of ν implied by the estimate of ξ. With this detour, the estimates of both ξ and ν allow us to determine the scope of the financial accelerator.

Figure 1: *Elasticity of the credit spread and the marginal cost of external financing, and the capital-to-net-worth ratio*



3 Data

We use a large panel of firm-level balance sheet and income statement data ranging from 1998 to 2016, placed at our disposal by the Swiss Federal Statistical Office (SFSO). The dataset is underlying official GDP data and other National Account statistics. The sample is a comprehensive draw from the population of Swiss firms,[4] including all the industries in the economy, except the financial and public sectors.[5] The dataset comprises over 118,800 observations at an annual frequency, from 25,300 firms, in an unbalanced panel. The SFSO collects data for all large firms annually. Smaller firms are replaced more frequently in the sample, with firms from the same industry and similar characteristics.[6] The data include detailed information on firm financing structure. Among others, the dataset includes firm outstanding debt, net worth, total assets, number of employees, value-added, and interest payments. The available balance sheet and income statement variables are listed in Tables 1 and 2, respectively. Even though we do not observe the entire universe of firms, the dataset has some advantages over more broadly available datasets, such as Compustat, in that it contains both large and small firms as well as both privately held and publicly listed firms. Depending on their legal form, firms do not necessarily have to publish their balance sheets or income statements; therefore, information on the financial position, in particular of smaller firms, tends to be less publicly available. It may be important to include such firms as they may have different financing structures than do larger, publicly held firms.

In the following we define the variables that are used to estimate the sensitivity of the finance premium to variation in net worth. While some variables are taken directly from the dataset, others are unobserved and have to be estimated.

The key variables that describe firms' financing structures are contained in the balance sheet data. Firm net worth $N_{i,t}$ is defined as firms' capital $Q_{t-1}K_{i,t}$ less outstanding

[4]The sample is not representative as it over-samples large firms. This is because the sample is used to project aggregate GDP, for which large firm statistics have higher information content. The sampling frame is divided by industry, respectively by sector (primary strata) based on the 2-digit NOGA classification (NOGA is the Swiss industry classification, similar to NACE) and size classes based on the number of employees (secondary strata). This stratification allows the SFSO to build the most homogeneous subpopulations possible, in terms of economic activity and size. A size limit is set for each economic sector, above which all the companies are surveyed. In the remaining strata, simple random samples are drawn. The sample size is set so total gross production and total full-time equivalents at the 2-digit NOGA can be estimated with a coefficient of variation of 2.5%. See BFS (2020) for details.

[5]The financial and public sectors are not included in our data. Therefore, the parameters, we estimate do not relate to these parts of the economy, which amount to approximately 20% of total GDP. These two sectors do, however, not reflect entrepreneurs in the BGG sense: for example, financial firms do not raise credit to invest in the classical way and the public sector in Switzerland is hardly likely to go bankrupt.

[6]Of the smallest firms, (firms with less than 10 full-time employment, FTE) 67% are three or less than three years in the sample, while 72% of the largest firms (firms with more than 250 FTE) are ten years or more in the sample. See Table 6.

Table 1: *Balance sheet variables*

Assets	**Liabilities**
Working capital	Current debt
Inventories	Long-term debt
Third-party securities	Provisions
Long-term accounts receivables	Net worth
Fixed assets (tangible assets, property, plant equipment)	
Intangible assets	
Others	

Note: This table shows a generic balance sheet. "Others" includes costs for incorporation, costs for increases in capital, and unpaid share capital. "Net worth" includes treasury stock, profit carryforward, and net profits.

Table 2: *Income statement variables*

Expenses	**Income**
Cost of materials	Revenue
Decrease in inventories	Increase in inventories
Personnel expenses	Other operating revenue
Interest payments	Subsidies
Other expenses	Dividend income from third-party securities
Loss on third-party securities	Income from third-party securities
Nonoperating expenses	Nonoperating revenue
Depreciation costs on fixed and intangible assets	Net loss
Tax expenses	
Net income	

Note: This table shows a generic income statement.

obligations $B_{i,t}$.[7] Following the BGG model, capital includes firms' liquid assets plus the collateral value of illiquid assets. $Q_{t-1}K_{i,t}$ consists therefore not only of physical capital but of all assets that are available in a given period, such as short-term liquidity. Outstanding obligations $B_{i,t}$ are the sum of all long- and short-term debt on which a firm must pay interest, i.e., total liabilities without provisions. On average, the outstanding debt amounts to 57.2% of firms' total capital (the median is at 59.4%). This suggests that external finance is an important part of firms' total capital. There is some sectoral heterogeneity. The transport sector and the restaurants and hotels sector operate with more debt per unit capital than the

[7]As the reference date of the balance sheet variables, such as the capital stock, is set at the end of the reporting period, these variables are taken from our dataset in $t-1$. Therefore, the quantity of capital productive in t is denoted as $K_{i,t}$ and is the capital reported at the end of the previous reporting period at the price of the previous reporting period Q_{t-1}. $Q_{t-1}K_{i,t}$ therefore corresponds to the BGG model's denotation $Q_tK_{i,t+1}$. In contrast, the variables taken from the income statement, such as interest payments, refer to the entire year t and enter the model contemporaneously.

pharmaceutical sector, for example (see Table 7).

A further central variable is the external finance premium, which is the difference of the return to capital and the risk-free rate, proxied by the 3-month LIBOR.[8] Gross return to capital $R^k_{i,t}$ is constructed following BGG's definition assuming that when a firm needs to take out external finance, the marginal cost of external finance will, in equilibrium, equal its expected return to capital. Because of diminishing returns, the return to capital depends inversely on the capital level. Assuming a Cobb–Douglas production function, the rent for a unit of capital is $\frac{1}{X_{i,t}}\frac{\alpha Y_{i,t}}{K_{i,t}}$, where $\frac{1}{X_{i,t}}$ is defined as the relative price of produced goods. Adding depreciation and considering the change in the price of capital, the gross return of capital is defined as:

$$R^k_{i,t} = \frac{\frac{1}{X_{i,t}}\frac{\alpha Y_{i,t}}{K_{i,t}} + Q_{i,t}(1-\delta_{i,t})}{Q_{i,t-1}}. \tag{4}$$

We measure the relative price of the produced goods at the firm level as $P^Y_{i,t}$ divided by aggregate price CPI_t.[9]. As capital is the sum of the physical capital and liquid assets, capital price $Q_{i,t}$ is a weighted average of the capital stock deflator and the GDP deflator. The weights are equal to the firm-level shares of physical capital and liquid assets to total capital. The output elasticity of capital, α, is estimated with the methodology developed by Wooldridge (2009), which uses a proxy variable approach to control for unobserved productivity.[10] Our estimate for α is 0.37, a value very close to BGG's assumption of 0.35. Depreciation rate $\delta_{i,t}$ is

[8] The choice of the risk-free rate is not relevant in our empirical analysis as it is used only to estimate the elasticities of the external financial premium, with equation (5), and the credit spread, with equation (6). Both equations include a time dummy that absorbs all aggregate variation and a constant that absorbs any level shifts in the financial premium or the credit spread resulting from the choice of the risk-free rate.

[9] This calculation gives us the following definition for the gross return to capital ($P^Y_{i,t}Y_{i,t}$, the firm-level nominal value added is taken from firms' income statements):

$$R^k_{i,t} = \frac{\frac{1}{CPI_t}\frac{\alpha P^Y_{i,t}Y_{i,t}}{K_{i,t}} + Q_{i,t}(1-\delta_{i,t})}{Q_{i,t-1}}$$

[10] We estimate α using the GMM procedure described in Rovigatti and Mollisi (2018), which is based on firms' intermediate goods purchases.

derived from firms' depreciation expenditures on physical capital included in our dataset.[11][12] The return to capital minus the 3-month LIBOR is our measure for the external finance premium.

In addition to the sensitivity of the external finance premium, we estimate the sensitivity of the credit spread to changes in the net-worth-to-capital ratio. The credit spread is defined as the difference between contractual interest rate $Z_{i,t}$ and the short-term risk-free rate and is used to proxy for the unobserved external finance premium (Gilchrist, Ortiz, and Zakrajsek, 2009). The contractual interest rate paid by firms is measured by the ratio of the interest payments to the total outstanding debt. Defined in this manner, the contractual interest rate reflects the average interest rate over all debt contracts that a firm holds.[13]

Column (1) of Table 3 shows the means of the annual gross marginal product of capital (MPK, as defined in equation (4)). The overall mean estimated with our dataset is 1.19 and is in line with the estimates of Lowe, Papageorgiou, and Perez-Sebastian (2019) for the private sector in advanced countries.[14] Columns (2) and (3) show the means of the external finance premium ($r_t^k - r_t$) and the credit spread ($z_t - r_t$), respectively. As the BGG calibration is defined for a quarterly frequency, the credit spread and external finance premium shown in the table are quarterly estimations. The mean external finance premium is approximately

[11] As firm-level depreciation rates are erratic, we average the rates over firms by year. It is important not to average over time to consider the fact that the overall depreciation rate tends to increase over time due to a rising share of short-lived capital goods, such as IT products. This per annum average depreciation rate, which is equal for all firms each year, is then weighted with the share of physical capital for each firm per year. As a result, $\delta_{i,t}$ varies by firm and year.

[12] The estimates of the elasticity of the financial premium are similar if the estimation is conducted using sector-level output elasticities and sector-level depreciation rates (see B.5 in the Appendix).

[13] BGG assume that the interest rate that entrepreneurs must pay on their loans is reset every period, depending on their net-worth-to-capital ratio in that given period. In the data, this precondition is clearly not fulfilled: arguably, many firms hold debt with a duration of over a year. Therefore, our measure of firms' average interest rate also includes the interest rates that were set at an earlier date, depending on firm net-worth-to-capital ratios at that time. Consequently, the estimated sensitivity using this measure of average interest rate must be interpreted as a lower bound. Table 11 in the Appendix shows the estimates of the sensitivity of the credit spread using an interest rate that is derived from the interest rate payments on additional debt taken out in period t. As expected, the elasticity of the credit spread based on this 'marginal' interest rate is higher than the elasticity estimated with the average rate.

[14] Various authors, such as Mello (2009) or Caselli and Feyrer (2007), estimate a net marginal product of capital of approximately 11%-12% for high income countries. However these aggregate figures have been relativised by Lowe, Papageorgiou, and Perez-Sebastian (2019), who distinguished between the private and public marginal product of capital. They show that the overall marginal product of capital is pulled down by the low rates in the public sector. Their estimates for the private-sector net marginal product of capital in advanced countries sit at approximately 20%. Thus, our estimates for $R_{i,t}^k$ are plausible.

Table 3: *Return on capital and interest rate*

	Gross MPK $R^k_{i,t}$ *per year*	*External finance premium in basis points per quarter*	*Credit spread in basis points per quarter*
Aggregate	1.19	407	47
Sector			
Business Services 1	1.30	612	43
Business Services 2	1.27	571	45
Construction	1.27	558	21
Education	1.25	514	38
Energy	1.07	152	50
Entertainment	1.23	472	46
Health	1.19	392	47
IT	1.27	559	45
Manufacturing Investment Goods	1.13	286	83
Manufacturing Pharma	1.17	358	59
Manufacturing Watches	1.16	338	48
Manufacturing Other	1.20	419	56
Mining	1.10	218	36
Restaurants Hotels	1.23	454	48
Trade	1.15	333	50
Transport	1.17	360	43
Firm size (number of full time employees)			
<10	1.19	401	55
10-19	1.20	417	51
20-49	1.19	405	45
50-249	1.19	413	46
>250	1.18	383	52

Note: This table shows the estimate of the annual marginal product of capital (MPK), defined in equation (4), Column (1) shows the resulting estimate of the external finance premium on a quarterly basis (the difference between the quarterly MPK, Column (2) shows the risk-free rate $r^k_{i,t} - r_t$, Column (3) shows the credit spread $(z_i, t - r_t)$.

Sector definitions: Business services 1 (real estate activities; legal; accounting; management; architecture; engineering activities; scientific research and development; and other professional, scientific and technical activities), business services 2 (administrative and support service activities), construction, education (not including public schools), energy (energy supply, water supply, and waste management), entertainment (arts, entertainment, recreation and other services), health (human health and social work activities), IT (information and communication), manufacturing of pharmaceutical goods, manufacturing of investment and intermediate goods, manufacturing of watches (watches, computer, electronic and optical products), manufacturing of other goods, mining (mining and quarrying), restaurants and hotels (accommodation and food service activities), trade (retail and wholesale trade and repair of motor vehicles and motorcycles), and transport (transportation and storage).

410 basis points,[15] while the average credit spread is 47 basis points.

There is heterogeneity across the sectors. The external finance premium tends to be high in some services sectors, such as "business services" and "IT" and low in the energy and mining sectors. For the credit spread, the manufacturing sector tends to have larger credits spreads compared to the services sector. There is also some heterogeneity between the size groups (defined by the number of full-time equivalent employees). The external finance premium tends to decrease in firm size, although not monotonically. That larger firms hold more capital is consistent with the decreasing returns assumption.[16] No such clear pattern emerges for the credit spread.

4 Parameter estimates

In this section, we estimate ν and ξ, which are the elasticities of the external financial premium and the credit spread, respectively. Parameters ν and ξ are estimated in equations (5) and (6) in the log-linearised form (logarithms are denoted in small letters):

$$r_{i,t}^k - r_t = c - \nu[n_{i,t} - (q_{i,t-1} + k_{i,t})] + D^{time} + D^{sector} + D^{size} + \varepsilon_{i,t} \tag{5}$$

$$z_{i,t} - r_{i,t} = c - \xi[n_{i,t} - (q_{i,t-1} + k_{i,t})] + D^{time} + D^{sector} + D^{size} + \varepsilon_{i,t}, \tag{6}$$

where $n_{i,t} - (q_{i,t-1} + k_{i,t})$ is the log of the net-worth-to-capital ratio and D^{time}, D^{sector} and D^{size} are the time, sector, and size fixed effects, respectively.[17] Our focus is on the variation of net worth across firms, in contrast to the variation within firms over time. Consequently, we

[15] The financial premium can shift depending on which risk-free rate is used. Our measure of the risk-free rate is the LIBOR. Any higher measure of the risk-free rate leads to a lower financial premium. However, as the risk-free interest rate is an aggregate variable that is the same for all firms, this level shift would have no impact on our estimate of the elasticity of the finance premium as aggregate variation is absorbed by the time dummy in equation (5). Furthermore, to identify monitoring cost μ in Section 5, we do not use the level of the external finance premium but only its estimated reaction to changes in the leverage ratio.

[16] This assumption relates to the literature, which documents sectoral differences in monetary policy transmission. For example, Bäurle and Steiner (2015) show substantial cross-sectoral differences in the response of output to monetary policy shocks. Dedola and Lippi (2005) relate the variation of sector responses to microeconomic data and find that the responses correlate with durability and investment intensity, which supports the credit channel view.

[17] The sector and size dummies are defined as the sectors and size groups shown in Table 3. The time dummies are defined per year.

estimate the baseline model without firm fixed effects and control for sector fixed effects and firm size. Thus, our estimates exploit the variation in net worth across observations within sector-size bins. Our results are very similar if we include firm fixed effects (see Appendix B.4). In equation (5), we estimate the sensitivity of the external finance premium to variation in net worth ν. In equation (6), we estimate the sensitivity of the credit spread to variation in net worth ξ.

One caveat in estimating the two equations above using OLS is that there may be an endogeneity issue. Firms with higher net worth may have better investment opportunities, implying that a correlation between the external finance premium or the credit spread and the net worth of a firm may be driven by heterogeneous investment opportunities, rather than the BGG mechanism. Therefore, the net-worth-to-capital ratio must be instrumented by a variable that affects firm net worth but is unrelated to their business opportunities. Our instrumental variable consists of firms' net income (that is, $profits - losses$, which can be positive or negative) stemming from financial market securities and nonoperating activities. Financial market net income is generated because some firms hold a part of their financial wealth in securities, which yield a benefit or a loss and, in the case of stocks, a dividend. Such income is largely determined by movements in financial markets and affects the net worth of the single firm exogenously. Nonoperating revenue and expenses are explicitly defined as "inflows or outflows stemming from firm-external factors, such as unpredicted currency gains". Our exclusion restriction, on which the identification strategy relies, is the assumption that firm-specific variation in financial market income and nonoperating profits are related to a firm's creditworthiness only through the effect they have on the balance sheet. Fluctuations in asset prices or returns that are driven by macroeconomic fundamentals are absorbed by the time fixed effects. Furthermore, the sector fixed effects absorb sector-level variation in the return to capital or in the loan rates.

The variables included in the instrument are all taken directly from the firm income statements (see Table 2). Financial market income consists of the income from third-party securities plus dividend income from third-party securities, minus the loss on third-party securities. The net nonoperating profits is the difference between nonoperating revenue and nonoperating expenses.[18] The variables are lagged a year so the instrument coincides with the period in which the decisions upon capital purchases were made. The instrument is normalised with the total of all financial market and nonoperating transactions.[19]

Table 4 shows the results of the OLS and IV estimations. ν is the coefficient of $n_{i,t} - (q_{i,t} + k_{i,t})$ when external finance premium $r^k_{i,t} - r_t$ is the dependent variable. For ν, both the OLS estimate in Column (1) and the IV estimate in Column (2) are significant. The OLS estimate is, however, small and has the wrong sign, indicating that an increase in net worth implies a small decrease in the external finance premium. This finding suggests that the endogeneity problem might indeed be important, which is confirmed by the first-stage statistics of the IV estimation in Column (2). The instrument is highly significantly correlated with the regressor and therefore relevant. The IV estimate of ν is 0.043. This result is quite close to the parameter used in the BGG model (0.05). The sensitivity of the credit spread to changes in the net-worth-to-capital ratio, ξ, are shown in Columns (3) and (4), where $z_{i,t} - r_t$ is the dependent variable. Here too, the estimates show a large difference between the estimates based on OLS and those based on IV. The OLS estimate of ξ is negative and extremely small, while the IV estimate is 0.013, implying that firms with a higher net-worth-to-capital ratio pay a lower contractual interest rate and those that are highly leveraged pay a higher interest rate.

We conduct several robustness checks that we report and discuss in more detail in the Appendix. First, we extend the sample to all the available observations: The estimates shown in Table 4 include only those firms for which both the finance premium and the credit spread are available. As lagged variables are employed in the estimation of the gross return to capital, the number of observations for which ν can be estimated is smaller than it is for ξ. On the other hand, certain observations do not contain the full information needed to calculate the average interest rate. Table 8 in the Appendix shows the estimated coefficients using all the available observations. The estimated sensitivity using the whole sample is slightly

[18] Of the observations, 90% included in the estimation contain nonoperating revenue or expenses. The observations with net income from third-party securities are less common (47%). On average, the sum of nonoperating revenue and financial market income amounts to 7.3% of a firm's net worth.

[19] We test the robustness of our results using several variations of this baseline instrument specification. The resulting coefficients are discussed in Appendix B.2 and shown in Tables 9 and 10.

Table 4: *Estimates for ν and ξ*

	(1) OLS	(2) IV	(3) OLS	(4) IV
Dependent variable	$r^k_{i,t} - r_t$		$z_{i,t} - r_t$	
Estimated coefficient	ν		ξ	
$[n_{i,t} - (q_{i,t} + k_{i,t})]$	-0.009***	0.043***	-0.000	0.013***
	(0.000)	(0.013)	(0.000)	(0.003)
First stage				
Instrument		0.0021***		0.0021***
		(0.003)		(0.003)
F test		38.83		38.83
Sector fixed effects	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes
Firm size control	Yes	Yes	Yes	Yes
Observations	40903	40903	40903	40903

Note: This table shows the estimates of the coefficients ν and ξ from equations (5) and (6). Robust standard deviations in parentheses, ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. The F Statistic of the first-stage regression reports the Kleibergen-Paap F Statistic.

smaller for ν and minimally higher for ξ.

Furthermore, we report and discuss in Appendix B.2 variations in the baseline instrument, where we exclude or include several components of financial market and nonoperating income and losses. We find slightly lower estimates for ν than we do in the baseline when financial write-downs are included (0.032). When the instrument is divided, ν proves to be a bit higher for financial market income (0.058) and not significant for nonoperating income. The same pattern is valid for the estimates of ξ. We find similar estimates for ν, when the instrument is normalised with value added or with capital. For ξ, the estimate is lower when normalised with value added and not significant when normalised with capital.

As an additional robustness check, we show in Appendix B.3 the estimate of ξ using a proxy for the 'marginal' interest rate, which attempts to consider temporal congruency. As expected, the estimated sensitivity is higher than it is in the baseline specification.

Finally, we report our baseline results including firm fixed effects. Again, our results are similar to our baseline estimates.

5 Implications of our estimates within the costly state verification framework

As described in more detail in Section 2, the BGG model building on a CSV framework is characterised by different deep parameters, namely the exogenous death rate of firms γ, the standard deviation of the idiosyncratic productivity shock σ and monitoring cost μ as a fraction of realised payoffs. However, directly estimating these parameters in practice may be difficult. This is particularly true for the death rate of firms[20] and the monitoring cost (see also the discussion in Carlstrom and Fuerst (1997) (CF), who suggest a monitoring cost in the range of 0.2-0.3.) Because the deep parameters are difficult to estimate directly, they are usually set to match the empirical estimates of implied (steady state) magnitudes, such as the bankruptcy rate, the capital ratio or the spread between the loan rate and the safe interest rate.

As an example, both BGG and CFP set the standard deviation of the productivity shock to $\sigma = 0.28$ and the capital ratio to roughly $\kappa = 2$.[21]. BGG set the steady state value of $R^K - R$ to 200 basis points, referring to the historical average spread between the prime lending rate and the six-month Treasury bill rate. CFP, in contrast, define the model's risk premium as the credit spread, i.e. $Z - R$, and set its steady state value to 200 basis points (both annualised quarterly values). This difference implies a substantially different monitoring cost: BGG obtain $\mu = 0.12$ (i.e. somewhat lower than CF) and CFP obtain $\mu = 0.63$ (substantially higher than CF). As a result, CFP obtain a nearly four times higher elasticity of the external finance premium to the leverage ratio of $\nu = 0.188$ compared with BGG's $\nu = 0.05$. Similarly, the elasticity of the loan rate to the leverage ratio is $\xi = 0.045$ in CFP, while BGG obtain

[20]Note that this is not the same as the bankruptcy rate; whether a firm "dies" is unrelated to the realisation of the idiosyncratic productivity shock in a specific period.
[21]CFP state in their paper that they set $\kappa = 2$. However, according to our calculations, CFP actually work with a value of 1.989

only $\xi = 0.018$.[22]

Table 5 reports the BGG and CFP model calibrations together with our results. Column (1) is based on our estimate of $\nu = 0.043$, and Column (2) is based on our estimate of $\xi = 0.013$. These estimates are close to those of the BGG model and diverge quite strongly from the CFP model calibration. The mapping between μ and elasticities ν and ξ is influenced by the calibration of σ and κ. We derive the capital ratio κ directly from our dataset and obtain a value of 2.46, see Table 7, which is somewhat higher than BGG model's calibrated value of 2. The standard deviation of the productivity shock σ is obtained from the residuals of our estimated production function, see Section 3. As result, we obtain estimates for μ of 0.15 based on $\hat{\nu}$ and of 0.20 based on $\hat{\xi}$.[23]

Table 5: *Parameter calibrations*

	BLS ($\hat{\nu}$)	BLS ($\hat{\xi}$)	BGG	CFP
σ	0.20	0.20	0.28	0.28
κ	2.46	2.46	2.0	0.199
μ	0.15	0.20	0.12	0.63
ν	0.043	0.056	0.050	0.188
ξ	0.013	0.013	(0.018)	(0.045)

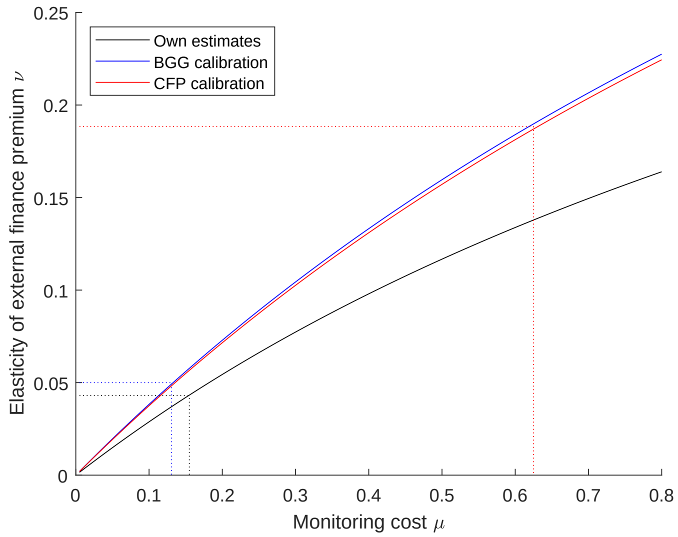
Note: BLS: Bäurle, Lein, Steiner; BGG: Bernanke, Gertler, Gilchrist (1998); CFP: Carlstrom, Fuerst, Paustian (2016); Values in parentheses are not stated explicitly by the authors.

Figure 2 illustrates the interplay between the σ and κ calibrations and the μ and ν mapping. The blue and the red lines show the mapping between μ and ν for the BGG and CFP model calibrations, respectively. The black line represents the mapping using our σ and κ

[22]Elasticity ν is key in determining the size of the financial accelerator. Deep parameters σ and μ do not play any further role in the linearised BGG model other than determining the elasticities ν (and ξ). However, CFP argue that the optimal lending contract in the BGG financial accelerator model allows for indexation to various aggregate quantities. As this indexation reduces fluctuations in leverage, the financial accelerator channel is much less important than it is in the BGG model despite the higher elasticity.

[23]Our values for μ remain quite stable if we combine our estimated elasticities ν and ξ with the BGG and CFP model calibrations for σ and κ:
Based on our estimate of ν, we obtain $\mu = 0.115$, using either the BBG or CFP calibrations for σ and κ.
Based on our estimate of ξ, we obtain $\mu = 0.050$ using the BBG model calibration and $\mu = 0.057$ using the CFP model calibration.

Figure 2: *Elasticity of the external finance premium with respect to leverage ratio ν for varying levels of monitoring cost μ*

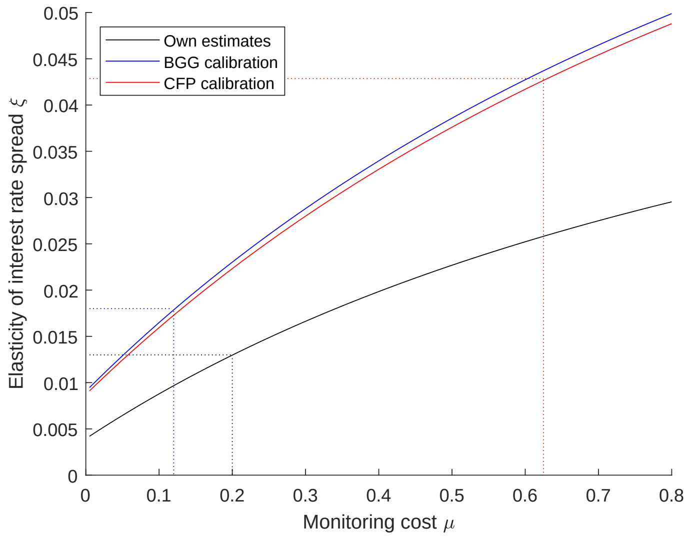


calibrations.[24] The horizontal lines mark the implied values of ν (BGG and CFP models) and our estimated value of ν. The vertical lines mark the resulting value for μ. As the black curve is less steep than the blue/red curves, we obtain a monitoring cost $\mu = 0.15$, which is somewhat higher than the BGG model calibration. The difference with the CFP model calibration remains substantial, also in terms of the monitoring cost.

The same exercise can be done for ξ, the elasticity of the bond spread with respect to the leverage ratio. Figure 3 plots ξ as a function of μ. Again, the black line refers to our κ and σ calibrations, and the red and the blue lines, to the CFP and BGG model calibrations, respectively. We see that our baseline estimate can be achieved by setting $\mu = 0.20$. Thus, our estimates of both ν and of ξ imply monitoring costs that are somewhat higher than they are in the BGG model, within the range suggested by Carlstrom and Fuerst (1997), but considerably lower than they are in the CFP model.

[24] As described in detail in Levin, Natalucci, and Zakrajsek (2004), for any given combination of μ, σ^2 and the external finance premium level, there is an optimal default threshold $\bar{\omega}$ and an optimal leverage ratio κ. We use these relationships to calculate, in a first step, the implied external finance premium and the implied credit spread over a fine grid of μ and ω given our estimate of σ^2 obtained from the data. In a second step, we identify for each μ the value for ω matching the leverage ratio obtained from the dataset. Finally, we derive for each μ the implied external finance premium and the implied credit spread consistent with empirical estimates of σ^2 and κ. It is straight forward to numerically calculate for each μ the magnitudes of η and ν, i.e. the effect of a small log-change in the value of κ on the external finance premium and the credit spread as shown in Figures 2 and 3

Figure 3: *Elasticity of the bond spread with respect to leverage ratio ξ for varying levels of monitoring cost μ*



Using Swiss data, we conclude that, a monitoring cost in the range of roughly one fifth of the return on capital is consistent with our estimated elasticities. The comparison with the BGG and CFP models shows that there is some sensitivity with respect to the calibration of κ and σ. However, under the assumptions that the monitoring cost in the US and Switzerland are of the same magnitude, our results suggest that BGG's calibration for μ and its implied value for ν are somewhat low, while CFP's calibration for μ and the implied value for ν are at the very high end.[25]

6 Conclusion

Structural models featuring financial frictions are widely used in research and policy institutions to understand the role of firms' financing structure for macroeconomic outcomes. We focus on one type of financial friction, which is the costly state verification framework based on Bernanke, Gertler, and Gilchrist (1999). The main mechanism in this model is that, due to imperfect information, lenders must pay a monitoring cost to observe firms' realised return after default. This mechanism implies that a financial friction arises and external

[25]The primary goal of CFP is to show that the financial accelerator is not important if indexing of financial contracts is allowed for. This conclusion holds also when $\mu = 0.12$.

finance becomes more expensive than internal finance. At the same time, the premium firms must pay on external finance decreases in firm net worth, because the risk of bankruptcy and thus of the lender having to pay the monitoring cost is lower. Therefore, the sensitivity of firms' external finance premium to their net worth is directly related to the structural parameter quantifying the monitoring cost and thus the extent of external finance.

We use unique firm-level balance sheet and income statement information for 25,300 Swiss firms to estimate the sensitivity of firms' external finance premium to net worth and the implied monitoring cost. In addition, we estimate how firm credit spreads, which are also related to monitoring costs, vary with net worth. Using both approaches allows us to provide a range of monitoring cost that are consistent with our data. The range is between 15 and 20 percent of the realised gross return on capital. This range of estimates is consistent with an economically significant financial accelerator mechanism.

References

Bäurle, G., and E. Steiner (2015): "How do individual sectors respond to macroeconomic shocks? A structural dynamic factor approach applied to Swiss data," *Swiss Journal of Economics and Statistics*, 151(3), 167–225.

Bernanke, B., and M. Gertler (1989): "Agency Costs, Net Worth, and Business Fluctuations," *The American Economic Review*, 79(1), 14–31.

Bernanke, B. S., and M. Gertler (1995): "Inside the Black Box: The Credit Channel of Monetary Policy Transmission," *The Journal of Economic Perspectives*, 9(4), 27–48.

Bernanke, B. S., M. Gertler, and S. Gilchrist (1999): "The financial accelerator in a quantitative business cycle framework," in *Handbook of Macroeconomics*, ed. by J. B. Taylor, and M. Woodford, vol. 1 of *Handbook of Macroeconomics*, chap. 21, pp. 1341–1393.

BFS (2020): "Buchhaltungsergebnisse schweizerischer Unternehmen," *Bundesamt für Statistik (BFS)*, Sep, `https://www.bfs.admin.ch/bfs/de/home/aktuell/neue-veroeffentlichungen.gnpdetail.2020-0318.html`.

Carlstrom, C. T., and T. S. Fuerst (1997): "Agency Costs, Net Worth, and Business Fluctuations: A Computable General Equilibrium Analysis," *American Economic Review*, 87(5), 893–910.

Carlstrom, C. T., T. S. Fuerst, and M. Paustian (2016): "Optimal Contracts, Aggregate Risk, and the Financial Accelerator," *American Economic Journal: Macroeconomics*, 8(1), 119–47.

Caselli, F., and J. Feyrer (2007): "The marginal product of capital," *The quarterly journal of economics*, 122(2), 535–568.

Christensen, I., and A. Dib (2008): "The financial accelerator in an estimated New Keynesian model," *Review of Economic Dynamics*, 11(1), 155–178.

Christiano, L. J., R. Motto, and M. Rostagno (2008): “Shocks, structures or monetary policies? The Euro Area and US after 2001,” *Journal of Economic Dynamics and Control*, 32(8), 2476–2506.

Christiano, L. J., M. Trabandt, and K. Walentin (2011): “Introducing financial frictions and unemployment into a small open economy model,” *Journal of Economic Dynamics and Control*, 35(12), 1999–2041, Frontiers in Structural Macroeconomic Modeling.

De Graeve, F. (2008): “The external finance premium and the macroeconomy: US post-WWII evidence,” *Journal of Economic Dynamics and Control*, 32(11), 3415–3440.

Dedola, L., and F. Lippi (2005): “The monetary transmission mechanism: Evidence from the industries of five OECD countries,” *European Economic Review*, 49(6), 1543–1569.

Gilchrist, S., A. Ortiz, and E. Zakrajsek (2009): “Credit risk and the macroeconomy: Evidence from an estimated dsge model,” *Unpublished manuscript, Boston University*, 13.

Levin, A. T., F. M. Natalucci, and E. Zakrajsek (2004): “The magnitude and cyclical behavior of financial market frictions,” Discussion paper.

Lowe, M., C. Papageorgiou, and F. Perez-Sebastian (2019): “The public and private marginal product of capital,” *Economica*, 86(342), 336–361.

Meier, A., and G. Müller (2006): “Fleshing out the Monetary Transmission Mechanism: Output Composition and the Role of Financial Frictions,” *Journal of Money, Credit and Banking*, 38(8), 2099–2133.

Mello, M. (2009): “Estimates of the marginal product of capital, 1970-2000,” *The BE Journal of Macroeconomics*, 9(1).

Rovigatti, G., and V. Mollisi (2018): “Theory and practice of total-factor productivity estimation: The control function approach using Stata,” *The Stata Journal*, 18(3), 618–662.

Smets, F., and R. Wouters (2007): “Shocks and Frictions in US Business Cycles: A Bayesian DSGE Approach,” *The American Economic Review*, 97(3), 586–606.

Townsend, R. M. (1979): "Optimal contracts and competitive markets with costly state verification," *Journal of Economic Theory*, 21(2), 265–293.

Walentin, K. (2005): "Asset pricing implications of two financial accelerator models," .

Wooldridge, J. M. (2009): "On estimating firm-level production functions using proxy variables to control for unobservables," *Economics letters*, 104(3), 112–114.

Appendix to "Firm net worth, external finance premia and monitoring cost"

A Additional information on the data

Table 6: *Share of firms per number of years in sample by FTE group, in%*

	FTE groups (number of full time employees)				
	<10	10 − 19	20 − 49	50 − 249	>250
Number of years in sample	Share of firms per number of years in the sample by FTE group				
1	30.0	11.4	4.5	1.4	0.6
2	21.4	13.9	6.7	2.5	1.1
3	16.0	17.0	9.3	4.2	1.4
4	17.0	20.9	15.5	8.1	2.4
5	6.4	12.1	9.7	4.5	2.2
6	2.6	6.5	9.2	5.5	3.0
7	2.5	7.2	12.7	7.9	4.0
8	1.3	4.3	8.8	15.7	11.3
9	0.3	0.8	1.9	1.4	2.0
10	0.2	0.6	2.6	2.1	1.7
11	0.6	1.7	3.6	2.4	2.7
12	0.1	0.3	2.4	2.0	1.4
13	0.2	0.4	1.6	2.7	1.7
14	0.1	1.0	3.3	4.3	2.3
15	0.5	0.8	3.2	7.4	8.3
16	0.1	0.3	0.9	3.1	3.6
17	0.1	0.2	1.0	4.5	6.2
18	0.2	0.4	1.4	6.9	12.0
19	0.5	0.4	1.6	13.5	32.1
	Total number of observations per FTE group				
	9320	11730	34826	61906	14437

Table 7: *Sample Statistics*

	Observations		*Debt/Capital in%*		*Interest paym. per 100 CHF value added*	
	Total	Firms	Mean	Median	Mean	Median
Aggregate	118837	25324	57.2	59.4	3.3	1.2
Sectors						
Business Services 1	9699	2780	57.6	59.5	3.8	0.6
Business Services 2	5208	1530	59.4	61.4	1.3	0.3
Construction	10754	2241	61.8	64.6	1.6	0.8
Education	2078	531	60.2	62.9	1.4	0.4
Energy	4556	873	51.6	52.2	6.5	3.1
Entertainment	3633	1055	55.4	56.2	2.2	0.6
Health	4884	1179	55.1	56.6	1.5	0.6
IT	5697	1372	55.2	56.0	2.2	0.5
Manufacturing Pharma	929	142	48.2	46.1	4.4	1.8
Manufacturing Investment Goods	20226	3401	54.6	56.2	3.2	1.8
Manufacturing Watches	4721	815	51.7	51.5	3.0	1.3
Manufacturing Other	12898	2420	57.6	60.8	3.3	1.8
Mining	933	168	45.6	43.9	2.6	1.6
Restaurants Hotels	4725	1058	64.9	69.5	4.5	2.1
Trade	21909	4600	57.2	59.1	4.8	1.7
Transport	5987	1159	63.1	66.6	3.1	1.5

Note: business services 1 (real estate activities; legal; accounting; management; architecture; engineering activities; scientific research and development; and other professional, scientific and technical activities), business services 2 (administrative and support service activities), construction, education (not including public schools), energy (energy supply, water supply, and waste management), entertainment (arts, entertainment, recreation and other services), health (human health and social work activities), IT (information and communication), manufacturing of pharmaceutical goods, manufacturing of investment and intermediate goods, manufacturing of watches (watches, computer, electronic and optical products), manufacturing of other goods, mining (mining and quarrying), restaurants and hotels (accommodation and food service activities), trade (retail and wholesale trade and repair of motor vehicles and motorcycles), and transport (transportation and storage).

B Robustness tests

B.1 Whole sample

In the baseline specification, observations are considered only for which both the finance premium and the credit spread are available. As lagged variables are employed in the estimation of the gross return of capital, the number of observations for which ν can be estimated is smaller than that for ξ. On the other hand, certain observations do not contain the full information needed to calculate the average interest rate. Table 8 shows the estimated coefficients using all the available observations. For the estimation of ν, 6% more observations enter the regression than in the baseline specification shown in Table 4. The estimation of ξ contains 42% more observations. The estimated sensitivity using the whole sample is for the finance premium slightly weaker than it is for the baseline estimate. For the interest spread, the sensitivity is practically the same.

Table 8: *IV-Estimates for ν and ξ using all the available observations*

	(1)	(2)
Dependent variable	$r^k_{i,t} - r_t$	$z_{i,t} - r_t$
Estimated coefficient	ν	ξ
$[n_{i,t} - (q_{i,t} + k_{i,t})]$	0.037***	0.014***
	(0.011)	(0.003)
First stage		
Instrument	0.022***	0.019***
	(0.003)	(0.003)
F test	48.87	47.56
Sector fixed effects	Yes	Yes
Time fixed effects	Yes	Yes
Firm size control	Yes	Yes
Observations	43352	58034

Note: This table shows the estimates of the coefficients ν and ξ using all the available observations. Robust standard deviations in parentheses, $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$. The F statistic of the first-stage regression reports the Kleibergen-Paap F statistic.

B.2 Alternative instruments

In the following we test variations of the baseline instrument. In the baseline specification, the instrument consists of financial market income, which includes the income from third-party securities plus dividend income from third-party securities minus the loss on third-party securities, and net nonoperating profits, which is the difference between nonoperating revenue and nonoperating expenses. The instrument is normalised with the total of all financial market and nonoperating transactions.

We test five instrument modifications. In Specification (1), financial write-downs are included in the instrument. Financial write-downs occur when the market value of an asset falls below its book value and it is evident that the market value will not recover the book value in the future. The write-down is the difference between the book value and the value a firm would receive from selling the asset. Thus, as for the other financial market variables contained in the baseline instrument, financial write-downs are determined by movements in financial markets and they can be assumed to affect the net worth of the single firm exogenously. However, this variable is omitted from the baseline specification because the firm has some scope to influence the level of the write-down and its timing. Therefore, this component may, in some cases, not be completely exogenous to firms' operating business.

Further, we estimate the sensitivity of the finance premium when the instrument is split in two components. In Specification (2), the counter includes only financial market income, and in Specification (3), only net nonoperating profits. Two further modifications are tested with Specification (4), in which the instrument is normalised with firms' value added in the denominator, and Specification (5), in which the denominator is firms' capital $Q_{i,t-1}K_{i,t}$.

The results are shown in Table 9 for ν and in Table 10 for ξ. The first-stage estimates show that the instrumental variable was robust to variations in its composition or to the normalisation method in all cases except for Specification (3), in which the counter included only nonoperating income. Apart from this specification, the instrument has the correct sign and is significantly correlated with the regressor and therefore relevant.

The results in Table 9 show that the elasticity of the finance premium to changes in the net-worth-to-capital ratio is relatively stable if the write-downs are added to the instrument or if the instrument variable is normalised differently. The splitting of the instrument shows that financial income has a stronger impact on the sensitivity of the finance premium than when it combined with non-operating income.

The estimates of the elasticity of the interest rate spread listed in Table 10 show that the estimates of ξ are robust to the inclusion of the write-downs and to the exclusion of the nonoperating income. However, ξ is not robust to the other modifications.

Table 9: *IV-Estimates for ν using alternative instrument specifications*

Dependent variable	$r^k_{i,t} - r_t$				
	(1)	(2)	(3)	(4)	(5)
Instrument	Including write-downs	Including only financial income	Including only nonoper. income	Normalised with value added	Normalised with capital
Estimated coefficient	ν				
$[n_{i,t} - (q_{i,t} + k_{i,t})]$	0.032**	0.059***	0.150	0.062***	0.059***
	(0.013)	(0.007)	(0.313)	(0.019)	(0.016)
First stage					
Instrument	0.018***	0.087***	0.002	0.106***	0.135***
	(0.003)	(0.007)	(0.004)	(0.027)	(0.020)
F test	29.27	155.29	0.24	15.25	8.33
Sector fixed effects	Yes	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes
Firm size control	Yes	Yes	Yes	Yes	Yes
Observations	40903	40903	40903	40903	40903

Note: This table lists the elasticity of the financial premium to changes in the net-worth-to-capital ratio, ν, for the different instrument specifications. Robust standard deviations in parentheses, ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. The F statistic of the first-stage regression reports the Kleibergen–Paap F statistic.

Table 10: *IV-Estimates for ξ using alternative instrument specifications*

Dependent variable	$z^k_{i,t} - r_t$				
	(1)	(2)	(3)	(4)	(5)
Instrument	Including write-downs	Including only financial income	Including only non-oper. income	Normalised with value added	Normalised with capital
Estimated coefficient	ξ				
$[n_{i,t} - (q_{i,t} + k_{i,t})]$	0.015***	0.013***	0.018	0.006*	0.000
	(0.003)	(0.002)	(0.043)	(0.003)	(0.009)
First stage					
Instrument	0.018***	0.087***	0.002	0.106***	0.135***
	(0.003)	(0.007)	(0.004)	(0.027)	(0.047)
F test	29.27	155.29	0.24	15.25	8.33
Sector fixed effects	Yes	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes
Firm size control	Yes	Yes	Yes	Yes	Yes
Observations	40903	40903	40903	40903	40903

Note: This table lists the elasticity of the interest rate spread to changes in the net-worth-to-capital ratio, ξ, for the different instrument specifications. Robust standard deviations in parentheses, ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. The F statistic of the first-stage regression reports the Kleibergen–Paap F statistic.

B.3 Marginal interest rate

In their model, BGG assume that the interest rates that entrepreneurs must pay on their loans are set afresh each period, depending on their net-worth-to-capital ratio in that period. Typically, however, firms do not fully renew their loan stock every year. Ideally, for the interest rate to be temporally congruent with the net worth ratio, one would need data on firms' interest payments classified by the years in which the contracts were concluded. This information is, however, not available in our dataset. In the baseline specification, contractual interest rate $Z_{i,t}$ is measured by the ratio of firms' interest payments to their total outstanding debt. The average interest rate in period t therefore also includes the interest rates that are set at an earlier date, depending on the firm net-worth-to-capital ratio at that time. Thus, the average interest rate is not fully temporally congruent with the net worth ratio. Therefore, the estimated sensitivity using the average interest rate in the baseline specification must be seen as a lower bound.

We construct an alternative interest measure to better consider the temporal congruency. This 'marginal' interest rate proxies the interest rate on the additional debt taken out in period t and is defined as the change in interest payments over the change in debt. This measure has two caveats: First, this method excludes the new debt contracts that a firm concludes when it rolls over maturing loans. Second, only observations for which the change in debt and the interest payments are positive are considered. Doing so reduces greatly the number of observations and may cause a selection bias towards expanding firms. Nonetheless, this measure reveals insights into how high the sensitivity of the interest spread may be, when the temporal congruency is considered.

Specification (1) in Table 11 shows the baseline estimates. Specification (2) lists the estimated sensitivity of the credit spread using the 'marginal' interest rate measure. As expected, the estimated sensitivity using spreads based on the 'marginal' interest rate is higher than that based on the average rate.

Table 11: *IV-Estimates for ξ using the average and the marginal interest rates*

Dependent variable	Spread $z_{i,t} - r_t$ based on the	
	(1) Average interest rate	(2) Marginal interest rate
$[n_{i,t} - (q_{i,t} + k_{i,t})]$	0.013***	0.019***
	(0.003)	(0.006)
First stage		
Instrument	0.021***	0.034***
	(0.003)	(0.006)
F test	38.83	33.95
Sector fixed effects	Yes	Yes
Time fixed effects	Yes	Yes
Firm size control	Yes	Yes
Observations	40903	12718

Note: This table shows the estimates of the coefficient ξ in Equation (6). Specification (1) is the baseline regression, which is estimated with a spread based on the average interest rate (total interest payments divided by outstanding debt). Specification (2) is estimated with a spread based on the 'marginal' interest rate (change in interest payments over the change in debt). Robust standard deviations in parentheses, ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. The F statistic of the first-stage regression reports the Kleibergen–Paap F statistic.

B.4 Firm fixed effects

ν and ξ are structural parameters. Our interest focuses therefore on the variation of net worth across firms, in contrast to the variation within firms over time. Consequently, we estimate the baseline model with random effects and control for sectoral and size differences that may influence the estimates. To test if our estimates are biased by any omitted time-invariant firm characteristics, we estimate equations 5 and 6 with firm-fixed effects. The results are shown in Table 12. The coefficients are similar to those in the baseline estimates. This result indicates that there is no significant variation between firms that has not been absorbed by the sector and the size control variables and that could have biased the estimates of ν and ξ in the baseline specification.

Table 12: *IV–Estimates of ν and ξ, estimated with a fixed effects model*

Dependent variable	$r^k_{i,t} - r_t$	$z_{i,t} - r_t$
Estimated coefficient	ν	ξ
$[n_{i,t} - (q_{i,t} + k_{i,t})]$	0.056**	0.011*
	(0.022)	(0.007)
First stage		
Instrument	0.008***	0.008***
	(0.002)	(0.002)
F test	13.69	3.69
Firm fixed effects	Yes	Yes
Time fixed effects	Yes	Yes
Observations	37924	37924

Note: Robust standard deviations in parentheses, ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. The F statistic of the first-stage regression reports the Cragg–Donald Wald F statistic.

B.5 Alternative estimate of the financial premium

As the firm-level depreciation rates are quite erratic, we average the depreciation rate in the baseline specification over all the firms per year. We compute an alternative measure of $R^k_{i,t}$, in which the firm-level depreciation rates are aggregated at the sector level and the output elasticity of capital is estimated at sector level α_s.

The elasticity of ν estimated with the external finance premium, which is computed with this alternative estimate of the financial premium, is listed in Table 13, Specification (2) together with the baseline estimate. Both of the elasticities are very similar.

Table 13: *IV–Estimates for ν using alternative measures of the external finance premium*

Dependent variable	$r^k_{i,t} - r_t$	
	(1)	(2)
	Baseline	$R^k_{i,t}$ computed with sectoral depreciation rates and α_s
Estimated coefficient	ν	
$[n_{i,t} - (q_{i,t} + k_{i,t})]$	0.043***	0.039***
	(0.013)	(0.010)
First stage		
Instrument	0.0021***	0.0022***
	(0.003)	(0.003)
F test	38.83	43.63
Sector fixed effects	Yes	Yes
Time fixed effects	Yes	Yes
Firm size control	Yes	Yes
Observations	40903	39177

Note: This table shows the estimates of coefficients ν from Equation (5) for the baseline specification and for an alternative measure of the external finance premium computed with the sector-level depreciation rates and the output elasticities of capital. Robust standard deviations in parentheses, $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$. The F statistic of the first-stage regression reports the Kleibergen–Paap F statistic.

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