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FRICTIONS AND ADJUSTMENT MECHANISMS IN THE SWISS ECONOMY

THREE EMPIRICAL ESSAYS USING FIRM-LEVEL DATA

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Frictions and adjustment mechanisms in the Swiss economy
Three empirical essays using firm-level data

Elizabeth Steiner

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Abstract

This thesis analyses the impact of firm-level frictions on adjustment mechanisms. It consists of three empirical studies that are based on a large and detailed data set of Swiss firms. These data enable the studies to account for the fact that firms are highly heterogeneous and that some firms are more exposed to frictions than others.

The first essay analyses the response of firms' markups following an exchange rate shock. The adjustment of markups towards a new optimum proves to differs strongly across firms. Large firms vary their markup substantially, especially if they are also highly profitable or export intensive. In contrast, firms with low profitability, low productivity, low markups as well as small and domestic-oriented firms do not adjust their markups significantly following a change in the exchange rate. The second essay, co-authored with Gregor Bäurle and Sarah M. Lein, estimates firms' employment adjustment to changes in output. The results show that for firms in financially strained situations, the sensitivity of employment to fluctuations in output increases considerably. When output changes, financially tighter firms resize their labour force more than firms that have abundant funding. This implies that such firms drive the fluctuations of employment over the cycle. The third essay, also co-authored with Gregor Bäurle and Sarah M. Lein, estimates the sensitivity of the cost of external finance to firms' net worth. The results show that firms' cost of external finance and firms' net worth are inversely related. This is consistent with models that integrate financial frictions by means of a financial accelerator. Based on the estimated sensitivity, a range for the monitoring cost is derived. The monitoring cost is the cost, which financial intermediaries have to pay to be able to observe firms' realized return on capital. The estimated range is consistent with an economically significant financial friction. The results of these three essays provide micro-data evidence that frictions can substantially hamper the transmission of shocks and that the response differs strongly across firms.

Keywords: Firm behaviour, frictions, adjustment mechanism, firm-level data, heterogeneity, markup, price setting, exchange rate, financial tightness, employment, labour hoarding, external finance premium, net worth

Résumé

Cette thèse explore l'effet des frictions sur les mécanismes d'ajustement macroéconomiques, au niveau des entreprises. Elle est composée de trois études empiriques qui s'appuient sur une base de données très détaillée sur les entreprises en Suisse. Ces données permettent de tenir compte de la grande hétérogénéité existante entre les entreprises qui font que les entreprises peuvent être exposées d'ampleur très différent aux frictions.

La première étude analyse la réponse des marges bénéficiaires à la suite d'un choc sur le taux de change. L'ajustement des marges diverge fortement entre les entreprises. Les grandes entreprises ajustent leur marge de manière substantielle, en particulier si elles sont très profitables ou exportent la majeure partie de leur production. En revanche, les entreprises avec une profitabilité, une productivité, des marges ou une part d'export basse n'ajustent pas leur marge de manière significative. La deuxième étude, co-écrite avec Gregor Bäurle et Sarah M. Lein, estime l'ajustement de l'emploi au niveau des entreprises après un changement de leur production. Les résultats montrent que si une entreprise est contrainte financièrement, elle réagit nettement plus fortement à des changements de production qu'une entreprise avec des finances solides. Ceci implique que ce sont les entreprises financièrement contraintes qui sont en premier lieu responsables des fluctuations de l'emploi durant les cycles économiques. La troisième étude, également co-écrite avec Gregor Bäurle et Sarah M. Lein, estime la réaction du coût du financement externe à des variations du capital propre. Les résultats montrent que le coût du financement externe augmente lorsque le capital propre d'une entreprise diminue. Ceci est consistent avec les modèles macroéconomiques qui intègrent les frictions financières à travers un accélérateur financier. A partir de ces estimations, un intervalle pour le coût du monitoring est dérivé. Ceci est le coût que les intermédiaires financiers doivent payer pour pouvoir observer le revenu du capital d'une entreprise. L'intervalle estimée indique que les frictions financières sont significatives. Les résultats de ces trois études mettent en évidence à l'aide de

micro-données que les frictions peuvent entraver substantiellement la transmission des chocs et que l'ajustement à ces chocs diverge largement entre les entreprises.

Mots clés: Comportement des entreprises, frictions, mécanismes d'ajustement, micro données, hétérogénéité, détermination des prix, taux de change, frictions financières, emploi, rétention de la main-d'œuvre, coût du financement externe, capital propre.

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General introduction

In a perfect world, without frictions, producers and financial intermediates are homogeneous, atomistic, risk-neutral agents with complete information and operating in perfect competition with one another. Utility is maximised and resources are used efficiently. Prices adjust to equate supply and demand in all markets simultaneously. The adjustment to disturbances is therefore instantaneous and costless. Empirical evidence reveals, however, that this so-called Walrasian equilibrium concept, on which models such as Real Business Cycle models are based, rarely holds. In many cases, the no-friction assumption is not consistent with empirical facts. Agents face uncertainty, wealth is not distributed equally, information is asymmetric and the adjustment to changes is often costly. Consequently, the pass-through of shocks is incomplete. There exist labour market rigidities and price stickiness. Models including such frictions tend to replicate reality better. For example, by including price stickiness, new Keynesian models drop the assumption that prices adjust to clear markets instantaneously. Financial accelerator models account for the negative impact of financial frictions by making external finance more expensive for firms, which are more likely to default on their debt.

In my doctoral thesis, I focus on frictions at the firm level. I provide micro-data evidence that frictions have an impact on how firms respond to changes. Based on a very large and detailed data set of Swiss firms, I show, for example, that firms only partially adjust their employment to a change in output because of high adjustment costs. Additionally, it is shown that external finance is more expensive than internal finance because of information frictions between financial intermediaries and firms.

Moreover, the essays show the response to a shock varies strongly across firms. While some types of firms adjust to disturbances rapidly, others react only partially and slowly. According to my findings, firm size, profitability, productivity, access to internal and external funding and leverage ratio are firm-specific features that have a large impact on the

pass-through of shocks. As firms are highly heterogeneous in respect to these features, it is hardly surprising that the response to a shock varies strongly across firms. The composition of an economy is therefore an important factor in explaining the incomplete adjustment to shocks at the aggregate level.

In my first essay, I focus on the pass-through of changes in the exchange rate into markups. My contribution is twofold. First, I estimate firm-level markups for the Swiss manufacturing sector. Second, I estimate how these markups adjust to fluctuations in the exchange rate. My results provide strong evidence that the response is very heterogonous across different types of firms: While smaller firms typically leave their markup unchanged, large firms adjust their markup significantly.

Markups are estimated using data on expenditure and revenue of Swiss manufacturing firms for the period 2012-2017 following the production approach described in De Loecker and Warzynski (2012). The data are matched with firm-level export statistics making it possible to include the trade intensity of firms in the analysis.

I analyse how firms adjust their markups to a change in the exchange rate using the large appreciation of the Swiss franc, which followed the removal of the EUR/CHF floor in January 2015. The appreciation was not only large and sudden but there is also clear evidence that it was exogenous to firms' pricing decisions. The change in the exchange rate was perceived by firms to be permanent and importantly, apart from the exchange rate shock, most other macroeconomic factors developed quite steadily during that period. These factors provide a perfect setting to estimate the causal impact of an exchange rate shock on firms' markups.

The results suggest that large firms, which typically have high markups and are more productive, exhibit strong strategic complementarities and are able to adjust their markup unrestrictedly. Moreover, my estimates show that if large firms are also highly profitable the markup pass-through increases substantially and is practically complete if large firms are also export intensive. In contrast, smaller firms are less able to adjust their markup because, for example, they have to preserve internal liquidity even at the cost of losing market share. Low liquidity therefore acts as a friction, hampering the transmission of an exchange rate shock into markups. Although smaller firms are in the majority, larger firms with an unhampered pass-through have a strong influence on aggregate development owing to their sheer size.

My second essay documents the role of firm-level financial tightness on employment adjustment. The results show that the adjustment of firms' employment to changes in output depends on their financial situation. Firms with limited funding availability resize their labour force more strongly than firms that have abundant funding available. Firms that are not in a financially tight situation are able to hoard more labour.

I distinguish between tightness in internal funding, measured by low liquidity or low profits, and tightness in external funding, measured by low collateral or a small balance sheet. The results show that both types of tightness have a large impact. When internal and external financial tightness occur jointly, firms lay off twice as many employees, compared to firms that are not in a financially strained situation.

The amplifying effects of financial tightness are quite similar in upturns and downturns. Firms in a strained financial situation not only decrease their employment more when output decreases but also increase their employment more strongly when output increases. The results are therefore consistent with the view that financial tightness impedes the labour hoarding behaviour of firms, because firms that hoard labour during a downturn do not hire as much labour in an upturn. Furthermore, the impact of financial tightness is generally lower for firms paying high wages. This result suggests that it is particularly costly to lay off and recruit again workers with higher wages, who tend to be more-skilled workers.

I conduct four tests to examine the causal interpretation of the estimates. First, industry-level output (instead of firm-level output) is used to identify demand shocks. Second, I look at the cross-sectional variation in employment during the Great Recession and the recovery thereafter. Third, the estimation is performed with industry-level measures of financial tightness. Fourth, for a subset of firms, an exogenous measure of firms' financial tightness is used as a measure for internal tightness. The results from these tests strongly suggest that the causal interpretation is correct.

By means of a counterfactual analysis, I show that financial tightness impedes labour hoarding also at the aggregate level. Employment would have fallen by only two thirds of its actual decline during the Great Recession if financial tightness had not hindered labour hoarding. This implies that financially tighter firms amplify the co-movement between employment and output. In contrast, a weak cyclicality of employment, caused by strong labour hoarding, is largely driven by financially healthy firms.

My third essay focuses on financial frictions in the credit market that arise due to

information asymmetries between borrowers (firms) and lenders (financial intermediaries). The estimated parameters show that such frictions cause costs that are economically significant and can lead to an amplification of aggregate shocks.

Bernanke and Gertler (1995) provide the theoretical ground of the so-called financial accelerator models. Such models include a friction that makes it costly for financial intermediaries to retrieve the remaining capital from a firm after it has gone bankrupt. Because of this cost (named the monitoring cost), firms that are more likely to go bankrupt have to pay higher cost for external finance than firms, which are less likely to go bankrupt. In the model, firms with a higher leverage ratio (capital-to-net-worth ratio) are assumed to have a higher probability of going bankrupt. This mechanism has an aggregate impact because in a downturn the leverage ratio increases for many firms and so external financing becomes more expensive in the aggregate. This in turn has a negative impact on overall investment activity, amplifying the initial shock. Bernanke and Gertler (1995) propose a calibration for the relevant parameters of their model. This essay provides empirical estimates of these parameters using firm-level balance sheets and income statements.

The sensitivity of the external finance premium to firms' leverage ratios is estimated for two different measures of external finance premium. These results confirm that firms that are highly leveraged pay a higher external finance premium than those with a low leverage ratio. To identify the supply curve of external finance, I use changes in net worth stemming from net financial income and net nonoperating income as an instrument. While these sources of income contribute to firms' earnings and thus have an impact on their leverage ratio, they are unrelated to firms' demand for external funding.

Besides the sensitivity of the external finance premium, two further parameters are also derived from the data: the standard deviation of the idiosyncratic productivity shock and the average capital ratio. With these parameters, it is possible to derive the monitoring cost. As two different estimates of the sensitivity of the financial premium are available, I am able to provide a range for the monitoring cost. The monitoring cost is estimated to range between 15% and 20%. These estimates are consistent with an economically significant financial friction and are a bit higher than are those proposed by Bernanke and Gertler (1995) (they assume 12%).

These three essays, while focusing on quite different issues, come to the common conclusion that firm-level frictions play an important role in adjustment mechanisms. Given

that firms are highly heterogeneous and that some firms are more exposed to frictions than others, it is hardly surprising that the response to an aggregate shock varies strongly across firms. Consequently, the aggregate response to an aggregate shock depends strongly on the firm structure of an economy. These findings also imply that some firms are set to benefit more than others from a given policy – and that thereby policy measures have a distributive impact.

Chapter 1

How do firm-specific features influence the exchange rate pass-through into markups?[1]

1 Introduction

Changes in the exchange rate can have a strong effect on macroeconomic variables such as sales and relative prices. The pass-through depends a lot on how willing and how capable firms are to absorb exchange rate movements by adjusting their markups. However, the transmission of exchange rate shocks into markups is an issue that has not yet been fully resolved in the empirical literature, primarily because markups are not directly observable and the data needed to estimate them are often not available. Empirical work on the pass-though of exchange rate movements into markups is therefore sparse. One of the few exceptions is the work of Caselli, Chatterjee, and Woodland (2017), who analyse the response of markups to exchange rate shocks depending on productivity at the product level. This paper adds to the empirical literature by computing firm-level markups for the Swiss manufacturing sector and estimating their response to an exchange rate shock depending on five different firm characteristics derived from the same data set. Thus, not only is the mean response of markups to an exchange rate shock estimated but also the

[1]I thank Daniel Kaufmann for his guidance and valuable advice. Furthermore, I also thank Mauro Caselli, Sarah Lein and Yannic Stucki for their helpful comments. I thank the participants at the IRENE PhD Meeting at the University of Neuchâtel and those of the Macro Reading Group of the University of Basel for their useful comments and suggestions.

heterogeneity of the pass-through across different types of firms is determined.

The fact that firms differ strongly between each other in many respects suggests that markup-setting behaviour may also differ strongly between firms. For example, Amiti, Itskhoki, and Konings (2019) demonstrate that firms facing nominal rigidities, choose their invoicing currency endogenously depending on their optimal price pass-through, which depends on their profit function and their markup elasticity. Firms that price to market and for which it is optimal to leave prices in foreign currency stable will choose to vary their markup. In contrast, firms, which exhibit no strategic complementarities in price setting, tend to apply a constant markup-pricing rule. As the exposure to market frictions varies across firms, it is appropriate to analyse the exchange rate pass-through into markups at the firm level. Thus, the approach of this paper is to use firm-level heterogeneity in markup elasticity to understand better the aggregate pass-through of exchange rate movements into markups.

Markups are estimated using a large panel of firm-level expenditures and revenue data for the period 2012-2017. From this data source one can extract further variables, such as firms' size, profitability and productivity, which are used to estimate the heterogeneity of the response. Moreover, these data are merged with firm-level export and import data, from which a measure of export-intensity is constructed. These data therefore enable not only a comprehensive but also a consistent analysis of the pass-through heterogeneity.

On the methodological side, this paper builds on the work of De Loecker and Warzynski (2012), who developed a framework with which firm-level markups can be estimated using input and output data. The markup is defined as the output elasticity of a variable input divided by the input's share of revenue. An advantage of this so-called 'production function approach' is that it allows to measure firms' markups without having to make any assumptions on the demand function or on the competitive environment.

The pass-through of the exchange rate into markups is estimated within the framework of an event model. Besides the mean pass-through, heterogeneity is analysed based on five firm-specific features, which may influence firms' capability or willingness to adjust their markups: size, level of markup, export intensity, profitability and productivity. Combined regressions are run to test if being large, export intensive, highly profitable, highly productive or having a high markup are different facets of the same feature, or if these features have an independent, mutually amplifying impact on the pass-through.

The analysis exploits the large, sudden and persistent appreciation of the Swiss franc against the euro of 15 January 2015, after which the EUR/CHF exchange rate[2] stabilised rapidly at 12% below the pre-shock level. This shock was especially relevant for Swiss manufacturing firms because Switzerland is a small open economy with exports and imports of goods amounting to around a third of total GDP. Moreover, interdependencies along the production chains are especially intense with the euro area, its main trading partner. Additionally, Kaufmann and Renkin (2018) and Bonadio, Fischer, and Sauré (2020) show clear evidence that the shock was unexpected by firms, financial markets and economists alike. In contrast to many pass-through studies, this unparalleled event therefore enables a clear identification of the causal effect between the exchange rate and markups.[3]

Three firm-specific control variables are taken into account in order to catch factors that potentially may affect markups independently from the exchange rate. The variable designed to control for changes in material costs in foreign currency proves to be of particular relevance, while the variables constructed to control for changes in demand and changes in the USD/CHF exchange rate are not significant.

The results show that the average firm does not significantly adjust its markup in response to an exchange rate shock. Thus, the mean response confirms models, which assume monopolistic competition and constant elasticity of substitution demand with a constant markup-pricing rule. However, this is only part of the story: the results also provide strong evidence that the response is very heterogonous across different types of firms. While smaller firms leave their markup unchanged, the elasticity of large firms is estimated to be around 40%. Moreover, the combined regressions show that if large firms are also highly profitable the markup pass-through increases to 65% and is practically complete if the large firms are also export intensive. These results are consistent with the findings of Amiti, Itskhoki, and Konings (2019), who show that large firms exhibit strong strategic complementarities in contrast to small firms which apply a constant markup-pricing rule. They are also in line with the findings of Gilchrist, Schoenle, Sim, and Zakrajsek (2018)

[2]The EUR/CHF exchange rate is defined as the amount of Swiss francs (CHF) to be paid for one euro (EUR)

[3]The EUR/CHF exchange rate shock of 15 January 2015, has been used by various authors to estimate the impact of exogenous exchange rate movements. Bonadio, Fischer, and Sauré (2020) estimate the speed of the response of prices in the days following the shock. Kaufmann and Renkin (2018) estimate the pass-through into import and export prices depending on the invoicing currency with monthly data for the period 2015-2017. They also provide an indirect estimate the markup elasticity using the elasticity of export prices relative to domestic prices of the same firm. Auer, Burstein, and Lein (2021) estimate the sensitivity of import prices and import shares of consumer goods in the aftermath of the shock.

who show that firms with unhampered access to external finance have a strong incentive to lower markups in order to preserve their market share. On the other hand, limited access to external finance acts as a major friction, which leads firms to leave their markup stable in order to preserve internal liquidity. Although smaller firms are in the majority and shape the mean response, large firms with an unhampered pass-through have a strong influence on aggregate development owing to their sheer size.

In contrast, the combined regressions with highly productive firms or firms with a high markup show that the response is not amplified if these firms are also large. This indicates that these three features are not independent to one another. While there are rationales for each of these three channels, it is not possible with the available data set to distinguish which of the three features (size, productivity or high markup level) is the cause of the strong pass-through.

These results provide evidence that the capability of a firm to decrease its markup following an appreciation is a key factor in explaining the elasticity of markups. A firm needs to have the scope to decrease its markup. If it has a high markup or high profits preceding the shock it will have the necessary leeway to adjust its markup in order to preserve market share. The exposure to the exchange rate, measured as the export share, also has a strong impact. In contrast, low markups and low profits, which tend to be characteristic to smaller firms, act as substantial frictions, which hamper the transmission of an exchange rate shock into markups.

The remainder of the paper is structured as follows: The next section discusses the five firm-specific features, which are included in the estimation. Section 2 describes the empirical model. Section 3 discusses the input data as well as the computation of the variables which enter the model. Furthermore, some stylised facts on the estimated markups are shown. The estimated results are presented in Section 5 and Section 6 draws conclusions.

2 Literature review

This work is embedded in a vast literature on the incomplete pass-through of exchange rate shocks into export quantities or into international prices. The increasing availability of datasets matching firm-level data with custom data has enabled a growing literature, which seeks to explain the heterogeneous response of sale prices to exchange rate fluctuations

depending on firm-level characteristics. One differencing feature which received special attention already in early years is the invoicing currency. Gagnon and Knetter (1995), for example, analyse the international automobile industry and find that variations in pass-through of exchange rate fluctuations into sale prices can be traced back to the invoicing currency. In more recent work, Gopinath, Itskhoki, and Rigobon (2010), Amiti, Itskhoki, and Konings (2019) and Amiti, Itskhoki, and Konings (2020) demonstrate that firms that desire to leave their prices in foreign markets stable chose to invoice in the currency of its customers and exhibit a high markup elasticity. Other firm-specific features have also been shown to be associated with varying levels of exchange rate pass-through into prices or markups. In the following, the five firm-level features, which enter the estimation of this paper, are discussed.[4]

The first firm-level feature is size. Because of their economic weight, the response of large firms plays a predominant role for the aggregate pass-through. Theoretically the impact of size could go in both directions. On the one hand, if one assumes that larger firms have a larger market share, size could be related to higher pricing power and lower markup adjustment. On the other hand, there are rationales for a stronger adjustment of markups and a lower pass-through into sale prices. Gilchrist, Schoenle, Sim, and Zakrajsek (2018) show with their two-country model that when hit by adverse shocks, firms in countries with unhampered access to external finance have a strong incentive to lower markups in order to preserve or even increase their market share. In contrast, limited access to external finance acts as a major friction, which can lead firms to leave their markups stable or even raise them in order to preserve internal liquidity even at the cost of losing market share.[5] As shown by Gertler and Gilchrist (1994) the access to external finance is strongly linked to size because of the costs of asymmetric information. Small firms tend to have had little experience in the credit market, and there is limited available information on their creditworthiness. In contrast, information on large firms is much more available and less costly. Thus, large firms are set to have easier and cheaper access to external finance and be less affected by external

[4]Invoicing currency will not be used as a firm-level feature that influences the exchange rate pass-through in this paper because the markup used in this paper is a firm-level markup (see footnote 19). A product-level or even a product-country-level markup would be necessary to estimate the impact of firms' invoicing currency on markups.

[5]Montero and Urtasun (2021) confirm these findings in an empirical study using Spanish manufacturing data on markups during the Great Recession (2008-2012). Despite the sharp fall in economic activity, sub-industries with limited access, and therefore costly access, to external finance raised their markups in order to increase current cash flows and meet their ongoing financial commitments. Furthermore, Dai, Nucci, Pozzolo, and Xu (2021) show that the exchange rate pass-through into domestic prices is affected by the degree to which a firm can access external finance.

finance frictions. This allows large firms to adjust their markups more flexibly than smaller firms. An alternative line of argument is proposed by Amiti, Itskhoki, and Konings (2019) who show that small firms charge low markups and therefore do not have the capability of lowering them. In contrast, larger firms charge higher markups and have the capability to adjust them. This suggests that size is strongly related to the level of markup, which is the second feature that is analysed.

Markup elasticity is inherently tied to the level of markups. Firms with a high market share have a low price elasticity of demand and can therefore charge a high markup. Furthermore, as derived by the models developed by Burstein and Gopinath (2014) and Atkeson and Burstein (2008), firms with high markups choose to keep their prices and quantities more stable so that the markup elasticity is also increasing in firms' market share. This implies that markup and markup elasticity co-move positively. Intuitively, firms with high markups have scope to decrease them. Thus, the level of markups preceding the exchange rate shock is set to be a decisive factor influencing the pass-through of an exchange rate shock into markups. This channel may be binding for firms facing strong strategic complementarity which would optimally choose to keep their sale prices stable by varying their markups.[6] If, however, they are limited by low markups they will not have the capability to vary them optimally.

A further feature is the export intensity channel and seems at first sight quite straight forward: Highly export-oriented firms are more strongly exposed to the exchange rate and will presumably adjust their markups more strongly to exchange rate shifts than domestic-oriented firms. However, as shown by Amiti, Itskhoki, and Konings (2014) the import share plays an equally important role. Import-intensive exporters have a lower exchange rate pass-through into their export prices, because they benefit from the positive, counterbalancing exchange rate effects on their marginal costs. As many export-intensive firms are among the largest importers, the counterbalancing impact of imports may substantially moderate the adjustment of markups.

The fourth feature relates to firms' financial health. Firms in a healthy financial condition have more leeway to actively adjust their markups. In contrast, as shown by de Almeida (2015), firms in a tight financial position refrain from decreasing their prices in a crisis

[6] As shown in the endogenous currency choice model developed by Gopinath, Itskhoki, and Rigobon (2010), because of price setting rigidities, exporting firms facing strong strategic complementarity will choose to keep prices in the consumer's currency stable. Such firms will prefer to export in the consumer currency and accordingly they will choose to vary their markups.

in order to maintain short-term profits even at the expense of future market shares. Heterogeneity in the profitability of firms may therefore have an impact on the heterogeneity of the pass-through of an exchange rate shock into markups.

The fifth feature is productivity. Using French firm-level data, Berman, Martin, and Mayer (2012) provide strong evidence that high-productive exporting firms adjust their unit value in domestic currency much more strongly than low-productive firms. Accordingly, high productive firms price more to market by absorbing changes in the exchange rate in their markups, while their export volumes are less sensitive. They explain this mechanism with the monopolistic competition theory of Melitz and Ottaviano (2008), which lays down that price elasticity of demand increases with price. As high-productive firms are low-price firms, they face a less elastic demand. Consequently, high productive firms price more to market by absorbing changes in the exchange rate in their markups, while their export volumes are less sensitive.[7] According to these findings, the level of firms' productivity is therefore predicted to have an impact on the pass-through of exchange rate shocks into markups. A number of studies have confirmed these results, such as Berthou, Dhyne, Bugamelli, Cazacu, Demian, Harasztosi, Lalinsky, Meriküll, Oropallo, and Soares (2015) who use cross-country and cross-sector data provided by the Competitiveness Research Network (CompNet) or Li, Ma, and Xu (2015) using Chinese firm-level data. Caselli, Chatterjee, and Woodland (2017) show with Mexican data that in response to a change in the real exchange rate, markups and producer prices react more pronouncedly for products with higher productivity.

In the literature, the relationship between export intensity, size, productivity and the level of markups is highly ambiguous. In the model of Melitz and Ottaviano (2008), larger markets have a higher level of product variety and host more productive firms that set lower markups. Higher competition forces the least productive firms to exit the market and reallocates market shares towards more productive, larger, exporting firms with lower markups. However, Bellone, Musso, Nesta, and Warzynski (2016) extend the Melitz and Ottaviano (2008) model with a quality-enhancing channel and show that the

[7] A further mechanism that links productivity and the elasticity of markups runs through the distribution costs. Products, which are closer to the firm's core competency, have a higher productivity and relatively lower prices. For lower price goods, distribution costs account for a larger fraction of total costs. As distribution costs are not affected by changes in the exchange rate (as they are paid in local currency), producers of such goods have to adjust their prices less to changes in the exchange rate. Caselli, Chatterjee, and Woodland (2017) show that in response to a change in the real exchange rate, markup and producer prices react more pronouncedly for products with higher productivity, a consequence of local distribution costs.

least productive firms respond to global competition by lowering quality, markups and prices on the export market. In contrast, the more productive firms respond by raising quality, markup and price on the export market. According to their findings, markups are increasing in productivity, and export intensity.[8]

3 Empirical strategy

This paper tests if and how strongly firms adjust their markups in the aftermath of an exchange rate shock using an event study model. In what follows, I explain the identification and estimation strategy

3.1 Identification of the shock

The analysis exploits the large, sudden and persistent appreciation of the Swiss franc against the euro of 15 January 2015, when the Swiss franc appreciated by nearly 15% against the euro. Thereafter, the exchange rate stabilised relatively rapidly and remained in a quite narrow bound until mid-2017. In annual terms, the EUR/CHF exchange rate decreased by 12.1% in 2015. In 2017, the exchange rate was still 8.5% below its pre-shock level. This shock was very relevant for Swiss firms because Switzerland is a small open economy with exports and imports of goods amounting to around a third of total GDP. Moreover, interdependencies along the production chains are especially intense with the euro area, its main trading partner.

A key point is, however, that the drop was not only large and economically relevant but that this unparalleled event provides a singular context, which can be used to lay down an identification strategy to estimate the exchange rate pass-through. First, the shock was exogenous. Second, in its aftermath the new exchange rate level was seen to be persistent. Third, there were no major other factors that influenced the economy in years before and after the shock.

There is clear evidence that the sudden appreciation of the Swiss franc of 15 January

[8]These findings are in line with the model developed by Atkeson and Burstein (2008). They show that markups are inherently correlated with the level of productivity. If a firm becomes more productive and can decrease its costs relative to other firms and will decrease its prices in order to gain market share. The firm will however decrease its prices less than the decrease in costs and increase hereby its markup. Accordingly, markup is increasing in productivity. A positive relationship between markups and productivity is also a key element of more recent literature, such as Autor, Dorn, Katz, Patterson, and Van Reenen (2020), who focus on the rise of 'superstar firms' and show that large firms have high markups and are more productive.

2015 was exogenous to firms' pricing decisions at the time. Kaufmann and Renkin (2018) attest that the shock aroused from the policy decision of the Swiss National Bank (SNB) and was completely unexpected by professional forecasters up to the moment it occurred. Bonadio, Fischer, and Sauré (2020) analyse the EUR/CHF forward rates and conclude that also financial market participants had not anticipated the shock. Indeed, during the three years preceding the exchange rate shock of January 2015, fluctuations in the EUR/CHF exchange rate were very moderate due to the exchange rate floor policy conducted by the SNB, which was put in place on 6 September 2011. The long period of exchange rate stability came to a sudden end on 15 January 2015, when the SNB made the announcement that it would terminate its policy of the minimum exchange rate. The Swiss franc appreciated immediately against the euro. Setting down that the exchange rate shock in 2015 was independent to firms' pricing decisions makes it possible to identify a causal effect between the exchange rate and markups.

Furthermore, Kaufmann and Renkin (2018) show that the appreciation was perceived by firms to be permanent.[9] This is a decisive point as it lays the ground for firms to adjust their prices. Besides, Kaufmann and Renkin (2018) analyse the economic environment before and after the shock and attest that, apart from the exchange rate shock, most other macroeconomic factors developed quite steadily during that period.

3.2 Empirical model

The impact of the exchange rate shock exchange rate shock is estimated following the methodology used by Kaufmann and Renkin (2018) in which time-dummies capture the effect of the shock:

$$\mu_{it} = \alpha_i + \sum_{year \neq 2014} \gamma_{year} D_t^{year} + \beta X_{it} + \epsilon_{it} \tag{1.1}$$

The dependent variable μ_{it} is the log-markup of firm i in year t. The time-dummies D_t^{year} are equal to one in the corresponding year, otherwise zero. The time-dummy for the

[9] The authors analyse the individual responses of the KOF Consensus Forecast, a survey, which contains the exchange rate forecasts of 20 economists. According to this survey, the 12-month forecasts of the EUR/CHF exchange rate declined directly after the exchange rate shock of January 2015 and remained stable over the following years. Kaufmann and Renkin (2018) find further evidence that firms perceived the shock to be permanent in the development of the applications to the Swiss short-time work scheme. The short-time work scheme is a governmental program designed to give firms financial support in bridging temporary reductions of working hours. The applications for short-time work increased only little following the shock of January 2015, indicating that a large majority of firms did not expect the appreciation to be temporary.

year before the shock D_t^{2014} is omitted. The response is therefore normalised to zero in the year preceding the shock. The impact of the exchange rate on markups is measured by the dummy coefficients, γ_{year}, which can be interpreted as the response of markups relative to the year before the shock. A control function, X_{it}, has been introduced into the model to catch factors that potentially may affect markups independently to the exchange rate. It contains three control variables: a firm-specific material cost index in foreign currency, a firm-specific demand index in foreign currency and a firm-specific exchange index rate variable to control for potential changes in other currencies than that in which the shock occurred.[10] The regression is estimated with firm fixed effects.

The markups, which enter the empirical analysis, are estimated with firm-level data on expenditures and revenue. The result of equation (1.1) is, therefore, the estimated response of the realised markups. If prices are sticky, the realised markups may, however, not correspond to the desired markups. Frictions in price setting could cause markups not to react as strongly or as quickly as desired by the firm.[11] Thus, price stickiness, which is not controlled for in equation (1.1), may lead to a lower pass-through than that, which would be optimal for firms, at least in the first year after the shock (2015).[12] However, in the analysed sample, the impact of price stickiness may actually be small as the exchange rate shock of January 2015 was extraordinary large and, according to Alvarez, Lippi, and Passadore (2017), the response of prices to an exchange rate shock depends on the size of the shock.

In order to be able to assign the estimated results to the exchange rate shock of January 2015, the coefficients of the time-dummies preceding the event, γ_{2012} and γ_{2013}, should not be significantly different to zero given that during this period the EUR/CHF exchange rate was more or less flat. The dummy coefficients for 2015-2017 can be interpreted as the cumulated change in markups resulting from the exchange rate shock of January 2015.

The heterogeneity across firms is introduced into the model by means of a dummy-variable representing a given firm-specific feature. For each of the five firm-level features described in Section 2 a firm-specific dummy has been constructed. These feature-dummies are set to equal 1 for those firms in the upper fifth quintile of the

[10] See Section 4.4 for the description of the control variables.

[11] Amiti, Itskhoki, and Konings (2020) discuss the divergence between the desired and the realised price and find that the loss that arises because of price stickiness drives firms' choice of invoicing currency.

[12] Kaufmann (2009) calculates the frequency of price changes and the number of quarters between price adjustments using price quotes of the products underlying the Swiss consumer price index between 2000-2005. According to his results, prices of industrial goods sold at the consumer level in Switzerland are on average adjusted every 4.5 quarters.

distribution. Otherwise it takes the value 0.[13] Equation (1.2) is enhanced with such a firm-specific feature-dummy-variable $D_i^{Feature}$. The marginal impact of a single firm-specific characteristic on the pass-through of the exchange rate into markups is measured by the coefficients of the interaction term of the time-dummies with a given feature-dummy ψ_{year}. The feature-dummy itself is absorb by the firm-fixed effects:

$$\mu_{it} = \alpha_i + \sum_{year \neq 2014} \gamma_{year} D_t^{year} + \sum_{year \neq 2014} \psi_{year} D_t^{year} D_i^{Feature} + \beta X_{it} + \epsilon_{it} \quad (1.2)$$

In a further step, the model is extended to estimate the impact of two feature-dummies simultaneously. With these combined estimates one can test whether the various features are independent from one another, and therefore have an amplifying impact on the pass-through, or not. Given the economic importance of large firms, the size-dummy D_i^{Size} is included in all regressions and the interaction terms of the other features are added in turn:

$$\begin{aligned} \mu_{it} = \alpha_i &+ \sum_{year \neq 2014} \gamma_{year} D_t^{year} + \sum_{year \neq 2014} \psi_{year} D_t^{year} D_i^{Size} \\ &+ \sum_{year \neq 2014} \phi_{year} D_t^{year} D_i^{Feature} + \sum_{year \neq 2014} \chi_{year} D_t^{year} D_i^{Size} D_i^{Feature} \\ &+ \beta X_{it} + \epsilon_{it} \end{aligned} \quad (1.3)$$

The difference between the sum of the estimates of ψ_{year}, ϕ_{year} and χ_{year} from equation (1.3) and ψ_{year} from equation (1.2) gives evidence if the additional feature has an amplifying effect on the pass-through.

4 Data and measurement

This section provides an overview of the raw data and some stylised facts on the estimated markups. Furthermore, a description of the feature dummies and the control variables are given. Details on the methodology with which markups are estimated can be found in Section A.1 in the Appendix.

[13] The exact specification of the feature-dummies is given in Section 4.3

4.1 Raw Data

The two main data sources used in this paper are data on expenditures and revenue, which are used to estimate the markups, and goods import and export data, which are used to define the export intensity of a firm and compute the firm-level control variables. Both sources are matched at the firm-level. As the import and export data only comprise goods, the analysis has been restrained to the manufacturing sector as this is the sector in which goods play a predominant role, in contrast to the service sector.

Annual markups are estimated for the manufacturing sector for the period 2012-2017 using a large panel of firm-level balance-sheet and income-statement data (value added statistics) provided by the Swiss Federal Statistical Office (SFSO).[14] The dataset contains all required variables to estimate firm-level markups: revenue, intermediate goods, labour costs and the capital stock.[15] The data set comprises $10,158$ observations from $2,462$ firms. It is an unbalanced panel; that is, not every firm is observed for all years. The sample is a comprehensive draw from the population of Swiss manufacturing firms, including all sub-industries of the manufacturing sector (see Table 1.6). However, while it includes many of the large and medium-sized firms, the data do not cover the full universe of firms of the small and very small firms, which are underrepresented.

Firm-level data custom data is also supplied by the SFSO. These data contain information on the amount of exports and imports by firm, in CHF including a breakdown by region and invoicing currency. The custom data are used to define an export-intensity feature dummy. Furthermore, they are used to compute the weights which enter the calculation of the three firm-level control variables: The regional breakdown of imports is used to construct a firm-level material cost index in foreign currency. The regional breakdown of exports is used to build a proxy of firms' foreign demand. The currency breakdown is used

[14]The sample is not a representative sample as it over-samples large firms. This is because the sample is used to project aggregate GDP, for which large firms' statistics have a higher information content. The sampling frame is broken down by industries, respectively by sectors (primary strata) on the basis of the 2-digit NOGA classification (NOGA is the Swiss industry classification, similar to NACE) and size classes on the basis of 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 companies are surveyed. In the remaining strata, simple random samples are drawn. The sample size is set so that 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.

[15]Firm-level input and output prices are not available. Where firm-level revenue and intermediate goods are used in physical terms, the nominal variables from the dataset are deflated with sub-sector deflators taken from the National Account statistics. The methodology developed by De Loecker and Warzynski (2012) has found a solution to circumvent the missing price variation between firms within sub-sectors. See the discussion of the data in Section A.2.1 in the Appendix.

to calculate the export share in euro, which is the proxy for firms' exposure to the EUR/CHF exchange rate.

Export and import data that can be linked to firm-level balance sheet data are only available for the years 2016 and 2017. Failing to have a better alternative, it is therefore assumed that the average export and import shares of 2016-2017 are constant over the whole estimation period. Eventual shifts in export and import weights due to the exchange rate shock are not taken into account. As described in Section 4.3, export weights are used to classify firms in a high or a low export intensity bin. If the shifts were heterogeneous across firms, some firms may be classified incorrectly as being an export-intensive firm, i.e. being one of the 20% most export intensive firms in the years preceding the shock. However, while this may occur for some firms at the margin, one can assume that the bulk of export intensive firms in the period preceding the shock were also export intensive following the shock so that the impact on the estimated pass-through is probably small.[16] Literature justifies this assumption. Amiti, Itskhoki, and Konings (2014), who measure the pass-through of an exchange rate shock into sale prices with Belgian data, confirm that import shares invoiced in a given currency prove to be very persistent over time, even following a sharp exchange rate shock. Actually, even though they could use a time-variant measure of import intensity in their baseline specification, they replace it by time-invariant one arguing that in this way the measurement error can be reduce while their results are only little affected by this choice.[17]

For more details and sample statistics on the raw data see Section A.2 in the Appendix.

4.2 Markups

Markups for the Swiss manufacturing sector are estimated per firm and per year. The estimation methodology applied in this paper follows closely the so-called 'production function approach' described in De Loecker and Warzynski (2012), who extended the model originally proposed by Hall, Blanchard, and Hubbard (1986). An extensive description

[16] Export and import data are additionally used to compute weights, which are used for the calculation of firm-level control variables, in particular for the computation of a firm-specific material cost index (See Section 4.4). As material prices were more or less flat in the years preceding the exchange rate shock (see Figure 1.3) a bias in the weights in the years before the shock probably have only a minor impact on computed material cost index. (see more details on the export and import data in Section A.2.2)

[17] Furthermore, the Swiss export data used by Auer, Burstein, Erhardt, and Lein (2019), which stretches from 2013 to 2015, show that, at least at the aggregate level, the shares of exports invoiced in CHF, EUR or USD were exceptionally stable before and after the EUR/CHF shock.

of the production function approach is provided in Section A.1 in the Appendix. This approach assumes that firms minimize costs and that they are price takers in input markets. Taking labour as the variable input, markups are defined as the output elasticity of labour multiplied by the inverse of the labour share in total revenue:

$$\mathcal{M}_{it} = \theta_{it}^{L} S_{it}^{L^{-1}}$$

Using the output elasticity of labour and the labour expenditure share in revenue to derive markups assumes that the Swiss labour market is very flexible. Although, in international comparison, the Swiss labour market is ranked as one of the most flexible, with relatively few regulations regarding the hiring and laying off of staff (Di Tella and MacCulloch, 2005),[18] this assumption may not fully hold. However, this issue is attenuated by the fact that we employ annual data.

While the labour share can be taken directly from the firm data, the output elasticity of labour has to be estimated by means of a production function. Productivity is controlled for in the production function in order to resolve the simultaneity problem, which is brought up because productivity affects the amount of inputs, which flows into production. It is assumed that production follows a second order translog production function. This makes it possible to estimate an output elasticity that varies between firms. Markups are computed using variables which relate to the firm as a whole. Therefore, the estimated markup is a firm average, covering all products and activities a firm produces and sells in a given year.[19]

Table 1.1 lists the means, the medians, the weighted means[20] and the standard deviations of the estimated markups for the whole sample and by sub-sector. The mean markup over all observations is 1.26, meaning that firms set their sale price equal to their marginal cost plus an upcharge of 26% of the marginal cost. The median is lower, at 1.13%. The weighted mean amounts to 1.81% and is thus more than 40% above the mean. This means that larger firms tend to have higher markups. The standard deviation of the sub-sector

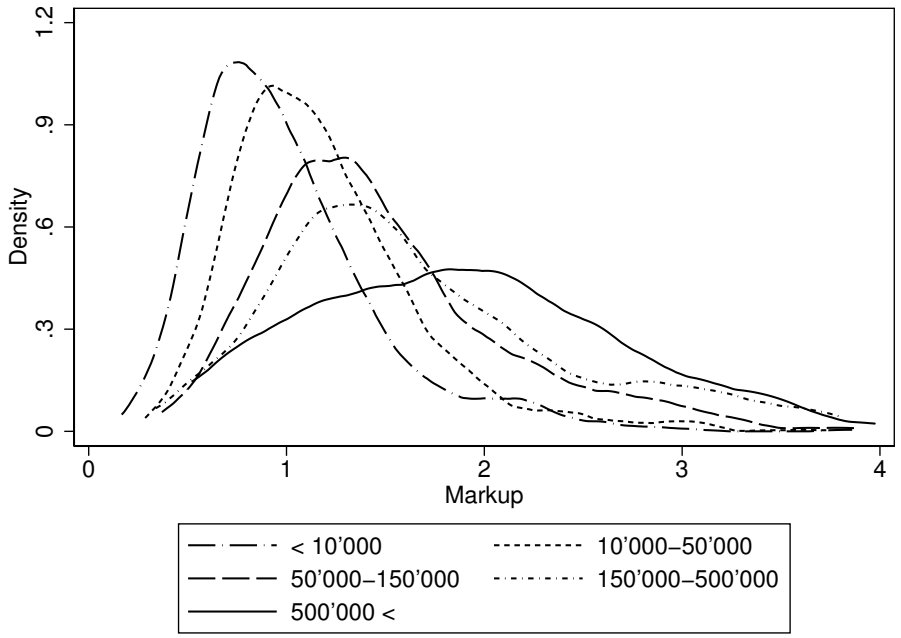
[18] Most labour contracts in Switzerland have a mutual notice period of two to three months. An employer may terminate the employment of an employee with a notice period of two (three) months if the employee has been employed in the company for less (more) than 10 years.

[19] Firms produce a variety of goods and services and sell them to a variety of customers, which are active in a variety of markets (e.g. domestic versus foreign markets). A firm typically charges different markups on its various products and in the various markets in which the products are sold in. Firm-level markups estimated with the production approach therefore reflect the average markup across all the products a firm sells.

[20] Markups are weighted by their size, which is measured by their revenue. The aggregate markup is computed using a two step aggregation procedure. First, a weighted mean is constructed at the sub-sector level using firm-level data. Second, the sub-sector weighted means are aggregated using sub-sector weights derived from the production data from the national accounts. (see A.2.4 for details on the aggregation method).

means is only 0.17, indicating that the between-sector heterogeneity is quite low. In contrast, the heterogeneity within firms of the same sub-sector is much higher, in particular for the sub-sectors 'IT and watches', 'Pharmaceuticals' and 'Chemicals'. The distribution between firms is particularly large in the pharmaceutical sector. In this sub-sector the difference between the median and the weighted mean is especially large, indicating that this sub-sector is composed of few very large firms with high markups and many smaller firms with low markups. The high within-sub-sector and low between-sub-sector heterogeneity makes the sub-sector perspective is not particularly informative. A more interesting desegregation is by size. Figure 1.1 shows the distribution of markups for different size classes. This figure shows clearly that larger firms tend to have larger markups, although here too, the dispersion is large.[21]

FIGURE 1.1: DISTRIBUTION OF MARKUPS BY SIZE GROUP



Notes: This figure shows the kernel density estimates for five size groups, whereby size is defined by firms' mean annual revenue in CHF, for manufacturing firms between 2012 and 2017.

The revenue of the fifth largest firms in the sample amounts to 81% of total revenue. Because of their economic weight, the development of large firms' markups plays a predominant role for the aggregate development. Figure 1.2 depicts the development of the

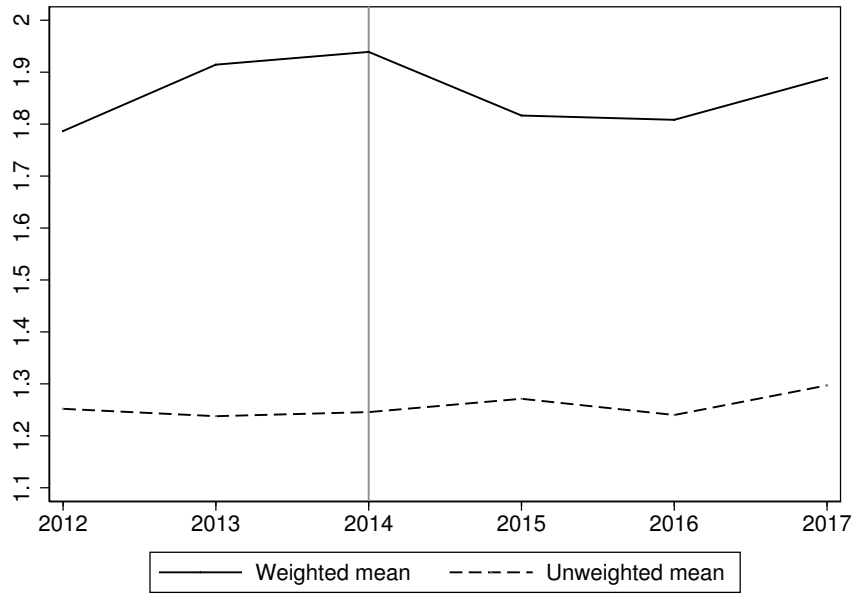
[21] Besides, Figure 1.1 shows that a not negligible share of firms are estimated to have a markup smaller than unit. This feature is analysed by Caselli, Schiavo, and Nesta (2018), who estimate markups with approximately the same methodology as in this paper and find that in their sample of French manufacturing firms around 14% of firms display markups lower than unit, many of which for more than one year. From other papers they deduce that this share is even higher for markups estimated with Indian or Mexican data (between 25% and 45% of observations).

TABLE 1.1: DESCRIPTIVE STATISTICS FOR SWISS MARKUPS 2012-2017

	median	mean	weighted mean	stdev
Whole sample				
	1.13	1.26	1.81	0.66
$Within\ sub-sectors$				
Food, Tobacco	1.19	1.32	1.77	0.65
Textiles	1.42	1.49	1.85	0.58
Wood	1.1	1.29	1.54	0.54
Paper	1.23	1.31	1.60	0.51
Print	1.19	1.2	1.30	0.31
Chemicals	1.03	1.25	1.62	0.82
Pharmaceuticals	0.71	0.95	2.05	0.87
Plastics	1.08	1.19	1.38	0.5
Glass	0.92	1.08	1.28	0.6
Basic metals	1.06	1.3	1.90	0.69
Metal products	1.08	1.13	1.23	0.35
IT Watches	1.42	1.63	2.46	0.97
Electrical	0.93	1	1.14	0.52
Machines	1.15	1.24	1.54	0.52
Vehicles	1.07	1.14	1.38	0.51
Furniture	0.89	0.94	1.01	0.28
Other	1.03	1.13	1.42	0.51
$Between\ sub-sectors$				
	median of medians	mean of means	mean of weighted mean	stdev of means
	1.08	1.21	1.56	0.17

weighted mean (solid line) and the unweighted mean (dashed line) of markups between 2012 and 2017. A striking feature of this figure is that the weighted mean, which is representative for the aggregate of firms, is markedly higher than the unweighted mean, which reflects the development of the average firm. Besides, this figure also shows that the weighted mean developed very differently to the unweighted mean in the aftermath of the exchange rate shock. The vertical line separates the pre-shock phase (2012-2014) and the post-shock phase (2015-2017). While the unweighted mean markup increased slightly in 2015, the weighted mean decreased by 6.3%. This indicates that large firms were a driving force behind the aggregate squeeze in markups following the appreciation.

FIGURE 1.2: MARKUPS, MEAN AND WEIGHTED MEAN



Notes: This figure shows the annual mean of the weighted and unweighted markups for Swiss manufacturing firms between 2012 and 2017. Markups are weighted by their size, which is measured by their revenue. See A.2.4 for aggregation method.

4.3 Firm-specific feature-dummies

For each of the five firm-level features described in Section 2 a firm-specific dummy has been constructed. These feature-dummies are set to equal 1 for those firms in the upper fifth quintile of the distribution. Otherwise it takes the value 0. Therefore, the coefficients of the feature-dummies in equation (1.2) and (1.3) measure the marginal impact of the upper 20%-highest firms.

Size is the first feature. Because of their economic weight, the response of large firms plays a predominant role for the aggregate pass-through. Size is measured by firms' average revenue in the years before the shock (2012-2014). It is assumed that large firms have unhampered access to external finance and more scope to lower their markups and therefore will have a higher markup elasticity compared to smaller firms.

The second feature is the pre-shock-level channel of markups, which determines the capability of a firm to adjust it markup, assuming that high-markup firms are set to have a higher markup elasticity. The markup-dummy is constructed with firms' average markup in the years preceding the exchange rate shock (2012-2014).

The third feature is the export intensity. Firms with a high export intensity are more strongly exposed to the exchange rate and will presumably respond more strongly to

changes in the exchange rate than firms with low exports by varying their markups. Firms' exposure to the EUR/CHF exchange rate is proxied by the share of firms' revenue stemming from exports in EUR, whereby revenue and exports are measured in CHF.[22]

The fourth feature proxies the financial health of a firm. Firms in a tight financial position refrain from decreasing their prices in a crisis in order to maintain short-term profits even at the expense of future market shares. A frictionless response of markups is only possible if a firm is in solid financial health. High-profit firms are therefore set to have a higher markup elasticity. Earnings before interest rates and taxes (EBIT) per unit revenue in the year preceding the shock is taken as a proxy of financial strength.

The fifth feature is the firm's productivity. Productivity is defined by total factor productivity (TFP). In the production function used to estimate firm-level markups, TFP has been controlled for, as TFP could potentially impact markups and bias the markup estimates. This makes it possible to use TFP as an explanatory variable for the response of markups to a exchange rate shock. TFP is derived from a firm-level production function estimated with the methodology developed by Wooldridge (2009). The average TFP in the years preceding the shock are used. Markup elasticity is assumed to be increasing in TFP

In the Swiss manufacturing sector, size is correlated with the level of markup, profitability and productivity but not with export intensity. The latter is actually not really correlated with any other feature. This contrasts with the model of Melitz and Ottaviano (2008), which shows that more productive firms are larger, export more and have higher profits. The lack of correlation may be related to the fact that the exporting segment of the Swiss manufacturing sector is very heterogenous and not dominated by a specific type of firm. The use of Swiss data makes it therefore possible to differentiate between the impact caused by the export intensity channel and that caused by size, productivity or profitability

.

4.4 Control variables

Although most macroeconomic factors, beside the EUR/CHF exchange rate, developed quite steadily before and after the exchange rate shock of 2015, variables which may have had an influence on markups should enter the control function. Three control variables have

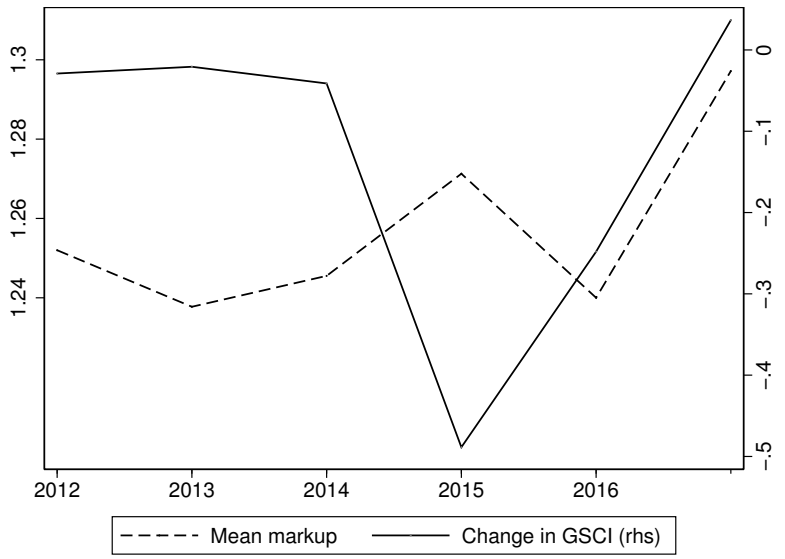
[22] In Section A.3.5 in the Appendix, a robustness test is conducted, in which firms' export intensity is measured by their export share to the euro area instead of in EUR. The response to the exchange rate shock is very similar.

been constructed in order to prevent biased estimates. A detailed description on how the three control variables are constructed is provided in Appendix A.2.3

First, a firm-specific material cost index in foreign currency is built to control for changes in commodity prices. As shown in Figure 1.3, the mean markup (dashed line) was quite stable, around 1.21%, between 2012 and 2014. In 2015, however, it increased by 2.4%. This increase is at first glance surprising given that the sharp appreciation of the Swiss franc presumingly put pressure on sale prices and hence on markups. The rise in the average markup in 2015 is an indication that an additional factor may have had a counterbalancing impact on firms' markups.

The solid line in Figure 1.3 depicts the annual change in the Goldman Sachs Commodity Index (GSCI) denoted in USD. In 2015, the GSCI dropped by 38.7%. In 2016 it fell by further 22%. In 2017 it was more or less flat. The sharp drop in commodity prices in 2015 presumingly led to a decrease in firms' material costs, which may have led to a rise in markups, in spite of the negative impact of the appreciation. In order to asses correctly the impact of the appreciation on markups, one has to control for this effect.

FIGURE 1.3: MARKUPS AND THE CHANGE IN MATERIAL PRICES IN FOREIGN CURRENCY



Notes: The solid line shows the annual mean of the firm-specific markups. The solid line shows the annual change in the Goldmann Sachs commodity index in USD.

In the pass-through regression, one only wants to control for the worldwide drop in material costs without taking into account the decrease in import prices stemming from the appreciation. A firm-specific material cost index is constructed that excludes the impact of the appreciation of the Swiss franc:

$$Cost_{i,t}^{Materials} = \sum_c PPI_{c,t}^{For} Share_{c,i}^{Imp} + PPI_t^{Dom} Share_i^{Dom}$$

The index consists of two terms. The first term reflects the cost of materials which are directly imported by the firms. It is a weighted average of foreign producer prices, which are indexed at 100 in 2014. The weights are the firm-specific share of imported materials from a given country or region. The foreign producer prices are denominated in the respective foreign currency. This assures that only the change in price stemming from lower material prices is included in the index and that the decrease in import prices stemming from the appreciation is not taken into account. The second term covers the cost of materials bought on the domestic market. Importantly, the impact of the appreciation has been estimated and extracted from this term. The material cost index enters the control function as the cumulated change relative to 2014.[23]

Biased estimates may also come from a shift in the demand curve which could affect market conditions and lead to an adjustment in markups as described in Goldfajn and Werlang (2000). Furthermore, changes in the USD/CHF exchange rate may have an impact on markups, although data shows that the average firm trades over 90% of its imports or exports in Swiss francs or in Euros. Therefore, besides the firm-specific material costs index also a firm-specific foreign demand index and a firm-weighted USD/CHF index enter the control function.

5 Response of markups to changes in the exchange rate

In this section, the estimates of the pass-through of the exchange rate shock of January 2015 into markups are reported. First, the overall response estimated with equation (1.1) is shown in Table 1.2. For all specifications, the estimated dummy coefficients γ_{2012} and γ_{2013} are not significantly different to zero, as expected given that during the period preceding the shock, the EUR/CHF exchange rate was more or less flat.

The dummy coefficients for the years following the shock can be interpreted as the cumulated change in markups resulting from the exchange rate shock of January 2015. Specification (1) lists the coefficients when no control variables are included in the estimate. The coefficients reflect that what has been shown in Figure 1.3: markups increased in 2015

[23]The unweighted mean of markups (depicted in Figure 1.3) increased by 2.1% in 2015. If one deduces the estimated effect of material prices, the unweighted mean increases only very slightly in 2015, by 0.6%

and again in 2017. The coefficients are even highly significant.

TABLE 1.2: RESPONSE OF MARKUPS TO THE EXCHANGE RATE

	(1)	(2)	(3)
Response of markups relative to 2014			
γ_{2012}	0.004	0.001	0.001
	(0.006)	(0.006)	(0.006)
γ_{2013}	-0.006	-0.004	-0.004
	(0.004)	(0.005)	(0.005)
γ_{2015}	0.019***	-0.007	-0.007
	(0.006)	(0.015)	(0.015)
γ_{2016}	0.017**	-0.019	-0.021
	(0.007)	(0.022)	(0.022)
γ_{2017}	0.042***	0.021	0.019
	(0.008)	(0.016)	(0.016)
$\beta^{MaterialPrice}$		-1.407**	-1.396**
		(0.687)	(0.708)
$\beta^{ForeignDemand}$		-0.104	
		(0.327)	
$\beta^{USDindex}$		-0.028	
		(0.032)	
Observations	10158	10099	10099
Firm FE	yes	yes	yes

Notes: Estimated response of log-markups to the exchange rate shock of 15 January 2015, relative to 2014. The p-values are denoted as: ***$p < 0.01$, **$p < 0.05$, and *$p < 0.1$. Heteroskedasticity- and autocorrelation-consistent standard errors standard errors in parentheses.

In specification (2), which includes the three control variables, the coefficients of the dummy variables for the two years following the shock, 2015 and 2016, are negative but not significant. This indicates that, after having controlled for other influences, on average, firms did not respond to the exchange rate shock of January 2015 by increasing their markups. However, they did not significantly decrease them either. The only control variable which plays a significant role is the firm-specific material price index, which has a negative sign indicating that material prices are negatively correlated with markups, as expected.[24] The coefficient of the foreign demand index is not significant, confirming the assumption laid down in Kaufmann and Renkin (2018) that most macroeconomic factors,

[24]Kaufmann and Renkin (2018), who estimate the exchange rate sensitivity depending invoice currency, control for marginal costs using firm-level import prices in domestic currency. They find that the impact of their control variable in domestic currency on their results is small.

beside the EUR/CHF exchange rate, developed steadily before and after the exchange rate shock of 2015, and therefore had no significant impact on the development of prices and markups. The coefficient of the firm specific US dollar index is not significant either. This is not very surprising given the small amount of goods traded in US dollar.[25] In specification (3) the insignificant control variables are dropped from the regression without changing the results.

These first results show that on average firms did not respond to the exchange rate shock of January 2015 by significantly decreasing their markups.[26] In a next step, the impact of each of the five firm-level features are estimated using equation (1.2). In Panel 1) of Table 1.3 the response of the exchange rate shock measured by the sum of the coefficients of the time dummy, γ_{year}, and the interaction term, ψ_{year}, is shown for each channel. Panel 2) reports the total implied exchange rate elasticity in the year of the shock, i.e., in 2015, and in the year after the shock, i.e., in 2016. The implied elasticities are computed by dividing the marginal response in 2015 and 2016 relative to 2014 by the change in EUR/CHF exchange rate in 2015 and 2016 relative to 2014. Figure 1.4 replicates the results graphically.

Specification (1) lists the estimates for the 20%-largest firms. In the year of the shock, in 2015, large firms decreased their markups by 5.3% and left them at that level in the following year. Given that the exchange rate decreased by over 12%, the implied exchange rate elasticity amounts 40%, as shown in Panel 2) . The comparison of the pass-through of all firms in Table 1.3 and that of large firms reflect what is shown in Figure 1.2: While the mean markup, which is driven by a large number of smaller firms, remained practically unchanged, the weighted mean, which is driven by the response of large firms, decreased markedly. Thus, the response of the average firm confirms models, which assume a constant markup-pricing rule. In contrast, large firms react to an adverse exchange rate shock by decreasing their markups markedly and thereby shape the aggregate response. These results are consistent with the findings of Amiti, Itskhoki, and Konings (2019), who show that large firms exhibit strong strategic complementarities.

Specification (2) depicts the response of firms with a high markup preceding the shock. As size and the level of markups are closely related, it is not surprising that high-markup firms also adjust their markups strongly. The pass-through elasticity is 33% in the year of

[25] see Table 1.7 in the Appendix.

[26] These results contrast to those found by Caselli, Chatterjee, and Woodland (2017) who estimate with Mexican data that a depreciation lead to a significant increase of markups across all firms, however with quite a low elasticity of only 0.06

TABLE 1.3: RESPONSE OF MARKUPS TO THE EXCHANGE RATE SHOCK DEPENDING ON THE FIVE FIRM-LEVEL FEATURES

	large firms	high markups	high export share	high EBIT	high productivity
Panel 1) Total response of markups relative to 2014					
$\gamma_{2012} + \psi_{2012}$	-0.000	0.004	0.006	0.004	-0.010
$\gamma_{2013} + \psi_{2013}$	-0.003	0.004	0.007	-0.005	-0.016
$\gamma_{2015} + \psi_{2015}$	-0.053***	-0.042**	-0.040*	-0.040*	-0.064***
$\gamma_{2016} + \psi_{2016}$	-0.048*	-0.072***	-0.039	-0.048*	-0.062**
$\gamma_{2017} + \psi_{2017}$	-0.003	-0.033	0.006	-0.005	-0.020
Panel 2) Total implied exchange rate elasticity					
2015	0.413	0.327	0.309	0.308	0.501
2016	0.448	0.666	0.362	0.442	0.576

Notes: Panel 1) on the top shows the estimated average response of log-markups to the exchange rate shock of 15 January 2015, relative to 2014, depending on five firm-level features, measured as the sum of the coefficients γ_{year} and ψ_{year}. The p-values denoted as: ***$p < 0.01$, **$p < 0.05$, and *$p < 0.1$ are derived from the heteroskedasticity- and autocorrelation-consistent variances and covariances of the coefficients γ_{year} and ψ_{year}. Panel 2) reports the total implied exchange rate elasticity in 2015, and in 2016, which is computed by dividing the total response in 2015 resp. 2016 relative to 2014 by the change in EUR/CHF exchange rate 2015 resp. 2016 relative to 2014. Table 1.14 in the Appendix, reports the full results of equation (1.2).

the shock and is at its highest in the year following the shock, at 55.9%.

Firms with high export shares in EUR decreased their markups by 4.0% in the year of the shock. In the following years, the shock had no significant impact. The exchange rate elasticity is 30.9%. At first glance, this elasticity may seem to be low, given that all these firms sell a large share of their exports in EUR. Indeed, according to theory on invoicing currency, firms which prefer to export in foreign currency, choose to do so because they strive to keep prices in the foreign currency stable by varying their markup.[27] Kaufmann and Renkin (2018) provide empirical evidence that CHF-prices of exported products invoiced in EUR responded strongly to the exchange rate shock, implying these firms reacted to the shock by strongly decreasing their markups. There are however two explanations that suggest that the results may not be contradicting. First, one must keep in mind, that markups are defined at the firm level, not at the product level. This means that the dependent variable

[27] Based on the model of endogenous currency choice developed by Gopinath, Itskhoki, and Rigobon (2010), firms facing strong strategic complementarity will choose to export in the consumer currency and prefer to vary their markups in order to keep prices in the foreign currency stable.

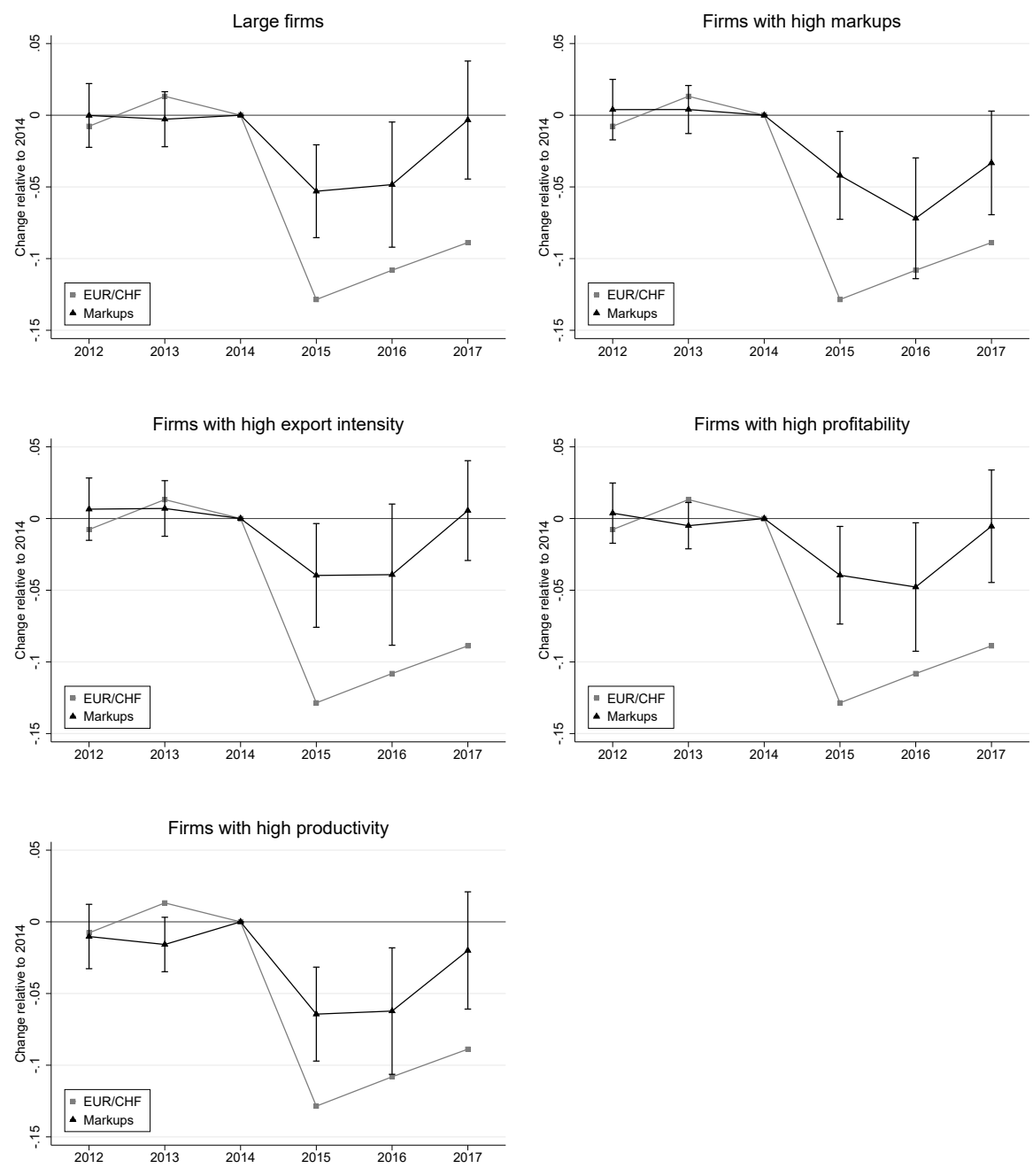
is the average markup over all the products that the firm produces. Not all firms in the upper fifth of the distribution only export products in EUR. Some of their products are sold to non-EUR markets, which were unaffected by the EUR/CHF appreciation or to the domestic market, which may be affected by the exchange rate through import competition, albeit to a lesser extent. Furthermore, if a firm imports goods in euro, the appreciation of the EUR/CHF exchange rate will have led to a decrease in their marginal costs, partly offsetting the negative impact stemming from reduced sale prices. This channel acts as a sort of 'natural hedging'. Amiti, Itskhoki, and Konings (2014) show that this channel can play a large role as many exporting firms tend to import a part of their intermediate goods. The data confirm this for Switzerland: the upper fifth euro-exporters import on average 40% of their intermediate goods in euro.

Specification (4) shows that highly profitable firms have a markup elasticity of around 30%. This suggests that firms in a healthy financial condition have more leeway to actively adjust their markups, while firms in a tight financial position refrain from decreasing their prices in a crisis in order to maintain short-term profits even at the expense of future market shares. Finally, highly-productive firms have a pass-through elasticity of 50.1%.

While all five features have a significant impact taken individually, combined regressions are run to test if the five features are independent from one another. As described in Section 2, in literature the theoretical relationship between size and productivity is well established. The relationship between the other firm-specific features is however ambiguous. Combined regressions are run in order to estimate if being large, export intensive, high profitability, highly productive or having high markups are different facets of the same feature, or if these features have an independent, mutually amplifying impact on the pass-through. Given the economic importance of large firms, the size-dummy is set fix in all regressions and the interaction terms of the other features are added in turn.

Table 1.4 lists the responses of the combined regressions. The response of large firms with a high markup is shown in column (1). The implied exchange rate elasticity is estimated at 41.7% in the year of the shock and 60.0% in the following year. Panel 3) shows that the increase compared to the average high-markup firm is small. The estimates in column (4) show that the elasticity of large firms with high productivity also remains practically unchanged compared to the average highly productive firm. This indicates that these three features (size, markup level and productivity) are not independent to one another. While

FIGURE 1.4: RESPONSE OF MARKUPS TO THE EXCHANGE RATE SHOCK DEPENDING ON THE FIVE FIRM-LEVEL FEATURES



Notes: The black lines show estimates of the average response of log-markups to the exchange rate shock of 15 January 2015, relative to 2014, depending on the five firm-level features, measured as the sum of the coefficients γ^{year} and ψ^{year}. The vertical bars denote the 90% confidence intervals, which are derived from the variances and covariances of the estimated coefficients γ^{year} and ψ^{year}. The grey line is the change in the EUR/CHF exchange rate relative to 2014.

there are rationales for each of these three channels, it is not possible with the data set to distinguish which of the three features is the cause of the pass-through.

Column (2) shows that for large and export intensive firms the implied exchange rate

elasticity increases close to 0.9 in the year of the shock. This means that large and export intensive firms practically completely adjust their markups, in favour of stable sale prices in foreign currency. Panel 3) shows that the elasticity is more than twice as high compared to the average export intensive firm. The implied markup elasticity of large and highly profitable firms, shown in column (3), is around 65%, up by 35% compared to the average high-profitable firm.[28]

Large firms, which are export intensive or highly profitable account for only 7.6% of all firms in the sample. Their aggregated revenue, however, amounts to 48% of total revenue. These figures underline the relevance of large firms for the aggregate development. Thus, while smaller firms are in the majority and shape the mean response, large firms with an unhampered pass-through have a strong influence on the aggregate development of markups.[29] These findings are in line with Gabaix (2011), who in respect of aggregate growth, shows that the development of the largest firms has a substantial impact on aggregate variation.

[28] While the point estimates in Table 1.4 indicate that the pass-through is very high for large firms when they are export intensive or highly profitable, Figure 1.5 shows that the dispersion of the response is however quite large and that the responses of the combined channels are not statistically different to the responses of single pass-through channels.

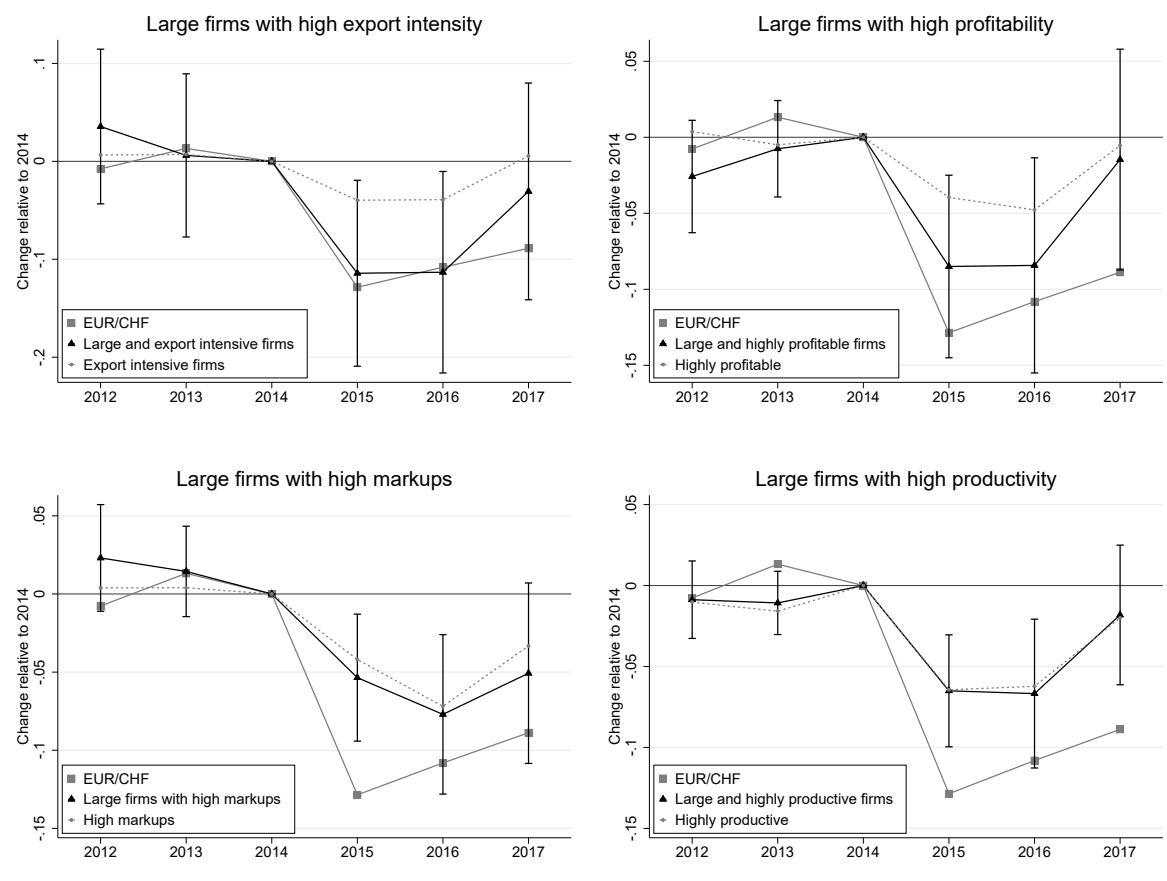
[29] Firms, which are large firms and export intensive account for only 2.3% of all firms in the sample and firms, which are large and highly profitable account for 6.2%. Section A.2.5 in the Appendix compares the development of markups for such firms with the average markup of the rest of the sample and shows the response of small, domestic oriented firms and lowly profitable firms. The estimated coefficients confirm that firms subject to strong frictions tend to leave their markups stable or even raise them in a crisis in order to preserve internal liquidity even at the cost of losing market share.

TABLE 1.4: RESPONSE OF MARKUPS TO THE EXCHANGE RATE SHOCK FOR LARGE FIRMS COMBINED WITH ANOTHER FIRM-LEVEL FEATURE

	(1) large and high markups	(2) large and high export share	(3) large and high EBIT	(4) large and high productivity
Panel 1) Total response of markups relative to 2014				
$(\gamma+\psi+\phi+\chi)_{2012}$	0.023	0.036	-0.026	-0.009
$(\gamma+\psi+\phi+\chi)_{2013}$	0.014	0.006	-0.008	-0.011
$(\gamma+\psi+\phi+\chi)_{2015}$	-0.054**	-0.114**	-0.085**	-0.065***
$(\gamma+\psi+\phi+\chi)_{2016}$	-0.077**	-0.113*	-0.084*	-0.067**
$(\gamma+\psi+\phi+\chi)_{2017}$	-0.051	-0.031	-0.015	-0.018
Panel 2) Total implied exchange rate elasticity				
2015	0.417	0.889	0.661	0.506
2016	0.713	1.047	0.779	0.617
Panel 3) Difference in elasticity compared to that of a single channel				
2015	0.090	0.580	0.353	0.005
2016	0.047	0.685	0.337	0.041

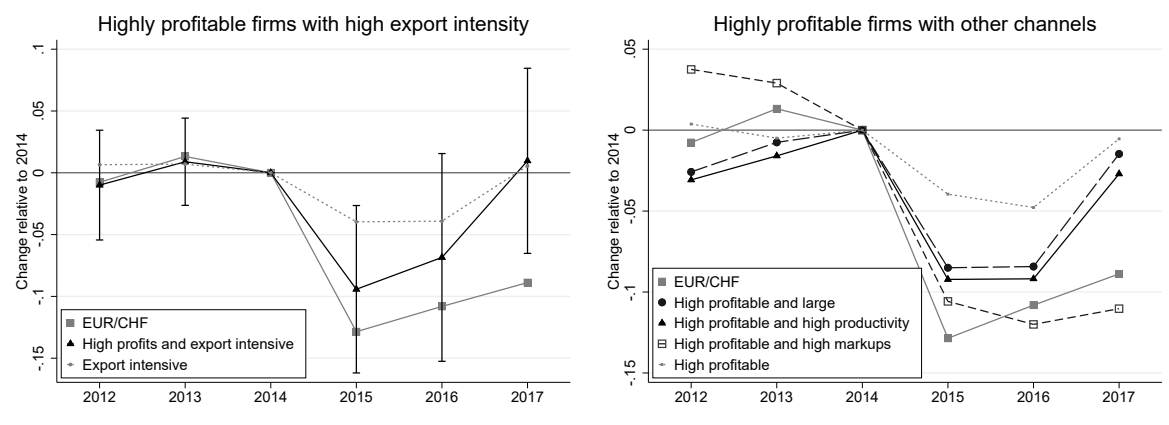
Notes: Panel 1) on the top shows the estimated average response of log-markups to the exchange rate shock of 15 January 2015, relative to 2014, for large firms with a further firm-level feature. The p-values denoted as: ***$p < 0.01$, **$p < 0.05$, and *$p < 0.1$ are derived from the heteroskedasticity- and autocorrelation-consistent variances and covariances of the coefficients γ_{year},ψ_{year},ϕ_{year},χ_{year}. Panel 2) reports the total implied exchange rate elasticity in 2015, and in 2016, which is computed by dividing the total response in 2015 resp. 2016 relative to 2014 by the change in EUR/CHF exchange rate 2015 resp. 2016 relative to 2014. Panel 3) reports the increase in implied elasticity between a single channel and the combined channels. Table 1.15 in the Appendix, reports the full results of equation (1.3).

FIGURE 1.5: RESPONSE OF MARKUPS TO THE EXCHANGE RATE SHOCK FOR LARGE FIRMS COMBINED WITH ANOTHER FIRM-LEVEL FEATURE



Notes: The black lines show estimates of the combined response of log-markups to the exchange rate shock of 15 January 2015, relative to 2014, measured as the sum of γ_{year},ψ_{year},ϕ_{year} and χ_{year}. The vertical bars denote the 90% confidence intervals, which are derived from the variances and covariances of the estimated coefficients. The grey line is the change in the EUR/CHF exchange rate relative to 2014. The dotted grey line are the estimates of the single channel.

FIGURE 1.6: RESPONSE OF MARKUPS TO THE EXCHANGE RATE SHOCK FOR HIGHLY PROFITABLE FIRMS COMBINED WITH ANOTHER FIRM-LEVEL FEATURE



Notes: The black lines show estimates of the combined response of log-markups to the exchange rate shock of 15 January 2015, relative to 2014, measured as the sum of γ_{year},ψ_{year},ϕ_{year} and χ_{year}. The vertical bars denote the 90% confidence intervals, which are derived from the variances and covariances of the estimated coefficients. The grey line is the change in the EUR/CHF exchange rate relative to 2014. The dotted grey line are the estimates of the single channel.

For completeness, the combined responses of highly profitable firms are showed in Figure 1.6. The chart on the left depicts the response of highly profitable and export intensive firms. The chart on the right shows the response of highly profitable firms which are also large, highly productive or highly profitable. These charts show that the response is strongly amplified if highly profitable firms are also export intensive or if they are large, highly productive or highly profitable.

The robustness of the results have been tested using several variations of the baseline specification. The results are reported in Appendix A.3. First the sample has been reduced to firms having at least one observation in the period before and at least one observation in the period after the shock, i.e., firms, which only have observations in the post-shock period have been dropped. Second, probability weights have been calculated using the number of firms in the true universe and the number of firms in the survey-sample. With theses weights the impact of the sampling bias has been tested. In a third test, sector-time effects have been added to the regression. Fourth, the baseline regression has been estimated with clustered standard errors based on full-time-employment, revenue and sector cells. Fifth, a robustness test is conducted, in which firms are classified by their export share to the euro area instead as their export share in euro. The results of these tests show that the baseline estimates remain robust to changes in specification.

In summary, the empirical results show that markups respond very heterogonously to

an exchange rate shock depending on firm-specific characteristics. Large, export intensive firms and large, highly profitable firms strongly adjust their markup following an exchange rate shock. It is, however, not possible to distinguish if this is because large firms have are also high productive or have high markups. In contrast, the average firm does not respond significantly to a change in the exchange rate implying that frictions hinder the markup pass-through for smaller firms, which account for the lion's share of firms.

6 Conclusions

This paper documents the pass-through of an adverse exchange rate shock on firm-level markups. In particular, the heterogeneity of the response is analysed. Markups are estimated using firm-level data from balance sheets and income statements of Swiss manufacturing firms for the period 2012-2017 following the production approach described in De Loecker and Warzynski (2012). The data are matched with firm-level export and import statistics making it possible to include the trade intensity of firms in the analysis. Besides the data, an key ingredient in the analysis is the exchange rate shock of January 15 2015, which provides a perfect setting to estimate the causal impact of an exchange rate shock on firms' markups.

For the empirical analysis, five firm-specific characteristics are defined as dummy variables, which are used to estimate if the pass-through is hampered or not. They are size, export intensity, profitability, productivity and the level of markups proceeding the shock.

The results provide strong evidence that the response is very heterogonously across different types of firms. While smaller firms leave their markup unchanged, the elasticity of large firms is estimated to be around 40%. Moreover, the combined regressions show that if large firms are also highly profitable the markup pass-though increases to 65% and is practically complete if large firms are also export intensive. These results suggest that large firms exhibit strong strategic complementarities and are capable to unhinderedly adjust their markup. Smaller firms, in contrast, are less able to adjust their markup, for example because they have to preserve internal liquidity even at the cost of loosing market share. Although such firms are in the majority, large firms with an unhampered pass-through have a strong influence on aggregate development owing to their sheer size.

The combined regressions for highly productive firms or firms with a high markup show

that the response is not amplified if they are also large. This indicates that these three features are not independent from each other. With the data set it is however not possible to distinguish which of the three features (size, productivity or high markup level) is the cause of the pass-through.

These results provide evidence that the capability of a firm to decrease its markup following an appreciation is a key factor in explaining the elasticity of markups. A firm needs to have the scope to be able to decrease its markup. If it has a high markup or high profits preceding the shock it will have the necessary leeway and will adjust its markup in order to preserve market share. On the other hand, a low markup and low profits, which tend to be characteristic to smaller firms, act as substantial frictions which hamper the transmission of an exchange rate shock into markups.

A Appendix

A.1 Estimating Markups

In monopolistic competition, the demand curve for a product is not perfectly elastic, the profit-maximizing firm has market power and is able to influence the price of its products. In such a situation of imperfect competition the firm's marginal revenue curve is downward sloping and lies under the average revenue curve. The firm will set its output at the point, where its marginal revenue equals its marginal costs. The price at which this output quantity is sold (i.e. the average revenue) is above the firm's marginal costs. The markup is defined as the wedge between sales prices and marginal costs of production.

Efforts have been undertaken to estimate markups with output prices and estimated marginal costs. For the computation of marginal costs assumptions on the structure of competition between firms have to be made. Furthermore, as detailed information on prices are often only available for very specific markets this method is not applicable to the whole economy. Markups have been estimated is such a manner by Berry, Levinsohn, and Pakes (1995) for the automobile industry or by Nevo (2001) for the ready-to-eat cereal industry.

A further approach is to estimate markups with a measure of industry concentration such as the Herfindahl-Hirschman index as in Burstein, Carvalho, and Grassi (2020). This method is suited to estimate markups of firms operating on the domestic market in a closed economy. In this case, competition is restrained to domestic firms in the same industry. However, when firms are exposed to international trade, one would have to include all competing firms abroad. If a firm is active on the domestic market, the foreign producers whose goods are or could be imported must be included. If the firm is active on the export market, its market power will depend on its market position abroad. To catch these effects, not only the competitive structure of the domestic industry must be known but also that of the competitors abroad. Such information is, however, rarely available.

The production approach, which is used in this paper, relies on the idea that under any form of imperfect competition, price does not equal marginal cost of production, and output elasticity does not equal its expenditure share. Markups are defined as the output elasticity of a variable input divided by the input's share of this input and this ratio is larger than one when a firm has a certain degree of market power. With this method, it is possible to estimate firm-level markups without any detailed price data and without having to define

any form of price competition among firms. Two assumptions have, however, to be made. First, it is assumed that an input of production can be adjusted without frictions and second, it is assumed that firms optimise their production by minimizing their costs.

A.1.1 Markups according to the production approach

In the framework of the production approach, markups are estimated using firms' output and their expenditures on variable inputs. Following De Loecker and Warzynski (2012), labour is the variable input in this study.[30]

Firms' output, Q_{it}, is produced using capital, K_{it}, labour, L_{it}, and intermediate inputs, M_{it}, given firms' productivity level, ω_{it}.

$$Q_{it} = f(K_{it}, L_{it}, M_{it}, \omega_{it}) \tag{1.4}$$

Applying cost minimization conditions, firms optimize their output with the following Lagrangian function:

$$L(K_{it}, L_{it}, M_{it}, \lambda_{it}) = r_{it}K_{it} + w_{it}L_{it} + P_{it}^{M}M_{it} + \lambda_{it}(Q_{it} - f(K_{it}, L_{it}, M_{it}, \omega_{it}) \tag{1.5}$$

where r_{it}, w_{it} and P_{it}^{M} are the rental rate of capital, the wage rate and the price of intermediate goods, respectively. The first-order conditions for the variable input labour is

$$\underset{L_{it}}{FOC} = w_{it} - \lambda_{it}\frac{\partial f(K_{it}, L_{it}, M_{it}, \omega_{it})}{\delta L_{it}} = 0 \tag{1.6}$$

which can be rearranged to:

$$\lambda_{,t}\frac{\partial f(K_{it}, L_{it}, M_{it}, \omega_{it})L_{it}}{\delta L_{it}Q_{it}} = \frac{w_{it}L_{it}}{Q_{it}} \tag{1.7}$$

The first term on the left-hand side, λ_{it}, is the cost of producing one more unit of Q_{it}, i.e. the marginal cost of production for a given level of output. Markups enter the model through λ_{it}. In a world in which firms are in perfect competition, the marginal cost of

[30] Theoretically the production approach is applicable to all variable inputs, for which firms are price takers. So also material inputs or expenditures on electricity could be used. In De Loecker and Eeckhout (2017), for example, the sum of both material inputs and labour inputs are used. Raval (2019) provides an overview of markups estimates, using different variable inputs, different model specifications and different datasets and concludes that, contrary to what the production function would imply, the trends of markups using different measures of variable inputs differ depending on which variable inputs are used.

production equals the price of output. In the context of imperfect competition, firms can generate a markup and set their price higher than their marginal costs. In this case $\lambda_{it} = \frac{P_{it}}{\mathcal{M}_{it}}$ and the markup, $\mathcal{M}_{it}$, is greater than one.

The second term on the left-hand side of equation (1.7) is the output elasticity of labour. Denominating the output elasticity of labour as θ_{it}^{L} gives:

$$\frac{P_{it}}{\mathcal{M}_{it}}\theta_{it}^{L} = \frac{w_{it}L_{it}}{Q_{it}} \tag{1.8}$$

Rearranging terms, markups can therefore be defined as the output elasticity of labour multiplied by the inverse of the labour share in total revenue, S_{it}^{L}:

$$\mathcal{M}_{it} = \theta_{it}^{L}\frac{P_{it}Q_{it}}{w_{it}L_{it}} = \theta_{it}^{L}S_{it}^{L^{-1}} \tag{1.9}$$

A.1.2 Estimating output elasticity of labour

While the labour share can be taken directly from the firm data, the output elasticity has to be estimated by means of a production function. It is assumed that production follows a second order translog production function. This makes it possible to estimate an output elasticity that can vary between firms, as shown later in equation (1.15). Thus, the production function in equation (1.4) can be rewritten as follows (lowercase letters represent logarithms, all variables are defined in real terms):

$$\begin{aligned} y_{it} \quad = \quad & \beta_0 + \beta_k k_{it} + \beta_l l_{it} + \beta_m m_{it} + \beta_{kk}k_{it}^2 + \beta_{ll}l_{it}^2 + \beta_{mm}m_{it}^2 \\ & + \beta_{kl}k_{it}l_{it} + \beta_{km}k_{it}m_{it} + \beta_{ml}m_{it}l_{it} + \beta_{klm}k_{it}l_{it}m_{it} + \omega_{it} + \epsilon_{it} \end{aligned} \tag{1.10}$$

β_0 is the time invariant mean-efficiency across firms and time, ω_{it} is the unobserved, firm specific, time variant log TFP level. ϵ_{it} is an i.i.d error term, which includes unanticipated shocks to production and measurement error. ϵ_{it} is unexpected by the firm and independent of the rest of the variables.

A key issue is the simultaneity problem, which is brought up because TFP affects the amount of inputs, which flows into production: Firms set their optimal level of labour, capital and material inputs depending on their level of TFP, which they themselves know although it is for the statistician unobservable. At the firm level, input factors are correlated

with TFP. A firm-level productivity shock potentially influences the optimal amount of input factors and lead to a bias in the estimated markup. Thus, in the production function, one has to control for productivity.

As proposed by Levinsohn and Petrin (2003), Ackerberg, Caves, and Frazer (2006) and Wooldridge (2009), material inputs can be used to proxy the unobserved TFP, whereby three assumptions must made. Firstly, it is assumed that firms first observe the productivity shock and that thereafter they accordingly choose their amount of material inputs, in function of the level of their capital stock.

$$m_{it} = m(\omega_{it}, k_{it}, Z_{it}) \tag{1.11}$$

Z_{it} contains control variables that could affect the optimal material input demand. Exchange rates are therefore included in the control function as they are prone to influence the relative prices of the input factors and thus the input demand choices of firms.

Secondly, it is assumed that material inputs are monotonically dependent on productivity (more productive firms always use more inputs). Equation (1.11) can be therefore be inverted and material goods can be used to proxy productivity.

$$\omega_{it} = m^{-1}(m_{it}, k_{it}) \tag{1.12}$$

Thirdly, it is assumed that log TFP follows a first-order Markov process and ω_{it} can be proxied by its lag .

$$\omega_{it} = g[m^{-1}(m_{it-1}, k_{it-1})] \tag{1.13}$$

Using this framework, output elasticities can be estimated in two steps. In a first step, predicted values for output, $\hat{y}_{it}$, and the error term, $\hat{\epsilon}_{it}$ are estimated using the equation: $y_{it} = \phi(k_{it}, l_{it}, m_{it}) + \epsilon_{it}$.

In a second step, (1.13) is plugged into (1.10) giving:

$$\begin{aligned} \hat{y}_{it} \quad = \quad & \beta_0 + \beta_k k_{it} + \beta_l l_{it} + \beta_m m_{it} + \beta_{kk} k_{it}^2 + \beta_{ll} l_{it}^2 + \beta_{mm} m_{it}^2 \\ & + \beta_{kl} k_{it} l_{it} + \beta_{km} k_{it} m_{it} + \beta_{ml} m_{it} l_{it} + \beta_{klm} k_{it} l_{it} m_{it} \\ & + m^{-1}(m_{it-1}, k_{it-1}) + u_{it} \end{aligned} \tag{1.14}$$

m^{-1} is approximated with a second order polynomial and l_{it} and m_{it} are instrumented

with their lags. Using standard GMM techniques, equation (1.14) is estimated for each year and sector separately. The firm-level output elasticity of labour, θ_{it}^L, equals:

$$\theta_{it}^L = \beta_l + 2\beta_{ll} l_{it} + \beta_{kl} k_{it} + \beta_{lm} m_{it} + \beta_{lkm} k_{it} m_{it} \tag{1.15}$$

Using a translog production function, therefore, enables to estimate individual firm-level output elasticities and thereby catch the heterogeneous factor input intensity between firms.[31]

Using θ_{it}^L and the labour share markups can be estimated. However, following De Loecker and Warzynski (2012), only the part of revenues, which is correlated with variables impacting input demand should is used in the calculation of the labour share. Thus, total revenues as observed in the data has be corrected by the residuals, $\hat{\epsilon}_{it}$, which were retrieved in the first step. So that markups are equal to

$$\mathcal{M}_{it} = \theta_{it}^L \frac{w_{it} L_{it}}{\frac{P_{it} Q_{it}}{exp(\hat{\epsilon}_{it})}} \tag{1.16}$$

A.2 Data description

A.2.1 Input data for the estimation of markups

The labour share in equation (1.9) is computed in nominal terms as the wage sum divided by revenue, whereby both variables are taken directly from firms' income statements.

The firm-level output elasticity of labour is estimated using the coefficients and variables in equation (1.15). All variables enter the equation in physical terms. Labour is measured by full-time-equivalent employment and, therefore, does not need to be deflated. Revenue and intermediate goods, however, are taken from the dataset in nominal terms. Unfortunately, firm-level output and input prices are not available. Nominal revenue is therefore deflated with the sub-sector production deflator and material inputs are deflated with the sub-sector deflator of intermediate goods. These NACE-2-digits-deflators are taken from the National Account statistics provided by the Swiss Federal Statistical Office (SFSO). Thus, the deflators

[31] In contrast, a Cobb-Douglas production function implies that all firms in the same sector and year work with the same production technology. Using a Cobb-Douglas production function, the following equation will be estimated:
$\hat{y}_{it} = \beta_0 + \gamma_0 + \theta^K k_{it} + \theta^L l_{it} + \theta^M m_{it} + m^{-1}(m_{it-1}, k_{it-1}) + u_{it}$,

In this case the output elasticity of labour equals θ^L, which is common for all firms for each year and sector.

do not take price differences across firms of the same sub-sector into account. De Loecker and Warzynski (2012) have, however, introduced an adjustment in their methodology to circumvent for this omitted variation: unobserved price differences across firms within sub-sectors are picked up by the residuals of the production function ϵ_{it} in equation (1.10). This unobserved price variation re-enters the computation of markups in equation (1.16), in which ϵ_{it} is included.

Labour is defined as the full-time employment taken directly from the firm data set. As the reference date of balance sheet variables, such as the capital stock, are set at the end of the reporting period, these variables are taken from the data set in $t-1$. Therefore, k_{it} is the capital stock reported at the end of the previous reporting period. The capital stock is deflated with the capital stock deflator taken from the national accounts.

Table 1.5 list the definition and the source of the variables used for the estimation of the markups.

TABLE 1.5: DEFINITIONS AND SOURCES OF INPUT VARIABLES

	Definition	Source
Variables used for the labour share in equation (1.9)		
$P_{it}Q_{it}$	Revenue (nominal)	Value added statistics
$w_{it}L_{it}$	Wage sum (nominal)	Value added statistics
Variables used in the production function, equation (1.14)		
y_{it}	Sales, nominal revenue, deflated with the sub-sector production deflator	Value added statistics, national accounts
k_{it}	Capital stock of the previous year, deflated with the capital stock deflator	Value added statistics, national accounts
l_{it}	Employment, full-time equivalent	Value added statistics
m_{it}	Material expenditure, deflated with the sub-sector intermediate goods' deflator	Value added statistics, national accounts

Notes: The value added statistics and the data from the national accounts are provided by the SFSO. The wage sum is the sum of wages, expenditures for temporary work and ancillary wage costs.

Table 1.6 lists some sample statistics of the value added statistics data set by sub-sector. The number of observations per sub-sector and their share are listed in the first two columns. In the third column, the number of firms by sub-sector are shown. In the last two columns the average revenues per sub-sector are listed. The average revenue varies strongly between

the sub-sectors and also the differences between the mean and the median are very large. This reflects the high heterogeneity throughout the Swiss manufacturing sector.

TABLE 1.6: SAMPLE STATISTICS BY SUB-SECTOR, 2012-2017

	Observations		*Firms*	*Revenue*	
	number	share in %	number	mean	median
Food, Tobacco	1162	11.4	311	98227	26606
Textiles	395	3.9	100	21871	10866
Wood	316	3.1	93	28508	15829
Paper	265	2.6	59	45577	19018
Print	322	3.2	87	23998	14280
Chemicals	608	6.0	147	129313	36693
Pharmaceuticals	368	3.6	81	943894	50428
Plastics	548	5.4	131	46288	24407
Glass	402	4.0	102	57523	29737
Basic metals	378	3.7	80	55527	14636
Metal products	1095	10.8	256	35123	21714
IT Watches	1305	12.8	287	174298	38447
Electrical	456	4.5	111	124630	53925
Machines	1630	16.0	380	76631	34904
Vehicles	340	3.3	83	92279	13180
Furniture	261	2.6	70	24289	16856
Other	307	3.0	84	81702	22504
Total	10158		2462	113950	26111

Notes: The sub-sectors are defined accoring to the NOGA classification as follows (NOGA code in parentheses): Food, Tobacco: Manufacture of food products, beverages, tobacco products (10-12). Textiles: Manufacture of textiles, wearing apparel, leather products (13-15). Wood: Manufacture of wood products except furniture (16). Paper: Manufacture of paper and paper products (17). Print: Printing and reproduction of recorded media (18). Chemicals: Manufacture of chemicals, coke and refined petroleum products (19-20). Pharmaceuticals: Manufacture of pharmaceutical products (21). Plastics: Manufacture of rubber and plastic products (22). Glass: Manufacture of other non-metallic mineral products (23). Basic metals: Manufacture of basic metals (24). Metal products: Manufacture of fabricated metal products, except machinery and equipment (25). IT Watches: Manufacture of computer, electronic and optical products, including watches (26). Electrical: Manufacture of electrical equipment (27). Machines: Manufacture of machinery and equipment n.e.c. and repair and installation of machinery and equipment (28+33). Vehicles: Manufacture of motor vehicles and other transport equipment (29-30). Furniture: Manufacture of furniture (31). Other: Other manufacturing (33).

A.2.2 Export and import data

Export and import data are used to compute the export and import intensity of firms. As firm level export and import data only exist from 2016 onwards, the matching of the export and import data with the income-statement data is only possible for 2016 and 2017. For these two years the two data sets are merged and the annual exports and imports per firm are computed as an average over both years. The firm-specific export intensity is defined

as the average of these two years and assumed to be time-invariant throughout the whole estimation period.

The export and import data set covers the full population of firms, which exported or imported goods in 2016 or 2017. Hence, firms, which are in the income statement data set in 2016 and 2017 but not in the export and import data set, are defined to have had no exports or imports of goods and an export and import intensity of zero.

A first problem may arise because the assumption that the export and import shares are constant throughout the estimation period may be wrong, overseeing eventual shifts in export and import weights due to the exchange rate shock. This may be a problem for two reasons: First, if the shifts were heterogeneous across firms, some firms may be classified incorrectly as being an export-intensive firm, i.e. being one of the 20% most export intensive firms in the years preceding the shock. However, while this may occur for some firms at the margin, one can assume that the bulk of export intensive firms in the period preceding the shock were also export intensive following the shock. Therefore, one can assume that the impact on the estimated pass-through is small and not biased in a given direction. Second, the import shares used to weigh the foreign PPI in the firm-specific material cost index may be not be correct in the years before 2016. However, as material prices were more or less flat in the years preceding the exchange rate shock (see Figure 1.3) a bias in the weights in the years before the shock probably have only a minor impact on computed material cost index.

A second problem refers to the sample of firms. The value added data set, with which markups are estimated, is an unbalanced panel and a comprehensive draw from the whole population. The SFSO collects data for all large firms on an annual basis. Smaller firms, however, are subject to a gradual turnover. Every year the SFSO replaces some of them by firms from the same industry and similar characteristics. For the years 2012-2015, all firms, which are not in the income statement data set in 2016 or 2017, are dropped as it is not possible to compute their export intensity. In 2015, 2'552 firms of total 11'761 firms were dropped because they were not in the sample in 2016 or 2017. While the number of observations remains high, the draw tends however to tilted towards larger firms between 2012 and 2015.

A.2.3 Control variables

Firm-specific material cost index A firm-specific material price index has been constructed to control for the effect of material prices. In 2015, both worldwide commodity prices as well as the appreciation of the Swiss franc had a decreasing impact on imported material prices in Switzerland. It is important to disentangle both effects in order to control only for factors that affected markups independently to the exchange rate. A firm-specific material cost index is constructed that excludes the impact of the appreciation of the Swiss franc against the euro as follows:

$$Cost_{i,t}^{Materials} = \sum_c PPI_{c,t} Share_{c,i}^{Imp} + PPI_t^{Dom} Share_i^{Dom}$$

The first term on the right-hand side reflects the cost of materials which are directly imported by the firms. It is a weighted average of foreign producer prices, which are indexed at 100 in 2014. The foreign producer prices are denominated in the respective foreign currency. This assures that the variation in the exchange rate of the Swiss franc is not taken into account. The weights are the firm-specific share of imported materials. Foreign producer prices in the respective foreign currency are grouped in five regions: the euro area, non-euro European countries, USA, China and the rest of the world. The producer price index of the non-euro European countries is a weighted average of the country-level producer prices, whereby the country weights are the respective GDP shares. The producer price index for the rest of the world is constructed in the same manner and contains the producer price indices of four countries: Russia, Brazil, India and Japan.[32]

The second term covers the cost of materials bought on the domestic market. Materials are defined as intermediate goods and energy. There exists a sub-index of the Swiss producer price index for both categories. The price of materials in Switzerland is constructed as weighted average of the Swiss producer price indices for intermediate goods, PPI_t^M, and energy, PPI_t^{Engy}. The weights, $weight_t^{Interm}$ and $weight_t^{Engy}$ are taken from the Swiss PPI index. PPI_t^{Engy} is multiplied by 18.4%, the share of total energy purchased by the manufacturing sector:[33]

[32] All PPI data is provided by Datastream

[33] https://www.bfe.admin.ch/bfe/de/home/versorgung/statistik-und-geodaten/energiestatistiken/gesamtenergiestatistik.html

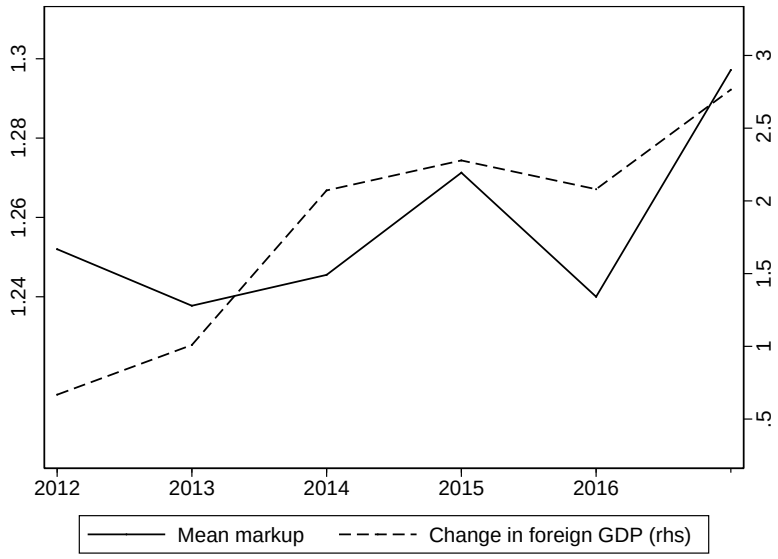
$$PPI_t^M = PPI_t^{Interm} \frac{weight_t^{Interm}}{weight_t^{Interm} + weight_t^{Engy} * 0.18} + PPI_t^{Engy} \frac{weight_t^{Engy} * 0.18}{weight_t^{Interm} + weight_t^{Engy} * 0.18}$$

In order to extract the variation in the EUR/CHF exchange rate that is contained in this domestic material cost index, its quarter on quarter change is regressed against the quarter on quarter change of the EUR/CHF exchange rate. The variation in the domestic cost index that can be explained by the variation of the EUR/CHF exchange rate is then deduced from PPI_t^M, leaving us with PPI_t^{Dom} which is used as a proxy for the non-imported material costs in the definition above.

The material cost index enters the control function, X_{it} in equation (1.2) as the cumulated change relative to 2014

Firm-specific foreign demand index Shifts in demand could affect market conditions and change firms' scope to adjust prices. Goldfajn and Werlang (2000) show that in a boom firms find it easier to increase sale prices, while in recessions some firms tend to decrease prices. As domestic demand is endogenous to the exchange rate, foreign demand in foreign currency is taken to proxy a demand shift. Figure 1.7 depicts the mean markup over time (solid line) together with the growth in Swiss export-weighted foreign GDP (dashed line).

FIGURE 1.7: MARKUPS AND THE CHANGE IN FOREIGN DEMAND



Notes: The solid line shows the annual mean of the firm-specific markups. The dashed line shows the annual the change in the Swiss export weighted foreign GDP.

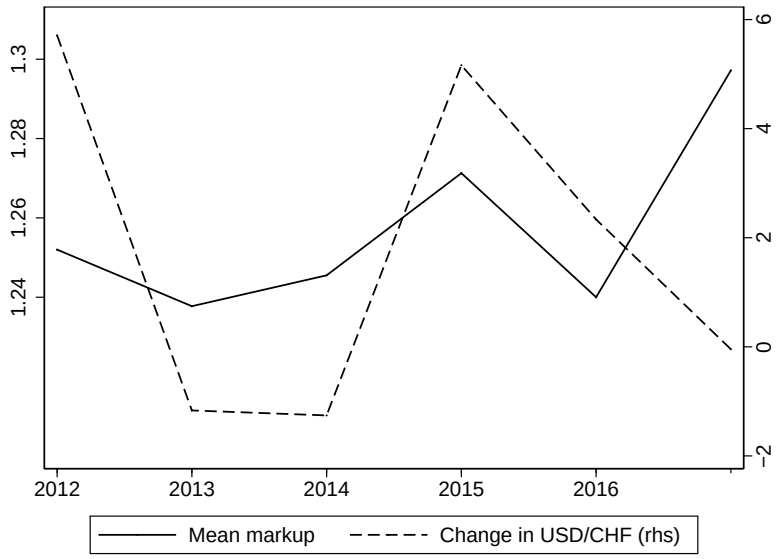
Therefore, a control variable for firm-specific foreign demand is constructed, in which foreign GDP in USD is weighted by the firm-specific export share to that region:

$$Demand_{i,t}^{Foreign} = \sum_c GDP_{c,t}^{USD} Share_{i,c}^{Exp}$$

The denomination in a common foreign currency assures firstly, that the appreciation is extracted from the control variable and secondly, that the contributions from each region can be added up. The export regions are the European countries, USA and China. Foreign demand enters the control function, X_{it} as the cumulated change relative to 2014.

Firm-specific US dollar index Although the US dollar is not a very important invoicing currency for Swiss firms, it may have had an impact on markups. Indeed, between 2012 and 2017 the USD/CHF exchange rate was not completely flat. In particular, in 2015 the USD appreciated against the CHF, leading to more favourable exchange rate conditions for firms exporting US dollar and adverse conditions for firms importing in US dollar, as show in Figure 1.8.

FIGURE 1.8: MARKUPS AND THE CHANGE IN FOREIGN DEMAND



Notes: The solid line shows the annual mean of the firm-specific markups. The dashed line shows the annual the change in the USD/CHF exchange rate.

In order to control for this effect, a USD/CHF exchange index rate based on the firm-specific share of exports and imports in US dollar and defined as the change against 2014 has been introduced in the control function.

$$\Delta USD_{i,t} = \Delta USD/CHF_t Share_i^{Exp-USD} - \Delta USD/CHF_t Share_i^{Imp-USD}$$

As shown in Table 1.7 the US dollar is however not a very relevant invoicing currency for the Swiss manufacturing sector. In the data sample used in this paper, the average share of exports in US dollars was only 4.4% over all firms . The share of imports in US dollar was on average 7.7%. In contrast, share of exports in euro was on average 41.9% and that of imports 81.4%. The figures on the right hand side of the table show the average export and import shares not by firm but over all exports and imports respectively. These figures suggest that larger firms tend to trade more intensely in US dollar and less in euro than smaller firms.

TABLE 1.7: SHARE OF EXPORTS AND IMPORTS BY CURRENCY, IN %

	Average of firms' export shares	Average of firms' import shares	Share of all exports	Share of all imports
CHF invoiced	52.5	8.9	34.4	9.4
EUR invoiced	41.9	81.4	34.8	60.2
USD invoiced	4.4	7.7	10.9	17.1
ROW invoiced	1.2	2.0	19.8	13.3

Notes: Shares of exports by currency in total exports and shares of imports by currency in total, 2016-17, in the manufacturing sector.

A.2.4 Computation of weighted mean

Larger firms are well-covered in firm-level data sets like the one used for in this paper. Typically, in the course of time, firm coverage increases and the share of small firms increases. As explained in Bajgar, Berlingieri, Calligaris, Criscuolo, and Timmis (2019), the incomplete coverage of small firms and the shift over time can lead to biased aggregations. Using unbiased sub-sector weights from the national accounts in a two step aggregation procedure helps mitigate this bias: First, a weighted mean is constructed at the sub-sector level, $\mathcal{M}_{jt} = \sum \mathcal{M}_{it} \frac{Revit}{Rev_{jt}}$. Rev_{it} is the revenue of firm i operating in sector j and $Revjt$ is the total revenue of sector j. Rev_{it} and Rev_{jt} are taken from the firm-level data. Second, the sub-sector weighted means are aggregated using sub-sector weights derived from the production data from the national accounts, $\mathcal{M}_t = \sum \mathcal{M}_{jt} \frac{Prod_{jt}}{Prod_t}$, where $Prod_{jt}$ is the nominal gross production of the manufacturing sub-sector j according to national accounts' data and $Prod_t$ is total nominal manufacturing gross production.

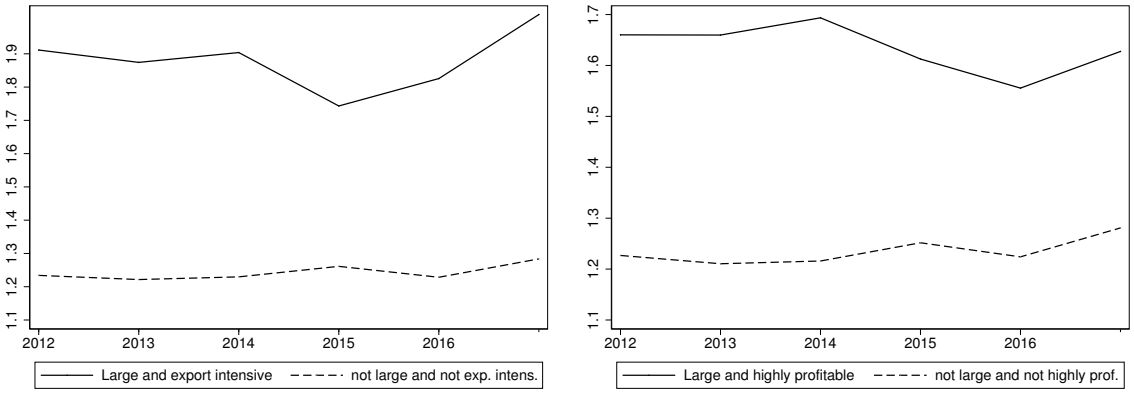
A.2.5 Markups of large and non-large firms

Firms, which are large firms and export intensive account for only 2.3% of all firms in the sample and firms, which are large and highly profitable account for 6.2%. Nonetheless,

while not being typical for all firms, these firms have a large influence on aggregate development owing to their sheer size.

Figure 1.9 displays the annual development of the mean markup for large firms which are at the same time export intensive (left chart, solid line) and highly profitable (right chart, solid line). For comparison, the mean markup of the rest of the sample (dashed line) is shown. The mean markup of the large and export intensive or large and profitable firms is clearly higher than that of the rest of the sample. Besides, such firms reacted to the exchange rate shock by strongly decreasing their markups.

FIGURE 1.9: MEAN MARKUP OF LARGE FIRMS



(a) Large and export intensive

(b) Large and highly profitable

In Table 1.8 the response of the fifth smallest firms, the firms with the fifth lowest export share and the fifth lowest profitability are shown. For 2015, the sign of the coefficients are in four of five cases positive. However, none of them is significantly different to zero. These estimates indicate that firms subject to strong frictions tend to leave their markups stable or even raise them in a crisis in order to preserve internal liquidity even at the cost of losing market share. These results confirm the findings of Gilchrist, Schoenle, Sim, and Zakrajsek (2018).

TABLE 1.8: RESPONSE OF MARKUPS OF SMALL, DOMESTIC ORIENTED AND LOW PROFITABLE FIRMS

	(1) small firms	(2) low export share	(3) low EBIT	(4) small and low export share	(5) small and low EBIT
Panel 1) Total response of markups relative to 2014					
2012	-0.025	-0.002	0.007	-0.044	-0.019
2013	-0.005	-0.009	-0.008	-0.003	-0.020
2015	0.013	-0.003	0.015	0.008	0.035
2016	-0.023	-0.019	0.004	-0.018	0.014
2017	0.006	0.019	0.055	-0.015	0.016

Notes: The results in this table are for the lowest fifth of the distribution for size, export share and profitability. The p-values are based on heteroskedasticity- and autocorrelation-consistent standard errors and denoted as: ***$p < 0.01$, **$p < 0.05$, and *$p < 0.1$.

A.3 Robustness tests

A.3.1 Sample reduced to firms having observations before and after the shock

As described in Section A.2.2, the data set is an unbalanced panel, meaning that not every firm is observed for all years. The following table shows the response of markups using a reduced sub-sample of firms, which have at least one observation in the period before and at least one observation in the period after the shock, i.e., firms, which only have observations in the post-shock period have been drop. In all, 11.7% of the observations included in the baseline regressions have been dropped from the sample. A comparison with the figures in the last column of Table 1.2 and the corresponding columns of Table 1.3 and Table 1.4 shows that the exclusion has little impact on the level of the coefficients. In contrast to the baseline estimates, however, the coefficients of specification (2) and (4) are not significant in 2016.

TABLE 1.9: RESPONSE OF MARKUPS USING A SAMPLE ONLY INCLUDING FIRMS WITH AT LEAST ONE OBSERVATION BEFORE AND AFTER THE SHOCK

	(1) all firms	(2) large firms	(3) high export share	(4) high EBIT	(5) large and high export share	(6) large and high EBIT
Panel 1) Total response of markups relative to 2014						
2012	0.004	0.001	0.007	0.008	0.036	-0.025
2013	-0.003	-0.003	0.007	-0.005	0.007	-0.008
2015	-0.004	-0.050**	-0.038*	-0.036*	-0.112*	-0.82**
2016	-0.016	-0.044	-0.043	-0.042	-0.110*	-0.80*
2017	0.024	-0.000	0.012	-0.002	-0.029	-0.012
Panel 2) Total implied exchange rate elasticity						
2015		0.386	0.297	0.297	0.276	0.475
2016		0.405	0.617	0.397	0.393	0.533
Observations	8914	8914	8914	8914	8914	8914

Notes: The results in this table are based on a sample only including firms which have at least one observation in the years before the shock and one observation in the years following the shock. The p-values denoted as: ***$p < 0.01$, **$p < 0.05$, and *$p < 0.1$ are derived from the heteroskedasticity- and autocorrelation-consistent variance-covariance matrices.

A.3.2 Estimation including sector-time effects

Table 1.10 shows the response of markups estimated with a regression including sector-time effects. The pattern of the estimated responses is similar to that of the baseline. The coefficients are, however, somewhat lower. The implied elasticity of large and export intensive firms in 2015 was 80% and that of large and profitable firms was 50%. In the baseline specification the estimated elasticities are 90% and 65%, respectively. These results indicate the baseline results include a small effect due to time-variant sector-specific factors. The reason is, however, not clear. The lower response may be due to sector-specific issues, which were independent to changes in the exchange rate. They could, however, simply indicate that certain sectors reacted to the exchange rate shock in 2015 and 2016 more strongly than others because of factors other than firm size, export intensity and profitability.

TABLE 1.10: RESPONSE OF MARKUPS INCLUDING SECTOR-TIME EFFECTS

	(1) all firms	(2) large firms	(3) high export share	(4) high EBIT	(5) large and high export share	(6) large and high EBIT
Panel 1) Total response of markups relative to 2014						
2012	0.028**	0.018	0.022	0.020	0.014	-0.033
2013	0.005	0.002	0.007	-0.002	-0.011	-0.019
2015	0.001	-0.043***	-0.024	-0.023	-0.100**	-0.063**
2016	-0.016	-0.037**	-0.022	-0.029*	-0.89**	-0.046
2017	0.000	-0.008	-0.016	-0.000	-0.038	0.024
Panel 2) Total implied exchange rate elasticity						
2015		0.336	0.184	0.177	0.779	0.486
2016		0.344	0.203	0.271	0.825	0.423

Notes: The results in this table are estimated with sector-time effects included in the regressions. The p-values denoted as: ***$p < 0.01$, **$p < 0.05$, and *$p < 0.1$ are derived from the heteroskedasticity- and autocorrelation-consistent variance-covariance matrices.

A.3.3 Clustered standard errors

In the baseline specification, standard errors are clustered at the firm-level as many firms are observed over several periods. An alternative clustering has been tested: In Table 1.11 standard errors are clustered by revenue size as this is a key level of treatment in this analysis. The revenue size cells are additionally subdivided by sector-groups as firms of the same sub-sector group may be related to each other and by full-time-employment groups as firms of a given sub-sector are sampled based on their number of employees (see Footnote 11). For most specifications, the significance of the response remains the same as in the baseline estimation, except for large firms in 2016, specification (2) and export intensive firms in both 2015 and 2016, specification (3). The response of large and export intensive firms is however just as significant as in the baseline estimation.

TABLE 1.11: ESTIMATES OF CLUSTERED STANDARD ERRORS BASED ON FULL-TIME-EMPLOYMENT, REVENUE AND SECTOR CELLS

	(1) all firms	(2) large firms	(3) high export share	(4) high EBIT	(5) large and high export share	(6) large and high EBIT
Panel 1) Total response of markups relative to 2014						
2012	0.001	-0.000	0.007	0.004	0.036	-0.026
2013	-0.004	-0.003	0.007	-0.005	0.006	-0.008
2015	-0.007	-0.053**	-0.040	-0.040*	-0.114**	-0.085**
2016	-0.020	-0.048	-0.039	-0.048*	-0.113*	-0.084*
2017	0.000	-0.003	0.006	-0.005	-0.031	-0.015
Panel 2) Total implied exchange rate elasticity						
2015		0.412	0.309	0.308	0.889	0.661
2016		0.448	0.362	0.442	1.047	0.780

Notes: The estimates in this table are estimated clustered by full-time-employment, revenue and sector. The p-values denoted as: ***$p < 0.01$, **$p < 0.05$, and *$p < 0.1$ are derived from the heteroskedasticity- and autocorrelation-consistent variance-covariance matrices.

A.3.4 Sampling bias

As described in Section A.2, the draw of the value added data set is tilted towards larger firms. For five full-time-employment size classes, weights have been calculated using the number of firms in the true universe and the number of firms in the survey-sample.[34] With these weights it is possible to test how strongly the estimated coefficients are biased due to the sampling bias.

Table 1.12 shows that the pattern of the estimated responses is similar to that of the baseline. However, as smaller firms, which tend to react less to an exchange rate shock have a higher weight, the estimated coefficients are somewhat lower and the standard errors somewhat higher. The implied elasticity of large and export intensive firms in 2015 was 85% and that of large and profitable firms was 62%. In the baseline specification the estimated elasticities are 90% and 65%, respectively. These results show that the bias due to the sampling bias exists but is not very large.

[34]This information is only available for 2019 and 2020. Given that the SFSO has not changed its sampling frame recently, it is assumed that the average weights of 2019-2020 were valid in 2012-2017.

TABLE 1.12: RESPONSE OF MARKUPS USING A WEIGHTED ESTIMATION TO CORRECT FOR SAMPLING BIAS

	(1) all firms	(2) large firms	(3) high export share	(4) high EBIT	(5) large and high export share	(6) large and high EBIT
Panel 1) Total response of markups relative to 2014						
2012	0.005	0.001	0.012	0.005	0.036	-0.024
2013	-0.005	-0.002	0.007	-0.004	0.009	-0.008
2015	-0.004	-0.047**	-0.029	-0.038*	-0.109**	-0.079**
2016	-0.011	-0.038	0.020	-0.034	-0.103	-0.075*
2017	-0.027*	0.004	0.020	0.007	-0.027	-0.008
Panel 2) Total implied exchange rate elasticity						
2015		0.364	0.225	0.294	0.848	0.615
2016		0.355	0.201	0.313	0.949	0.691

Notes: This table shows estimated coefficients corrected for the sampling bias. The p-values denoted as: ***$p < 0.01$, **$p < 0.05$, and *$p < 0.1$ are derived from the heteroskedasticity- and autocorrelation-consistent variance-covariance matrices.

A.3.5 Exports to euro area

As described in Section 4.3, a firm is classified to have a high export share if it is one of the 20% most export intensive firms in the years following the shock. Export intensity is defined in the baseline specification as the share of firms' revenue stemming from exports in EUR, whereby revenue and exports are measured in CHF. One could however argue that all exports to the euro area are influenced by a change in the exchange rate, independently on the invoicing currency. Table 1.13 lists the estimated coefficients for export-intensive firms, whereby firms are classified by their share of revenue stemming from exports to the euro area.

The response with one interaction term, specification (1),is very similar to the baseline response. The estimated coefficients of the combined regression, specification (2), are somewhat higher, especially for the second year after the shock (2016).

TABLE 1.13: RESPONSE OF MARKUPS FOR EXPORT-INTENSIVE FIRMS, CLASSIFIED DEPENDING ON THEIR EXPORT SHARE TO THE EURO AREA

	(1) high export share	(2) large and high export share
Panel 1) Total response of markups relative to 2014		
2012	0.001	0.021
2013	-0.001	0.011
2015	-0.042*	-0.134**
2016	-0.045	-0.175***
2017	0.001	-0.061
Panel 2) Total implied exchange rate elasticity		
2015	0.324	1.045
2016	0.415	1.619

Notes: This table lists the response of the exchange rate shock of January 2015 into markups for export-intensive firms, whereby firms are classified by their export share to the euro area. The p-values denoted as: ***$p < 0.01$, **$p < 0.05$, and *$p < 0.1$ are derived from the heteroskedasticity- and autocorrelation-consistent variance-covariance matrices.

A.4 Full estimate results

Table 1.14 and Table 1.15 list the estimated coefficients of equation (1.2) and equation (1.3), respectively.

TABLE 1.14: COEFFICIENTS OF EQUATION (1.2)

	large firms	high markups	high export share	high EBIT	high productivity
γ_{2012}	0.001	0.001	-0.001	0.001	0.004
	(0.006)	(0.006)	(0.007)	(0.007)	(0.006)
γ_{2013}	-0.005	-0.006	-0.006	-0.004	-0.002
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
γ_{2015}	0.006	0.007	-0.004	0.000	0.009
	(0.015)	(0.015)	(0.016)	(0.015)	(0.015)
γ_{2016}	-0.010	0.000	-0.023	-0.014	-0.006
	(0.022)	(0.022)	(0.023)	(0.022)	(0.022)
γ_{2017}	0.026*	0.037**	0.018	0.025	0.030*
	(0.016)	(0.016)	(0.018)	(0.016)	(0.016)
ψ_{2012}	-0.002	0.002	0.007	0.002	-0.014
	(0.015)	(0.014)	(0.015)	(0.014)	(0.015)
ψ_{2013}	0.002	0.010	0.013	-0.001	-0.014
	(0.013)	(0.011)	(0.013)	(0.011)	(0.013)
ψ_{2015}	-0.059***	-0.049***	-0.036**	-0.040**	-0.073***
	(0.015)	(0.012)	(0.015)	(0.016)	(0.015)
ψ_{2016}	-0.039**	-0.072***	-0.017	-0.034*	-0.056***
	(0.018)	(0.015)	(0.018)	(0.019)	(0.018)
ψ_{2017}	-0.030	-0.070***	-0.012	-0.030	-0.050**
	(0.022)	(0.019)	(0.020)	(0.022)	(0.022)
$\beta_{MaterialPrice}$	-1.302*	-1.157	-1.572**	-1.390*	-1.299*
	(0.706)	(0.718)	(0.775)	(0.711)	(0.708)
Constant	0.102***	0.102***	0.103***	0.102***	0.102***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Observations	10099	10099	10099	10099	10099
Fixed effects	yes	yes	yes	yes	yes

Notes: Estimated response of log-markups to the exchange rate shock of 15 January 2015, relative to 2014. The p-values are denoted as: ***$p < 0.01$, **$p < 0.05$, and *$p < 0.1$. Heteroskedasticity- and autocorrelation-consistent standard errors standard errors in parentheses.

TABLE 1.15: COEFFICIENTS OF EQUATION (1.3)

	(1) large and high markups	(2) large and high export share	(3) large and high EBIT	(4) large and high productivity
γ_{2012}	0.005	0.001	-0.001	0.004
	(0.007)	(0.007)	(0.007)	(0.006)
γ_{2013}	-0.005	-0.008	-0.005	-0.002
	(0.006)	(0.006)	(0.006)	(0.005)
γ_{2015}	0.018	0.011	0.011	0.009
	(0.015)	(0.016)	(0.016)	(0.015)
γ_{2016}	0.006	-0.013	-0.005	-0.009
	(0.022)	(0.024)	(0.022)	(0.022)
γ_{2017}	0.039**	0.026	0.032*	0.029*
	(0.016)	(0.018)	(0.016)	(0.016)
ψ_{2012}	-0.016	0.002	0.017	-0.046
	(0.017)	(0.015)	(0.016)	(0.036)
ψ_{2013}	-0.000	0.015	-0.000	-0.102**
	(0.014)	(0.013)	(0.013)	(0.042)
ψ_{2015}	-0.050***	-0.039**	-0.028*	-0.069***
	(0.014)	(0.015)	(0.016)	(0.019)
ψ_{2016}	-0.073***	-0.013	-0.022	-0.005
	(0.017)	(0.018)	(0.020)	(0.034)
ψ_{2017}	-0.061***	-0.014	-0.033	-0.077
	(0.021)	(0.020)	(0.023)	(0.049)
γ_{2012}	-0.023	-0.007	0.010	0.006
	(0.018)	(0.016)	(0.018)	(0.039)
γ_{2013}	-0.014	0.004	0.004	0.004
	(0.017)	(0.014)	(0.016)	(0.059)
γ_{2015}	-0.068***	-0.060***	-0.051***	-0.010
	(0.018)	(0.015)	(0.015)	(0.030)
γ_{2016}	-0.030	-0.033*	-0.028	0.081**
	(0.023)	(0.019)	(0.020)	(0.040)
γ_{2017}	-0.013	-0.029	-0.030	0.026
	(0.027)	(0.024)	(0.025)	(0.049)
χ_{2012}	0.057*	0.040	-0.052	0.028
	(0.031)	(0.053)	(0.032)	(0.055)
χ_{2013}	0.033	-0.005	-0.006	0.089
	(0.028)	(0.056)	(0.028)	(0.074)
χ_{2015}	0.046*	-0.026	-0.017	0.005
	(0.028)	(0.059)	(0.038)	(0.038)
χ_{2016}	0.019	-0.054	-0.028	-0.134**
	(0.034)	(0.062)	(0.045)	(0.055)
χ_{2017}	-0.016	-0.013	0.017	0.004
	(0.044)	(0.072)	(0.052)	(0.070)
$\beta_{MaterialPrice}$	-1.115	-1.489*	-1.286*	-1.327*
	(0.718)	(0.774)	(0.712)	(0.710)
Constant	0.102***	0.103***	0.102***	0.102***
	(0.004)	(0.004)	(0.004)	(0.004)
Observations	10099	10099	10099	10099
Fixed effects	yes	yes	yes	yes

Notes: Estimated response of log-markups to the exchange rate shock of 15 January 2015, relative to 2014. The p-values are denoted as: ***$p < 0.01$, **$p < 0.05$, and *$p < 0.1$. Heteroskedasticity- and autocorrelation-consistent standard errors standard errors in parentheses.

Chapter 2

Employment adjustment and financial tightness – evidence from firm-level data* [1]

1 Introduction

Employment typically rises in booms and decreases in recessions. However, often firms only partially adjust their workforce; that is, they 'hoard labour' in downturns and subsequently hire less in upturns. Employers confronted with a temporary drop in output retain more employees than they actually require because they expect to need those workers again in the future. Because of the costs associated with hiring and firing staff, labour hoarding can be the optimal response of firms facing labour market frictions. Labour hoarding has therefore an investment-like feature: the costs of hoarding labour in the short term are higher than the average unit costs. These costs have to be beared in the present. By contrast, in the future, when demand picks up, the gains of labour hoarding materialise in the form of lower labour adjustment costs, such as lower recruiting and training costs. Similar to investment decisions, labour hoarding decisions do not immediately generate returns. No contemporaneous pay-off can be used to pay the extra wages.

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While there is ample evidence for the existence of labour hoarding[2], less is known about the reasons why some firms hoard more labour than others. The timing mismatch between the costs of and the gains from labour hoarding has to be financed and, presumably, as it similarly does on the investment in physical capital, the financial health of a firm will impact its ability to hoard labour. In this paper, we therefore examine the differences in financial tightness across firms and assess how it influences the firms' hoarding behaviour. Focusing on the effect of financial tightness on the cyclicality of employment, we examine the hypothesis that in a downturn, firms that are in a financially tighter situation are not able to hoard labour to the same extent that firms that are not in a financially tight situation are able to do and consequently have to hire more labour in a subsequent upturn.

To estimate the impact of the firms' financial situation on labour hoarding, 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 data set is underlying official GDP data and other national account statistics. The sample is a comprehensive draw from the population of Swiss firms, including all industries of the economy, except the financial and public sectors[3]. Unlike many data sets using firm-level balance-sheet information, the panel does not select in favour of publicly listed firms. This is important because financial tightness presumably matters even more for the smaller, non-listed firms, which have less access to external finance than the larger publicly listed firms. Furthermore, using Swiss data has a specific advantage: In many countries, the firms' employment adjustment behaviour is affected by strict labour market legislation. Employment protection rules hamper the flexibility of changes in employment. Thus, against the backdrop of high labour adjustment costs with legal restrictions, a sluggish reaction of the firms' labour demand to shocks in those countries may reflect optimal behaviour. The Swiss labour market, by contrast, in international comparison, is ranked as one of the most flexible, with relatively few regulations regarding the hiring and laying off of staff (Di Tella and MacCulloch (2005)).[4]

[2]See Biddle (2014) for a comprehensive overview of the key literature on labour hoarding.

[3]The financial and public sectors are not included in our data. Therefore, the estimated parameters do not relate to these parts of the economy but to all other sectors, whose value added amounts to around 80% of total GDP

[4]Most labour contracts in Switzerland have a mutual notice period of two to three months. An employer may terminate the employment of an employee with a notice period of two (three) months if the employee has been employed in the company for less (more) than 10 years. At the same time, wage cuts are arguably not widely used as an alternative to cut employment, because there is evidence that wages are downward rigid, even during periods of very low or even negative inflation, as shown in Funk and Kaufmann (2022) and Fehr and Goette (2005).

We estimate the impact of a change in value added at the firm-level on the change in employment, depending on various measures of financial tightness. By combining balance sheet and income statement data, we are able to analyse which source of financial tightness is relatively more important for labour hoarding – we distinguish between tightness in internal funding, such as low liquidity and low profits, and tightness in external funding, such as low collateral or a small balance sheet. Furthermore, control variables are added to our estimation in order to absorb variation, which may bias the estimated coefficients. The exogeneity of our right-hand side variables is a particular concern in our analysis. We therefore implement four adjustments to the baseline model in order to foster the causal interpretation of our estimates. First, we use industry-level instead of firm-level output to identify demand shocks. Second, we look at the cross-sectional variation of employment during the Great Recession and the recovery. Third, we use industry-level measures of financial tightness. Fourth, we use a measure of exogenous variation of firms' financial tightness that is available for a subset of firms. Furthermore, we can observe the average wage paid in a firm. With this variable, we can analyse if firms that employ high-wage workers also tend to hoard more labour. This outcome would be expected from evidence that shows that hiring costs are larger for skilled workers than for unskilled workers (Blatter, Muehlemann, and Schenker (2012)).

Our results show that financial tightness considerably increases the sensitivity of employment to fluctuations in output. When output changes, financially tighter firms resize their labour force substantially more than firms that have abundant funding availability. In particular, firms with low liquidity and low profits, as well as firms with a small balance sheet, have to lay off substantially more workers during downturns, i.e., when the output of a firm declines. The estimated effect of low collateral is weaker and not always robust. The strongest impact is observed when internal and external tightness occurs jointly. The amplifying effects of financial tightness is quite similar in upturns and downturns. Financially tighter firms not only reduce their workforce more when demand decreases but also hire more labour when demand increases. Our results are therefore consistent with the view that financial tightness hampers the labour hoarding ability of firms. We find further that the effect of financial tightness on labour hoarding is more pronounced for firms paying high wages. High-wage firms hoard more labour, suggesting that high-wage employees are associated with higher hiring and firing costs. We take our firm-level findings to the macro

level by means of a counterfactual analysis and show that up to 25% of the variance in aggregate employment can be explained by financial tightness.

In analysing labour hoarding in combination with financial tightness measures, our paper links with two strands of the literature: On the one hand, we contribute to the literature on labour hoarding, which focusses on the observed procyclical labour productivity caused by the firms' tendency to retain more workers than necessary during downturns and therefore hire less workers during upturns. This firm behaviour is explained by the potentially large costs that are associated with adjustments in employment. These costs include not only direct costs, such as redundancy costs and the costs for searching, hiring and training new staff but also indirect costs, such as the reduced motivation of the remaining staff or the risk of losing market share if demand were to pick up suddenly, leaving a firm without enough staff to meet the higher demand. Crawford, Jin, and Simpson (2013), for example, describe the decrease in labour productivity in the UK following the Great Recession. They find that one reason that firms hoard labour is that they want to be able to respond more quickly to a subsequent increase in demand. Bryson and Forth (2015) find evidence of labour hoarding especially of high skilled labour.[5] Social pressure, which is typically stronger in family firms, establishments located closer to headquarters and smaller firms, has also proven to have a moderating effect on the firms' firing decisions, as shown by Kim, Haider, Wu, and Dou (2019).[6]

On the other hand, we contribute to the literature on employment and financial constraints, which provides evidence that financial constraints have a direct effect on employment. Cantor (1990), Sharpe (1994), Funke, Maurer, and Strulik (1999), Ogawa (2003) and Drakos and Kallandranis (2006), examine the impact of firm-side financial constraints. They find that a firm's leverage ratio is an important determinant of employment.[7] Falato and Liang (2016) demonstrate that the tightness of loan covenants has a substantial impact

[5]For further examples see Barth, Davis, Freeman, and Kerr (2017) and Gertler and Gilchrist (2018) and Biddle (2014) and references therein.

[6]Further evidence is provided by Bassanini, Brunello, and Caroli (2017)

[7]Financial constraints can also stem from the credit suppliers side. For example, Benmelech, Bergman, and Seru (2011) and Benmelech, Frydman, and Papanikolaou (2019) show that the reduced capability of credit suppliers to lend has been an important determinant of the firms' employment adjustment decisions during large recession. Further analyses focusing on the supply of credit as a source of financial constraint have been carried out by Chodorow-Reich (2014), Duygan-Bump, Levkov, and Montoriol-Garriga (2015) and Basci, Baskaya, and Kilinc (2011), amongst others.

on employment cuts.[8] Cunat, Caggese, and Metzger (2019) examine the impact of financial constraints on the firing decisions of firms. They show that financially constrained firms tend to fire more workers with shorter tenure and less of those with longer tenure, even though the ones with shorter tenure tend to have higher productivity potential. This leads to a misallocation of labour (similar to capital in Bernanke, Gertler, and Gilchrist (1996)).[9] This literature, however, does not distinguish between hoarding behaviour and permanent employment adjustment.

The role of financial constraints in labour hoarding, i.e., the sensitivity of employment to changes in demand, has been analysed less extensively. Giroud and Mueller (2017) show that demand shocks during the Great Recession had large effects on employment in firms with high leverage. More recently, using Taiwanese data on manufacturing firms, Chen and Kao (2020) show that for firms facing less pressure from financial constraints, labour hoarding is more pronounced. In addition, the literature on short-time working programmes is related to our paper, since these programmes can be viewed as a subsidy on labour hoarding. Using the data for Germany and Switzerland, Balleer, Gehrke, Lechthaler, and Merkl (2016) and Kopp and Siegenthaler (2020), respectively, show that the availability of short-time working programmes dampened the decline in aggregate employment during the Great Recession. Cahuc, Kramarz, and Nevoux (2018) find that short-time working subsidies only save jobs in firms hit by a sharp drop in their revenues but do not save jobs in less severely hit firms. Credit-constrained firms in particular benefit from the use of short-time work to finance their labour hoarding. Such subsidy schemes can be seen as an additional source of financing that relaxes financial constraints, increasing thereby the ability to hoard labour in a recession, which can be welfare improving (Giupponi and Landais (2018)). The findings in these papers suggest that during a recession employment declines more in firms that face financial constraints, which is in line with the findings reported in this paper. In addition to the existing evidence, while focusing on labour hoarding and not the evaluation of short-term working programmes, we examine several

[8]Related to this, Adelino, Schoar, and Severino (2015) find that small businesses in areas with greater increases in house prices experienced a stronger growth in employment than large firms in the same areas and industries, emphasizing the role of the collateral channel. In addition, Borisov, Ellul, and Sevilir (2015) find that firms that are able to increase their funding availability by going public increase their employment more than similar firms that remain private.

[9]Related to this, Züllig (2020) shows empirically and theoretically within a search-and-matching model that firms shift the composition of their workforce towards workers with lower wages when hit by a financial shock. However, and in some contrast to the literature, García-Posada Gómez (2019) assesses the impact of credit constraints on inventories, investment and employment and finds that these constraint primarily affect investment but not employment.

financial tightness indicators of an internal (reduced internal funding opportunities) type and an external (reduced access to external funding opportunities) type; we find that both types matter for labour hoarding. We show that financially healthy firms reduce employment less in when their output declines but also hire less when their output increases, which is consistent with the notion of labour hoarding. In addition, we provide a counterfactual exercise and show that reduced financial tightness would result in a lower variation in aggregate employment because firms would engage in more labour hoarding.

The next section discusses our empirical model. Section 3 describes the firm-level data used in our analysis. The estimation results are presented in Section 4 and are complemented with a discussion of the identification issues in Section 5. The macroeconomic implications are analysed in Section 6. Section 8 draws conclusions.

2 An empirical model of labour demand

This section shows the empirical estimation equation we estimate and how this equation is motivated by the literature on labour demand and the firms' financial situation.

Our underlying empirical model is a partial adjustment model, which models labour demand $e_{i,t}$ of firm i in period t (all in logs) as the weighted sum of past employment and the adjustment to desired $e^*_{i,t}$ employment as follows:

$$e_{i,t} = \alpha e_{i,t-1} + \beta e^*_{i,t}, \tag{2.1}$$

where $e^*_{i,t}$ denotes short-term equilibrium employment, which is defined as optimal employment in the absence of adjustment costs. Such a partial adjustment model can be derived as the optimal adjustment of labour demand if a labour adjustment is costly due to factors, such as hiring and firing costs. We show a sketch of the derivation of this equation from the firms' profit maximisation subject to quadratic adjustment costs in Appendix B.1.

Following a negative demand shock leading to a decrease in $e^*_{i,t}$, labour demand remains above $e^*_{i,t}$ in the period in which the shock occurs. There are two reasons for this. First, adjustment costs are assumed to be convex; therefore, a one-time adjustment of the labour force generates higher costs than a series of small adjustments cumulating to an reduction of the same magnitude.[10] Second, if a demand shock is temporary, a complete downward

[10] Blatter, Muehlemann, and Schenker (2012) document that hiring costs are convex in Switzerland.

adjustment in labour would have to be fully reversed when the demand shock fades. Because labour adjustment is costly, it is optimal for firms to adjust their labour only partially when a demand shock is expected to be temporary. In this case, firms hoard labour.

While there is no obvious reason why convex adjustment costs should interact with a firm's financial situation, a large literature has documented that financial constraints imply higher cost of financing (Bernanke, Gertler, and Gilchrist (1996)).[11] The higher the costs of financing are, the less firms value future adjustment costs versus today's non-adjustment costs. Since hoarded labour has to be financed in advance (by paying salaries to extra workers when demand decreases) and pays off in the future (by saving future hiring costs when demand increases again), the adjustment of labour to demand shocks is likely to be larger if firms are faced with financial shortages.

A typical empirical specification of the partial adjustment model assumes that desired employment $e^*_{i,t}$ is a linear function of demand $y_{i,t}$ and wages $w_{i,t}$ (see Appendix B.1 or, for example, Nickell, 1986 or Ogawa, 2003) plus other exogenous factors $X_{i,t}$. Taking first differences ensures the stationarity of the variables. This yields the basic empirical labour demand equation as follows:

$$\Delta e_{ti} = \tilde{\gamma}_n \Delta e_{i,t-1} + \tilde{\gamma}_y \Delta y_{i,t} + \tilde{\gamma}_w \Delta w_{i,t} + \tilde{\beta} X_{i,t} + \epsilon_{i,t}. \tag{2.2}$$

However, against the backdrop of the previous discussion, we allow the coefficient $\tilde{\gamma}_y$ to vary with the presence of financial tightness (defined more clearly below). To gain a complete picture of the channels through which financial tightness works, we distinguish between external financial tightness and internal financial tightness. External financial tightness ($Ext_{i,t}$) hinders firms in obtaining funds from outside investors and lenders, while internal financial tightness ($Int_{i,t}$) reduces internal funds that could be used to finance labour hoarding. It is assumed that firms adjust their employment concurrently, when output changes and that firms' employment decisions are based on their financial situation before output changes. Thus, both $Ext_{i,t}$ and $Int_{i,t}$ enter the model with a lag of one year.

Thus, the response of employment to changes in demand in equation (2.2), γ_y, is a linear

[11] In the original work of Nickell (1986), the coefficient β in the labour demand equation (2.1) is an inverse function of the real interest rate. Even though Nickell does not model financial frictions, the financial frictions literature shows that external finance is more costly for constrained firms than for unconstrained firms Bernanke and Gertler (1995). As a result, future misalignment with equilibrium employment and, therefore, future adjustment costs are discounted with a higher factor, and the concurrent adjustment is more complete ($\tilde{\gamma}_y$ is larger for financially constrained firms than for financially unconstrained firms).

combination of our measures of financial tightness, $\tilde{\gamma}_y = \gamma_y + \gamma_{y,ext} Ext_{i,t-1} + \gamma_{y,int} Int_{i,t-1}$. Combining this linear function of $\tilde{\gamma}_y$ with equation (2.2), we obtain the following baseline estimation equation:

$$\begin{aligned} \Delta e_{ti} &= \tilde{\gamma}_n \Delta e_{i,t-1} + \gamma_y \Delta y_{i,t} + \gamma_{y,int} Int_{i,t-1} \Delta y_{i,t} + \gamma_{y,ext} Ext_{i,t-1} \Delta y_{i,t} \\ &\quad + \gamma_{int} Int_{i,t-1} + \gamma_{ext} Ext_{i,t-1} + \tilde{\gamma}_w \Delta w_{i,t-1} + \tilde{\beta} X_{i,t-1} + \epsilon_{i,t}, \end{aligned} \tag{2.3}$$

where Δe_{ti} is the log-change in employment, $\Delta y_{i,t}$ is the log-change in output (value added), and $\Delta w_{i,t}$ is the average wage in a firm (the total wage payments divided by the number of full-time-equivalent employment (FTE)).[12] Our focus is on the estimates of the coefficients of the interaction terms, $\gamma_{y,ext}$ and $\gamma_{y,int}$, which are estimated simultaneously.

The vector $X_{i,t}$ includes various control variables. In the literature, one finds strong evidence that financial tightness influences investment. If financially tight firms are forced to disinvest, labour-capital complementarities could cause firms to reduce their labour force (Caggese and Cunat (2008) or Benmelech, Bergman, and Seru (2011)). To control for this effect, $X_{i,t}$ includes the change in the firm's capital stock.[13] To control for the impact of different levels of capital intensity between firms, $X_{i,t}$ also contains the capital-stock-to-FTE ratio in $t-1$. Changes in firm-level output could be driven by demand and supply shocks. To isolate demand shocks, we control for an important component of supply shocks: changes in productivity.[14] We also include firm-specific fixed effects capturing sustained differences in firm-specific employment growth. Time-fixed effects have also been added to the equation to control for changes in aggregate employment growth.[15]. In addition to the baseline

[12] An elasticity of employment with respect to an output of less than unity implies procyclical labour productivity and might indicate that firms hoard labour (Biddle (2014)), even though procyclical labour productivity might also be a result of other mechanisms. Using changes in housing prices to estimate demand shocks, as in Giroud and Mueller (2017), has the advantage over our setup, as the response of employment is more closely tied to changes in demand. Below, we show that changes in output, which are likely to be temporary, yield results similar to our baseline estimates, suggesting that using output as a measure of $\Delta y_{i,t}$ tends to capture temporary changes in demand. Given that both approaches show that financial tightness impedes labour hoarding, the results presented in this paper corroborate the findings in Giroud and Mueller (2017) and show that it also has implications for labour productivity, as discussed in the conclusion.

[13] The capital stock is also part of the labour demand equation derived in the Appendix and used by other studies, e.g., Nickell (1984), Burgess (1988), or Nickell and Nicolitsas (1999).

[14] Productivity shocks are defined as changes in total factor productivity, which are derived from a Cobb-Douglas production function estimated separately for each industry.

[15] In principle, financial tightness could interact with all variables in the model, i.e., with all control variables included in $X_{i,t}$. We checked the robustness of our results for these extended specifications and found only very minor differences (see Section B.5 in the Appendix). Furthermore, it is conceivable that the internal and external financial tightness reinforce each other, motivating that $\tilde{\gamma}_y$ may also depend on the interaction term $\gamma_{y,ext,int} Int_{i,t-1} Ext_{i,t-1}$. However, the estimate of $\gamma_{y,ext,int}$ turned out to be very small and mostly statistically insignificant. We have therefore omitted these further interaction terms in the baseline specification.

model, we estimate three alternative specifications giving a special focus to the symmetry between when output of a firm increases or decreases, the dependence of the adjustment to the wage level and the transitory feature of labour hoarding.

The exogeneity of our right-hand side variables is a particular concern in our analysis. Our baseline model assumes that changes in employment are driven by changes in output and that changes in output are independent to the fact if a firm is financially tight or not. There are two sources of potential endogeneity: the endogeneity of firm output and the endogeneity of the financial tightness indicators. In Section 5, we therefore implement four adjustments to the baseline model in order to foster the causal interpretation of our estimates. The first two address the identification of demand shocks at the firm level. The other two address the identification of financial tightness at the firm level. First, we use industry-level instead of firm-level output to identify demand shocks. Second, we look at the cross-sectional variation of employment during the Great Recession and the recovery. Third, we use industry-level measures of financial tightness. Fourth, we use a measure of exogenous variation of firms' financial tightness that is available for a subset of firms.

In the following section, we provide firm-level measures of financial tightness and describe how these measures are incorporated into equation (2.2).

3 Data Description

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 data set is underlying official GDP data and other national account statistics. The sample is a draw from the population of Swiss firms including all industries of the economy, except the financial and public sectors.[16] The data set comprises 104181 observations at an annual frequency and includes 20819. It is an unbalanced panel; that is, we do not observe every firm for all 19 years. The SFSO collects data for all large firms on an annual basis. Smaller

[16]The sample is not a representative sample as it over-samples large firms. This is because the sample is used to project aggregate GDP, for which large firms' statistics have a higher information content. The sampling frame is broken down by industries, respectively by sectors (primary strata) on the basis of the 2-digit NOGA classification (NOGA is the Swiss industry classification, similar to NACE) and size classes on the basis of 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 companies are surveyed. In the remaining strata, simple random samples are drawn. The sample size is set so that 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.

firms are replaced more frequently in the sample, with firms from the same industry and similar characteristics.[17] Even though we do not observe the entire universe of firms, the data set has some advantages over more broadly available data, 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 and therefore information on their financial position, in particular of smaller firms, tends to be less publicly available. It may be important to include such firms as they may differ from larger, publicly held firms regarding their external and internal financial tightness.

Employment is defined in full-time equivalent (FTE) units in logs denoted by $e_{i,t}$. Output is measured by subtracting intermediate goods expenditure from total sales; the formulation is the official calculation used by the SFSO for value added.[18] Our dataset also includes a measure of average wages, $w_{i,t}$, which are measured as total wage expenditures divided by employment. It also includes physical capital, which we measure by its book value in the balance sheet. Table 2.1 lists the number of observations, the number of firms, the average full-time employment and the average output per firm for each industry, all of which are the key variables in our empirical section.

Furthermore, the dataset contains information that can be used to construct firm-specific measures of external and internal financial tightness. External financial tightness hinders firms from obtaining funds from outside investors and lenders. A firm faces internal financial tightness if it is more difficult to bridge a drop in demand by using internal funds.

In the spirit of Kaplan and Zingales (1997), we classify situations of financial tightness based on indicators constructed from the firms' balance sheets. We use several measures of financial tightness of a firm, as described in the next paragraph. To do so, we first define a firm as being in a financially tight situation if its value for a given financial situation indicator is above (below) the median value of that indicator. We then define a dummy variable with the value 1 if the firm is below the median and with the value 0 if it is above the median.[19] This value is defined for each firm-year observation such that a firm can be defined as being above the median in one period but below in another.

[17] 67% of the smallest firms (firms with less than 10 FTE) are three or less than three years in the sample, while 72% for the largest firms (firms with more than 250 FTE) are ten years or more in the sample.

[18] Note that even if a firm operates across borders, the data excludes all foreign activities. Thus, output, labour costs, numbers of employees, costs for intermediate goods etc. all relate to Swiss activities.

[19] In Section B.3.3 in the Appendix, we look at a finer grid, not just above and below median.

TABLE 2.1: SAMPLE STATISTICS

	Observations		*Employment*	*Value added*
	Total	Firms	average per firm	average per firm
Whole sample	74065	16338	181	33080
Industries				
Business Serv. 1	5066	1397	126	34113
Business Serv. 2	1991	612	218	20124
Construction	6644	1570	140	14546
Education	1299	350	106	10964
Energy	3113	547	97	39184
Entertainment	1942	519	80	12381
Health	3390	899	101	8287
IT	3043	768	212	56274
Manuf. Pharma	618	112	635	500871
Manuf. Invest.	13766	2488	176	26447
Manuf. Watches	3428	644	254	20238
Manuf. Other	8690	1579	139	49131
Mining	612	115	46	8852
Rest. Hotels	3580	785	116	9008
Trade	13038	3176	232	40820
Transport	3845	777	378	51981

Notes: Employment is the number of full-time equivalents (FTE). Value added is stated in nominal CHF. The industries comprise the following: Business Services 1 (Real estate activities, legal, accounting, management, architecture, engineering activities, scientific research and development, 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, 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, repair of motor vehicles and motorcycles); and Transport (Transportation and storage).

First, we look at two measures defining the external financial situation of a firm. For our first measure, we use the size of a firm's balance sheet. The idea behind using the balance sheet size as a measure for the financial situation is related to the costs of asymmetric information and firms' capital market access. Firms with a small balance sheet tend to have had little experience in the credit market, and therefore there is limited available information on their creditworthiness. Bernanke, Gertler, and Gilchrist (1996), Gertler and Gilchrist (1994) and Caggese and Cunat (2008) show that smaller firms are restricted in the form of external finance they are able to access and have to rely heavily on credit funding. In contrast, information on firms with large balance sheets is much more available, and larger firms make greater use of other forms of external funding such as equity and commercial paper. Our second measure is the amount of collateral a firm owns. We define collateral as

TABLE 2.2: MEASURES OF FINANCIAL TIGHTNESS

	Liquidity		*Profitability*		*Collateral*		*Bal.Sheet*	
	Md	Sd	Md	Sd	Md	Sd	Md	Sd
Whole sample	2.75	24.18	0.30	0.11	0.49	4.42	14310	1482181
Within industries								
Business Serv. 1	1.72	6.70	0.10	0.28	0.18	3.86	12177	662295
Business Serv. 2	1.86	3.38	0.07	0.16	0.16	0.67	6385	118884
Construction	2.25	1.64	0.07	0.10	0.36	0.58	11168	63570
Education	1.30	0.97	0.04	1.13	0.38	1.48	8075	29358
Energy	5.97	51.57	0.26	0.24	1.32	19.76	31065	722144
Entertainment	1.90	2.06	0.07	0.18	0.56	1.13	6225	136773
Health	1.27	0.44	0.04	0.18	0.84	3.65	5948	27814
IT	2.23	4.49	0.09	0.37	0.16	0.78	12147	978099
Manuf. Pharma	3.65	15.57	0.25	1.10	0.66	1.16	66739	8705574
Manuf. Invest.	2.94	3.39	0.13	0.24	0.56	1.01	19571	233431
Manuf. Watches	3.03	2.64	0.10	0.16	0.64	0.87	12297	142928
Manuf. Other	2.82	4.96	0.15	0.27	0.39	0.84	23288	991043
Mining	3.60	2.60	0.18	0.20	0.97	2.01	14026	31332
Rest. Hotels	2.19	0.80	0.09	0.29	0.91	1.30	7217	50212
Trade	5.95	50.04	0.17	0.24	0.29	0.67	19540	1521905
Transport	2.50	9.05	0.08	0.16	0.76	1.44	16605	4341944
Between industries								
Industr.-means	3.42	3.30	0.12	0.08	0.75	1.12	50699	406424

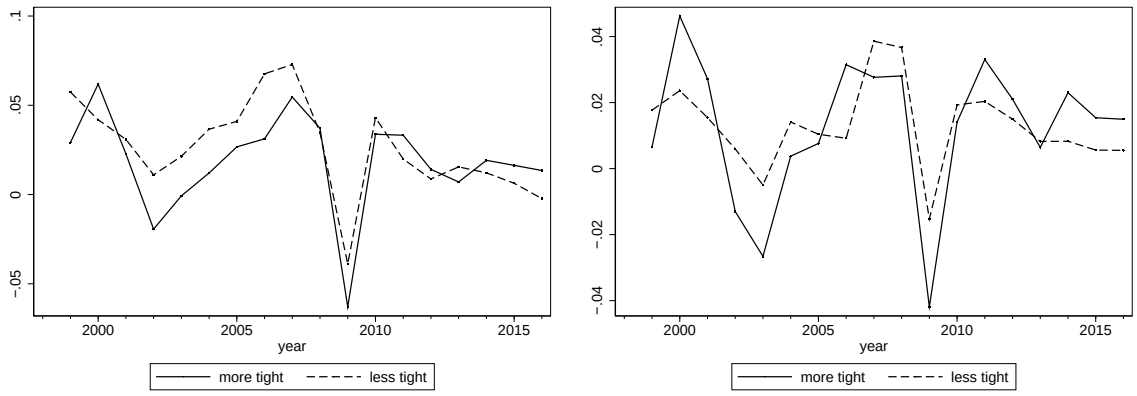
Notes: This table reports summary statistics for the financial tightness variables. Md denotes the median, and sd denotes the standard deviation. Firms are classified into industries according to the SFSO definition. Figures 2.3-2.10 in the appendix show distributions of these variables.

the sum of a firm's structures (buildings and land) and machines per unit of outstanding debt. Because it is riskier to lend to firms with low collateral, firms with low collateral have limited or more-costly access to external finance.

Second, we derive two different indicators for a firm's internal financial tightness. The data come from the firms' income statements. Our first measure is liquidity, which is defined as the ratio of sales to labour costs, following Aghion, Farhi, and Kharroubi (2015). Because profits are usually regarded as the main source of internal funding for investment, including the investment in labour hoarding, our second measure is the level of profits; we define profit as EBIT (earnings before interest rates and taxes) per unit of output, which is a measure of a firm's profitability.

The medians and the standard deviations of our financial tightness indicators are listed in Table 2.2. The first row shows statistics for all observations, and the rows below show statistics for the 16 industries. These figures show that the heterogeneity within industries can be very large. The last row shows the between-industry variation, i.e., the medians

FIGURE 2.1: AVERAGE GROWTH IN EMPLOYMENT AND OUTPUT FOR FIRMS IN A FINANCIALLY MORE AND LESS TIGHT SITUATION (1999-2016)



(a) Output (b) Employment

Notes: The panel on the left shows average output growth for more liquidity-tight firms (solid line) and for less liquidity-tight firms (dashed line). The right panel shows average employment growth. The averages are built by using firm-level growth rates weighted by the number of full-time equivalents.

and standard deviations of the 16 industry-medians. The between-industry variation is low compared to the variation within industries. This indicates clearly that to capture the whole scope of heterogeneity within an economy, it is useful to employ firm-level data. Figures 3-10 in the Appendix show the distribution of the tightness indicators over the whole sample and for the individual sectors.

To illustrate the aggregate dynamics of the key variables, that is, the changes in output and the changes in employment, we show the average growth in employment and in output of our sample over time. We distinguish between firms in more and less tight financial situations (In Figure 2.1, the solid lines reflect the growth for firms that are classified as those in a financially tighter situation, and the dashed lines reflect the growth of firms in a financially less tight situation). Taking the example of liquidity tightness, we illustrate the aggregate dynamics. While the fluctuations in output growth are similar for both groups of firms, growth in employment fluctuates markedly more for financially tighter firms. Moreover, there is a clear difference in the decline in employment during the Great Recession, in which firms that are financially less tight reduce employment by only 1.5%, while financially tighter firms reduce employment by 4.2%, thus reducing employment more than twice as much as firms that are financially less tight. This figure motivates our analysis of the impact of financial tightness on the intertwinement of employment and output.

4 Empirical analysis and results

This section reports estimates of the employment elasticity and differences across financially constrained and unconstrained firms. We address the potential endogeneity of output more thoroughly in Section 5. In Section 4.1, we report the baseline regressions. Then, shedding light on specific aspects of labour hoarding, we show three refinements of the baseline equation. First, in Section 4.2, we distinguish between firms with decreases and firms with increases in output. The results are very similar. This similarity shows that financial constraints have a symmetric impact on labour hoarding. Second, in Section 4.3, we show that firms that pay high wages tend to hoard more labour if they are financially unconstrained. Third, in Section 4.4, we show that our findings are similar if we focus only on a temporary change in output, i.e., a change consistent with a cyclical shock to demand. In the Appendix, we conduct various robustness test, and we look at the effect of financial tightness at different levels of its distribution.

4.1 Baseline specification

Based on using equation (2.3), the impact of a one percent decrease in output on employment is displayed in Table 2.3. The upper panel 1 shows the estimated results of $\tilde{\gamma}_y$ for the four different combinations of financial tightness indicators. The direct impact of a one percent decline in output is given by γ_y on the first line. $\gamma_{y,int}$ is the marginal effect of facing internal financial tightness, and $\gamma_{y,ext}$ the marginal effect of facing external financial tightness.

Column (1) shows the results for estimates including liquidity as a measure of internal financial tightness and collateral as a measure of external financial tightness. Firms that are not financially tight reduce employment by only 0.17% in response to a one percent decline in output, with an elasticity significantly below one, which suggests that these firms hoard labour.[20] If a firm faces liquidity tightness, this elasticity almost doubles, compared to the firms with no liquidity tightness. If the firm is short of collateral, the firm lays off 0.04 percentage points more employment than other firms, implying that firms with collateral

[20]Note that a coefficient below one may not necessarily be evidence only for labour hoarding. This under-reaction to changes in demand could also come from the presence of convex adjustment costs. However, as the coefficient is very small, it seems implausible that convex adjustment costs alone could explain the small size of this coefficient. Moreover, the finding that the coefficient is larger for financially constrained firms suggests that the small coefficient is (at least partially) due to labour hoarding, as there is no obvious reason why convex adjustment costs should interact with financial constraints (while it is quite plausible that labour hoarding should).

shortages decrease their employment by approximately one-fourth more than firms with no collateral shortages.

All alternative measures of internal and external tightness show that firms that are in a financially strained situation hoard less labour than other firms. Columns (2), (3) and (4) report the results for other measures and combinations of financial tightness indicators, including profitability as an internal tightness indicator and the size of the balance sheet as an external tightness indicator. The estimates of $\gamma_{y,int}$ and $\gamma_{y,ext}$ indicate that all four measures of financial tightness, taken alone, have a detrimental impact on the employment adjustment. While the impact of low collateral is somewhat lower, the other indicators have a substantial impact.

The estimates above are based on regressions including both the external and the internal financial tightness indicators. They thus have a conditional interpretation; that is, the coefficient on the internal financial tightness indicator is for a firm that experiences no external financially tight situation. Firms might be financially tight in both dimensions, internally and externally. To give a simple illustration of the elasticities for more and less financially tight firms, in panel 2, we report the coefficient for the firms with no financial tightness in the first row, which is identical to the coefficient γ_y in panel 1). The second row shows the elasticity for a firm that faces only an internal financial tightness (the sum of γ_y and $\gamma_{y,int}$); the third, the elasticity of a firm that faces only external financial tightness (the sum of γ_y and $\gamma_{y,ext}$); and the last row shows the coefficient of a firm, which is faced with financial tightness in both dimensions.

Panel 2 lists the implied employment elasticity depending on firms' financial tightness. For a firm with no tightness (i.e., the dummy variables $Int_{i,t-1}$ and $Ext_{i,t-1}$ are equal to zero), the implied employment elasticity equals γ_y. For a firm with only internal or external tightness, the implied employment elasticity equals $\gamma_y + \gamma_{y,int}$ and $\gamma_y + \gamma_{y,ext}$, respectively. The implied employment elasticity for a firm, which is internally and externally tight, equals $\gamma_y + \gamma_{y,int} + \gamma_{y,ext}$. Panel 2 shows that a firm's employment elasticity is between 0.17% and 0.19% if both of its financial tightness indicators are zero (first row). Internally and externally tight situations lead to a marked rise in this elasticity (second and third rows), as discussed above. The strongest impact, however, is observed when internal and external tightness occurs jointly. In that case, firms lay off twice more employees than do other firms. Panel 3 shows that the share of firms experiencing tightness in both dimensions, internally and

externally, is not negligible. Depending on the specification, the share of firms for which both tightness indicators suggest a financially strained situation accounts for 23% - 31% of the observations.

TABLE 2.3: EMPLOYMENT ELASTICITIES AND FINANCIAL TIGHTNESS

1) Employment elasticity for not tight firms and marginal effects of financial tightness				
Specification	(1)	(2)	(3)	(4)
Measure of internal tightness	Liquidity	Profitability	Liquidity	Profitability
Measure of external tightness	Collateral	Collateral	Balance sheet	Balance sheet
γ_y	0.170***	0.194***	0.172***	0.186***
	(0.008)	(0.008)	(0.006)	(0.006)
$\gamma_{y,int}$	0.151***	0.128***	0.114***	0.094***
	(0.010)	(0.010)	(0.010)	(0.010)
$\gamma_{y,ext}$	0.044***	0.033***	0.113***	0.127***
	(0.009)	(0.009)	(0.010)	(0.011)
R^2	0.373	0.379	0.378	0.388
2) Implied employment elasticity $\tilde{\gamma}_y$ depending on financial tightness				
No tightness	0.170	0.194	0.172	0.186
Only internal	0.320	0.322	0.286	0.281
Only external	0.213	0.227	0.286	0.314
Internal and external	0.364	0.355	0.400	0.408
3) Number of observations				
No tightness	19,799	20,896	27,182	26,854
Only internal	20,538	19,441	14,780	15,108
Only external	20,298	19,258	12,928	13,311
Internal and external	18,537	19,577	24,297	23,914

Notes: The first panel 1) on the top shows the response in employment to a one percent change in output, depending on whether a firm faced financial tightness in the previous period. The direct impact of a one percent decline in output is given by γ_y on the first line. $\gamma_{y,int}$ is the marginal effect of facing internal financial tightness, and $\gamma_{y,ext}$is the marginal effect of facing external financial tightness. Robust standard errors are in parentheses; ***$p < 0.01$, **$p < 0.05$, and *$p < 0.1$. Panel 2) reports the sum of the interaction coefficients (the standard deviations have been excluded; all are significant at the one percent level). The last panel shows the number of observations for each specification.

4.2 Symmetry

Do firms react symmetrically to changes in output? Alternatively, is the impact of financial tightness asymmetric, that is, stronger during the recession than in the following upturn? To analyse this, we estimate our model to include separately observations with a negative change in output and observations with a positive change in output. Table 2.4 reports the

results for decreases in output.[21]

The elasticities of the firms in a downturn are all very similar to those displayed in Table 2.3. In a downturn, approximately one fourth of the firms face tightness along both dimension and lay off twice more employees than firms that face no financial tightness.

In an upturn, financial tightness could theoretically have either a dampening or an enhancing impact on employment elasticity. In the first case, the rationale is that financial tightness has a negative impact on employment growth, both in a downturn as well as when demand increases. In this case, the marginal effects of financial tightness is negative, and financially strained firms have lower implied elasticities than other firms, meaning that firms facing financial tightness lay off more labour in a downturn and take on less labour in an upturn.

The second case is based on the idea that labour hoarding is a cyclical phenomenon with an investment character: firms keep on more labour than necessary in a downturn so that they will not have to hire as much new staff in the subsequent upturn. Financially tighter firms, however, are unable to hoard the optimal amount of labour and are forced to lay off more staff than desired in a downturn. In turn, in an upturn, they have to re-hire more labour for each percentage point rise in output. The interaction terms have positive coefficients, and both in a downturn and in an upturn, the implied employment elasticity is higher than that of firms facing no financial tightness.

[21] We have tested the results when an downturn (upturn) is defined relative to growth at the economy-level. For this analysis, the firms are divided into a downturn bin if their change in value added lies below the nominal GDP growth level and into an upturn bin if their change in value added lies above this aggregate growth level. The results are similar to the baseline specification and are reported in the appendix (Tables 2.19 and 2.20).

TABLE 2.4: EMPLOYMENT ELASTICITIES AND FINANCIAL TIGHTNESS IN DOWNTURNS

1) Employment elasticity for not tight firms and marginal effects of financial tightness				
Specification	(1)	(2)	(3)	(4)
Measure of internal tightness	Liquidity	Profitability	Liquidity	Profitability
Measure of external tightness	Collateral	Collateral	Balance sheet	Balance sheet
γ_y	0.166***	0.197***	0.171***	0.190***
	(0.014)	(0.013)	(0.012)	(0.011)
$\gamma_{y,int}$	0.168***	0.151***	0.133***	0.116***
	(0.018)	(0.019)	(0.018)	(0.020)
$\gamma_{y,ext}$	0.041**	0.031*	0.111***	0.126***
	(0.016)	(0.017)	(0.020)	(0.020)
R^2	0.338	0.354	0.341	0.358
2) Implied employment elasticity $\tilde{\gamma}_y$ depending on financial tightness				
No tightness	0.166	0.197	0.171	0.190
Only internal	0.334	0.348	0.303	0.305
Only external	0.207	0.228	0.282	0.316
Internal and external	0.376	0.379	0.414	0.432
3) Number of observations				
No tightness	8852	9882	12178	12623
Only internal	8468	7438	6037	5592
Only external	9119	9176	5801	6443
Internal and external	7562	7505	9994	9352

Notes: The first panel 1) on the top shows the response in employment to a one percent change in output, depending on whether a firm faced financial tightness in the previous period. The direct impact of a one percent decline in output is given by γ_y on the first line. $\gamma_{y,int}$ is the marginal effect of facing internal financial tightness, and $\gamma_{y,ext}$ is the marginal effect of facing external financial tightness. Robust standard errors are in parentheses; ***$p < 0.01$, **$p < 0.05$, and *$p < 0.1$. Panel 2) reports the sum of the interaction coefficients (standard deviations have been excluded; all are significant at the one percent level). The last panel shows the number of observations for each specification.

The results displayed in Table 2.5 show that the estimates of $\gamma_{y,int}$ and $\gamma_{y,ext}$ are all significantly positive, with elasticities similar to those for downturns. These results indicate that financial tightness amplifies the fluctuations of employment and weakens those of labour productivity. In contrast, when caused by strong labour hoarding, weak cyclicality of employment is a sign of financially healthy firms.

Table 2.17 in the appendix reports the difference between the coefficients estimated for downturns and upturns. The differences are only significant for the marginal effect of internal tightness. The positive sign means that internally financially tighter firms re-hire less labour in an upturn than they laid off in a previous downturn. This feature is, however,

economically small.[22]

TABLE 2.5: EMPLOYMENT ELASTICITIES AND FINANCIAL TIGHTNESS IN UPTURNS

1) Employment elasticity for not tight firms and marginal effects of financial tightness				
Specification	(1)	(2)	(3)	(4)
Measure of internal tightness	Liquidity	Profitability	Liquidity	Profitability
Measure of external tightness	Collateral	Collateral	Balance sheet	Balance sheet
γ_y	0.197***	0.223***	0.195***	0.212***
	(0.015)	(0.015)	(0.012)	(0.013)
$\gamma_{y,int}$	0.126***	0.077***	0.081***	0.042**
	(0.020)	(0.018)	(0.020)	(0.018)
$\gamma_{y,ext}$	0.049***	0.040**	0.153***	0.167***
	(0.018)	(0.018)	(0.020)	(0.020)
R^2	0.371	0.378	0.376	0.384
2) Implied employment elasticity $\tilde{\gamma}_y$ depending on financial tightness				
No tightness	0.197	0.223	0.195	0.212
Only internal	0.322	0.300	0.276	0.253
Only external	0.246	0.262	0.348	0.378
Internal and external	0.371	0.339	0.429	0.420
3) Number of observations				
No tightness	10947	11014	15004	14231
Only internal	12070	12003	8743	9516
Only external	11179	12072	7127	6868
Internal and external	10975	10082	14303	14562

Notes: The first panel 1) on the top shows the response in employment to a one percent change in output, depending on whether a firm faced financial tightness in the previous period. The direct impact of a one percent decline in output is given by γ_y on the first line. $\gamma_{y,int}$ is the marginal effect of facing internal financial tightness, and $\gamma_{y,ext}$ is the marginal effect of facing external financial tightness. Robust standard errors are in parentheses; ***$p < 0.01$, **$p < 0.05$, and *$p < 0.1$. Panel 2 reports the sum of the interaction coefficients (standard deviations have been excluded; all are significant at the one percent level). The last panel shows the number of observations for each specification.

4.3 Low-wage versus high-wage firms

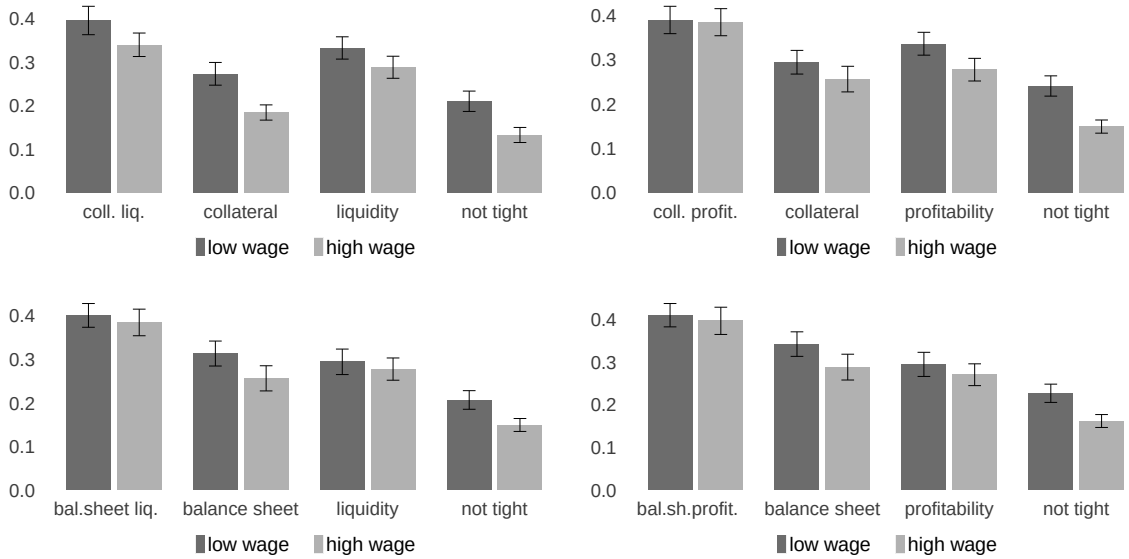
The wage level is likely to influence labour hoarding behaviour. However, it is a priori unclear whether firms in the high-wage segment hoard more or less labour than firms in the low-wage segment. There are two opposing effects. On the one hand, adjustment costs are probably higher for high-wage jobs, because of two reasons. First, firing

[22] We furthermore show in Appendix B.4 that while resulting in relatively small and insignificant coefficients of the financial tightness indicators, estimating an error-correction relationship between employment and output by using a mean group estimator and adding the financial tightness indicators to this equation does not change the short-term adjustment coefficients. However, a caveat is that since we have a small number of time periods, relative to a cross-sectional dimension, the estimator of the long-run equation is not consistent.

costs are set to be higher owing to higher redundancy payments and more-generous dismissal conditions. Second, because the wage level should be determined by a worker's productivity, high-wage jobs will probably require higher hiring costs and higher initial training costs. Hiring costs are especially high when the human capital is scarce or very firm-specific. For example, Blatter, Muehlemann, and Schenker (2012) provide evidence that hiring costs as a share of wage costs are higher in occupations with higher skill requirements. This means that the costs of laying off high-wage jobs might be larger than those of laying off low-wage jobs. On the other hand, one could argue that dismissing a worker with a high wage decreases wage expenditures more than dismissing a worker with a low wage. In this case, the costs of laying off workers with high-wage jobs are larger than those of laying off workers with low-wage jobs.

To test which hypothesis dominates, we split our sample at the median firm-level average wage. In our data set, we do not have wage data per employee; we only have the average wage per firm. Therefore, we cannot distinguish between different jobs within the same firm. Thus, the classification by firm-level average wage, which we use for this exercise, is only a proxy. Especially for firms with very heterogeneous remuneration schemes, the average could be misleading. The results in Figure 2.2 show that for all specifications, the employment elasticities of high-wage firms (light grey bars) are lower than those for low-wage firms (dark grey bars). This suggests that the first channel dominates; i.e., in the high wage segment, hiring and firing costs tend to be relatively more important than the wage savings. The error bars showing the 95% confidence intervals suggest, however, that the difference in hoarding behaviour is only significant for firms facing no financial tightness: High-wage firms only hoard more labour when they dispose of sufficient funding opportunities. The elasticity of high-wage, not financially tight firms is a third lower than that of low-wage firms. High-wage firms that face only external financial tightness (i.e., no internal financial tightness) also tend to hoard significantly more labour. However, if a firm faces internal financial tightness, its labour hoarding behaviour does not differ much if they pay high or low wages. The implied elasticity for firms facing internal and external financial tightness is in all specifications very similar.

FIGURE 2.2: EMPLOYMENT ELASTICITIES AND FINANCIAL TIGHTNESS BY WAGE LEVEL



Notes: The light grey bars represent the high-wage firms and the dark grey bars the low-wage firms. The two bars in the first column represent the implied labour elasticity for firms with both an internal and an external financially tight situation, as measured by $\gamma_y + \gamma_{y,int} + \gamma_{y,ext}$. The two bars in the second column represent externally tight firms, as measured by $\gamma_y + \gamma_{y,ext}$; the two bars in the third column represent internally tight firms, as measured by $\gamma_y + \gamma_{y,int}$, and the two bars in the fourth column represent the labour elasticity for firms with no financial tightness, as measured by γ_y. The error bars represent the 95% confidence intervals.

4.4 Transitory feature of labour hoarding

We have shown that financial tightness can have a substantial influence on employment because it hampers the ability of firms to hoard labour. In this section, we focus on the transitory feature of labour hoarding. The expected persistence of a downturn plays a crucial role in the labour hoarding behaviour of firms. If firms believe that the downturn is temporary, downsizing their labour force will entail future re-hiring costs; therefore, the incentives to hoard labour are high. If, however, firms associate the change in demand with permanent developments, they will have an incentive to more or less completely adjust their labour force to the lower level of output.[23]

We test whether the results previously obtained above are influenced by firms that adjust their employment to permanent changes in demand. To do this, we re-estimate the baseline equation by using only those observations for which we have an indication that the change in demand is temporary. We use the sum a firm spends on temporary work to capture the cyclical movement of employment: because temporary work is quickly available and

[23]For example, Baily, Bartelsman, and Haltiwanger (2001) analyse the cyclicality of labour productivity, focusing on the impact of a transitory demand shock. They measure the transitory shocks as the deviation of downstream demand from the linear trend.

easily reversible, it will be used by firms as a buffer to regulate their labour force when they assume the fluctuations in demand will be temporary. In contrast, it would be inefficient for employers to take on temporary work for a permanent job because the retention level is generally low and the fixed costs of work-related training are therefore less worthwhile (Booth, Francesconi, and Frank (2002)). Thus, if firms assume that an increase in demand is permanent, they will hire permanent workers, while if an upturn is seen to be temporary, it will be more attractive to take on temporary workers.[24] Accordingly, if firms expect a downturn to be temporary, they will try to keep as much as possible of their permanent labour force and diminish their costs by reducing temporary work with no redundancy pay (Dolado, García-Serrano, and Jimeno (2002)).

We assume, therefore, that when an upturn (decline) in output occurs together with a rise (decline) in temporary work, the firm believes that the fluctuations in demand are temporary. We proceed by looking at the sample sub-set, in which changes in output occur together with a change in temporary work and the two move in the same direction. Because the expenditures for temporary work only amount to 2.0% of total labour costs on average (see Table 2.13 in the Appendix), it is fair to claim that the total change in employment is not influenced in a meaningful way by changes in the costs for temporary work. Across sectors, there are some differences in the share of temporary work. While construction has the highest higher share (4.6%), education employ the lowest (0.9%). The figures in Table 2.13 show, however, that the dispersion across sectors is overall small. As not all firms employ temporary work, this exercise reduces the sample to approximately $29,084$ observations. Roughly half of them change output in the same direction as temporary work, as shown in the summary statistics for this sample (Table 2.14 in the Appendix).[25]

Table 2.6 displays the results for a one percent decrease in output. The results are very similar to the results shown in Table 2.3. This suggests that the influence of financial tightness on employment applies to the cyclical component of a labour adjustment.

[24] While firms will eventually react with an adjustment of the permanent workforce to permanent shocks, we cannot exclude that they to some extent first adjust their temporary workforce.

[25] Around one fourth of the firms in the total sample use temporary labour. The firms in this sample are approximately 30% larger on average (both in terms of employment and in terms of value added) than the firms for the whole sample, suggesting that larger firms tend to use temporary labour more intensively. The constraint variables for this sample have similar medians as the full sample and in most sectors have a lower dispersion (see Table 2.15 in the Appendix).

TABLE 2.6: EMPLOYMENT ELASTICITIES AND FINANCIAL TIGHTNESS FOR TEMPORARY EMPLOYMENT

1) Employment elasticity for not tight firms and marginal effects of financial tightness				
Specification	(1)	(2)	(3)	(4)
Measure of internal tightness	Liquidity	Profitability	Liquidity	Profitability
Measure of external tightness	Collateral	Collateral	Balance sheet	Balance sheet
γ_y	0.214***	0.236***	0.224***	0.238***
	(0.017)	(0.017)	(0.014)	(0.014)
$\gamma_{y,int}$	0.134***	0.109***	0.091***	0.070***
	(0.023)	(0.023)	(0.024)	(0.023)
$\gamma_{y,ext}$	0.045**	0.036*	0.140***	0.151***
	(0.020)	(0.021)	(0.024)	(0.023)
R^2	0.384	0.393	0.393	0.405
2) Implied employment elasticity $\tilde{\gamma}_y$ depending on financial tightness				
No tightness	0.214	0.236	0.224	0.238
Only internal	0.348	0.345	0.314	0.308
Only external	0.259	0.273	0.364	0.389
Internal and external	0.393	0.382	0.455	0.459

Notes: The first panel 1) on the top shows the response in employment to a one percent change in output, depending on whether a firm faced financial tightness in the previous period. The direct impact of a one percent decline in output is given by γ_y on the first line. $\gamma_{y,int}$ is the marginal effect of facing internal financial tightness, and $\gamma_{y,ext}$ is the marginal effect of facing external financial tightness. Robust standard errors are in parentheses; ***$p < 0.01$, **$p < 0.05$, and *$p < 0.1$. Panel 2) reports the sum of the interaction coefficients (the standard deviations have been excluded; all are significant at the one percent level).

5 Identification

A causal interpretation of our estimates requires that the right hand side variables are exogenous. This is certainly a concern in our estimation reported above. We therefore go step-by-step through each potential source of endogeneity: the endogeneity of the lagged firm-level output and the endogeneity of the financial tightness indicators. We address the potential endogeneity of output with two alternative strategies. First, we instrument firm-specific output with output at the sectoral level. Second, we focus on an episode, the Great Recession, which is widely recognized as an exogenous shock to foreign demand for Swiss output. To foster our causal interpretation of the effect of financial tightness, we also pursue two alternative strategies. First, we replace firm-specific financial tightness indicators with financial tightness indicators defined at the industry level. Second, we estimate the effect of changes in revenue from financial assets, which are arguably exogenous to shocks to firm-specific employment, on labour hoarding.

5.1 Variation of output at the sectoral level

In Section 4, firm-level variation in output is used as an explanatory variable to proxy for demand shocks. One concern in that specification is that shocks to firm-specific employment could affect the firms' output. We test whether our baseline results are affected by this potential endogeneity problem by using changes in industry-level output as an instrument for firm-level output. Aghion, Farhi, and Kharroubi (2015) argue that the use of output at the higher level of aggregation can reduce the scope for reverse causality because the changes in employment of an individual firm will not influence the characteristics of a whole industry. We therefore estimate equation 2.3 employing 2SLS and instrument log-changes in firm-level output $\Delta y_{i,t}$ by log-changes in industry-level output $\Delta y_{j,t}$, where firm i is part of industry j.

The results of the 2SLS estimation is displayed in Table 2.7. The standard errors are clustered at the industry level to take into account the fact that the instrument varies at the level of industries but not across firms within the same industry. Most elasticity estimates remain significant except for those of the collateral tightness indicator, which was also economically small in the main specification. These results suggest that the effect of collateral tightness is not robust and therefore not significantly different from zero. The other three tightness indicators are robust to the use of industry-level output as an instrument for firm-level output. The coefficients of the interaction terms, $\gamma_{y,int}$ and $\gamma_{y,ext}$, are slightly lower than those in the baseline specification shown in Table 2.3. Meanwhile, the direct impact of output variation on employment is somewhat larger but does not alter our main interpretation.

TABLE 2.7: 2SLS: EMPLOYMENT ELASTICITIES WITH INDUSTRY-LEVEL VALUE-ADDED

1) Employment elasticity for not tight firms and marginal effects of financial tightness				
Specification	(1)	(2)	(3)	(4)
Measure of internal tightness	Liquidity	Profitability	Liquidity	Profitability
Measure of external tightness	Collateral	Collateral	Balance sheet	Balance sheet
γ_y	0.300***	0.312***	0.307***	0.310***
	(0.087)	(0.082)	(0.081)	(0.075)
$\gamma_{y,int}$	0.122**	0.120***	0.095**	0.090**
	(0.049)	(0.044)	(0.046)	(0.038)
$\gamma_{y,ext}$	0.023	0.009	0.097**	0.106***
	(0.035)	(0.034)	(0.038)	(0.037)
$F\ \Delta y_{i,t}$	197.8	243.5	158.4	205.5
$F\ Int_{i,t-1}\Delta y_{i,t}$	17.0	147.4	17.9	153.5
$F\ Ext_{i,t-1}\Delta y_{i,t}$	82.2	86.2	27.8	26.6
2) Implied employment elasticity $\tilde{\gamma}_y$ depending on financial tightness				
No tightness	0.300	0.312	0.307	0.310
Only internal	0.422	0.432	0.401	0.399
Only external	0.323	0.321	0.404	0.416
Internally and external	0.444	0.441	0.499	0.505

Notes: The first panel 1) on the top shows the response in employment to a one percent change in output, depending on whether a firm faced financial tightness in the previous period. The direct impact of a one percent decline in output is given by γ_y on the first line. $\gamma_{y,int}$ is the marginal effect of facing internal financial tightness, and $\gamma_{y,ext}$ is the marginal effect of facing external financial tightness. The standard errors are in parentheses (clustered at the industry level); ***$p < 0.01$, **$p < 0.05$, and *$p < 0.1$. $F\ \Delta y_{i,t}$, $F\ Int_{i,t-1}\Delta y_{i,t}$ and $F\ Ext_{i,t-1}\Delta y_{i,t}$ are the robust Angrist-Pischke F-statistics of the first-stage regressions for the change in output and the two interaction terms. Panel 2 reports the sum of the interaction coefficients (standard errors have been excluded; all are significant at the 1% level).

5.2 Variation in 2009 and 2010

In addition to the estimation in Section 5.1, we estimate the effect of financial tightness on labour hoarding, as specified in equation (2.3), by looking at the cross-sectional variation in the firms' financial conditions when the firms entered the Great Recession period.

In Switzerland, the Great Recession led to a large and broad-based decline in output (as also shown in Figure 2.1) that we assume to have been driven by an exogenous negative demand shock.[26] The Great Trade Collapse, which followed the Great Recession in the US in the second half of 2008, hit European countries suddenly, synchronically and severely

[26]The share of firms in our sample that experienced a decline in output in 2009 was much higher than that in 2008 (56% compared to 37%). Moreover, the average growth in the output of all firms was clearly negative, with an average firm growth rate of -5.9% in 2009 (compared to 3.0% in 2008). Average employment growth fell from 1.9% in 2008 to -2.3% in 2009.

(Baldwin (2009)). Thus, the spillovers to a small open European economy such as that of Switzerland were arguably exogenous to a large part of the Swiss firms.[27]

If the change in Swiss output during the recession year 2009 was driven by a exogenous negative demand shock, we can use this shock to identify a causality between the change in output and the change in employment.[28] The estimates of the equation (2.3) for the recession year 2009 are displayed in Table 2.8.[29]

Column (1) shows the results for estimates including liquidity as a measure of internal tightness and collateral as a measure of external tightness. Firms that do not face financial tightness reduced employment by only 0.26% in response to a one percent decline in output, with an elasticity significantly below one, which suggests that they hoarded labour. If a firm was low in liquidity in 2008, it laid off 0.17 percentage points more employment during the recession than a firm with high liquidity, implying that low-liquidity firms decreased their employment substantially more than other firms. Meanwhile, collateral tightness did not increase the elasticity significantly.

Columns (2), (3) and (4) report the results for other measures and combinations of tightness indicators, including profitability as a measure of internal financial tightness and the size of the balance sheet as a measure of external financial tightness. While the impact of low collateral is not significant, the other indicators of tightness all have a substantial impact.

[27]For example, in the first quarter of 2009, the Swiss National Bank wrote in its quarterly bulletin (Swiss National Bank (2009a)): "In the fourth quarter of 2008, real GDP dropped by 1.2% in annualised terms. While the contraction in economic activity appeared to be less pronounced in Switzerland than in the major European countries, this figure nevertheless obscures the extent of the collapse in global demand, in particular in the manufacturing industry, with the concomitant sharp drop in exports." Later, in the second quarter of 2009, they stated: "Initially, the crisis mainly affected exports and the financial industry, but in recent months it also had a noticeable impact on the domestic economy. However, there were still striking differences. Businesses in the export industry continued to fare markedly worse than firms that cater to domestic demand." (Swiss National Bank (2009b)). These statements are consistent with the view that from the perspective of the Swiss economy, the great recession in 2009 was mainly an external demand shock. Unfortunately, in the dataset, we do not have any direct information on the export share in output per firm, nor can we match the data to any trade databases that would allow more specific information about the export structure of each firm, which is information that would be necessary to define similar instruments as Berman, Berthou, and Héricourt (2015). However, Bäurle and Steiner (2015) show that the Swiss economy reacts strongly to foreign demand shocks. The elasticity of Swiss GDP to foreign GDP is approximately 0.4. As the domestic oriented public sector is omitted in our data, this relation is presumably even stronger when using our dataset.

[28]Such an identification strategy has also been used by Greenstone, Mas, and Nguyen (2020), who look at the Great Recession to estimate the effects of financial constraints on the real economy. Similarly, Siemer (2019), Popov and Rocholl (2015), and Duygan-Bump, Levkov, and Montoriol-Garriga (2015) use this period to quantify the effect of financial constraints on employment and unemployment.

[29]Data on short-time work programmes in Switzerland are available since 1984. The data show that, during the sample analysed (1998 to 2016), the use of such programmes was confined. At its peak in 2009, the number of hours worked covered by the short-time work reached only 0.20% of total hours worked. Given the low usage of short-time work during the observed sample, we assume that our coefficients are not significantly biased by short-time programmes..

TABLE 2.8: IMPACT OF 1% CHANGE IN OUTPUT ON EMPLOYMENT DURING THE RECESSION OF 2009

1) Employment elasticity for not tight firms and marginal effects of financial tightness				
Specification	(1)	(2)	(3)	(4)
Measure of internal tightness	Liquidity	Profitability	Liquidity	Profitability
Measure of external tightness	Collateral	Collateral	Balance sheet	Balance sheet
γ_y	0.260***	0.300***	0.253***	0.272***
	(0.029)	(0.028)	(0.023)	(0.023)
$\gamma_{y,int}$	0.165***	0.093***	0.136***	0.067**
	(0.030)	(0.031)	(0.031)	(0.032)
$\gamma_{y,ext}$	0.018	-0.006	0.086***	0.112***
	(0.029)	(0.030)	(0.030)	(0.032)
R^2	0.528	0.523	0.531	0.529
2) Implied employment elasticity $\tilde{\gamma}_y$ depending on financial tightness				
No tightness	0.260	0.300	0.253	0.272
Only internal	0.425	0.394	0.389	0.338
Only external	0.278	0.294	0.339	0.383
Internal and external	0.443	0.387	0.475	0.450
3) Number of observations				
No tightness	713	734	1068	1075
Only internal	655	634	577	570
Only external	736	702	381	361
Internally and external	575	609	653	673

Notes: The first panel 1) on the top shows the response in employment to a one percent change in output, depending on whether a firm faced financial tightness in the previous period. The direct impact of a one percent decline in output is given by γ_y on the first line. $\gamma_{y,int}$ is the marginal effect of facing internal financial tightness, and $\gamma_{y,ext}$ is the marginal effect of facing external financial tightness. Robust standard errors are in parentheses; ***$p < 0.01$, **$p < 0.05$, and *$p < 0.1$. Panel 2) reports the sum of the interaction coefficients (the standard deviations have been excluded; all are significant at the one percent level). The last panel shows the number of observations for each specification.

Panel 2 shows that during the Great Recession, while a firm's employment elasticity was between 0.25% and 0.29% if it was not facing financial tightness (first row), internal and external tightness led to a marked rise in this elasticity (second and third rows), as discussed above. Firms with both internal and external financial tightness reduced labour the most. Panel 3 shows that the share of firms that were internally as well as externally financially strained was not negligible. Depending on the specification, the share of firms that were financially strained according to both indicators (internal and external) accounted for 21% to 25% of all observations.

The findings above for the period of the Great Recession show that firms in a tight financial situation were less able to hoard labour than firms in a better financial situation.

To corroborate the results from the recession, we test if the negative impact of financial tightness on employment during the 2009 recession will be reversed in a positive impact during the subsequent upturn in 2010.[30]

TABLE 2.9: IMPACT OF 1% CHANGE IN OUTPUT ON EMPLOYMENT DURING THE UPTURN OF 2010

1) Employment elasticity for not tight firms and marginal effects of financial tightness				
Specification	(1)	(2)	(3)	(4)
Measure of internal tightness	Liquidity	Profitability	Liquidity	Profitability
Measure of external tightness	Collateral	Collateral	Balance sheet	Balance sheet
γ_y	0.161***	0.193***	0.160***	0.176***
	(0.030)	(0.030)	(0.021)	(0.022)
$\gamma_{y,int}$	0.130***	0.047	0.088**	0.013
	(0.040)	(0.038)	(0.043)	(0.040)
$\gamma_{y,ext}$	0.034	0.013	0.136***	0.161***
	(0.035)	(0.035)	(0.037)	(0.035)
R^2	0.356	0.348	0.365	0.361
2) Implied employment elasticity $\tilde{\gamma}_y$ depending on financial tightness				
No tightness	0.161	0.193	0.160	0.176
Only internal	0.292	0.240	0.249	0.189
Only external	0.195	0.206	0.297	0.337
Internal and external	0.326	0.253	0.385	0.350
3) Number of observations				
No tightness	650	671	987	999
Only internal	562	541	530	515
Only external	643	628	306	300
Internal and external	506	521	538	544

Notes: The first panel 1) on the top shows the response in employment to a one percent change in output, depending on whether a firm faced financial tightness in the previous period. The direct impact of a one percent decline in output is given by γ_y on the first line. $\gamma_{y,int}$ is the marginal effect of facing internal financial tightness, and $\gamma_{y,ext}$ is the marginal effect of facing external financial tightness. Robust standard errors are in parentheses; ***$p < 0.01$, **$p < 0.05$, and *$p < 0.1$. Panel 2) reports the sum of the interaction coefficients (the standard deviations have been excluded; all t are significant at the one percent level). The last panel shows the number of observations for each specification.

The data confirms this hypothesis. The results are displayed in Table 2.9. The estimates of $\gamma_{y,int}$ and $\gamma_{y,ext}$ are significantly positive for internal liquidity tightness and external balance sheet tightness, with elasticities similar to those during the recession of 2009. Even though internal profitability tightness and external collateral tightness are not significantly different from zero, they are not negative. This implies that it was the financially strained firms that

[30] Again, there is no evidence that financial tightness has an asymmetric effect in upturns and downturns (Table 2.21 in the appendix.

triggered the labour market upturn that occurred in the aftermath of the Great Recession.[31]

5.3 Variation in financial tightness at the sectoral level

Another source of a potential identification issue is the firm-level definition of financial tightness, which might be correlated with other firm-level primitives that influence firm-level employment and output. In our baseline specification, financial tightness enters the model with a lag of one year; i.e., it reflects the financial situation of the firm *before* the period of observation in output and employment. This reduces the role of contemporaneous changes in output or employment on financial tightness measures. Furthermore, firm-fixed effects are included in our panel data estimation. This implies that time-invariant firm-specific features, which may influence employment or output, are not driving the results. It is, however, possible that time-variant, firm-endogenous characteristics play a role. We therefore consider two further specifications. In this section, we define tightness indicators at the industry level. In the following section, we use an exogenous variation to the firms' financial tightness indicator and show that the main correlation reported above remains valid.

Industry-level tightness indicators are calculated similarly to the tightness indicators at the firm level; i.e., the average per year of all firms' tightness indicators in a given sector is calculated. An industry is defined as facing financial tightness if its industry average is below the median of all industries for a given year. The industries are again defined at the 4-digit NOGA level. We then replace the firm-level tightness indicator by the industry-level tightness indicator in equation 2.3 and re-estimate the equation. Again, we cluster standard errors at the industry level to take into account that the indicators now vary at the level of the industry.

Table 2.10 reports our results. The coefficients are similar to those in the baseline table. While low collateral combined with low liquidity is not significant and therefore not robust, all other tightness indicators have a similar impact as in the baseline specification.

[31] In Table 2.18 in the Appendix we show the estimated elasticities for the sample excluding 2009 and 2010. The results are very similar. This indicates that it is not the crisis, which drives the baseline results.

TABLE 2.10: EMPLOYMENT ELASTICITIES WITH FINANCIAL TIGHTNESS MEASURED AT THE INDUSTRY-LEVEL

1) Employment elasticity for not tight firms and marginal effects of financial tightness				
Specification	(1)	(2)	(3)	(4)
Measure of internal tightness	Liquidity	Profitability	Liquidity	Profitability
Measure of external tightness	Collateral	Collateral	Balance sheet	Balance sheet
γ_y	0.183***	0.179***	0.188***	0.195***
	(0.020)	(0.021)	(0.014)	(0.015)
$\gamma_{y,int}$	0.118***	0.117***	0.093***	0.084***
	(0.028)	(0.024)	(0.024)	(0.022)
$\gamma_{y,ext}$	0.029	0.043*	0.050**	0.052**
	(0.023)	(0.024)	(0.021)	(0.021)
R^2	0.364	0.363	0.364	0.363
2) Implied employment elasticity $\tilde{\gamma}_y$ depending on financial tightness				
No tightness	0.183	0.179	0.188	0.195
Only internal	0.300	0.297	0.282	0.279
Only external	0.212	0.223	0.239	0.247
Internal and external	0.330	0.340	0.332	0.330

Notes: The first panel 1) on the top shows the response in employment to a one percent change in output, depending on whether a firm faced financial tightness in the previous period. The direct impact of a one percent decline in output is given by γ_y on the first line. $\gamma_{y,int}$ is the marginal effect of facing internal financial tightness, and $\gamma_{y,ext}$ is the marginal effect of facing external financial tightness. Robust standard errors are in parentheses; ***$p < 0.01$, **$p < 0.05$, and *$p < 0.1$. Panel 2) reports the sum of the interaction coefficients (the standard deviations have been excluded; all are significant at the one percent level).

5.4 Variation of financial tightness due to financial profits

We analyse the impact of the possible endogeneity of the financial tightness indicators by using a measure of exogenous variation to the firms' profits. Some firms hold financial assets, and in our database, these firms report their revenue stemming from these assets. We test if an exogenous change in profits stemming from a change in financial profits impacts employment in the same way as operative profits do. Financial revenue and write-downs occur when firms hold financial assets that gain or lose in value or when the firm receives a dividend payment on their financial assets. According to Swiss accounting standards, these include only profits or losses with variable returns, which are arguably unpredictable. Fixed interest payments or interest income have a separate position on the balance sheet and are not included in net financial revenue. The underlying assumption is that variation in financial profits in period $t-1$ reflects changes in profits that are orthogonal to firms' shocks that drive both output and employment in period t.

We implement this idea by estimating equation 2.2 with $\tilde{\gamma}_y$ specified as follows:

$$\tilde{\gamma}_y = \gamma_y + \gamma_{y,fin} ProfFin_{i,t-1} + \gamma_{y,op} ProfOp_{i,t-1}, \tag{2.4}$$

where profitability is divided in two variables: financial profitability, $ProfFin_{i,t-1}$, is the part of the financial tightness indicator due to low profitability, which is driven by the revenue from holding financial assets minus the losses due to firms' write-downs on financial assets, while operative profitability $ProfOp_{i,t-1}$ is calculated as the difference between total profitability and financial profitability.

Note that we do not use a binary classification of profitability as in the baseline case but use the level variable directly. The reason is that the share of financial profits in total profits is usually small and that therefore, financial profits are not a decisive factor behind a firm's classification in the bin with high and low financial tightness. Our analysis in Section B.3.3 in the Appendix suggests, however, that small changes only have an effect in the upper half of the distribution, in which financial tightness has a monotonic impact on employment (see Figure 2.11). Thus, we reduce our sample to the upper half of the distribution, in which we can expect a monotonic effect of financial tightness. Because of this, and not all firms have financial income or write-downs, the sample is reduced to $10,120$ observations in this analysis.

Table 2.11 shows the estimated coefficients, confirming that firms with larger financial or operating profitability (less tight) adjust employment less than firms facing financial tightness. The coefficients of the two interaction terms for financial and operating profitability are not significantly different from each other. Thus, a one percent decline in financial profitability has a qualitatively similar effect on labour hoarding as a one percent decline in operating profitability, suggesting that the internal financial tightness that hinders labour hoarding is not solely a result of unobservable idiosyncratic factors, which might influence both profitability and employment. Together with the fact that net financial profits are arguably exogenous to a firm's idiosyncratic shocks, as argued above, we interpret this as evidence that the financial situation causally impacts labour hoarding behaviour.

TABLE 2.11: EMPLOYMENT ELASTICITIES WITH EXOGENOUS VARIATION IN PROFITABILITY

γ_y	0.247***
	(0.027)
$\gamma_{y,fin}$	-0.333***
	(0.075)
$\gamma_{y,op}$	-0.272***
	(0.072)
Robust standard errors in parentheses	
***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.	

Notes: Estimated effect of internal tightness measured by financial profits ($\gamma_{y,fin}$) and operating profits ($\gamma_{y,op}$) separately. Financial profits are only components of the balance sheet and are exogenous to a firm's productivity or idiosyncratic shocks. Robust standard errors in parentheses; ***$p < 0.01$, **$p < 0.05$, and *$p < 0.1$.

6 Macroeconomic implications

Our final application is to estimate how large the macroeconomic impact of financial tightness is on employment growth. We take our firm-level findings to the macro level by means of a counterfactual analysis. We estimate a counterfactual aggregate employment growth series excluding the impact of financial tightness on the labour hoarding behaviour of firms. First, at the firm level, we exclude the impact of financial tightness by deducting the interaction terms combining financial tightness and output growth, as in equation (4), from actual employment. Then, these firm-level counterfactual growth rates are weighted with the number of employees of each firm and added up to an aggregate counterfactual growth series.[32] The results of this exercise show that the effect of financial tightness on labour hoarding is quantitatively important for aggregate employment. Table 2.12 shows the percentage reduction in the variance of the counterfactual compared to actual aggregate employment.[33] Depending on the specification, the variance of the aggregate employment growth would be 17.5% to 27.9% lower if internal and external financial tightness had not influenced the scope of the firms' labour hoarding. As seen in all previous estimates, the impact is smaller when only a single tightness indicator is taken into account.

The Great Recession is a good example, with which one can illustrate the impact of

[32]Employment growth is aggregated using a two-step aggregation procedure. First, a weighted mean is constructed at the sector level using firm-level data. Second, the sector weighted means are aggregated using sector weights derived from the SFSO employment statistics. This two-step aggregation procedure helps mitigate any possible bias which might occur because the coverage of small firms is smaller than that of large firms.

[33]Figure 2.12 in the Appendix illustrates the counterfactual reported in column (1) for all time periods. Note that the effect looks slightly smaller than suggested by the reduction in the variance because this graphical representation illustrates a reduction in the standard deviation. As expected from a labour hoarding perspective, the effect is rather small during more tranquil periods, while it is quite substantial during the recession in 2009 or the recovery in 2010.

TABLE 2.12: REDUCTION IN VARIANCE OF THE COUNTERFACTUAL COMPARED TO ACTUAL AGGREGATE EMPLOYMENT

Specification	(1)	(2)	(3)	(4)
Measure of internal tightness	Liquidity	Profitability	Liquidity	Profitability
Measure of external tightness	Collateral	Collateral	Balance sheet	Balance sheet
Excluding impact of only internal constraints	-23.36	-15.30	-18.88	-12.45
Excluding impact of only external constraints	-9.19	-7.87	-8.59	-9.18
Excluding impact of internal and external constraints	-27.94	-19.02	-23.11	-17.46

financial tightness on employment growth: aggregate employment of the firms included in our sample increased by 3.5% in 2008, when the economy was still growing dynamically in a period shortly before the recession set in. In 2009, aggregate employment decreased by 1.2% and rose by 2.1% in 2010.[34] The fluctuations in employment would have been smaller if the firms had faced no financial strains in liquidity and collateral. The counterfactual would have increased by 2.9% in 2008, decreased by 1.1% in 2009, and would have increased again by1.0% in 2010. Thus, while aggregate employment growth decreased by 4.7% from peak to trough, our counterfactual only decreased by 4.0%. During the upturn in 2010, employment growth increased by 3.3%, while the counterfactual only increased by 2.1%. For the other combinations of financial tightness measures, the change in employment growth lies in the same range.

This example describes well the impact of the firms' financial tightness on the labour hoarding behaviour: financial tightness is not the cause of employment cycles, but it influences the extent of employment fluctuations.

7 Further tests

We have conducted further estimates to test the correctness of our baseline specification and the robustness of our results.

In Section B.3.3, we analyse the monotonicity of the impact of financial tightness on employment for a finer grid. The results of this exercise show that financial tightness does not have a linear influence on employment. The decrease is in most cases monotonic only in the upper end of the distribution, for firms that have less financial tightness. At the lower end, where firms are in financially more tight situations, the pattern is not clear-cut.

[34] These figures do not coincide exactly with the official labour statistics (the payroll survey and the labour force survey) because the source is different and some sectors such as public administration and financial services are not included in our data set. However, the overall development is similar.

These results indicate that our binary classification with the median as the threshold in the baseline specification is a sound choice. We illustrate this feature with a linear estimation complemented by a piece-wise estimation.

Further, in Section B.4, we test if the financial situation of a firm has long-term effects. We find that the long-run employment elasticity for firms, is in all cases very small and mostly not significant.

In Section B.5, we conduct several robustness tests with alternative specifications. For example we add industry-fixed effects interacted with the measures of financial tightness or industry-level trends. We also run the estimation with industry-fixed effects, instead of firm-fixed effects. Such alterations have practically no impact on the marginal effect of financial tightness on employment.

8 Conclusions

This paper documents the role of financial tightness on employment adjustment by using firm-level data from balance sheets and income statements, including firm-level employment statistics. We use a large unbalanced panel of firm-level balance sheet and income statement data ranging from 1998 to 2016, including all industries of the economy, except the financial and public sectors. Also included are very small firms, which typically do not publish their financial statements. We find that the adjustment of the firms' employment to changes in output depends on their financial situation. Firms with limited funding availability resize their labour force more strongly than firms that have abundant funding availability. Firms that are not in a financially tight situation are able to hoard more labour.

More specifically, we show not only that limited external financing is an important factor but also that the availability of internal funding, in particular, has a large influence. The strongest effect is observed if internal and external financial tightness occur jointly. Furthermore, the impact of financial tightness is generally lower for firms paying high wages. This result suggests that it is particularly costly to lay off workers with higher wages, who tend to be more-skilled workers.

The amplifying effects of financial tightness are quite similar in upturns and downturns. Firms in a strained financial situation not only decrease their employment more when

output decreases but also increase their employment more strongly when output increases. Our results are therefore consistent with the view that financial tightness impedes the labour hoarding behaviour of firms, because firms that hoard labour during a downturn do not hire as much labour in an upturn. We furthermore show by means of a counterfactual analysis that this effect is relevant for aggregate employment, suggesting that employment would have declined by around two thirds of its actual decline during the Great Recession if financial tightness would not have hindered labour hoarding. This implies that financially tighter firms amplify the co-movement between employment and output. In contrast, a weak cyclicality of employment, caused by strong labour hoarding, is largely driven by financially healthy firms.

These results complement the large body of literature on the role of financial constraints on investment; in this literature, financial constraints are typically found to increase the sensitivity of investment to shocks. Through this channel, financial frictions are found to amplify the propagation of shocks to the macroeconomy. Our results suggest that a similar mechanism works through the labour market and that the depth of financial frictions is potentially important to understand labour hoarding, confirming and extending the findings in Giroud and Mueller (2017). As we look at the response of employment to changes in output, our results have implications for the cyclicality of labour productivity. In particular, an economy with more financially healthy firms would be characterized by more cyclical labour productivity. An interesting avenue for future research would be to examine the strong increase in the cyclicality of labour productivity documented in Fernald and Wang (2016) and to evaluate the role of firms' improved financial health and reduction in financial tightness.

B Appendix

B.1 An empirical model of labour demand

In our empirical section, we estimate a labour demand equation. This equation can be derived from a partial equilibrium model, largely following Nickell (1986) and Nickell and Nicolitsas (1999). Even though we do not explicitly derive the financial tightness indicators from a microfoundation, this short sketch of a model is helpful for understanding the empirical estimation equation in the main text. Note that we refer here to financial constraints, not financially tight situations, because the former is the standard term used in most of the literature.

We assume a simple production function, which is identical for all firms. Firms produce output y by using labour n and capital k according to the production function (lowercase letters are all in logs):

$$y_t = a_t + \alpha n_t + (1-\alpha)k_t, \tag{2.5}$$

where a denotes productivity.

Firms maximise profits and take an iso-elastic demand curve with demand elasticity ε as given. The equilibrium level of labour is therefore given by the following first order condition:

$$n_t^* = \tilde{a_0} - w_t + y_t + a_t, \tag{2.6}$$

where $\tilde{a_o} \equiv -1/(\alpha-1)ln(\varepsilon\alpha)$ is a constant and w_t is the log real wage.

Adjusting labour is costly, and adjustment costs are denoted by the quadratic function $C_t = W_t \frac{b}{2}(\Delta N_t)$. The firm maximises the present discounted value of the firm as follows:[35]

$$max \sum_{k=0}^{\infty} E_t[\beta^{t+k}(P_{t+k} * Y_{t+k} - W_{t+k}N_{t+k} - C_{t+k})], \tag{2.7}$$

where β is the discount factor defined as an inverse function of the real interest rate $\beta = \frac{1}{1-r}$. Nickell (1986) shows that log-linearizing the first order condition yields the following:

$$n_t = \mu n_{t-1} + (1-\mu)(1-\mu\beta)\sum_{k=0}^{\infty}(\mu\beta)^k n_{t+k}^*., \tag{2.8}$$

[35] To simplify, we assume that the aggregate price level is equal to one in all periods.

where μ is the stable root of the Euler equation.

Plugging (2.6) into (2.8) and assuming that real wages, output, and productivity follow AR(1) processes, [36] we obtain the following:

$$n_t = \mu n_{t-1} + a_0 + a_1 y_t + a_2 a_t + a_3 w_t + \varepsilon_t, \tag{2.9}$$

where $a_0 \equiv \tilde{a_o}(1-\mu)$, $a_1 \equiv \frac{(1-\mu)(1-\mu\beta)}{1-\mu\beta\rho_y}$, $a_2 \equiv \frac{(1-\mu)(1-\mu\beta)}{1-\mu\beta\rho_a}$, and $a_3 \equiv \frac{(1-\mu)(1-\mu\beta)}{1-\mu\beta\rho_w}$.

Following a large literature based on Bernanke, Gertler, and Gilchrist (1996), we assume that if firms are financially constrained, it becomes more expensive for them to obtain external finance.[37] Therefore, financing hoarded labour becomes more expensive, especially for firms with internal funds, such as cashflows or retained earnings, that are insufficient. If this is the case, then a_1 is a positive function of the financial constraint, and firms that are financially constrained are expected to have a larger a_1 than financially unconstrained firms.[38] Denote the indicator for a financially constrained firm i as $I(constrained) = 1$ and zero otherwise; then, the estimation equation is given by the following:

$$n_{it} = \mu n_{i,t-1} + a_{i0} + a_1^{unconstr} y_{it} + a_1^{constr} I(constrained)_i \times y_{it} + a_2 a_{it} + a_3 w_{it} + \varepsilon_{it}; \tag{2.10}$$

Thus, employment depends on lagged employment, a firm fixed effect, output and output interacted with the financial constraint, productivity, and real wages.

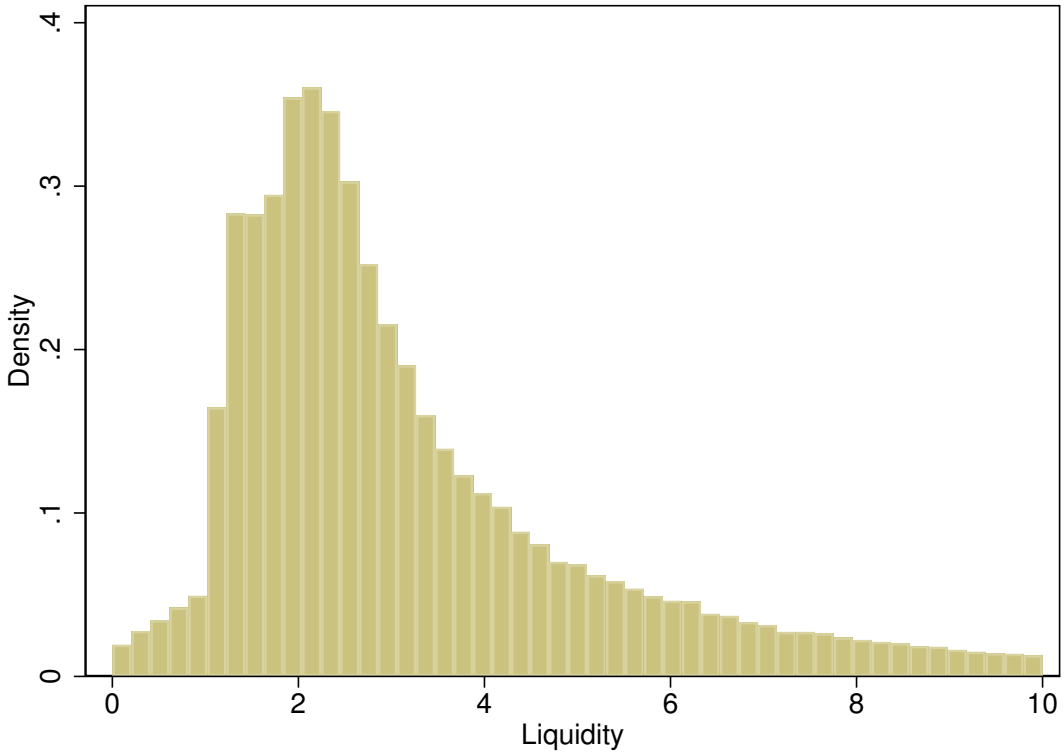
[36] The AR(1) processes are specified as $w_t = \rho_w w_{t-1} - p + \varepsilon_t^w$, $y_t = \rho_y y_{t-1} + \varepsilon_t^y$, and $a_t = \rho_a a_{t-1} + \varepsilon_t^a$, where all $E_t \varepsilon_{t+1} = 0$ are uncorrelated.

[37] Costs, such as agency costs and asymmetric information, lead to an imperfect substitutability between internal and external funds and thereby to a premium on external finance (Bernanke and Gertler, 1995).

[38] In addition, a_2 and a_3 can depend on the financial constraint. We tested this empirically and found these interaction terms to be very close to zero and statistically insignificant. We therefore did not add these interactions to our baseline regressions.

B.2 Descriptive statistics

FIGURE 2.3: LIQUIDITY, 1999-2016



Notes: Distribution of firms' liquidity (sales to labour costs ratio)

FIGURE 2.4: LIQUIDITY, BY INDUSTRY, 1999-2016

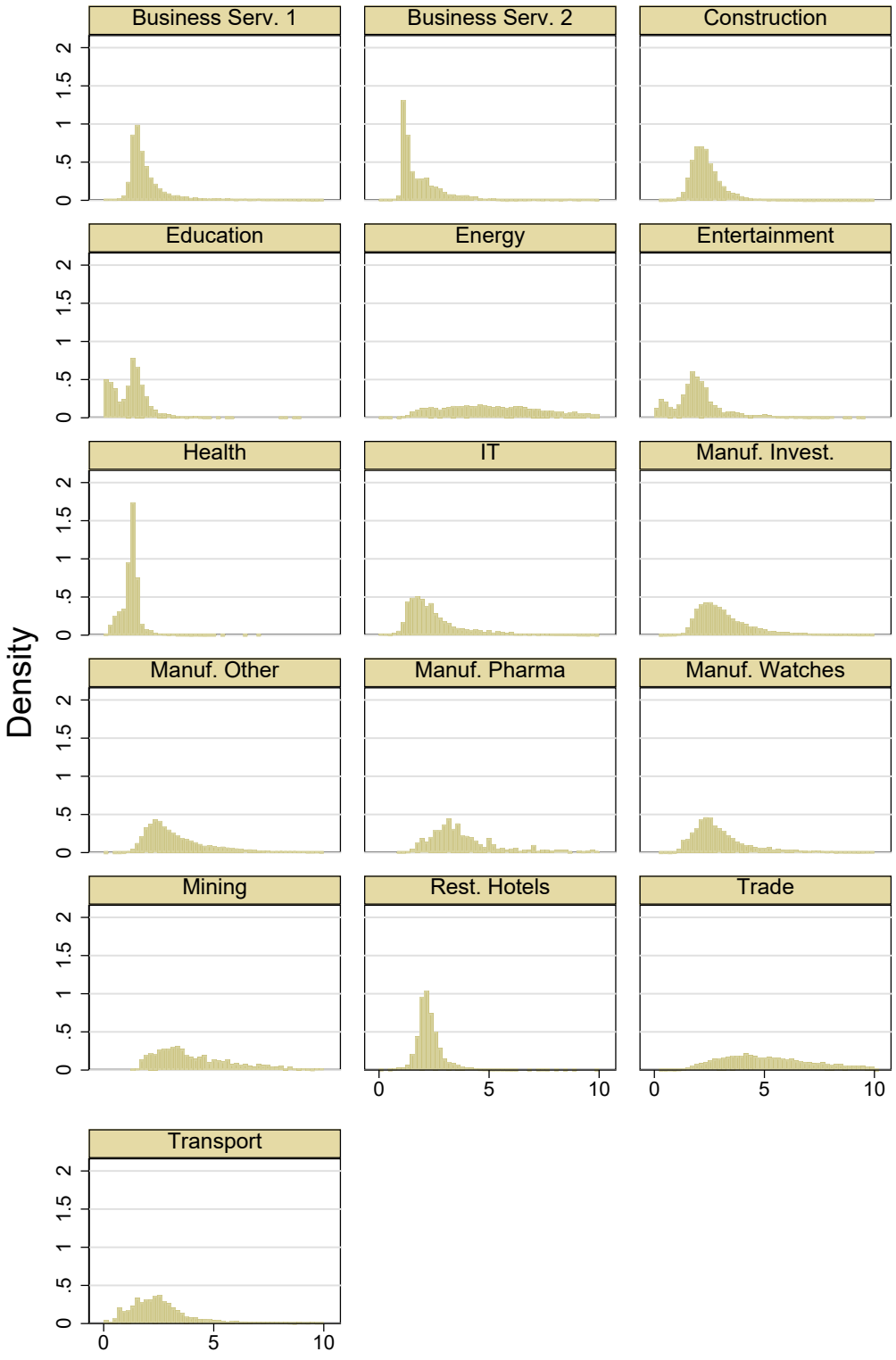
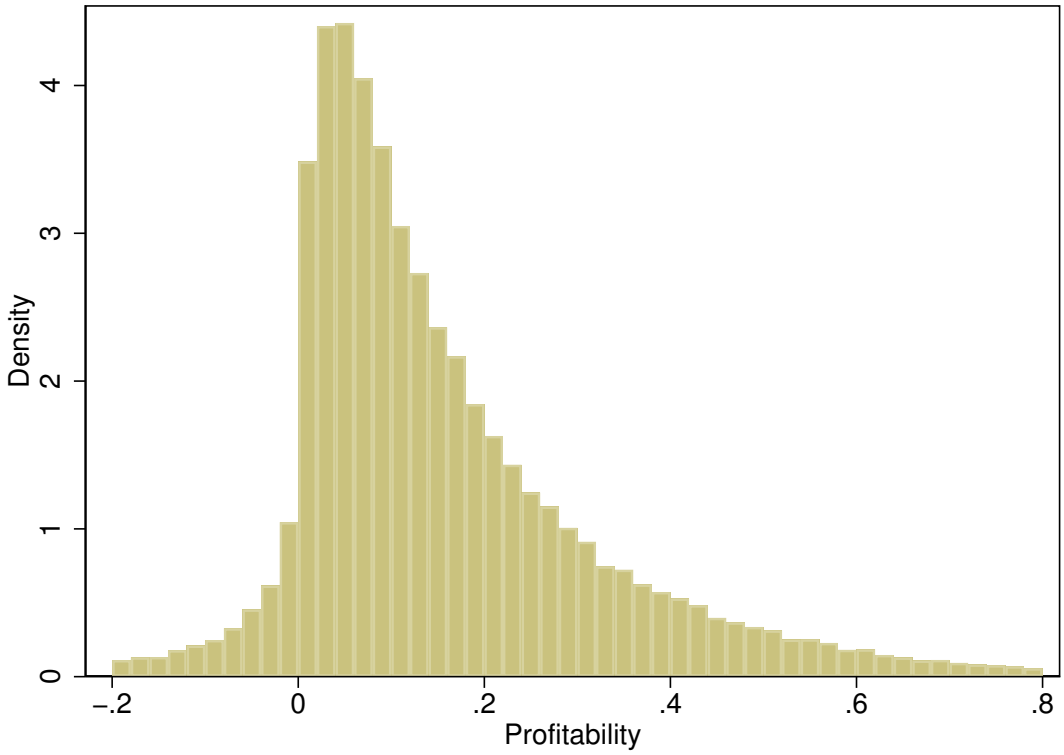


FIGURE 2.5: PROFITABILITY, 1999-2016



Notes: Distribution of firms' profitability (EBIT to value added ratio)

FIGURE 2.6: PROFITABILITY, BY INDUSTRY, 1999-2016

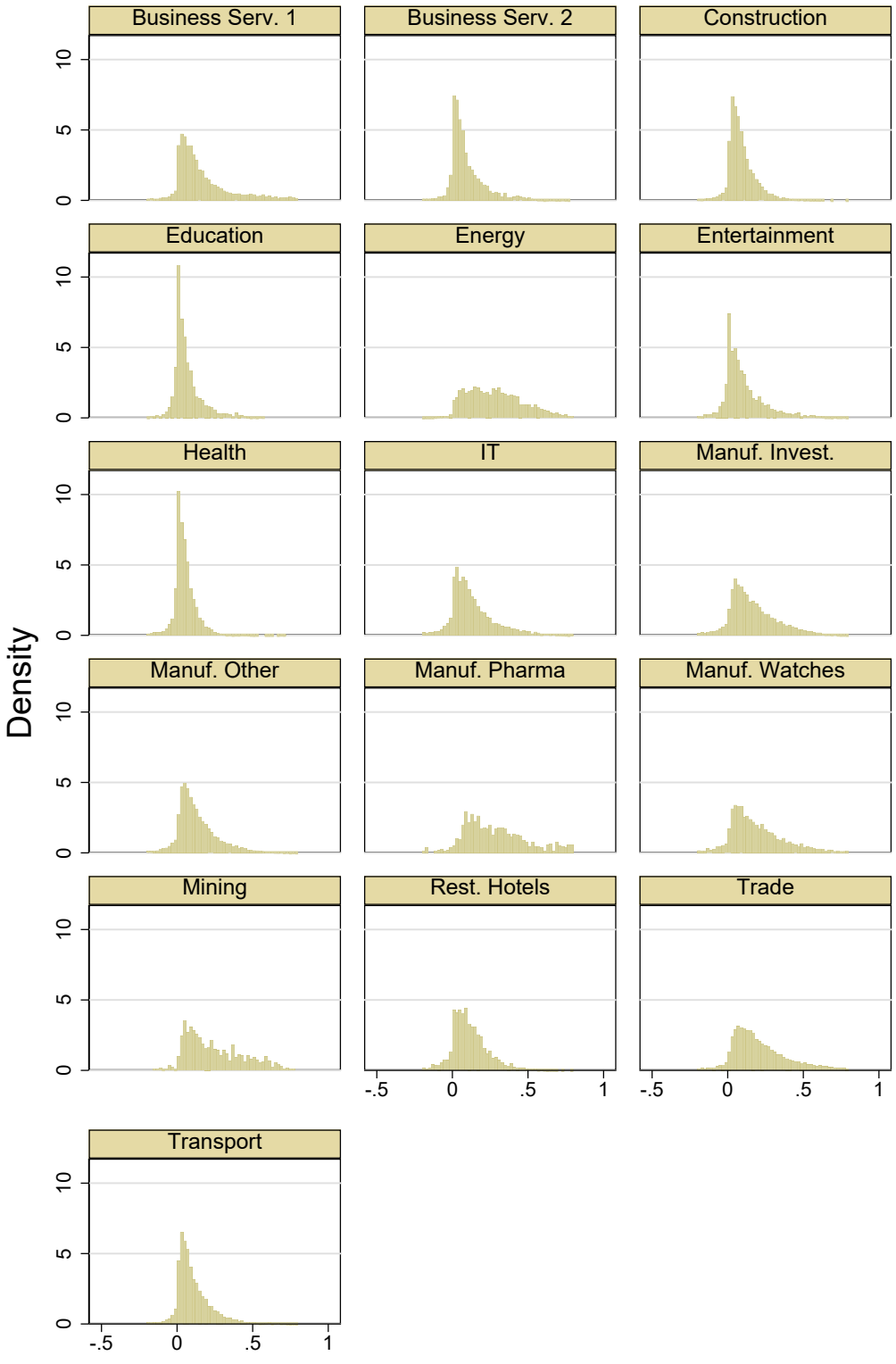
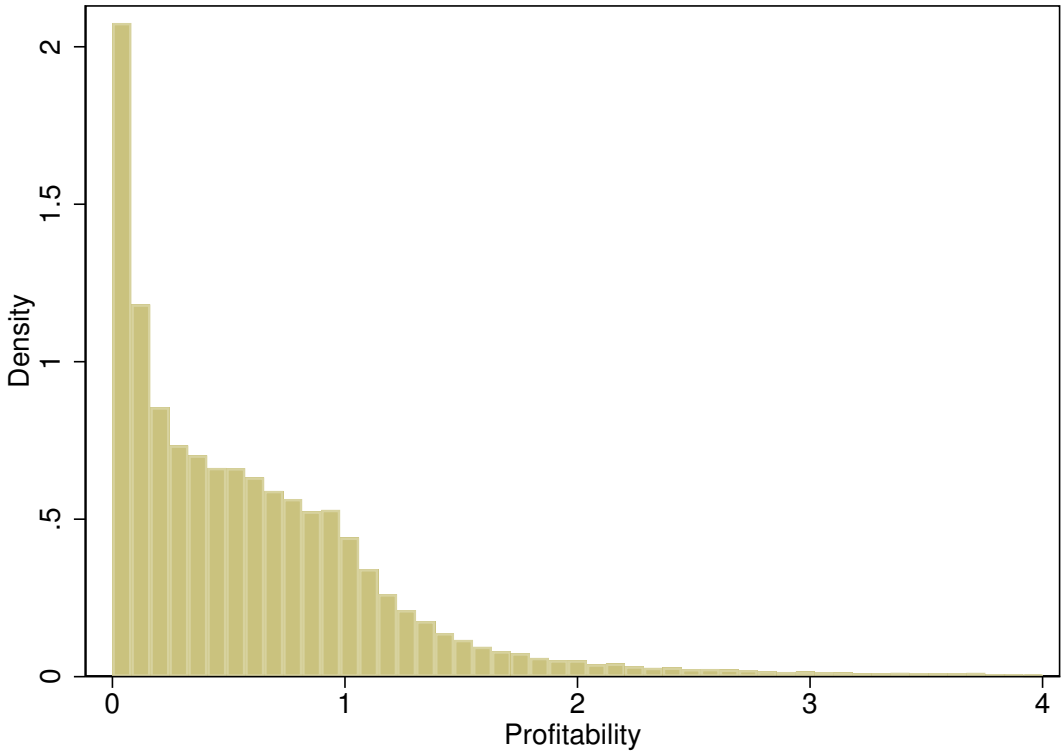


FIGURE 2.7: COLLATERAL, 1999-2016



Notes: Distribution of firms' collateral (sum of a firm's structures (buildings and land) and machines per unit of outstanding debt)

FIGURE 2.8: COLLATERAL, BY INDUSTRY, 1999-2016

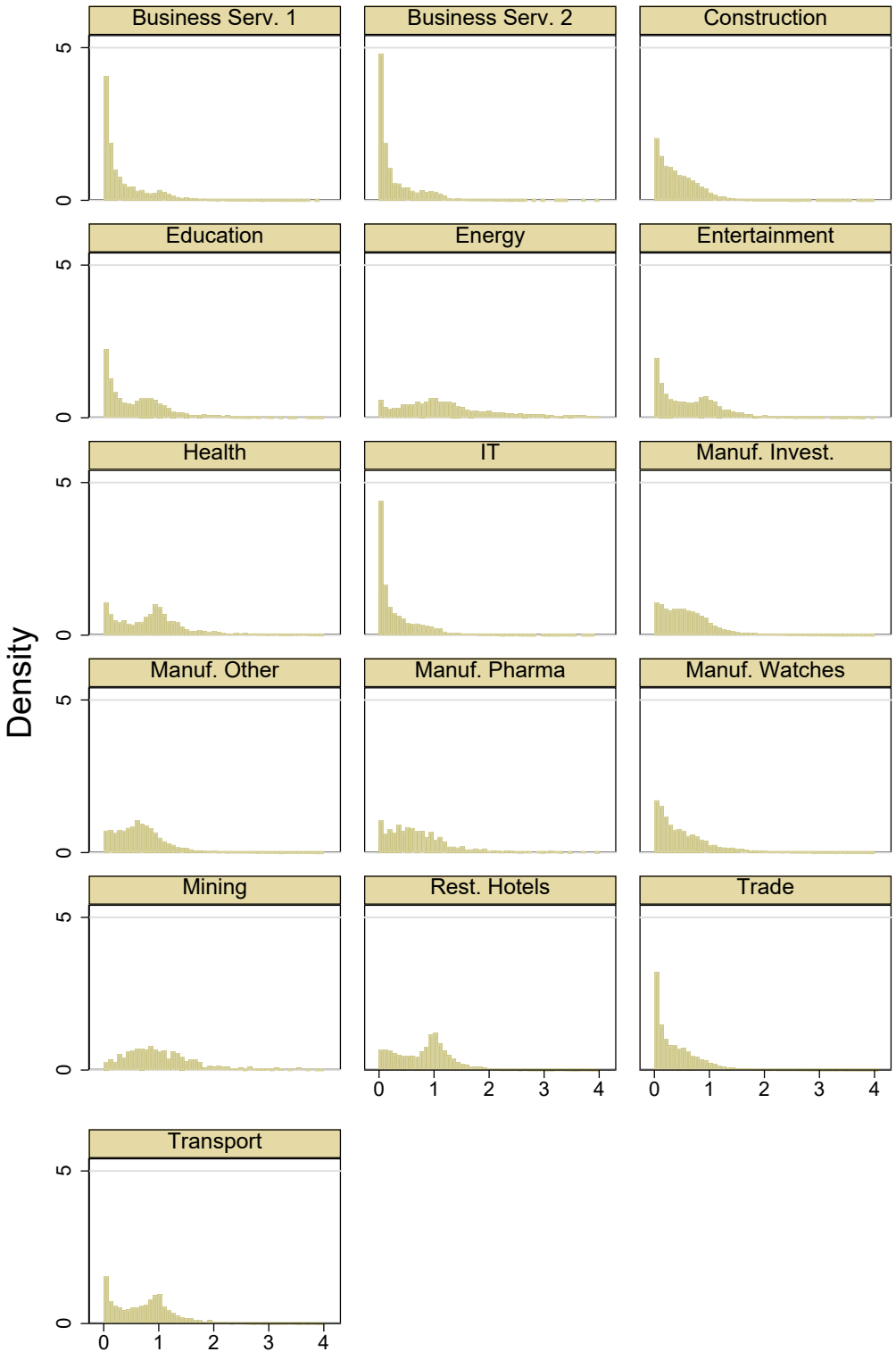
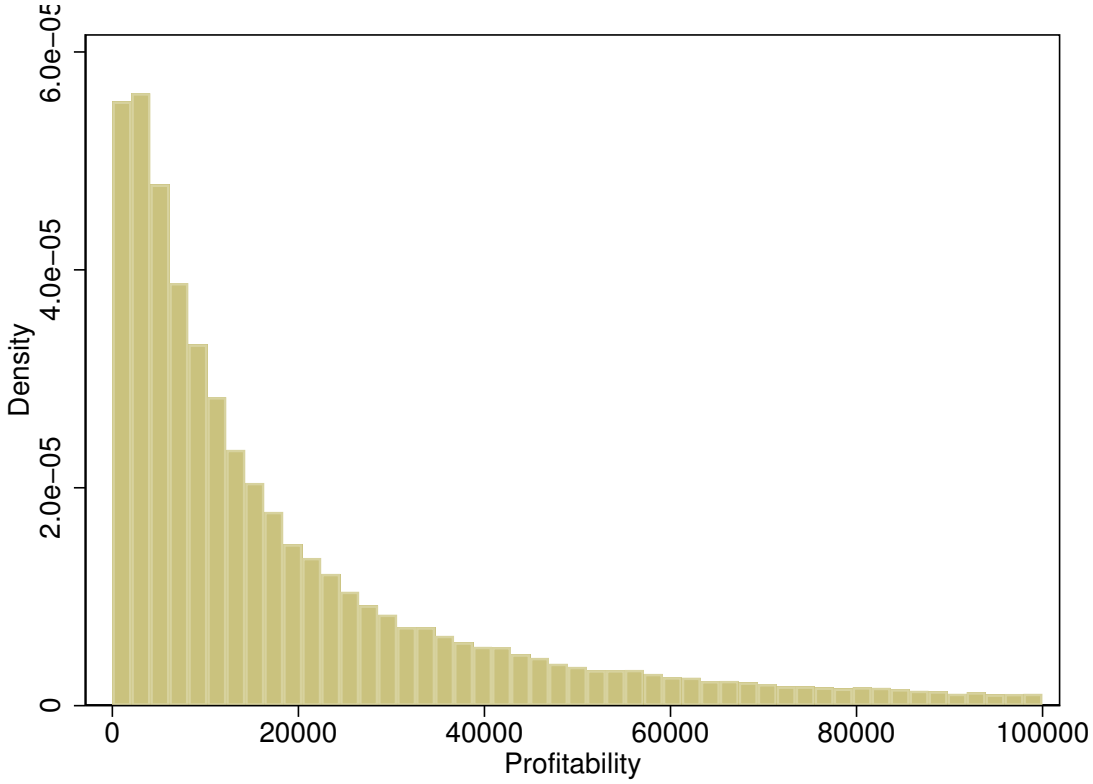


FIGURE 2.9: SIZE OF BALANCE SHEET, 1999-2016



Notes: Distribution of the size of balance sheet (in 1000 CHF)

FIGURE 2.10: SIZE OF BALANCE SHEET, BY INDUSTRY, 1999-2016

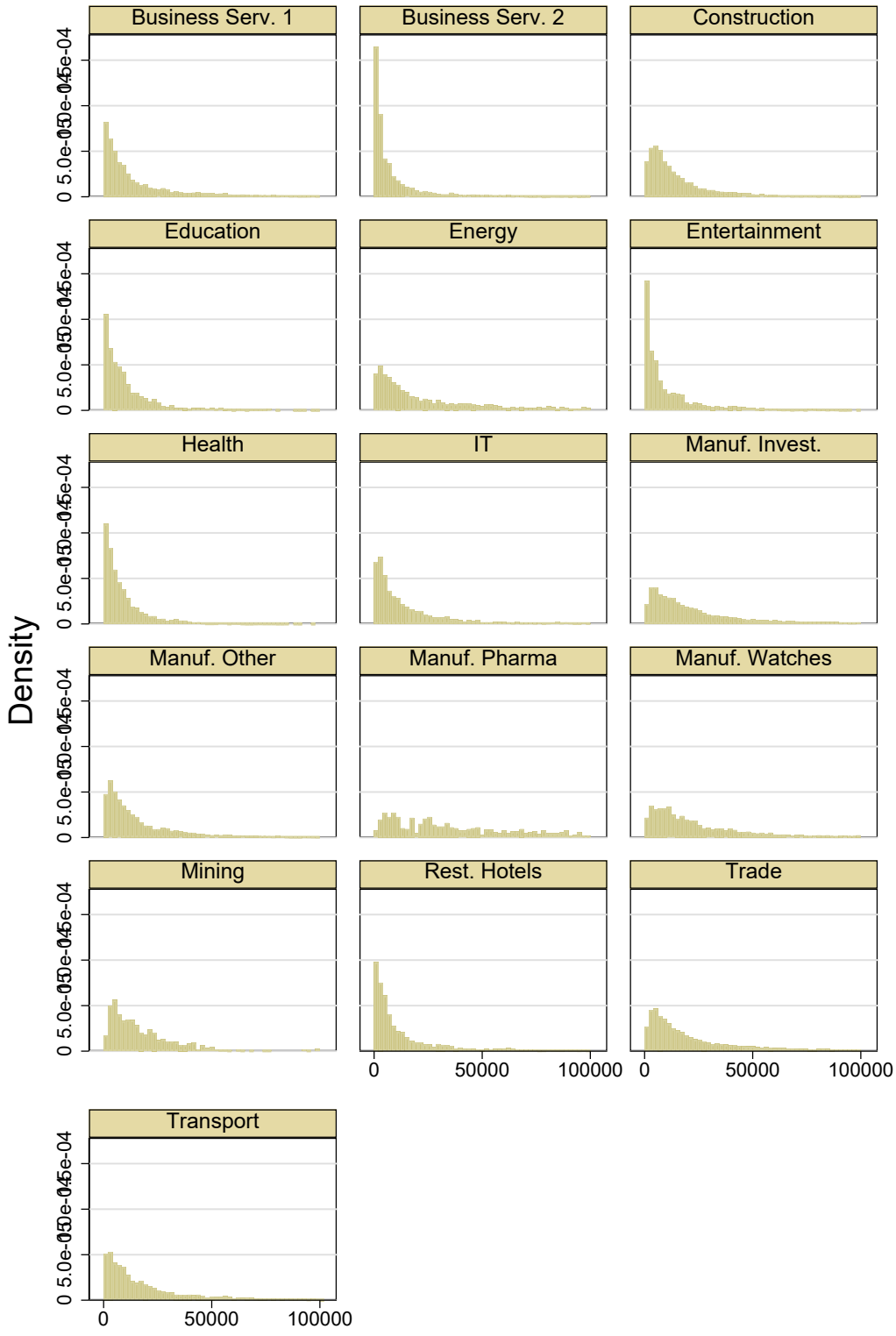


TABLE 2.13: AVERAGE SHARE OF EXPENDITURES ON TEMPORARY WORK TO TOTAL LABOUR COSTS

	in%
Aggregate	2.0
Industry	
Business Services 1	1.3
Business Services 2	2.1
Construction	4.6
Education	0.9
Energy	1.8
Entertainment	1.7
Health	1.0
IT	1.9
Manufacturing Pharmaceuticals	1.0
Manufacturing Investment goods	1.8
Manufacturing Watches and electronics	1.9
Manufacturing Other	1.3
Mining	2.8
Restaurants Hotels	1.4
Trade	1.1
Transport	1.4

TABLE 2.14: SUMMARY STATISTICS FOR TEMPORARY DEMAND SHOCK SAMPLE

	Observations		*Employment*	*Value added*
	Total	Firms	average per firm	average per firm
Whole sample	15440	5530	243	48783
Industries				
Business Serv. 1	774	318	182	53013
Business Serv. 2	406	195	326	29604
Construction	2534	810	150	17589
Education	112	65	97	12772
Energy	615	204	163	66359
Entertainment	232	107	95	17722
Health	787	381	108	9658
IT	501	205	320	90433
Manuf. Pharma	167	51	994	852151
Manuf. Invest.	3586	1080	225	35384
Manuf. Other	1650	540	185	31176
Manuf. Watches	739	246	233	38721
Mining	112	41	58	12099
Rest. Hotels	370	159	211	16943
Trade	2137	865	300	53990
Transport	718	263	766	117097

Notes: See table 2.1 in the main text. These summary statistics apply to the sample that is in the definition for temporary demand shocks.

TABLE 2.15: SUMMARY STATISTICS FOR THE FINANCIAL TIGHTNESS VARIABLES FOR TEMPORARY DEMAND SHOCK SAMPLE

	Liquidity		*Profitability*		*Collateral*		*Bal.Sheet*	
Whole sample	2.72	19.65	0.11	0.20	0.46	4.17	18886	2365154
Within industries								
Business Serv. 1	1.85	13.67	0.10	0.22	0.15	1.07	21198	577647
Business Serv. 2	1.76	2.19	0.06	0.15	0.18	0.51	8825	109524
Construction	2.26	1.26	0.07	0.09	0.32	0.48	12094	70482
Education	1.35	0.87	0.04	0.12	0.37	0.71	6795	27083
Energy	5.00	8.89	0.24	0.18	1.32	19.80	50128	965420
Entertainment	1.92	2.02	0.06	0.23	0.38	0.83	11420	98573
Health	1.31	0.41	0.04	0.08	0.87	2.19	7363	38123
IT	2.38	4.49	0.12	0.17	0.23	0.56	19900	1726019
Manuf. Pharma	3.87	16.53	0.30	0.27	0.62	0.93	82432	12092312
Manuf. Invest.	2.97	2.34	0.13	0.19	0.53	0.93	25072	280966
Manuf. Other	3.04	2.36	0.10	0.17	0.62	0.84	16065	214073
Manuf. Watches	2.70	1.76	0.15	0.38	0.43	0.85	25055	382069
Mining	3.41	2.87	0.18	0.18	1.32	1.31	18254	32656
Rest. Hotels	2.07	0.47	0.08	0.13	0.65	0.88	9302	40175
Trade	5.76	50.55	0.18	0.23	0.26	0.75	29924	2433298
Transport	2.63	3.37	0.08	0.13	0.76	1.26	24733	7896727
Between industries								
Industr.-means	2.51	1.25	0.10	0.07	0.48	0.36	19077	19252

Notes: See table 2.2 in the main text. These summary statistics apply to the sample that is in the definition for temporary demand shocks.

B.3 Additional results

B.3.1 Coefficient estimates for control variables

TABLE 2.16: IMPACT OF A 1% CHANGE IN OUTPUT ON EMPLOYMENT, FULL REGRESSION OUTPUT

	Coefficient	Std.Err.	t	p
γ_y	0.170	0.008	22.51	0.00
$\gamma_{y,int}$	0.151	0.010	14.97	0.00
$\gamma_{y,ext}$	0.044	0.009	4.88	0.00
γ_{int}	-0.028	0.002	-15.05	0.00
γ_{ext}	-0.003	0.001	-2.04	0.04
Δe (lag)	0.016	0.001	12.57	0.00
Δw	-0.587	0.011	-55.27	0.00
Δtfp	-0.008	0.003	-2.98	0.03
$\Delta capitalstock$	-0.079	0.006	-13.79	0.00
capital/labour (lag)	0.000	0.000	2.80	0.01
year				
2001	-0.000	0.002	-0.18	0.85
2002	-0.024	0.002	-9.66	0.00
2003	-0.036	0.002	-14.56	0.00
2004	-0.029	0.002	-12.21	0.00
2005	-0.020	0.002	-9.24	0.00
2006	-0.019	0.002	-8.33	0.00
2007	-0.011	0.002	-4.90	0.00
2008	-0.012	0.002	-5.24	0.00
2009	-0.044	0.003	-15.48	0.00
2010	-0.031	0.003	-12.17	0.00
2011	-0.016	0.002	-6.34	0.00
2012	-0.031	0.002	-13.20	0.00
2013	-0.034	0.002	-15.30	0.00
2014	-0.035	0.002	-15.55	0.00
2015	-0.045	0.002	-19.51	0.00
2016	-0.043	0.002	-18.62	0.00
Constant	0.051	0.002	23.36	0.00

Full regression output is shown for Equation (2.2), with low liquidity as a measure of internal financial tightness and a low collateral ratio as a measure of external financial tightness. Full regression outputs for the other specifications are available on request.

B.3.2 Tests for asymmetry and sensitivity to definitions of upturns and downturns

TABLE 2.17: ASYMMETRY BETWEEN DOWNTURN AND UPTURN, PANEL DATA ESTIMATION

Specification	(1)	(2)	(3)	(4)
Measure of internal tightness	Liquidity	Profitability	Liquidity	Profitability
Measure of external tightness	Collateral	Collateral	Balance sheet	Balance sheet
γ_y	-0.031	-0.026	-0.024	-0.022
	(0.020)	(0.019)	(0.017)	(0.016)
$\gamma_{y,int}$	0.042	0.074***	0.052*	0.074***
	(0.027)	(0.026)	(0.027)	(0.027)
$\gamma_{y,ext}$	-0.008	-0.009	-0.042	-0.040
	(0.025)	(0.025)	(0.028)	(0.029)

Notes: This table reports the difference between the coefficients for downturns and for upturns, both of which are reported in Tables 2.4 and 2.5. We subtract the coefficient for the upturn estimates from that of the downturn estimates. A negative and significant coefficient implies that a firm lays off more staff with a one percent decline in output than it hires with a one percent increase in output (and for a positive coefficient, vice versa). The standard deviation is in parentheses; ***$p < 0.01$, **$p < 0.05$, and *$p < 0.1$.

TABLE 2.18: EMPLOYMENT ELASTICITIES AND FINANCIAL TIGHTNESS FOR ALL YEARS EXCEPT 2009 AND 2010

1) Employment elasticity for not tight firms and marginal effects of financial tightness				
Specification	(1)	(2)	(3)	(4)
Measure of internal tightness	Liquidity	Profitability	Liquidity	Profitability
Measure of external tightness	Collateral	Collateral	Balance sheet	Balance sheet
γ_y	0.164***	0.187***	0.168***	0.182***
	(0.008)	(0.008)	(0.007)	(0.007)
$\gamma_{y,int}$	0.157***	0.138***	0.119***	0.103***
	(0.011)	(0.010)	(0.011)	(0.010)
$\gamma_{y,ext}$	0.049***	0.040***	0.118***	0.132***
	(0.009)	(0.009)	(0.011)	(0.011)
R^2	0.356	0.364	0.362	0.372
2) Implied employment elasticity $\tilde{\gamma}_y$ depending on financial tightness				
No tightness	0.164	0.187	0.168	0.182
Only internally	0.321	0.325	0.287	0.285
Only externally	0.213	0.227	0.286	0.313
Internally and externally	0.370	0.365	0.405	0.416
3) Number of observations				
No tightness	18,438	19,511	25,259	24,921
Only internal	19,254	18,181	13,732	14,070
Only external	18,919	17,909	12,111	22,482
Internal and external	17,357	18,367	22,881	22,482

Notes: The first panel 1) on the top shows the response in employment to a one percent change in output, depending on whether a firm faced financial tightness in the previous period. The direct impact of a one percent decline in output is given by γ_y on the first line. $\gamma_{y,int}$ is the marginal effect of facing internal financial tightness, and $\gamma_{y,ext}$is the marginal effect of facing external financial tightness. Robust standard errors are in parentheses; ***$p < 0.01$, **$p < 0.05$, and *$p < 0.1$. Panel 2) reports the sum of the interaction coefficients (the standard deviations have been excluded; all are significant at the one percent level). The last panel shows the number of observations for each specification.

TABLE 2.19: EMPLOYMENT ELASTICITIES AND FINANCIAL TIGHTNESS FOR FIRMS WITH A NEGATIVE DEVIATION FROM AGGREGATE NOMINAL GDP GROWTH

1) Employment elasticity for not tight firms and marginal effects of financial tightness

Specification	(1)	(2)	(3)	(4)
Measure of internal tightness	Liquidity	Profitability	Liquidity	Profitability
Measure of external tightness	Collateral	Collateral	Balance sheet	Balance sheet
γ_y	0.169***	0.198***	0.177***	0.194***
	(0.012)	(0.011)	(0.010)	(0.009)
$\gamma_{y,int}$	0.169***	0.167***	0.133***	0.135***
	(0.014)	(0.016)	(0.015)	(0.016)
$\gamma_{y,ext}$	0.051***	0.038***	0.116***	0.123***
	(0.013)	(0.014)	(0.016)	(0.016)
R^2	0.360	0.376	0.364	0.381

Notes: For all firms whose change in value added lies below nominal GDP growth, this table shows the employment response dependent on whether or not a firm was financially strained in the previous period. The direct impact of a one percent decline in output is given by γ_y on the first line. $\gamma_{y,int}$ is the marginal effect of facing internal financial tightness, $\gamma_{y,ext}$ is the marginal effect of facing external financial tightness, and $\gamma_{y,int,ext}$ is the marginal effect of facing both types of financial tightness. The standard deviation is in parentheses; ***$p < 0.01$, **$p < 0.05$, and *$p < 0.1$.

TABLE 2.20: EMPLOYMENT ELASTICITIES AND FINANCIAL TIGHTNESS INDICATORS FOR FIRMS WITH A POSITIVE DEVIATION FROM AGGREGATE NOMINAL GDP GROWTH

1) Employment elasticity for not tight firms and marginal effects of financial tightness

Specification	(1)	(2)	(3)	(4)
Measure of internal tightness	Liquidity	Profitability	Liquidity	Profitability
Measure of external tightness	Collateral	Collateral	Balance sheet	Balance sheet
γ_y	0.188***	0.216***	0.192***	0.211***
	(0.015)	(0.015)	(0.012)	(0.013)
$\gamma_{y,int}$	0.131***	0.077***	0.091***	0.046**
	(0.020)	(0.018)	(0.020)	(0.018)
$\gamma_{y,ext}$	0.052***	0.043**	0.152***	0.168***
	(0.018)	(0.018)	(0.020)	(0.021)
R^2	0.375	0.381	0.379	0.386

Notes: For all firms whose change in value added lies above nominal GDP growth, this table shows the employment response dependent upon whether or not a firm was faced by financial tightness in the previous period. The response in employment is shown for a one percent change in output. The direct impact of a one percent decline in output is given by γ_y on the first line. $\gamma_{y,int}$ is the marginal effect of facing internal financial tightness, and $\gamma_{y,ext}$ is the marginal effect of facing external financial tightness. Robust standard errors in parentheses, ***$p < 0.01$, **$p < 0.05$, and *$p < 0.1$.

TABLE 2.21: ASYMMETRY BETWEEN THE DOWNTURN IN 2009 AND THE UPTURN IN 2010

Specification	(1)	(2)	(3)	(4)
Measure of internal tightness	Liquidity	Profitability	Liquidity	Profitability
Measure of external tightness	Collateral	Collateral	Balance sheet	Balance sheet
γ_y	0.099**	0.107**	0.093***	0.096***
	(0.042)	(0.041)	(0.032)	(0.032)
$\gamma_{y,int}$	0.035	0.046	0.048	0.054
	(0.050)	(0.049)	(0.053)	(0.051)
$\gamma_{y,ext}$	-0.016	-0.019	-0.05	-0.049
	(0.056)	(0.046)	(0.048)	(0.048)

Notes: This table reports the difference between the coefficients reported in Tables 2.8 and 2.9, for the 2009 downturn and for the 2010 upturn; in the table, we subtract the coefficient for the upturn estimates from that of the downturn estimates. A positive and significant coefficient implies that a firm laid off more staff with a one percent decline in output than it subsequently hired with a one percent increase in output (and a negative coefficient vice versa). The standard deviation is in parentheses; ***$p < 0.01$, **$p < 0.05$, and *$p < 0.1$.

B.3.3 Marginal effects by extent of financial tightness

In the main specification, we have estimated the impact for a firm facing a financially tight situation compared to that for a firm not facing a financially tight situation. Here, we first analyse the impact of financial tightness on employment for a finer grid, which enables us to provide information on whether the impact of financial tightness on employment is evenly distributed. Thereafter, we estimate the equation by using continuous data. This allows us to gain a more detailed picture of the marginal effects of financial tightness indicators.

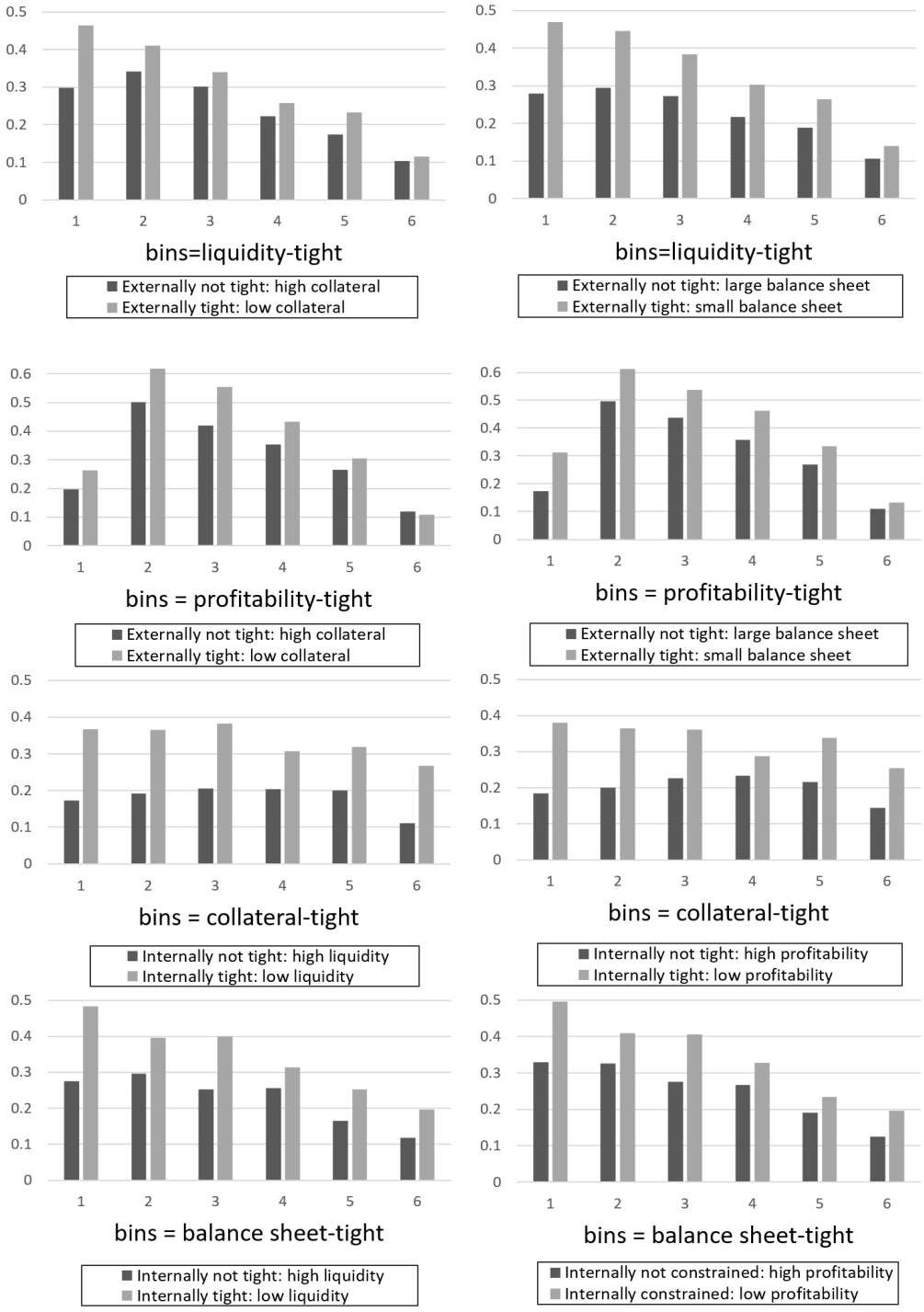
For the finer breakdown, we construct six equally sized bins. The baseline regression is estimated separately six times (once for each bin) for all eight specifications shown in Figure 2.11, resulting thereby in 32 separate estimates.

The upper left chart in Figure 2.11 shows the results for the specification in which the liquidity tightness indicator is combined with the collateral tightness indicator. Note that liquidity is divided into six bins, while the collateral tightness remains a binary variable. The first bin contains the lowest sixth of the distribution, i.e., the most liquidity-tight firms, while the sixth bin contains the less liquidity-tight firms, i.e., the firms with the most-abundant liquidity. The black bars represent the impact of a one percent decrease in output for firms that have high collateral, and the grey bars represent the impact for firms that have low collateral, i.e., that face more financial tightness according to our definitions.

All charts in Figure 2.11 show that firms lay off more labour if they face tightness along both dimensions (grey bars are larger than the black bars). Thus, the results of the baseline specification are confirmed in this exercise. The bars tend to decrease from the first to the sixth bin. This indicates that the results shown in the body of the paper are not driven by the tails of the distributions.

Moreover, Figure 2.11 also shows that financial tightness does not have a linear influence on employment. The decrease is in most cases monotonic only in the upper end of the distribution (bins 4-6). At the lower end, where firms are in financially more tight situations (bins 1-3), the pattern is not clear-cut. In fact, the firms in bin 1 often have a lower elasticity than the firms in the following bins. This is the case especially for the profitability measure of financial tightness (both charts on the second line). Nonetheless, on average, the impact tends to be higher for financially tighter firms (bins 1-3) than for firms that are less financially tight (bins 4-6). These results indicate that our binary classification with the median as the threshold in the baseline specification is a sound choice. Depending on the point in the

FIGURE 2.11: EMPLOYMENT ELASTICITIES DURING A DOWNTURN AND PROVIDING A FINER CLASSIFICATION OF FINANCIAL TIGHTNESS INDICATORS



Notes: The black bars represent the impact of a one percent change in output on employment for a given bin if a firm is not in a financially tight situation, and financial tightness is reflected by the number of the bin. The grey bars include the additional impact of a second financial tightness indicator. Bin (1) contains the lowest sixth of the distribution of a given tightness, i.e., the firms with highest financial tightness, while bin (6) contains the firms that are least financially strained.

distribution, the coefficients of a linear specification would not be robust.

We illustrate this feature with a linear estimation complemented by a piece-wise estimation. Based on a linear specification, the impact of financial tightness on employment is shown in Table 2.22. The coefficients of the interaction terms, $\gamma_{y,int}$ and $\gamma_{y,ext}$, are significant in most cases and have the correct sign.[39] As a further robustness check, the estimation based on the observations that are classified as being those of firms in a financially tight situation in the baseline regression are shown in panel 2). Similarly, in panel 3, the results are shown for firms that are classified as not facing a financially tight situation). The results for the firms with more intense financial tightness show that there are two negative coefficients, namely, the two coefficients that measure the marginal impact of a change in profitability. This confirms the results discussed above. In these two specifications, external tightness has a positive and significant coefficient. Overall, the results in Section 2 indicate that it is not possible to measure the marginal effects of financial tightness on employment for firms in the lower part of the distribution. In contrast, the coefficients for the less-tight firms are mostly significant and positive, reflecting the monotonicity seen in Figure 2.11 for the upper range of the distribution.

[39]Financial tightness indicators are defined as the deviation of the annual mean from the firm-specific measure of tightness. Therefore, lower liquidity, lower profitability, lower collateral or a smaller balance sheet lead to a rise in the measure of tightness and should, in turn, lead to a larger adjustment in employment. Thus, the coefficient of the interaction terms, $\gamma_{y,int}$ and $\gamma_{y,ext}$, should be positive.

TABLE 2.22: EMPLOYMENT ELASTICITIES IN A LINEAR SPECIFICATION

1) Marginal effects of financial tightness - all firms				
Specification	(1)	(2)	(3)	(4)
Measure of internal tightness	Liquidity	Profitability	Liquidity	Profitability
Measure of external tightness	Collateral	Collateral	Balance sheet	Balance sheet
γ_y	0.250***	0.299***	0.288***	0.331***
	(0.006)	(0.008)	(0.006)	(0.007)
$\gamma_{y,int}$	0.001	0.151***	-0.000	0.068***
	(0.000)	(0.026)	(0.000)	(0.022)
$\gamma_{y,ext}$	0.004***	0.003***	0.053***	0.046***
	(0.001)	(0.001)	(0.003)	(0.003)
2) Firms classified as facing a financially tight situation in the baseline				
γ_y	0.339***	0.387***	0.361***	0.461***
	(0.076)	(0.048)	(0.041)	(0.025)
$\gamma_{y,int}$	0.007	-0.257***	0.003	-0.150**
	(0.013)	(0.044)	(0.011)	(0.067)
$\gamma_{y,ext}$	0.049	0.175***	0.052***	0.048***
	(0.078)	(0.065)	(0.015)	(0.013)
3) Firms classified as not facing a financially tight situation in the baseline				
γ_y	0.176***	0.301***	0.230***	0.307***
	(0.010)	(0.012)	(0.010)	(0.011)
$\gamma_{y,int}$	0.003***	0.433***	-0.000***	0.286***
	(0.001)	(0.041)	(0.000)	(0.033)
$\gamma_{y,ext}$	0.002***	0.002***	0.036***	0.018***
	(0.001)	(0.001)	(0.004)	(0.005)

Notes: This table reports the coefficients of a regression, in which financial tightness indicators are not classified as a zero/one variable, as in our baseline estimates, but instead as a continuous variable. In panel 1, we report the results for all firms, and in panel 2, we report the results for the firms that in our earlier specification are classified as facing financial tightness. In panel 3, we report the ones that are classified as not facing financial tightness in our baseline estimate. The standard deviation is in parentheses; ***$p < 0.01$, **$p < 0.05$, and *$p < 0.1$.

B.4 Longer-term effects

The baseline specification focuses on the short-term impact of financial tightness indicators on labour hoarding. In the following, we test if the financial situation of a firm has long-term effects. In a first step, we estimate the firms' desired employment $e^*_{i,t}$ by means of the following CD production function:

$$e^*_{i,t} = \frac{1}{\beta} y_{i,t} - \frac{1-\beta}{\beta} k_{i,t} - \frac{1-\beta}{\beta} tfp_{i,t} + \epsilon_{i,t}, \tag{2.11}$$

where $y_{i,t}$ is output, $k_{i,t}$ is the capital stock, $tfp_{i,t}$ is total factor productivity (all in logs),

and β is the CD production function parameter.

In a second step, the baseline regression equation (2.3) is augmented with the residuals from the long-term equation (2.11). The long-run response of employment to a change in output is given by the coefficient γ_{lr}, which measures the part of the deviation from the long-run relationship $\epsilon_{i,t}$ that will dissipate in the following period. $\gamma_{lr,int}$ and $\gamma_{lr,ext}$ measure the additional long-run effect stemming from internal and external financial tightness.

$$\begin{aligned} \Delta e_{ti} &= \gamma_{lr}\epsilon_{i,t-1} + \gamma_{lr,int}Int_{i,t-1}\epsilon_{i,t-1} + \gamma_{lr,ext}Ext_{i,t-1}\epsilon_{i,t-1} \\ &\quad +\tilde{\gamma}_n\Delta e_{i,t-1} + \gamma_y\Delta y_{i,t} + \gamma_{y,int}Int_{i,t-1}\Delta y_{i,t} + \gamma_{y,ext}Ext_{i,t-1}\Delta y_{i,t} \\ &\quad +\gamma_{int}Int_{i,t-1} + \gamma_{ext}Ext_{i,t-1} + \tilde{\gamma}_w\Delta w_{i,t-1} + \tilde{\beta}X_{i,t-1} + \epsilon_{i,t}, \end{aligned} \tag{2.12}$$

The estimate results are shown in Table 2.23. The long-term effect of a change in output on employment is shown in panel 1. γ_{lr}, the long-run employment elasticity for firms, is in all cases very small and mostly not significant. γ_{lr} has a negative sign and is significant only in one case. Moreover, $\gamma_{lr,int}$ and $\gamma_{lr,ext}$ are also very small and in most specifications insignificant. The short-term adjustment coefficients reported in panel 2 are quantitatively very similar to those of the baseline regression, indicating that including the long-term does not change the short-term estimates and is not an important mechanism per se. However, we have a rather short time period (T is substantially smaller than N); therefore, the long-run estimates may suffer from small sample problems.

TABLE 2.23: ELASTICITIES AND FINANCIAL CONSTRAINTS INCLUDING LONG-TERM EFFECTS

1) Long-term employment elasticity for not tight firms and marginal effects of financial tightness				
Specification	(1)	(2)	(3)	(4)
Measure of internal tightness	Liquidity	Profitability	Liquidity	Profitability
Measure of external tightness	Collateral	Collateral	Balance sheet	Balance sheet
γ_{lr}	0.007**	-0.005	0.006*	-0.007**
	(0.003)	(0.003)	(0.003)	(0.003)
$\gamma_{lr,int}$	0.003	0.002	0.004**	0.006***
	(0.002)	(0.001)	(0.002)	(0.001)
$\gamma_{lr,ext}$	-0.002	-0.002	0.002	-0.002
	(0.001)	(0.001)	(0.004)	(0.003)
2) Short-term employment elasticity for not tight firms and marginal effects of financial tightness				
γ_{y}	0.173***	0.192***	0.175***	0.183***
	(0.008)	(0.008)	(0.007)	(0.007)
$\gamma_{y,int}$	0.152***	0.128***	0.116***	0.095***
	(0.010)	(0.010)	(0.010)	(0.010)
$\gamma_{y,ext}$	0.043***	0.032***	0.114***	0.130***
	(0.009)	(0.009)	(0.010)	(0.011)
R^2	0.373	0.379	0.378	0.388

Notes: Panel 1 shows the long-term effects of a change in output on employment. γ_{lr} is the long-term effect on a firm not facing financial tightness. $\gamma_{lr,int}$ and $\gamma_{lr,ext}$ measure the additional long-term effect stemming from internal and external tightness. For a one percent change in output, panel 2 shows the employment response dependent upon whether or not a firm faced financial tightness in the previous period. The direct impact of a one percent decline in output is given by γ_y on the first line. $\gamma_{y,int}$ is the marginal effect of being in an internally tight financial situation, and $\gamma_{y,ext}$ is the marginal effect in an externally tight financial situation. Robust standard errors are in parentheses; ***$p < 0.01$, **$p < 0.05$, and *$p < 0.1$.

B.5 Further robustness tests

In the following, to test the robustness of our results, we conduct several estimates with alternative specifications.

In the baseline specification, equations use firm-fixed effects to control for firm-specific unobserved fixed effects that could be correlated with the regressor. It is therefore redundant to include industry-fixed effects in the regressions. It is however possible that industry-fixed effects interacted with the measures of financial tightness may have an impact on the degree of labour hoarding. The results of this test (column 2 in Table 2.24) are practically identical to those of the baseline specification, indicating that the inclusion of these interaction terms is not necessary.

Next, we test whether the inclusion of industry-level trends influences the reaction of employment to a change in output. For this purpose, we add industry-time-fixed effects to our baseline equation. The results (column 3) show that industry-time-fixed effects have

practically no impact on the marginal effect of financial tightness on employment.

Given we are working with an unbalanced sample of firms in which the industries remain constant over time, while the universe of firms changes from year to year, the unobserved heterogeneity caused by time independent factors may be better controlled for by introducing industry-fixed effects, instead of using firm-fixed effects. The estimate results (column 4) are very similar to the baseline results.

As already discussed, in a dynamic model such as ours, at least the lagged dependent variable might be correlated with the error term. The problem is typically addressed by using a GMM estimate, as proposed by Arellano and Bond. (1991) (column 5). The application of this estimator yields a slightly more pronounced effect of the financial tightness indicators. The small difference between the estimates of the coefficients of interest is likely caused by the fact that the autocorrelation of our dependent variable is quite contained, and with 19 years of data, the time-series dimension of our data set is reasonably large.[40]

[40]We use three lagged values of $\Delta e_{t-1,i}$ as a basis for the moment conditions. We test the validity of instruments using the Hansen statistic, and we test for remaining second-order autocorrelation in the first difference of the error term. Neither test points to misspecification; see Table 2.26 below.

TABLE 2.24: EMPLOYMENT ELASTICITIES, ALTERNATIVE SPECIFICATIONS

Specification	(1) Baseline	(2) Interaction with industry	(3) Industry-time fixed effects	(4) Industry-fixed effects	(5) GMM-based estimate
Measure of tightness: Collateral and Liquidity					
γ_y	0.170***	0.161***	0.151***	0.158***	0.149***
	(0.008)	(0.008)	(0.015)	(0.013)	(0.049)
$\gamma_{y,int}$	0.151***	0.156***	0.157***	0.168***	0.168***
	(0.010))	(0.020)	(0.020)	(0.018)	(0.027)
$\gamma_{y,ext}$	0.044***	0.047**	0.046**	0.037**	0.070**
	(0.009)	(0.019)	(0.019)	(0.016)	(0.026)
Measure of tightness: Collateral and Profitability					
γ_y	0.194***	0.193***	0.186***	0.187***	0.185***
	(0.008)	(0.015)	(0.015)	(0.013)	(0.047)
$\gamma_{y,int}$	0.128***	0.140***	0.136***	0.163***	0.192***
	(0.010)	(0.022)	(0.022)	(0.019)	(0.027)
$\gamma_{y,ext}$	0.033***	0.033*	0.032	0.024	0.054**
	(0.009)	(0.012)	(0.020)	(0.017)	(0.026)
Measure of tightness: Balance sheet and Liquidity					
γ_y	0.172***	0.167***	0.157***	0.156***	0.160***
	(0.006)	(0.013)	(0.013)	(0.010)	(0.046)
$\gamma_{y,int}$	0.114***	0.120***	0.120***	0.120***	0.122***
	(0.010)	(0.021)	(0.021)	(0.019)	(0.029)
$\gamma_{y,ext}$	0.113***	0.105***	0.106***	0.124***	0.131***
	(0.010)	(0.023)	(0.023)	(0.019)	(0.030)
Measure of tightness: Balance sheet and Profitability					
γ_y	0.186***	0.187***	0.178***	0.170***	0.190***
	(0.006)	(0.012)	(0.012)	(0.011)	(0.045)
$\gamma_{y,int}$	0.094***	0.107***	0.104***	0.124***	0.155***
	(0.010)	(0.023)	(0.023)	(0.019)	(0.029)
$\gamma_{y,ext}$	0.127***	0.116***	0.117***	0.132***	0.125***
	(0.011)	(0.023)	(0.023)	(0.019)	(0.030)

Notes: The first panel on the top shows the response in employment to a one percent change in output, to collateral and liquidity tightness measures for internal and external tightness, respectively. The direct impact of a one percent decline in output is given by γ_y on the first line. $\gamma_{y,int}$ is the marginal effect of being in an internally tight financial situation, and $\gamma_{y,ext}$ is the marginal effect of an externally tight financial situation. The standard deviation is in parentheses; ***$p < 0.01$, **$p < 0.05$, and *$p < 0.1$. The panels below repeat the same analysis for different tightness definitions, as indicated in the panel headers. The columns indicate the estimation strategy. In column (1), we repeat our baseline estimates; in column (2), we include industry-fixed effects interacted with the measures of financial tightness indicators; in column (3), we include industry and time fixed effects; in column (4), we include industry fixed effects and omit the firm-fixed effects. In column (5), we use GMM with three lagged values (starting from $t-2$) of the change in employment for the moment conditions.

In our baseline specification, to keep the number of coefficients small, we left out several interaction terms. While from a theoretical point of view, financial tightness should interact

with all variables in the model, the baseline equation includes only the interaction terms of financial tightness with the demand changes and the industry-fixed effects. We have conducted robustness tests by further including the interaction terms of financial tightness with the following variables: the change in employment in $t-1$ (column 2 in Table 2.25); the change in wages in t (column 3); the change in capital stock in t (column 4); the capital-stock-to-FTE ratio in $t-1$ (column 5); and finally, the change in total factor productivity in t (not shown in Table 2.25). These interaction terms are in some specifications significant, but the coefficients are very small, and the impact on labour elasticity is minor.

TABLE 2.25: EMPLOYMENT ELASTICITIES WHEN INCLUDING INTERACTION TERMS WITH OTHER VARIABLES IN THE EQUATION

Specification	(1) Baseline	(2) Interaction with $\Delta e_{i,t-1}$	(3) Interaction with $\Delta w_{i,t}$	(4) Interaction with change in capital stock	(5) Interaction with capital-stock -to-FTE-ratio
Measure of tightness: Collateral and Liquidity					
γ_y	0.170***	0.155***	0.153***	0.163***	0.159***
	(0.008)	(0.020)	(0.015)	(0.015)	(0.015)
$\gamma_{y,int}$	0.151***	0.161***	0.179***	0.155***	0.156***
	(0.010)	(0.015)	(0.021)	(0.020)	(0.020)
$\gamma_{y,ext}$	0.044***	0.048**	0.045**	0.045**	0.050***
	(0.009)	(0.019)	(0.019)	(0.019)	(0.019)
Measure of tightness: Collateral and Profitability					
γ_y	0.194***	0.195***	0.188***	0.196***	0.193***
	(0.008)	(0.015)	(0.015)	(0.015)	(0.015)
$\gamma_{y,int}$	0.128***	0.136***	0.164***	0.136***	0.136***
	(0.010)	(0.022)	(0.0223)	(0.022)	(0.022)
$\gamma_{y,ext}$	0.033***	0.032	0.027	0.030	0.034*
	(0.009)	(0.020)	(0.020)	(0.020)	(0.020)
Measure of tightness: Balance sheet and Liquidity					
γ_y	0.172***	0.167***	0.153***	0.168***	0.168***
	(0.006)	(0.013)	(0.012)	(0.013)	(0.013)
$\gamma_{y,int}$	0.114***	0.120***	0.139***	0.119***	0.119***
	(0.010)	(0.021)	(0.022)	(0.021)	(0.021)
$\gamma_{y,ext}$	0.113***	(0.104***	(0.127***	(0.105***	(0.105***
	(0.010)	(0.023)	(0.024)	(0.023)	(0.023)
Measure of tightness: Balance sheet and Profitability					
γ_y	0.186***	0.167***	***0.153	0.168***	0.168***
	(0.006)	(0.013)	(0.012)	(0.013)	(0.013)
$\gamma_{y,int}$	0.094***	0.120***	0.139***	0.119***	0.119***
	(0.010)	(0.021)	(0.022)	(0.021)	(0.021)
$\gamma_{y,ext}$	0.127***	0.104***	0.127***	0.105***	0.105***
	(0.011)	(0.023)	(0.024)	(0.023)	(0.023)

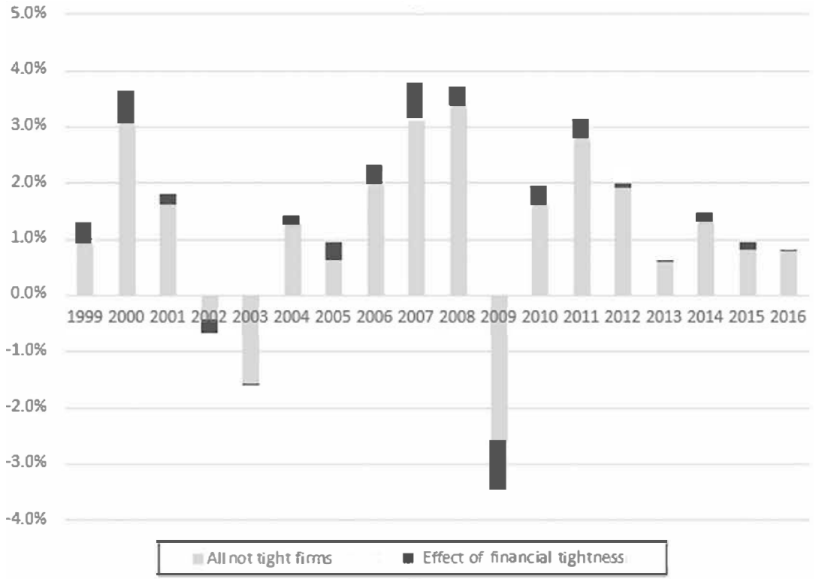
Notes: The first panel on the top shows the response in employment to a one percent decline in output to collateral and liquidity tightness indicators used as measures for internal and external tightness, respectively. On the first line, the direct impact of a one percent change in output is given by γ_y. $\gamma_{y,int}$ is the marginal effect of being in an internally financially strained situation, and $\gamma_{y,ext}$ is the marginal effect of being in an externally financially strained situation. The standard deviation is in parentheses; ***$p < 0.01$, **$p < 0.05$, and *$p < 0.1$. The panels below repeat the same analysis for different financial tightness definitions, as indicated in the panel headers. The columns indicate the estimation strategy. In column (1), we repeat our baseline estimates. In column (2), we interact the financial tightness indicator with the lagged change in employment; in column (3), with the change in the average wages; in column (4), with the change in the capital stock; and in column (6), with the K/E ratio.

TABLE 2.26: SPECIFICATION TESTS FOR GMM ESTIMATE

	Collateral Liquidity	Collateral Profitability	Balance sheet Liquidity	Balance sheet Profitability
Arellano-Bond test for 2nd-order autocorrelation	0.85	0.87	0.79	0.95
Hansen test for overidentifying restrictions	0.69	0.55	0.56	0.44

p-values (Hansen test: based on $\chi^2(90)$ distribution).

FIGURE 2.12: EMPLOYMENT GROWTH AND COUNTERFACTUAL



Notes: This figure shows the aggregate employment series and a counterfactual, in which we removed the effect due to financial tightness (shown here for the situation with no collateral and no liquidity tightness, i.e., column (1) in our baseline table 2.3.

Chapter 3

Firms' net worth and their external finance premium – evidence from firm-level data* [1]

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 chapter, we examine the sensitivity of a firm's cost of external finance to variation

*This paper is co-authored by Gregor Bäurle (Swiss National Bank, Regional Economic Relations) and Sarah M. Lein (University of Basel, Faculty of Business and Economics, CEPR, CESIfo, and KOF ETHZ) and is forthcoming as SNB Working Paper.

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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.[2] 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

[2]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.

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.[3] 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 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

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

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.[4] 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

[4]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.

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 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,

$$E_{t-1}[R_{i,t}^k] = \psi^{-1}(\kappa_{i,t})R_t. \tag{3.1}$$

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 (3.1), assuming a functional form on $\psi^{-1}(\kappa_{i,t}) = \kappa_{i,t}^{\nu}$

$$E_{t-1}[r_{i,t}^{k} - r_t] = \nu \; ln(\kappa_{i,t}), \tag{3.2}$$

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.

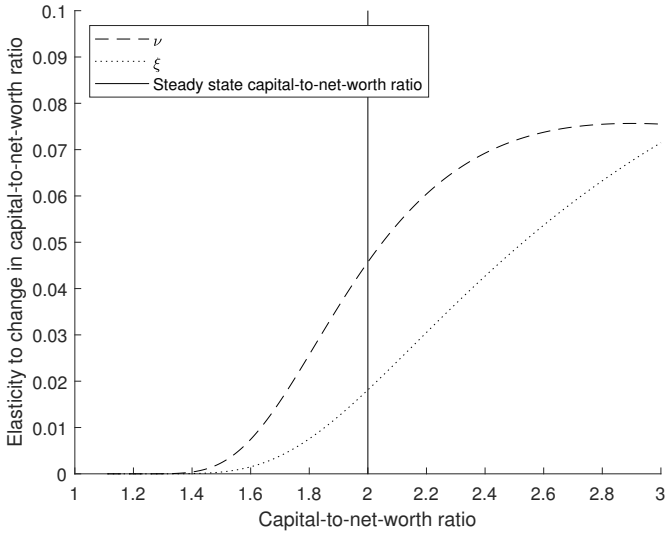
We also estimate an alternative specification replacing the marginal product of capital with the actual interest rate observed on debt. The difference between this actual interest rate on debt and the risk-free rate represents the credit spread that can be observed in the data. Importantly, in the CSV 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 (3.3), the sensitivity ξ is not necessarily equal to ν in equation (3.2):

$$z_{i,t} - r_t = \xi \; ln(\kappa_{i,t}). \tag{3.3}$$

Equations (3.2) and (3.3) 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 3.1 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 3.1: 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,[5] including all the industries in

[5]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.

the economy, except the financial and public sectors.[6] 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.[7] 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 3.1 and 3.2, 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 obligations $B_{i,t}$.[8] 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

[6] 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.

[7] 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 3.6.

[8] 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.

TABLE 3.1: 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 3.2: 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.

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 pharmaceutical sector, for example (see Table 3.7).

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.[9] 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

[9]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 (3.5), and the credit spread, with equation (3.6). 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.

capital is defined as:

$$R^k_{i,t} = \frac{\frac{1}{X_{i,t}} \frac{\alpha Y_{i,t}}{K_{i,t}} + Q_{i,t}(1-\delta_{i,t})}{Q_{i,t-1}}. \tag{3.4}$$

We measure the relative price of the produced goods at the firm level as $P^Y_{i,t}$ divided by aggregate price CPI_t.[10]. 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.[11] Our estimate for α is 0.37, a value very close to BGG's assumption of 0.35. Depreciation rate $\delta_{i,t}$ is derived from firms' depreciation expenditures on physical capital included in our dataset.[12][13] 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.[14]

Column (1) of Table 3.3 shows the means of the annual gross marginal product of capital (MPK, as defined in equation (3.4)). 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

[10]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):

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

TABLE 3.3: 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 (3.4), 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).

private sector in advanced countries.[15] 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 410 basis points,[16] 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.[17] No such clear pattern emerges for the credit spread.

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

[12] 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.

[13] 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 C.3 in the Appendix).

[14] 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 3.11 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.

[15] 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.

[16] 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.

[17] 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.

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 (3.5) and (3.6) in the log-linearised form (logarithms are denoted in small letters):

$$r^k_{i,t} - r_t = c - \nu[n_{i,t} - (q_{i,t-1} + k_{i,t})] + D^{time} + D^{sector} + D^{size} + \varepsilon_{i,t} \tag{3.5}$$

$$z_{i,t} - r_{i,t} = c - \xi[n_{i,t} - (q_{i,t-1} + k_{i,t})] + D^{time} + D^{sector} + D^{size} + \varepsilon_{i,t}, \tag{3.6}$$

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.[18] Our focus is on the variation of net worth across firms, in contrast to the variation within firms over time. Consequently, we 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 C.2.4). In equation (3.5), we estimate the sensitivity of the external finance premium to variation in net worth ν. In equation (3.6), 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

[18] The sector and size dummies are defined as the sectors and size groups shown in Table 3.3. The time dummies are defined per year.

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 3.2). 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.[19] 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.[20]

Table 3.4 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 correlated with the regressor and therefore relevant. However, the Kleibergen-Paap F Statistic is clearly below the threshold proposed by Lee, McCrary, Moreira, and Porter (2021) of 104.7 so that according to their findings we cannot exclude that there is no distortion. 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

[19] 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.

[20] We test the robustness of our results using several variations of this baseline instrument specification. The resulting coefficients are discussed in Appendix C.2.2 and shown in Tables 3.9 and 3.10.

a higher net-worth-to-capital ratio pay a lower contractual interest rate and those that are highly leveraged pay a higher interest rate.

TABLE 3.4: 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 (3.5) and (3.6). 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.

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 3.4 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 3.8 in the Appendix shows the estimated coefficients using all the available observations. The estimated sensitivity using the whole sample is slightly smaller for ν and minimally higher for ξ.

Furthermore, we report and discuss in Appendix C.2.2 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 C.2.3 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[21] 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 $\kappa = 2$.[22]. 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

[21] 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.

[22] CFP state in their paper that they set $\kappa = 2$. However, according to our calculations, CFP actually work with a value of 1.989

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 only $\xi = 0.018$.[23]

Table 3.5 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 3.7, 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 $\hat{\xi}$.[24]

TABLE 3.5: 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)

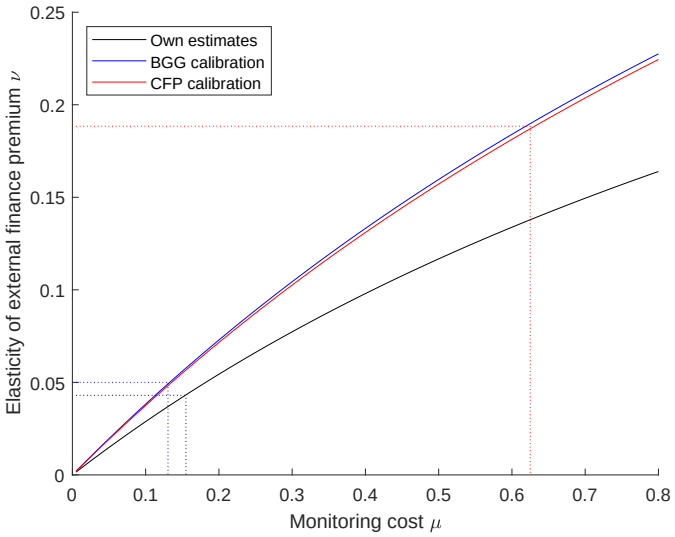
Note: BLS: Bäurle, Lein, Steiner; BGG: Bernanke, Gertler, Gilchrist (1998); CFP: Carlstrom, Fuerst, Paustian (2016); Values in parentheses are not stated explicitly by the authors.

Figure 3.2 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

[23] 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.

[24] 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 3.2: ELASTICITY OF THE EXTERNAL FINANCE PREMIUM WITH RESPECT TO LEVERAGE RATIO ν FOR VARYING LEVELS OF MONITORING COST μ



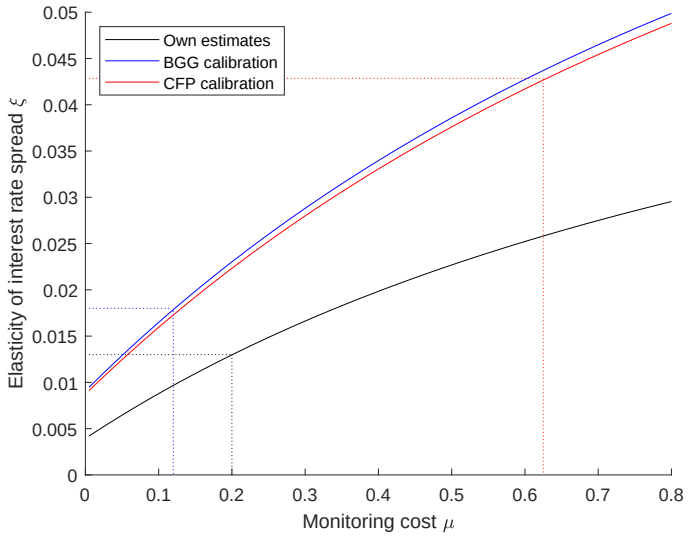
σ and κ calibrations.[25] The horizontal lines mark the implied values of ν (BGG and CFP models) and our estimated value of ν. The vertical lines mark the resulting value for μ. As the black curve is less steep than the blue/red curves, we obtain a monitoring cost $\mu = 0.15$, which is somewhat higher 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 3.3 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.

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

[25] 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 3.2 and 3.3

FIGURE 3.3: ELASTICITY OF THE BOND SPREAD WITH RESPECT TO LEVERAGE RATIO ξ FOR VARYING LEVELS OF MONITORING COST μ



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.[26]

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 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

[26]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 $\mu = 0.12$.

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.

C Appendix

C.1 Additional information on data

TABLE 3.6: 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 3.7: 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).

C.2 Robustness tests

C.2.1 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 3.8 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 3.4. 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 3.8: IV-ESTIMATES FOR ν AND ξ USING ALL THE AVAILABLE OBSERVATIONS

Dependent variable	(1) $r^k_{i,t} - r_t$	(2) $z_{i,t} - r_t$
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.

C.2.2 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 3.9 for ν and in Table 3.10 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 3.9 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 3.10 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 3.9: 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 3.10: 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.

C.2.3 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 3.11 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 3.11: 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 (3.6). 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.

C.2.4 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 3.5 and 3.6 with firm-fixed effects. The results are shown in Table 3.12. 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 3.12: 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.

C.3 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 3.13, Specification (2) together with the baseline estimate. Both of the elasticities are very similar.

TABLE 3.13: 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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