Shocks and the organization of the firm: Who pays the bill? *

Alessandro Sforza[†] *University of Bologna*

Edoardo Acabbi *University Carlos III*

March 7, 2021

Abstract

What happens to firms' organizational structure when they are hit by a negative shock? By matching employer-employee data with firm loans and bank balance sheets, I study firms' reactions to a credit shock–the global financial crisis—and compare it to a trade shock—the entry of China in the WTO. When hit by a credit supply shock, firms reduce employment of higher-skilled workers more than lower-skilled production workers, while no adjustment is found on the wages. In contrast, a trade shock affects the hierarchy of the firm from the bottom to the top: firms rescale the organization and reduce employment at all levels. Results support the existence of heterogenous complementarities between working capital and skills along the hierarchy of the firm. Abstracting from general equilibrium effects, I find that firms' organization is a key channel in the transmission of credit shocks to the real economy.

JEL Codes: F14, F16, G01, G21, L22, L23

*I thank Gianmarco Ottaviano, Henry Overman, Veronica Rappoport and Daniel Sturm for extensive advice and support. I thank Andrea Alati, Carlo Altomonte, Andrew Bernard, Lorenzo Caliendo, Luca Citino, Andrew Garin, Anna Gumpert, Giordano Mion, Monica Morlacco, Luca David Opromolla, Hanwei Huang, Steve Pischke, Frank Pisch, Catherine Thomas, Esteban Rossi-Hansberg, Thomas Sampson, Peter Schott, Vincenzo Scrutinio, Tommaso Sonno, Torsten Walter, and many seminar participants at LSE, Yale, Stockholm University, Banco de Espana, Banco de Portugal, CSEF, University of Bologna, Aarhus BSS, Maastricht University, Munich (LMU), CESIfo, Oslo, Sydney, Melbourne for useful conversations and comments. I am also thankful for the hospitality of the economics and research department at the Banco de Portugal and Yale School of Management where part of this research was conducted. All data work was conducted on site at the Banco de Portugal in Lisbon. I am grateful to the colleagues there for making this work possible—especially Amelia Andrade, Antonio Antunes, Isabel Horta Correia, Luisa Farinha, Manuela Lourenco, Pedro Prospero, Fatima Teodoro and Lucena Vieira. The analysis, opinions, and findings represent the views of the author, they are not necessarily those of Banco de Portugal. All remaining errors are mine. Correspondence by e-mail: alessandro.sforza3@unibo.it.

[†]Also associated with CESifo

1 Introduction

The way a firm organizes has important implications on the distribution of wages in the economy, as well as productivity and growth.[1] Yet when studying the transmission of shocks to the real economy, firms are usually treated as homogeneous entities. They are allowed to vary by size, productivity and shape, but the within-firm structure is considered fixed. Anecdotal evidence suggests that firms heterogeneosly respond to different types of shocks by changing their internal organization. For example, the 2007 financial crisis had tremendous employment effects across all skill groups, but in relative terms higher amongst high skilled production workers and white collars. Indeed, "*a feature of the 2007 recession is that it affected white-collar workers at least as much as, and probably slightly more than, less-skilled workers*" (Financial Times, April 2009). On the contrary, the entry of China in the WTO and the consequent diffusion of Chinese products into the world markets had a dramatic employment effect on blue collars (Autor et al. (2014)). Neverthless, to date, there is very little theoretical work and little empirical evidence on the within firm organizational response to shocks.

This paper shows empirically that the organization of the firm is a crucial element to understand differences in how the aggregate economy responds to different shocks. Measuring firms' organization and how firms react to different shocks is challenging. I build a novel dataset that brings together a matched employer-employee database, bank lending registry, and bank balance sheets over 16 years for the population of workers, firms and banks in Portugal. Crucially, observing the task complexity of each occupation allows to precisely map workers into the organization of the firm. I then exploit the differential exposure to the financial crisis of Portuguese banks and the bank-firm credit network to instrument for firms' credit supply. Following Paravisini et al. (2015), the analysis of the credit shock is based on two different pillars: (1) a firm-level instrument for the supply of credit to the firm that combines information on the firm's credit relationships with the bank's exposure to the foreign interbank market and (2) the panel dimension of the data, that allows me to look at the change in credit supply before and after the Lehman collapse, which generated the biggest freeze in the interbank borrowing market in recent years.

The empirical estimates return elasticities of organization to credit; a 10% drop in the supply of credit predicts a 2% drop in the ratio of team leaders to production workers, which in turns implies an increase in the span of control that team leaders have over production workers. However, the observed increase in the span of control can be driven by an increase in the number of production workers, by a decrease in the number of team leaders, or by a decrease of both, with the decrease in the number of team leaders being more pronounced than the decrease in the number of production workers. I find that the latter mechanism drives the results. Employment of high skilled workers

[1] See for example Black and Lynch (1997), Bloom et al. (2012), Caliendo et al. (2015a), Garicano (2000), Garicano and Rossi-Hansberg (2004), Hubbard and Garicano (2007), Ichniowski et al. (1997), Liberti (2017).

and team leaders drops by 1.75% with a 10% drop in credit, while the elasticity of production workers to a 10% drop in credit is 1.4%.

Understanding why shocks of different nature have contrasting effects on the real economy is key to target policies to specific groups of workers and efficiently counteract the negative effects of the shock. To gain insights on the mechanisms and highlight differences in firms' response to credit supply shocks and trade induced demand shocks, in the second part of the paper I examine how exposure to rising competition from China affects the organization choice of Portuguese firms. I follow Autor et al. (2014) and construct a sectoral measure of import penetration of Chinese exports to to the US to instrument for the drop in sales upon China's entry in the WTO. The length of the panel allows me to analyse firms' organizational reaction to a credit and a trade shock in the same economy.

Results show that firms react differently to a credit shock than a trade shock. Both induce the firm to cut overall employment, but the organization of the firm reacts differently across the two shocks. When hit by a negative credit supply shock firms shrink more the middle of the hierarchy, reducing employment of higher-skill workers more than lower-skill production workers at the bottom. In contrast, when hit by a negative trade shock the reduction is more pronounced for lower-skill production workers and less pronounced as we rise along the hierarchy of the firm.[2] The empirical findings highlight a novel heterogeneity in the degree of complementarity between working capital and each of the hierarchical layers. A shock to one specific input of production—working capital—translates into a stronger reduction of higher-skill workers, rather than production workers, while top managerial positions are not affected. In contrast, a trade induced demand shock affects the scale of the firm, therefore firms layoff in all layers.

This paper contributes to several strands of the literature. The transmission of a financial shock from banks to the real economy has been widely documented, but very little is known on the heterogeneous effects of a credit shock along the workers' tasks and skills distribution. The work by Chodorow-Reich (2014) documents the effects of a credit supply shock on the employment level of firms connected to more or less healthy banks, but cannot speak to the heterogeneous effects at the worker level due to data availability. Greenstone et al. (2014) look at the effect of credit reduction to small firms in the US. They exploit geographical variation in the distribution of the local branches of US banks to look at the effect of credit reduction on employment in counties differentially exposed to the shock. The recent paper by Berton et al. (2017) uses the methodology described in Greenstone et al. (2014) to show that a negative credit supply shock has an impact on firms' employment in one Italian region—Veneto—and the effect is heterogenous, and mostly

[2] In both cases, there is little or no adjustment on wages: presumably, the contractual rigidities of the Portuguese labour market allow little downward adjustments on the salaries. In line with this, I show that labour market rigidities play an important role: firms with a higher share of workers on temporary contracts before the crisis have a stronger reaction to negative shocks by reducing employment more.

concentrated among less educated workers.[3] I build on this literature and open the black box of the firm, showing how the organization responds to a negative credit supply shock and what the implications are for the different categories of workers.

Do firms react differently to a demand and a credit shock? A large literature in economics has documented the firms' employment response to a trade shock that increases the level of domestic competition, and reduces demand for both exporters as well as domestic producers. The paper by Autor et al. (2014) for example, analyzes the effect of exposure to international trade on earnings and employment of U.S. workers, from 1992 through 2007. The authors show that industry shocks to import competition in the aftermath of China's entry in the WTO and rise as a global exporter mostly affected workers in exposed industries and that earning losses were larger for individuals with low initial wages, low initial tenure, and low attachment to the labour force. Moreover, the paper documents that high wage workers suffered less because of a higher ability to move across employers, and eventually move out of manufacturing. These findings reveal that import shocks unevenly affect workers along the skill distribution, being tougher for blue collars than for white collars; however, the firm level mechanisms determining the worker level outcomes in terms of cumulated earnings is still unclear. Guadalupe and Wulf (2008) is one of the first papers to systematically look at the firms' internal organizational reaction to a trade shock. Along these lines, Friedrich (2015) empirically estimates the effect of trade shocks on wage inequality, decomposing inequality using the lenses of organizational models. He uses matched employer-employee data from Denmark to show that wage variation across hierarchical layers constitutes a systematic component of overall wage inequality. Moreover, the paper exploits a trade shock to Danish exporters in 2005 - the Cartoon crisis - to causally estimate how a drop in demand influences within firm wage inequality. My results confirm the findings of Autor et al. (2014), showing that the effect of a trade shock is more pronounced among lower-skill workers and decreases with the task complexity of the occupation. Moreover, I add on this literature by showing that these findings are consistent with a firm reorganization mechanism: when hit by a negative trade shock, firms shift to a different production scale and adjust their structure, laying off workers proportionally along the hierarchy, to minimize the costs associated with the new demand level.

[3] Focusing on exporters, Amiti and Weinstein (2011) look at the effect of financial crisis on Japanese exporters, while Foley and Manova (2015) explain that firms face more stringent capital constraints because of higher up-front expenses to enter foreign markets, higher variable costs related to delayed payments, shipment duties and freights, currency fluctuations and contractual risks. Moreover, Chor and Manova (2012) show that international commerce becomes more sensitive to financial conditions during crises. In a similar vein, Paravisini et al. (2015) look at the effect of bank credit shocks on the export behavior of Peruvian firms. They look at bank pre-crisis ratios of foreign funding to assets and use the share of firm credit from banks with foreign exposure above the median as an instrument for the intensity of the financial shock to firms. They find that capital shortage has a bigger effect on the intensive margin—quantity exported in a destination-product market—than on the extensive margin—entry or exit of firms. Other scholars focused on measuring the effect of banks' exposure to the financial shock on their credit supply. In this respect, Jiménez et al. (2011) is one of the first papers to show how to link bank exposure to financial shocks and firm credit supply while Iyer et al. (2014) use Portuguese data and show how banks with a high exposure to the interbank borrowing market reduced their credit supply growth.

A key implication of the paper is that studying firms' organization is key to understand aggregate outcomes. This insight is particularly relevant for the recent literature on knowledge hierarchies that documents how firms adjust their organization to increase or decrease their efficiency and output (e.g. Caliendo and Rossi-Hansberg (2012), Caliendo et al. (2015b), Caliendo et al. (2015a), Gumpert (2018), Antoni et al. (2019)).[4] Empirical studies are exploiting the increasing availability of matched employer-employee data, as well as information on managerial practices to describe the organization of the firm (see Bloom et al. (2011)). Theoretical contributions have provided a set-up to empirically study the nexus between firms' organization and productivity (see Caliendo and Rossi-Hansberg (2012) among others). This paper complements these works by showing causal evidence on the nexus between credit and organization as well as between trade and organization.

The rest of the paper is organized as follows. Section 2 describes the data used in the analysis, the mapping of workers in management layers and other firm level measures of organization. Section 3 presents the analysis on the reaction of firm organization to the credit shock and section 4 discusses the results through the lenses of a simple theoretical framework. Section 5 explores firms' organizational response to the trade shock and discuss how the organizational reaction differs across the two shocks. Section 6 reports additional margins of adjustment and placebo tests of the identification strategy. Section 7 concludes.

2 Data and descriptives

An important innovation of this article is to link datasets of loans and within firm organization to observe organizational changes of firms borrowing from different banks. The analysis draws on a unique dataset constructed using Portuguese data that brings together four different data sources: a matched employer-employee dataset virtually covering the entire population of firms and their workers in Portugal, a firm balance sheet dataset, a bank-firm loans dataset and a bank's balance sheet dataset. The dataset covers manufacturing and services firms of continental Portugal for the years 1997-2013.[5]

Employer-employee data come from *Quadros de Pessoal* (henceforth, QP), a data set made available by the Ministry of Employment of Portugal that draws on a compulsory annual census of all firms in Portugal employing at least one worker. The data set has been widely used in the labour literature and contains information on 350,000 firms and 3 million employees.[6] Reported data

[4] A related strand of literature uses an alternative modelling structure, the monitoring hierarchy framework, to have insights on simimal predictions (e.g. Chen (2017); Chen and Suen (2019); Spanos (2019)). Mariscal (2018) incorporates capital in a Caliendo and Rossi-Hansberg (2012) model and shows how new information technology explains the decline of the US labor share using a knowledge hierarchy framework.

[5] Information for the year 2001 for the matched employer-employee dataset was not collected so my sample excludes the year 2001. For the moment, I constraint my sample between 2003 and 2013.

[6] See for example Blanchard and Portugal (2001) which compares the US and Portuguese labour market looking

cover the firm itself, each of its plants and each worker employed by the firm. Variables available in the data set include the firm's location, industry, total employment, and sales. The worker-level data cover information on all personnel working for the reporting firms in a reference week in October of each year. They include information on occupation, earnings, and hours worked (normal and overtime). The information on earnings includes the base wage (gross pay for normal hours of work), seniority-indexed components of pay, other regularly paid components, overtime work, and irregularly paid components.

The second dataset is *Central do Balancos* (henceforth, CB), a repository of yearly balance sheet data providing economic and financial information on non-financial corporations operating in Portugal. This dataset contains information on all the firms in the Portuguese economy from 2006 onwards.[7] The data contains information on firm sales, material assets, cost of materials and third party supplies and services.

The third dataset is *Central de Responsabilidades de Crédito* (henceforth, CRC), a data base made available by Bank of Portugal containing all the credit exposures above 50 euros reported monthly by the universe of Portuguese credit institutions. The Reporting is mandatory and the objective is to increase the information set available to participating institutions to improve the risk assessment of potential borrowers. For each borrower, the dataset includes information on the number of banking relationships, total outstanding debt with each single institution and loan status (regular credit, overdue, written-off or renegotiated).[8]

The fourth dataset is *Balanco das institucoes monetarias and financeira* (henceforth, BBS), a repository of monthly balance sheet data for all the financial institutions in Portugal. The dataset includes information on the instruments and the counterparts of each transaction in the assets and liabilities for all the financial institutions in Portugal. For each bank or financial institution in a month, the dataset reports information on the transactions divided by maturity (for example, credits up to 1 year maturity, credits with maturity between 1 and 2 years, deposits with 90 days maturity, deposits up to 1 year maturity) the type of the counterpart (Central banks, banks, other financial intermediator, local government, regional government, national government and others), the location of the counterpart (aggregate of countries outside the Eurozone which includes Lithuania, Austria, Belgium, Cyprus, Slovenia, Slovak Republic, Spain, Estonia, Finland, France,

at the unemployment duration and worker flows, Cabral and Mata (2003) who study the evolution of the firm size distribution, Mion and Opromolla (2014) who show that the export experience acquired by managers in previous firms leads their current firm towards higher export performance, and commands a sizable wage premium for the manager or Mion et al. (2016) who look at how the knowledge a manager acquires spills over the new firm.

[7]Before 2005 CB was biased towards large firms; however, the value added and sales coverage was high. For instance, in 2003 firms in the CB dataset accounted for 88.8% of the national account total of non-financial firms' sales.

[8]Potential credit refers to all the credit not yet materialized, Overdue credits are credits for which the financial institution has a positive expectation of being reimbursed, Written-off credits are credits for which the financial institution has no expectation of being reimbursed and renegotiated credits are credits for which conditions have been renegotiated between the two parties. Before 2009, the dataset does not include information on collaterals or credit duration.

Greece, Netherlands, Ireland, Italy, Latvia, Luxembourg, Malta and Portugal).

2.1 From individual classification to firm level variables

Table 1 reports descriptives for 2005; manufacturing and services firms in my sample have on average 29 employees, and a wage bill of 522,801 euros. Firms have on average 1.23 layers of management, with the average salary in the top layer being 3.5 times higher than the average salary in the bottom layer.

In the bottom panel of table 1, I present descriptive statistics for credit and firm-bank relationships. On average, firms borrow 208,165 euros as working capital (as an average across firms and years), while 294,582 for long term investments. Interestingly, Portuguese firms on average have 2.2 bank relationship; this will provide useful variation to identify the credit supply shock and construct a firm level instrument for the shock.

To construct the occupational structure at the firm level I use the information contained in the matched employer-employee dataset. Each worker, in each year, has to be assigned to one of the 9 categories following a (compulsory) classification of workers defined by the Portuguese law.[9] Classification is based on the task performed and skill requirements, and each category can be considered as a level in a hierarchy defined in terms of increasing responsibility and task complexity. The 9 levels' hierarchy defined by the Portuguese law is detailed and is rarely found in its entirety in a Portuguese firm. To make the classification more representative of the reality of the Portuguese production network, I group some of the categories according to the description of the tasks performed and the wage distribution. I assign "Top executives (top management)" to occupation 3; "Intermediary executives (middle management)" and "Supervisors, team leaders" to occupation 2; "Higher-skilled professionals" and "Skilled professionals" to occupation 1; and the remaining employees, including "Semi-skilled professionals", "Non-skilled professionals", and "Apprenticeship" to occupation 0. This classification provides a good picture on the hierarchical organization of the firm and allows me to partition the available categories into management layers. The great majority of the firms in the sample satisfy a hierarchy—see table 2—and firms with a more complex organizational structure employ more workers, pay higher salaries and use more external credit—both long and short term—to finance their activity as it is clear from table 3.

I follow Caliendo et al. (2015b) in translating the number of different occupations present in a firm into layers of management. A firm reporting c occupational categories will be said to have $L = c - 1$ layers of management: hence, in the data I will have firms spanning from 0 to 3 layers of management. In terms of layers within a firm I do not keep track of the specific occupational categories but simply rank them. Hence a firm with occupational categories 2 and 0 will have 1 layer of management, and its organization will consist of a layer 0 corresponding to some skilled

[9] I use the Portuguese classification (Decreto Lei 121/78 of July 2nd 1978)

and non-skilled professionals, and a layer 1 corresponding to intermediary executives and supervisors.[10]

Figure 1 shows the distribution of sales by organization type. Firms with a higher number of management layers have a higher volume of sales. Table 3 shows how the hourly wage and the hours worked are increasing in the number of management layers. Moreover, the last two columns of the table show that a positive relationship exists also between the number of management layers and credit—both short and long term.

3 Credit & organizations

In this section I document how the internal organization of the firm responds to a credit shock—the financial crisis in 2009. First, section 3.1 presents a methodology that combines an instrument for credit supply and a difference in difference that allows to disentangle the effect of credit supply shock from the contemporaneous drop in demand. The identification of the credit supply shock follows the methodology described by Paravisini et al. (2015). However, the richness of the data allows to do an additional step and open the black box of the firm to look within the organization of labour of each firm before and after the credit shock. In a quest to provide evidence on the mechanism at work, I exploit a second shock in my sample period and extend the analysis of firms' organizational reaction to the exposure of the increase in Chinese competition that followed China's entry in the WTO in 2001. The methodology follows the work by Autor et al. (2013a) in constructing a measure of Chinese import penetration to instrument for the increase in competition for Portuguese producers.

3.1 The credit shock

The global financial crisis affected Portugal enormously and through different channels. In a very first phase, the Portuguese economy was almost untouched by the events happening in the US; the housing market did not suffer any bubble and the financial markets did not react to the first signs of financial distress in June 2007.[11] The tension in the interbank borrowing market started to be extremely high in September 2008, when Lehman Brothers filed for Bankruptcy.

The Portuguese banking system relied heavily on foreign interbank funding to finance loans

[10] A potential concern of this methodology is that firms can have layers with occupations that are not adjacent in the rank. In my sample however, 70% of the firms have adjacent layers and the share goes up to 85% if I use hours worked as a weighting factor. I perform the estimations using the categorization of occupation that define the managerial layers without filling non-adjacent occupations with the occupation above in the rank and results hold. Results using occupation can be found in the online appendix.

[11] The first episode of distress is the rescue by the investment bank Bear Stearns of a subsidiary edge fund that had invested heavily in subprime mortgages in the US. See Lourenço and Rodrigues (2015) for evidence on the evolution of the Portuguese housing market.

to individuals and firms because of a low aggregate saving rate of the Portuguese economy.[12] Figures 3 and 4 show respectively the drop in total short term credit in the Portuguese economy and the drop in total foreign interbank borrowing of Portuguese banks. The decline in the total amount of short term credit in the economy is remarkable (around 50%)[13] and although some of the drop of credit may be due to a drop in demand[14], the magnitude of the interbank borrowing decline suggests a potential important role played by the supply channel. The two factors together, drop in supply and demand, created an unprecedented tension in the labour market leading to extremely high unemployment levels; total unemployment rose up to 15% from 5% in 1998, while youth unemployment rose up to around 43% from an initial level of 13% in 1998.

Three characteristics make the financial crisis unique and important to study as a shock to the real economy: first, bank credit represent the major source of external financing for enterprises in Europe. The structure of the economy in many European countries is dominated by small and medium sized enterprises that do not reach a sufficient scale to access the financial market directly by issuing corporate bonds.[15] Second, lending relationships between firms and banks are stable overtime, making it very difficult for firms to switch bank.[16] Finally, the 2008-9 financial crisis began outside the corporate loan sector. These characteristics help designing an empirical methodology to causally identify the effect of a credit supply shock by making the shock orthogonal to the loan portfolio of the firms in the economy and by ensuring that firms are heterogeneously hit by the credit shock.

3.2 The empirical model

Studying the effect of a decrease in credit supply on firm level outcomes is challenging. The identification problem arises naturally because the amount of credit received by the firm is an equilibrium outcome between the amount of credit demanded by the firm and the amount the bank supplies. To address this concern, I follow Paravisini et al. (2015) and rely on two complementary methodologies: first, I instrument for the supply of credit, using shocks to the balance sheet of the banks lending to firm *i*. Second, to avoid to incur in a biased estimation due to non-random matching of firms and banks, I use the firm-bank network observed in a year out of the sample and

[12] See the BIS dataset on the specific dependence of Portuguese banks (see www.bis.org/statistics/about_banking_stats.htm)

[13] The liquidity crisis was unexpected across all European countries and not related to Portuguese institutions.

[14] Demand certainly played an important role as well: both domestic and foreign demand for Portuguese goods decreased sharply in the aftermath of Lehman collapse, and this led to a decrease in production and consumption.

[15] The Survey on Access to finance for Small and Medium enterprises of the ECB shows how SMEs use bank credit as main source of liquidity and financing; indeed, only 7% of the firms in Europe use the equity market to finance their activity. Moreover, the structural difference in firms' access to the financial market between US and Europe helps explaining why the banking system in Europe is 2.5 times the GDP, while in the US is only 0.7 times.

[16] See Bonfim and Dai (2012) for evidence on relationship lending in Portugal.

I control for the unobserved heterogeneity in the cross-section with firm fixed effects.[17] Moreover, I allow demand shocks to be varying across sectors and year and include sector-time fixed effect to account for this possibility and isolate the variation that comes from the credit supply shock only.

As a result, the estimation compares within firm variation in the hierarchical organization, accounting for time varying sectoral demand shocks. Intuitively, I compare the change in employment and organization of two identical firms producing leather shoes, but one happens to be linked to a negatively affected bank out of the n bank links the firm has, while the other has a lender portfolio that is not affected. The identification assumption is that factors other than bank credit that may affect the labour composition of the firm organization of leather shoes producers are not related to the debt composition of their bank; in other words, the debit composition of the bank affects labour choices of the firm only trough credit after accounting for firm heterogeneity in the matching. The identification assumption could be violated if a firm's bank affiliation is correlated with (i) labour demand for a specific product or (ii) non-credit firm-level shocks (e.g. firms' direct dependence on (foreign) funding not mediated by banks).

The latter concern can be immediately ruled out by two different observations. First, the Portuguese corporate bond market is very limited in size; very few firms issue bonds to finance their activity, while the great majority of firms rely on banks' loan.[18] Secondly, the average Portuguese firm in the sample has 20 employees; firms are too small to consider issuing bonds as a valid alternative to finance their activity. With respect to the first concern, if banks specialize in lending to firms producing a specific product and a dramatic demand shock affects that product at the same time as the credit shock, the inclusion of 2 digit sector-time fixed effects might not be enough to capture demand shocks. In fact, the inclusion of sector-time fixed effects captures credit demand variation only if changes in firms' credit demand are in expectations equally spread across all banks lending to the firm. In the appendix, I investigate whether banks specialize in a sector following the methodology in Paravisini et al. (2017) and I find that accounting for bank specialization in a 2 digit sector does not change the estimates.

The objective is to estimate the elasticity (η) of the organization (L) to credit (C) and I do so using the following specification:

$$L_{ist} = \eta * ln(C_{it}) + \delta_i + \gamma_{st} + \epsilon_{ist} \tag{1}$$

[17] In the appendix, I account for bank specialization in lending to firms in sector s following Paravisini et al. (2017). Suppose that a specific bank specializes in lending to firms producing leather shoes; then, if a trade shock hits all the firms in the leather shoes sector at the same time during the crisis, I wont be able to disentangle the trade shock from the credit supply shock. In section 6 I estimate the model using 2005 as a placebo shock. The exercise confirms that firms connected to different banks are on parallel trends before the drop in credit supply in 2009.

[18] Looking at the ECB survey on access to finance for enterprises, only 7% of the firms in the Portuguese economy report equity as a source of financing.

In the baseline estimates, L_{ist} measures the span of control across two adjacent layers of firm i in sector s at time t, C_{it} is the sum of all outstanding credit of firm i at time t, δ_i is a set of firm fixed effects accounting, for example, for managerial ability in firm i or for time invariant firm characteristic that might determine the bank-firm matching,[19] γ_{st} accounts for unobserved heterogeneity of sector s at time t, such as sector level demand shocks or changes in production costs due to increase in intermediates input costs.

I estimate equation 1 using shocks to the banks' balance sheet lending to firm i to instrument for the amount of credit granted to firm i at time t.

3.3 Interbank borrowing shock and credit supply

When the crisis hit the Portuguese banks in 2009, the dry up in liquidity reduced dramatically the funds available to the financial institutions. Moreover, because of a low aggregate saving rate in the economy, Portuguese banks heavily relied on foreign interbank borrowing to give credit to firms.[20]

The hypothesis behind the IV is that the contraction in credit supply in 2009 was larger for banks that relied more on foreign interbank funding before the crisis. To test this assumption, I use the following model:.

$$ln(C_{ibt}) = \beta f(FD_b) * Post_t + \theta_{ib} + \mu_{it} + \epsilon_{ibt} \tag{2}$$

where C_{ibt} is the average outstanding debt of firm i with bank b before and after the shock ($t = Pre, Post$), Pre and $Post$ are the 5 years before and after 2009. FD_b is the share (or a function) of foreign interbank funding over total asset of bank b measured in 2003 while $Post_t$ is a dummy taking value *1* if the period is after 2009. θ_{ib} and μ_{it} are firm-bank and firm-time fixed effects, aiming to capture all the time invariant heterogeneity in the demand and supply of credit (the former) and all the firm specific evolution of credit demand (the latter). The coefficient β measures how credit supply changes with foreign interbank funding, under the assumption that shocks to firms' demand of credit are on average equally spread across banks.

Equation 2 returns the *within-firm* estimator which compares the change in the amount of lending by banks with different dependence on foreign interbank funding to the *same firm*, before and after the interbank shock (2009).

[19] Firm fixed effects account for the possibility of positive or negative assortative matching between bank and firms. However, one might worry that firms can switch to more or less risky lenders in response to the credit shock; if that is the case, the instrument given that the instrument is constructed using the banking relationships in the pre-period, it will capture any variation in the post-period. Moreover, Bonfim and Dai (2012) show that banking relationships in Portugal are sticky and it have an average duration of 9 years. Finally, in section 6 I conduct a formal test for parallel trends to check that firms connected to more or less exposed banks in the pre-period are not sistematically different in the amount of credit received by their lender portfolio.

[20] See the BIS dataset on the dependence of Portuguese banks www.bis.org/statistics/about_banking_stats.html.

I use the years from 2004 to 2013 to estimate equation 2 in first differences, defining the pre-period to be from 2004 to 2008 and the post period from 2009 to 2013. I estimate the following equation that identifies the credit supply shock at bank level:

$$ln(C_{ibpost}) - ln(C_{ibpre}) = \beta f(FD_b) + \mu'_{it} + \epsilon_{ib} \tag{3}$$

FD_b is the value of interbank borrowing over total assets for bank b measured in a year out of the sample, 2003, μ'_{it} are *before-after* differences in firm fixed effects. I also inspect the relationship between foreign funding and credit supply described in equation 3 non parametrically in the appendix.

In table 7 I show the results of the estimation of equation 3 using different specification for the the interbank dependence. In column 1 I report results of the estimation of equation 3 using a linear function of the foreign interbank borrowing $FD = f(FD)$. Column 2 shows the correlation between short term credit and an indicator equal to 1 if the banks exposure to the to foreign interbank borrowing market is above the median, while column 3 reports the coefficient for banks with exposure above the average. In all the specifications, standard errors are clustered at bank level. The coefficients are all significant and, focusing on column 1, a magnitude of -1.831 implies that a one-percentage-point increase in the fraction of foreign funding before the crisis predicts a 1.831-percentage-point additional decline in credit supply, which in turn is a very big effect. Results in table 7 show that the same firm borrowing from 2 different banks faces a substantial drop in credit supply after 2009 from the bank that is more exposed to the interbank borrowing market. The within firm estimation confirms that the exposure of the bank to the foreign interbank borrowing market is an important determinant for the reduction in credit supply to firms.

3.4 Instrument and First Stage

Results in section 3.3 confirm the importance of bank balance sheet in predicting credit supply reductions: a higher exposure to the foreign interbank borrowing market leads to a higher reduction in the supply of credit by the bank. To estimate the effect of a credit supply shock to the organization of the firm, I construct a firm level instrument using shocks to the balance sheet of the banks, namely the variation in banks dependence to the foreign interbank market. I construct the firm level instrument in two steps: first, I use the average foreign dependence of the firm's banks, weighted by the fraction of credit from each bank, to instrument for credit supply:

$$Z_i = \sum_b w_{ib} * FD_b \tag{4}$$

In equation 4, w_{ib} is the share of bank b in total credit of firm i, and FD_b is the foreign dependence on bank b, defined as the exposure to foreign interbank borrowing market over total

assets. I allow FD_b to be a linear function, an indicator function equal to one if the bank exposure to foreign interbank funding is 10% percent above the mean among all banks, or a non linear function.

I the second step, I interact the instrument with the $Post_t$ dummy:

$$Z_{iPost} = Z_i * Post \tag{5}$$

The first stage regression of equation 2 is estimated using the following specification after taking first differences at both sides:[21]

$$ln(C_{iPost}) - ln(C_{iPre}) = \beta Z_i + \gamma_s' + \nu_i \tag{6}$$

where $\gamma_s' = \gamma_{post} - \gamma_{pre}$ is the first difference of sector fixed effects controlling for factors that affect the sector in which the firm operates.[22]

In the first stage I test if the firm level instrument is correlated with the total amount of credit received by the firm; moreover, constructing the instrument with the firm-bank links in a out of the sample year, 2003, and estimating equation 6 at firm level accounts for the concern of firms switching lenders in reaction of the negative shock.[23]

Results shown in table 8 confirm the relevance of the instrument. In columns 1 and 2 respectively, I define exposure to the foreign interbank borrowing market using a dummy equal to one if the exposure of the bank is above the median or the above the mean of the exposure of all banks in the year 2003; in column 3 I use a linear function of FD, while column 4 reports results using a third degree polynomial. All specifications show that the exposure to the foreign interbank borrowing market predicts a decrease in credit; I use the linear function of FD as defined in column 3 throughout the rest of the paper.[24]

3.5 From Credit to Workers

In the second stage I look at the effect of the instrumented credit supply shock on the organization of the firm. I estimate equation 1 by first differencing so to eliminate the firm fixed-effects:

$$ln(L_{isPost}) - ln(L_{isPre}) = \eta * [ln(C_{iPost}) - ln(C_{iPre})] + \gamma_s' + \epsilon_{is}' \tag{7}$$

[21] The *Post* dummy is equal to one for the years from 2009 to 2013, while it is equal to zero for the years from 2004 to 2008. The foreign dependence of each bank b as well as the weights, defined as the share of bank b credit to firm i over total credit of firm i are calculated in a pre-sample year, namely 2003.

[22] Estimating equation 6 in first differences allows me to eliminate firm fixed effects.

[23] Iyer et al. (2014) show that firms in Portugal do not switch bank when hit by a credit supply shock.

[24] In the appendix I show results of the estimation of equation 6 by quartiles of the distribution of the instrument to captures how the change in credit supply varies with different exposures to the shock. Results confirm the intuition that the correlation between the instrument and the change in short term credit increases in magnitude with the exposure of the firm to the shock.

In equation 7 the sector fixed-effects $\gamma'_s = \gamma_{sPost} - \gamma_{sPre}$ capture demand shocks specific to a sector s. The change in the amount of credit received by firm i, $[ln(C_{iPost}) - ln(C_{iPre})]$ is instrumented with Z_{iPost} defined in equation 5.

A formal test of the change in the hierarchical shape of the firm can be performed by constructing measures of span of controls defined as the ratio of number of workers in two adjacent layers. In table 9 I present the results for the estimation of equation 7 where the dependent variable is the change in the log ratio of workers in layer $L+1$ on workers in layer L. In columns from 1 to 3, the dependent variable is respectively the change in the ratio of team leaders to production workers, middle managers to team leaders and top managers to middle managers. When hit by a negative credit supply shock, firms shrink by reducing the ratio of team leaders to production workers (column 1) while the span of control ratios for the layers at the top of the hierarchy are unaffected by a reduction in the supply of credit (columns 2 and 3). The coefficients in table 9 are elasticities of the spans of control to credit. A 10% drop in the supply of credit predicts a drop in the ratio of team leaders to production workers of 2%, which in turns implies an increase in the span of control (column 1).

However, the observed increase in the span of control can be driven by an increase in the number of production workers, by a decrease in the number of team leaders, or by a decrease of both, with the decrease in the number of team leaders being more pronounced than the decrease in the number of production workers. To better understand which of the above mechanisms is driving the results, I estimate equation 7 focusing on each layer in the production structure. This procedure allows to draw a portrait of firms adjustment to the credit supply shock. Table 10 presents the results of the estimation of equation 7 for each management layer of the firm: in panel A I look at the number of workers in each layer and I find the biggest elasticity for the middle layers—employment of high skilled workers drops by 1.75% with a 10% drop in credit (column 1). Production workers at the bottom of the hierarchy are less affected by the shock (column 2), while non significant results are found for managerial layers at the top of the hierarchy (columns 3 and 4).[25] These findings are consistent with the results in table 9 and highlight that the increase in the span of control observed in column 1 is driven by a decrease in both team leaders and production workers, with the drop in the former being more pronounced than the latter. In panel B of table 10, I look at the intensive margin of adjustment within each layer, namely the average salary of the workers in each layer of the production hierarchy. No effect is found on wages for any of the layers; this is however not surprising given the high level of unionization of the Portuguese labour market that impedes any downward adjustment in the salaries (see Addison et al. (2015) for evidence on unionization and wage rigidity in Portugal).

[25] In the appendix I show the estimation of equation 7 for the groups of occupations used to construct the hierarchical structure of the firm. Results confirm and reinforce the findings of table 10: a 10% reduction in short term credit is associated with a 3.82% reduction of employment of high skilled production workers, while no effect is found on lower-skilled production workers neither on top managers.

Finally, I estimate equation 7 at firm level and check that the aggregate results are in line with the literature on the effect of credit shocks on employment (see for example Chodorow-Reich (2014)). Results are presented in table 11: when hit by a negative credit supply shock, firms shrink by reducing the number of workers and the total wage bill as well as the number of management layers. Indeed, the elasticity of number of workers and wage bill to a 10% drop in the supply of short term credit is respectively of 1.82% and 1.99%.[26] Comparing the elasticities obtained with the instrumental variable procedure to the ones obtained from the OLS estimation of equation 2, we notice a remarkable difference in the magnitude. The IV returns bigger coefficients and highlight the importance of instrumenting for credit supply to account for the attenuation bias generated by the contemporaneous drop in demand for firm credit.

Two considerations are in order: first, in line with the previous literature on the real effects of the credit shock, I find that firms shrink in response to a drop in the supply of credit by reducing the number of workers employed and the overall wage bill, but also the number of management layers.[27] Second, firms change their organization by laying off more in the middle and bottom layers than at the very top of the hierarchy: high skill workers and team leaders pay the highest bill of reorganizational responses to the credit crisis.

These results further highlight the importance of credit in determining the optimal organizational structure of the firm. The next section provides a simple mechanism to interpret and rationalize these findings, while in section 5 I test the validity of the mechanism by showing how firm organizations react to a trade shock.

4 Interpretation of the results

To structure the interpretation of the results and better understand the empirical analysis, this section presents a conceptual framework that illustrates the link between two different types of shock – a credit shock and a trade shock – on the organization of the firm and the substitutability between workers of different skill types and machineries. I then illustrate how to reconcile the findings of this paper with a differnent set of models, namely the capital skill complementarity framework similar to the one developed by Krusell et al. (2000).

[26] Results are in line with the findings of Caliendo et al. (2015b) and Caliendo et al. (2015a): firms systematically change the internal organization by reducing overall employment and the total wage bill as well as the number of managerial layers.

[27] The result on the number of management layers is consistent with the evidence provided by Caliendo et al. (2015b); **?**); Caliendo and Rossi-Hansberg (2012); Friedrich (2015) for a trade shock. However, the adjustment mechanism to a credit shock shows interesting differences with respect to the adjustment to a trade induced scale shock, which I extensively discuss in section 5.

4.1 Models of knowledge-based hierarchies

Models of firm organization — both knowledge-based hierarchies or incentive-based hierarchies — suggest that the optimal number of hierarchy layers increases with production scale. These models interpret managers as fixed costs that reduce marginal costs by making workers more productive; additional managers will decrease average costs if production scale is sufficiently large. Adding hierarchical layers has implications for the wage distribution within firms because higher-level managers receive high wages due to their productive effect on a large range of workers. At the same time, wages decrease for workers at the production level because managers can be considered either as problem solvers whose knowledge reduces skill requirements of workers, or supervisors whose monitoring substitutes for wage incentives to prevent shirking.

Suppose firms are structured as knowledge based hierarchy (as in Caliendo and Rossi-Hansberg (2012); Garicano (2000)) where production is a problem-solving process based on the labor knowledge.

More formally, production is a problem-solving process based on labor, knowlege and capital as in Mariscal (2018). Labor and capital are used both in the production at the plant and by managers solving problems. As in Caliendo et al. (2015b), the number of layers satisifies $1 \leq L \leq 3$ and workers in the firm are either production workers (at the bottom of the hierarchy) or higher skilled workers, wich we call managers when at the top of the hierarchical structure. As in Mariscal (2018), workers are combined with capital at each layer and the input bundle is $y_l \equiv \left(k_l^{\beta_l} + n_l^{\beta_l}\right)^{\frac{1}{\beta_l}}$. Assume that production at the bottom of the hierarchy takes place using 3 different inputs: labor from home n_{1h}, labor from abroad n_{1f} (outsourcing) and machineries k_1 or a combination of them, $y_1 \equiv \left(k_1^{\beta_1} + \left((\rho n_{1h} + (1-\rho) n_{1f}\right)^{\beta_1}\right)^{\frac{1}{\beta_1}}$. Assume also that the firm first decides on the share ρ of each labor input n depending on the relative price $\frac{n_h}{n_f} = f\left(\frac{w_{1f}}{w_{1h}}\right)$ and conditional on a level of knowledge; in other words, the firm decides on the knowledge of the production workers and on the share of domestic versus outsourced workers.

In this set-up, one unit of labor employed in production generates a unit mass of problems, which are production possibilities turned into output if they are solved using knowledge. Unsolved problems are sent to the managers at the immiediate above layer. We abstract from additional model details and we refer the reader to Caliendo and Rossi-Hansberg (2012) for an explanation of the knowledge-based hierarchy model with heterogeneous demand and Mariscal (2018) for the extension of knowledge-based hierarchy with capital.

The first order condition of the maximization problem of the firm leads to the capital labor trade-off faced in organizing production in each layer except for the CEO:

$$\frac{k_l}{n_l} = \left(\frac{p_l}{w(cz_l + 1)}\right)^{-\sigma_l} \tag{8}$$

where $\sigma_l \equiv \frac{1}{1-\beta_l}$ is the CES elasticity of substitution between capital and labor.

This set-up allows to analyse the effect of a credit shock and a trade shock on the organization of the firm. A credit shock can be seen as a shock to the cost of capital p_l, which depending on the elasticity σ_l will have heterogeneous effects on the capital-labor ratio in each layer of the hierarchy. The estimates in section 3.5 return the elasticity of substitution of each layer to a drop in the supply of credit, which is equivalent to an increase in the price of capital in this set-up. Indeed, the drop in credit has a stronger effect in the middle of the hierarchy and at the bottom, with firms shrinking by reducing the ratio of team leaders to production workers while the span of control ratios for the layers at the top of the hierarchy are unaffected by a reduction in the supply of credit. Result are consistent with a strong use of credit by the firm to finance expenses in machineries which are complementary with the knowledge of high-skill workers and substitutes with lower skill production workers.

The knowledge-based hierarchy set-up described above allows also to understand the effect of the entry of China in the WTO to the hierarchical organization of the firm. The China shock can be seen both as a demand shock that scales down total production of the firm, or as a outsourcing shock that allows firms to substitute production worker at home with labor from abroad. At the same time outsourcing implies higher comunication costs: when part of the production is outsourced in a third country, managers have a tougher time to solve problems that production workers can't solve both at home and abroad. This mechanism is similar to that of Antràs et al. (2008) who show that middle managers facilitate the transmission of knowledge across countries in the context of offshoring or to Antoni et al. (2019) who document that multi-establishment firms increase the use of middle-managers in presence of geographical comunication costs. In the framework presented above, a shock that decreases the cost of outsourcing would have the following impact to the structure of the firm : (i) firms would substitute some production workers from home with workers in the outsourcing country, (ii) the overall effect is less pronounced in the managerial layers because middle managers facilitate the transmission of knowledge across countries. Section 5 present evidence on the effect of the China shock on the organization of the firm, while section 6 presents a number of robustness that help excluding other potential mechanisms.

4.2 Models of capital skill complementarity

The firm level response to the credit shocks can be analysed in the context of a standard capital skill complementarity framework (e.g. Griliches (1969), Krusell et al. (2000) or Parro (2013)). In fact, results in section 3.5 are consistent with a working capital-layer complementarity mechanism: a decrease in the amount of credit that is used to finance working capital has a differential effect on different layers, depending on how much each layer – or skill group – is complementary with

the working capital available to the firm.[28] The different elasticities shown in table 10 suggest that the degree of complementarity is higher for the layer that includes higher-skill workers and team leaders, as well as for production workers. Additionally, table 9 shows that the reduction in team leaders is more pronounced than the reduction in production workers.

A way to theoretical characterize the empirical results is to use a production function that is Cobb-Douglas in the managerial inputs and physical capital, and CES in the two types of production worker inputs (high and low skilled production workers) and capital-equipment. Consider for example the production function described by Krusell et al. (2000):[29]

$$Y_{it} = A_{it} K_{ist}^{\alpha} M_{it}^{\beta} [\mu u_{it}^{\sigma} + (1-\mu)(\lambda k_{iet}^{\rho} + (1-\lambda) s_{it}^{\rho})^{\sigma/\rho}]^{\frac{1-\alpha-\beta}{\sigma}}$$

where M is the bundle of managers in efficiency unit, K_{st} is capital structure, S and L are respectively skilled workers and unskilled workers, K_{eq} is capital equipment and A is a neutral technological shifter. Moreover, μ and λ are parameters that govern the income shares, while σ and ρ are the relevant elasticities of substitution. In particular, $\frac{1}{1-\sigma}$ is the elasticity of substitution between equipments – or skilled labor – and unskilled labor, while $\frac{1}{1-\rho}$ is the elasticity of substitution between equipment and skilled labor. This set-up allows to test for the existence of capital-skill complementarity – if $\sigma > \rho$ the model validates the existence of capital-skill complementarity – and indirectly for the impact of a change in the amount of capital equipment available to the firm financed through short term credit on the relative skill demand and skill premium. The empirical estimates in section 3.5 confirm the existence of capital-skill complementarity, showing a lower elasticity of substitution for low skilled production workers to credit compared to higher skill production workers or team leaders. A formal test of the mechanism requires detailed information on the working capital use by layer, which is not available in the Portuguese firm level data.[30] However, in the next section I test if a different type of shock affects the organization of the firm in a completely different way that can be also reconciled with the framework described.

5 The trade shock

Do firms react differently when hit by a trade shock? Is the reaction consistent with the mechanisms described in section 4? In this section, I exploit the entry of China in the WTO and its rise as a global producer and exporter to understand and measure how Portuguese firms adjust their

[28] Short term credit is used to finance working capital and to roll on capital equipment investments. Widespread methods of equipment financing, like for instance leasing or long term rentals, involve the use of short term bank credit.

[29] See Krusell et al. (2000) for a detailed description of the capital-skill complementarity mechanism with multiple skill groups.

[30] As part of this research agenda, I am planning to conduct a firm level survey to gather additional information on working capital usage.

internal organization in response to an increase in competition, a drop in demand but also to a significant drop in the cost of outsourcing.

On the 11th of November 2001, China joined the World Trade Organization (WTO); the process of accession started some years before, but only from the end of 2001 WTO countries opened their markets to the Chinese exports. The entry of China in the WTO exposed Portuguese firms to an unprecedented degree of competition, both in the internal market and on the export markets. On the internal market, Chinese exports were cheaper and potentially substitutes of products traditionally produced by Portuguese firms. On the export markets, the inflow of Chinese products increased the degree of competition for Portuguese exporters. The combination of the two factors together generated a drastic drop in demand for Portuguese firms, both exporters and non-exporters. At the same time, the entry of China in the WTO represented also an unprecendented occasion to outsource part of the production abroad (or to import cheaper intermediate inputs).

I extend the sample to the years from 1998 to 2004 and add 2 digit sectoral level trade data to estimate the impact of exposure to Chinese import competition on the organization of the firm. To account for possible correlation between industry imports and industry domestic demand or productivity shocks, I follow Autor et al. (2013a) and instrument for the change in Portuguese imports from China using import growth in other high-income countries within 20 harmonized industries.[31] Key to the identification strategy is that China's rise as a global produced was driven by rapid improvements in the production structure of the country, including technology, infrastructure and urbanization, all contributing to a fast and unprecedented growth in total factor productivity (TFP).[32]

The theoretical intuition of the mechanism can be explained using a simple model with two sectors, one exposed to the trade shock and one that is not. As in the specific factor model, non labour factors are immobile across sectors, while in the long run labor is mobile between sectors and can freely relocate across regions. If productivity growth abroad causes product demand to fall for the exposed sectors at home, firms will have a drop in the total sales and consequently reduce labour demand. This in turn will cause a drop in nominal wages and force some workers to relocate to non-exposed sectors. However, frictions in moving labour between industries can slow the adjustments in the short run; nominal wages in the exposed sector will remain below those in non exposed industries during the transition until the economy fully adjust to the shock. At the same time, outsourcing production at the bottom of the hierarchy becames easier due to the drop in the tariff barriers and the open market. Firms would then use the opportunity to outsource part of the production exploiting the favourable wage differencial. This would in turn exacerbate the effect of the negative shock putting additional pressure at the bottom of the organization,

[31] The sectoral definition in the matched employer-employee dataset is harmonized 2 digit CAE classification and does not allow further level of detail. Moreover, data on firm-level trade transactions are not available to merge in combination with the other datasets used in this project for confidentiality reasons.

[32] See Hsieh and Klenow (2009) and Brandt et al. (2012) for evidence on China's total factor productivity growth.

namely for the production workers. The way firm adjust their organizational structure during the transition determines the aggregate employment outcomes.

Empirically, I follow Autor et al. (2014) and define a measure of trade exposure as the change in the import penetration ratio for a Portuguese industry over the period 1995 to 2004 as:

$$\Delta IP_{s,t} = \frac{\Delta M_{s,t}^{Pt,China}}{Y_{s,95} + M_{s,95} - E_{s,95}} \tag{9}$$

where for a Portuguese sector s, $\Delta M_{s,t}^{PT,CHINA}$ is the change in imports from China over the period 1995 to 2004 and $Y_{s,95} + M_{s,95} - E_{s,95}$ is the initial absorption measured as industry shipments $Y_{s,95}$ plus industry imports $M_{s,95}$ minus industry exports $E_{s,95}$. Trade data are available from 1995 onwards and this justifies the choice of 1995 as the base year to compute changes in import penetration.[33]

Changes in import penetration as defined in equation 9 can be in part contaminated by demand shocks to Portuguese industries. To isolate the supply-driven component of the Chinese import shock, I construct a measure of trade exposure as:

$$\Delta IP_{s,t}^{Other} = \frac{\Delta M_{s,t}^{US,China}}{Y_{s,95} + M_{s,95} - E_{s,95}} \tag{10}$$

where $\Delta IP_{s,t}^{US}$ is the change in imports from China from 1995 to 2004 to the US. The rationale behind choosing the US as the only market instead of using other OECD countries is to avoid that demand shocks in other countries can be correlated with demand shocks to Portuguese producers. Indeed, US is a small exporting market for Portuguese manufacturers, and it is very unluckily that a drop in demand in sector s in the U.S. market directly affects Portuguese exporters in a relevant manner. The identifying assumption for the import penetration measure as defined in equation 10 is that US is similarly exposed to the rise of Chinese imports but the industry import demand shocks are weekly correlated across them.

To measure the organizational reaction of firms to a drop in firms' sales, I would estimate the following equation:

$$ln(L_{it}) = \beta ln(Sales_{it}) + \theta_{st} + \mu_i + \epsilon_{it} \tag{11}$$

where L_{it} is a measure of organization of firm i at time t as defined in section 2.1, θ_{st} are sector-time fixed-effects and μ_i are firm fixed-effects. I estimate equation 11 using the Chinese trade shock and the measure of import penetration defined in equation 10 to instrument for the change in sales at the firm level after the entry of China in the WTO.

The hypothesis behind the instrument is that firms in more affected sectors have a more pro-

[33]The empirical estimation will use values of import penetration from 1998 to 2004.

nounced drop in sales than firms in less affected ones conditional on firm characteristics and business cycle fluctuations. The identification assumption of the instrument is that the exposure of Portuguese firms to import penetration in sector s affects the organization of the firm and its employment in each hierarchical layer only through the change in firm's sales once accounting for time invariant firm specificities. The estimate of the coefficient β of equation 11 returns the elasticity of the organization of the firm to a change in sales induced by a change in import penetration from China.

I estimate equation 11 after taking first differences for the periods 1998-2001 and 2002-2004.[34] The first stage is:

$$ln(Sales_{iPost}) - ln(Sales_{iPre}) = \beta \left[IP^{US}_{sPost} - IP^{US}_{sPre} \right] + \epsilon_{it} \tag{12}$$

where $IP^{US}_{sPost} - IP^{US}_{sPre}$ is the average change in import penetration from China to the US between the *Pre* period defined as the years from 1998 to 2001 and the *Post* period defined as the years from 2002 to 2004. [35]

The second stage is:

$$ln(L_{isPost}) - ln(L_{isPre}) = \beta \left[ln(Sales_{iPost}) - ln(Sales_{iPre}) \right] + \epsilon_{it} \tag{13}$$

where $ln(Sales_{iPost}) - ln(Sales_{iPre})$ is instrumented using $IP^{US}_{sPost} - IP^{US}_{sPre}$ and $ln(L_{isPost}) - ln(L_{isPre})$ are measures of the change in the organization of the firm as described in section 2.1. Table 12 reports the baseline results of the OLS estimation of equation 13 at firm level. A drop in log sales is correlated with the shrinkage of the organization, both in terms of number of workers in the firm (column 1), the total wage bill (columns 2 and 3) and the number of management layers; moreover, firms reduce employment in all layers as well as the wage bill (see table 13).

Table 16 presents the results for the instrumental variable estimation of equation 13 where the change in sales between the *Pre* and the *Post* 2001 is instrumented using the change in import penetration as defined in equation 10. In the first column I report the result of the first stage regression (equation 12): an increase in import penetration from China in the US predicts a significant reduction in the the log sales for the firms in the affected sectors in Portugal. In columns from 2 to 5, the table presents the estimations of the firm level adjustments to a change in sales. A 10% reduction in sales predicts a 15.7% reduction in employment and a 16% reduction in the total wage bill. Zooming inside the firm I find that firms reduce employment in all layers of the

[34] When analyzing the firm reorganization in response to the China shock, the sample is constraint to the years from 1998 to 2004 to exclude the financial crisis. On the contrary, the firm response to a credit shock is estimated with a sample that goes from 2004 to 2013.

[35] Following the methodology described in Autor et al. (2014), the average import penetration in sector s in each period of the two stacked periods is defined as $\frac{1}{T}\sum_{j=1}^{J} IP_j$ where T is the number of years in each stacked period and J are the countries in *Other* used to construct the instrument.

hierarchy except at the very top level (panel A of table 15). However, the reduction in employment are more pronounced at the bottom of the heirarchy and become less so as we go to the managerial layers. Moreover, some adjustments are found also on the wages; indeed, firms reduce the average wages both in the bottom layer (production workers) and in the mid-managerial layer (panel B of table 15).[36] In line with papers looking at employment effects of negative trade shocks (see for example Autor et al. (2013a), Autor et al. (2013b) and Autor et al. (2014)), workers at the bottom of the hierarchy are more affected by a negative shock. Indeed, I find that the elasticity of employment decreases in magnitude going up in the hierarchy, with lower values for managers at the top of the pyramid. I then formally test how a drop in sales induced by an increase in import penetration from China changes the span of controls across adjacent layers in the firm. The pattern of reorganization is clear from the estimates presented in table 14: the ratio of team leaders per production workers increases with a drop in sales, suggesting that the firm reduces the demand for workers at the bottom of the hierarchy more than in the layer of team leaders. Moreover, firms do not substantially adjust the ratio of middle managers to team leaders. This is consistent with the framework described in section 4.1, where firms react to the China shock by adjusting the scale and the composition of the workforce laying off in each layer of the hierarchical organization, but more so at the level of production workers. At the same time, the firm does not drammatically decrease the share of middle managers to facilitate the transmission of knowledge across countries in the context of offshoring, in line with the description by Antràs et al. (2008) and Antoni et al. (2019).

6 Robustness

How do contract types play a role in the firms' adjustment process to negative shocks? How do the results change constraining the sample to manufacturing only? In this section I explore the duality in contract types in the Portuguese economy to provide evidence of the role played by contract flexibility in allowing firms to reorganize more or less than less flexible counterparts. Moreover, I perform a set of robustness on the identification strategy and the results obtained in the previous sections.

Contract types

In a perfectly flexible and functioning labour market, firms could potentially reorganize their production in reaction of a shock without any constraint. However, with labour market frictions, reorganizations can be more problematic. The Portuguese legislation presents a wide contractual

[36]The wage rigidities in the Portuguese labour market suggest that firms adjust the average wage in the layer by changing the composition of workers in the layers, hence firing the most expensive (most tenured) workers. This is in line with the mechanisms found by Caliendo et al. (2015b) for French exporters.

portfolio to choose from when a firm decides to hire a new employee, but the two main categories are permanent contracts and temporary contracts representing more than 95% of the entirety of contract types in the sample. The main characteristic of permanent contracts in southern European countries (Portugal, Italy, Spain and France) is the high degree of protection for the employee; indeed, the costs of firing a worker with a permanent contract are very high for the firm which is only willing to bear the costs in extreme situations. On the other hand, temporary contracts present very little protection for the workers.

The existence of a dual labour market - with permanent and temporary contracts - creates heterogeneity across firms when looking at reorganizations: firms with a high share of permanent contracts face higher frictions to reorganization which can ultimately lead to a sub-optimal outcome, while firms that rely more on temporary contracts can freely adjust to market changes in a more dynamic way.

I exploit the heterogeneity in contract types and construct a measure of firm *flexibility* that splits firms into flexible and non flexible. I define the following measure of firm *flexibility:*

$$Flex = \frac{Temporary_{i,2003}}{Total_{i,2003}} > \sum_{i=1,N} \frac{\frac{Temporary_{2003}}{Total_{2003}}}{N} \tag{14}$$

The dummy *Flex* is constructed using pre-sample variation in intensity in temporary contracts. For each firm in 2003 I measure the share of temporary contracts over the total of temporary and permanent contracts N and I define the dummy *flex* to be equal to 1 if the firm share is above the mean of the sample (I will refer to this groups as of "flexible firms").[37]

I estimate equation 7 interacting the variable *flex* with the supply of credit both in the first stage and then in the second stage. Tables 17 and 18 report results of the estimation at the firm level (table 17) and layer level (table 18). Surprisingly, the coefficients of the interaction between the change in credit $\Delta ln(C_i)$ and the variable *flex* in all columns of table 17 have a lower magnitude compared to the coefficients for the change in credit $\Delta ln(C_i)$; flexible firms on average reduced employment and their wage bill less than their less flexible counterparts in the 5 years after the financial crisis. This apparently counterintuitive result aligns with the idea that flexibility increases the variance of firm employment by exacerbating immediate reaction to negative downturns, but also rehiring once out of the negative conjuncture.

In table 18 I present the results for the different layers: when looking inside the firm, the adjustment on the quantity of workers employed is bigger in the middle layers, even more when the firm is flexible. Flexible firms decrease less their total employment level 5 years after a negative credit supply shock; however, they adjust their internal organization by reducing the number of middle managers and higher skilled production workers or team leaders more than non flexible firms, while the adjustment on the lower skilled production workers side does not change across

[37] The average share of temporary contracts in my sample in the year 2003 is 20%.

the two groups of firms. [38]

Placebo test of the parallel trends

A potential concern with the identification strategy presented in section 3.2 is that firms connected to bad or good banks might be on different trends before the shock.[39] One way to test the validity of the parallel trend assumption when using shift-share type instrument in combination with a time varying shock is to define a placebo timing for the shock.[40] In this section I present a test of the parallel trend imposing the shock to happen in 2005 instead of 2009.

I estimate the following first stage regression:

$$ln(C_{iPost}) - ln(C_{iPre}) = \beta Z_i + \gamma'_s + \nu_i \tag{15}$$

where *Pre* is defined in the years 2004 and 2005 and *Post* is defined in 2006 and 2007. Using the years between 2004 and 2007 allows me to look at *normal* periods with no shock in the time period. I define the placebo shock to happen in 2005 and estimate the first stage defined in equation 15. Table 19 presents a not statistically significant coefficient with an f-test below 1. The placebo confirms that in normal times there is no statistical difference in the supply of credit to firms linked to more or less exposed banks conditional on time invariant firm characteristic and sector-time demand shocks. The result in table 19 provides strong evidence in support of the random matching of firms and banks in 2003 conditional on firms' time invariant characteristics. Indeed, the identification strategy correctly isolates a channel from banks to firms that is driven by a variation in bank's exposure to the foreign interbank borrowing market and is exogenous both to the firm and to the link between firms and banks.

Constraining the sample to manufacturing

A potential concern with the identification strategy presented in section 3.2 and most importantly when comparing the reaction of the firm across the two different shocks, the credit shock and the trade shock, is to have a sample of firms that are hit by both shocks. Indeed, studying the demand drop induced by the rise of China as a global producer and exporter of manufacturing products, constraints the direct effect to be on manufacturers only.

[38] The share of workers with temporary contracts in each layer is respectively 21% for production workers, 13% for team leaders, 8% for middle managers and 9% for top managers. This further highlights that the reaction of the firm is not entirely driven by the contractual composition of the workers in each layer of production, but rather by an economic mechanism that drives these adjustments.

[39] The potential endogeneity of the matching between firms and banks in the pre-sample is accounted for by the firm fixed-effects. If highly productive firms are matched with highly productive banks in a specific year (2003), the inclusion of firm fixed-effects controls for any differences across the two groups. However, firm fixed-effects cannot account for the possibility that the matching in the pre-sample places firms on different trajectories.

[40] An alternative is to modify the instrument using randomly generated weights and test if the instrument has predictive power in the first stage.

To this end, I perform the estimations of sections 3.1 and 5 constraining the sample on the 15 manufacturing sectors only. In tables 20 to 22 I report the results for the estimation of the effect of the credit shock on the manufacturing firms only. Tables 20 and 21 confirm that the main finding of the paper holds when conditioning the sample on manufacturing firms; firms react to a credit shock by shrinking, but they do so especially in the middle of the organization by reducing the number of high skill workers and team leaders more than production workers.[41] Moreover, in tables 23 and 24 I report the effect of the China shock on the manufacturing firms only. Conditioning on manufacturing firms, I find that the adjustment happens at the bottom of the hierarchy, while no effect is found on managerial positions of any level. This further strengthen the mechanism described in section 4: credit is complementary with production workers, and the degree of complementarity is heterogeneous across the two types of production workers, high skilled and low skilled. On the other hand, a trade shock that shifts the demand faced by the firm, leads to a decrease in the quantity produced, which for a manufacturing firm—with flatter organizational structures—immediately translates into a drop in demand for low skill production workers.

Dynamics: permanent or temporary shock?

The organizational choice of the firm is the results of a complex process: first, the entrepreneur observes the level of demand for the product she want to produce and then decides how to organize production. Obviously, the investment in the organizational structure by adding a layer of management depends on the scale of the output, and it does not immediately respond to minor changes to the demand level or input costs.[42] Changes in the organization are associated with permanent shocks: the firm is only willing to pay the fixed cost of adding a new management layer if the demand is expected to stay on a higher level for more than one period. On the other hand, the cost of restructuring by shrinking the organization will be incurred by the firm if the shift in the production possibility is permanent.[43]

A possible way to test the persistence of the shock is to look at the evolution of the coefficient one year, two years, three years, four years and five years after the shock. In graph 5, I plot the coefficients obtained by constraining the post period to one, two, three, four and five years in equation 7. The observed pattern is reassuring and confirms the results of tables 9 and 10: firms immediately react to the credit shock by laying off high skill workers and production workers,

[41] The list of sectors does not include construction both when using the full sample in the main analysis and when constraining the sample to manufacturing only. The reason is that the construction sector had a dramatic drop in the aftermath of the financial crisis of 2009, with a dramatic increase in sectoral unemployment rate; including construction would hugely increase the estimates and drive most of the findings.

[42] This is especially relevant in economies with labour markets rigidities, which augment the costs of hiring as well as the costs of firing workers.

[43] Besides the costs of firing, when firms re-organize by decreasing the number of workers employed, they take into account the future costs of searching and hiring new workers when the shock is reversed.

and they consistently do so over the five years of the post period. This confirms the persistence of the credit shock, and also helps explaining why we observe substantial firm reorganizations in the aftermath of the financial crisis.

Long term credit

Section 4 describes a simple mechanism that links working capital financed through short term credit to the organization of the firm, proposing a novel working-capital layer complementarity mechanism. Moreover, section 5 shows that a demand shock induces a different adjustment to the organization of the firm, while section 6 confirms that the differential adjustment does not depend on the transitory nature of the credit shock. A formal test of the mechanisms requires detailed information on the working capital use by layer, which is not available in the Portuguese firm level data.[44]

A further step in understanding the mechanism can be done using credit maturities: if long term credit has a similar effect on the organization, it would invalidate the idea behind the mechanism. In this section, I test what is the effect of a drop in supply of long term credit on the organization of the firm. Table 26 presents the estimates of equation 7 using credit with maturity above one year. Results confirm that long term credit does not have any effect in predicting the number of workers, the wage bill and the number of layers of the firm. Long term credit is mainly used to finance long term investments in structures and or plant expansions, so it is difficult to link with the investments in the "working" components of the organization of the firm. Credit maturity is thus a key determinant of how the firm responds to a credit shock. However, existing studies have usually overlooked it, finding contrasting effects. My results show that failing to take the maturity of credit into account is potentially one of the reasons behind the mixed evidence

7 Conclusion

This paper estimates the elasticity of the organization of the firm to credit supply shock and compares the organizational reaction of the firm to a trade shock, namely the China shock. I find that a reduction to the supply of short term credit affects the size of the firm and the organization of the workforce. Moreover, when faced with a restriction in credit, firms adjust their hierarchies by reducing the number of layers. In particular, firms shrink more in the middle of the production hierarchy when hit by a credit shock, consistent with a working capital-layer complementarity mechanism that forces the firm to adjust more on the high skill production workers in reaction to a shrinkage in the availability of working capital. These effects reveal the importance of credit

[44] This paper is part of a broader research agenda that aims at understanding how the organization of the firm affects firm performance. Future research aims at collecting new survey data on the of working capital by layer, information technology used in the firm and R&D expenditures.

channels to the determination of the organization of the firm and calls for further investigation to understand the welfare effects of such reorganizations.

I follow Paravisini et al. (2015) and use an estimation strategy that exploits the exposure of banks to the foreign interbank borrowing market to instrument for the supply of credit. Moreover, the drop in the liquidity available in the interbank market in the aftermath of Lehman bankruptcy provides an exogenous shock to study the differential change in credit supply to more and less exposed firms in the Portuguese economy. I reinforce the validity of the empirical strategy by performing a set of robustness to check the validity of the instrument and the importance of labour contracts.

The overall picture points at the importance of credit in the transmission of shocks from banks to the real economy. When hit by a negative credit supply shock firms shrink more in the middle of the hierarchy, reducing employment of higher-skill workers more than lower-skill production workers at the bottom of the hierarchy. In contrast, when hit by a negative trade shock the reduction is more pronounced for lower-skill production workers and decreases proportionally going up to managerial positions. The empirical findings highlight a novel heterogeneity in the degree of complementarity between working capital and each hierarchical layers. A shock to one specific input of production—working capital—translates into a stronger reduction of higher-skill production workers and team leaders than of lower-skill production workers, while top managerial positions are not affected. Consistent with the framework described in section 4.1, the China shock affects the scale of the firm, hence firms layoff proportionally in all layers, but more so at the level of production workers. At the same time, the firm does not drammatically decrease the share of middle managers to facilitate the transmission of knowledge across countries in the context of offshoring. Further investigation is needed to better understand the mechanism and provide a quantification of the welfare effects of credit induced firm reorganizations.

References

ADDISON, J. T., P. PORTUGAL, AND H. VILARES (2015): "Sources of the Union Wage Gap: Results from High-Dimensional Fixed Effects Regression Models," IZA Discussion Papers 9221, Institute for the Study of Labor (IZA).

AMITI, M. AND D. E. WEINSTEIN (2011): "Exports and Financial Shocks," *The Quarterly Journal of Economics*, 126, 1841–1877.

ANTONI, M., A. GUMPERT, AND H. STEIMER (2019): "Firm organization with multiple establishments," *CEPR working paper 13837*.

ANTRÀS, P., E. ROSSI-HANSBERG, AND L. GARICANO (2008): *Organizing Offshoring: Middle Managers and Communication Costs*, Cambridge, MA: Harvard University Press, 311–39, published versions have been posted with the written permission of the journals where they appeared. Standard copyright rules apply. Please download and print for personal use only. Luis Garciano's website. Esteban Rossi-Hansberg's website.

AUTOR, D. H., D. DORN, AND G. H. HANSON (2013a): "The China Syndrome: Local Labor Market Effects of Import Competition in the United States," *American Economic Review*, 103, 2121–68.

——— (2013b): "The Geography of Trade and Technology Shocks in the United States," *American Economic Review*, 103, 220–225.

AUTOR, D. H., D. DORN, G. H. HANSON, AND J. SONG (2014): "Trade Adjustment: Worker-Level Evidence," *The Quarterly Journal of Economics*, 129, 1799–1860.

BERTON, F., S. MOCETTI, A. PRESBITERO, AND M. G. RICHIARDI (2017): "Banks, Firms, and Jobs," *IMF working paper No. 17/38*.

BLACK, S. E. AND L. M. LYNCH (1997): "How to Compete: The Impact of Workplace Practices and Information Technology on Productivity," NBER Working Papers 6120, National Bureau of Economic Research, Inc.

BLANCHARD, O. AND P. PORTUGAL (2001): "What Hides Behind an Unemployment Rate: Comparing Portuguese and U.S. Labor Markets," *American Economic Review*, 91, 187–207.

BLOOM, N., M. DRACA, AND J. V. REENEN (2011): "Trade Induced Technical Change? The Impact of Chinese Imports on Innovation, IT and Productivity," CEP Discussion Papers dp1000, Centre for Economic Performance, LSE.

BLOOM, N., R. SADUN, AND J. VAN REENEN (2012): "The Organization of Firms Across Countries*," *The Quarterly Journal of Economics*, 127, 1663–1705.

BONFIM, D. AND Q. DAI (2012): "Bank size and lending specialization," *Working Papers*.

BRANDT, L., J. V. BIESEBROECK, AND Y. ZHANG (2012): "Creative accounting or creative destruction? Firm-level productivity growth in Chinese manufacturing," *Journal of Development Economics*, 97, 339 – 351.

CABRAL, L. AND J. MATA (2003): "On the Evolution of the Firm Size Distribution: Facts and Theory," *American Economic Review*, 93, 1075–1090.

CALIENDO, L., G. MION, L. D. OPROMOLLA, AND E. ROSSI-HANSBERG (2015a): "Productivity and Organization in Portuguese Firms," Working Paper 21811, National Bureau of Economic Research.

CALIENDO, L., F. MONTE, AND E. ROSSI-HANSBERG (2015b): "The Anatomy of French Production Hierarchies," *Journal of Political Economy*, 123, 809–852.

CALIENDO, L. AND E. ROSSI-HANSBERG (2012): "The Impact of Trade on Organization and Productivity," *Quarterly Journal of Economics*, 127, 1393–1467.

CARDOSO, A. AND P. PORTUGAL (2005): "Contractual Wages and the Wage Cushion under Different Bargaining Settings," *Journal of Labor Economics*, 23, 875–902.

CARNEIRO, A., P. G. AES, AND P. PORTUGAL (2012): "Real Wages and the Business Cycle: Accounting for Worker, Firm and Job-Title Heterogeneity," *American Economic Journal: Macroeconomics*, 4, 133–152.

CHEN, C. (2017): "Management Quality and Firm Hierarchy in Industry Equilibrium," *American Economic Journal: Microeconomics*, 9, 203–44.

CHEN, C. AND W. SUEN (2019): "The Comparative Statics of Optimal Hierarchies," *American Economic Journal: Microeconomics*, 11, 1–25.

CHODOROW-REICH, G. (2014): "The Employment Effects of Credit Market Disruptions: Firm-level Evidence from the 2008-09 Financial Crisis," *Quarterly Journal of Economics*, 129, 1–59, lead article.

CHOR, D. AND K. MANOVA (2012): "Off the cliff and back? Credit conditions and international trade during the global financial crisis," *Journal of International Economics*, 87, 117 – 133, symposium on the Global Dimensions of the Financial Crisis.

FOLEY, C. F. AND K. MANOVA (2015): "International Trade, Multinational Activity, and Corporate Finance," *Annual Review of Economics*, 7, 119–146.

FRIEDRICH, B. (2015): "Trade Shocks, Firm Hierarchies and Wage Inequality," Economics Working Papers 2015-26, Department of Economics and Business Economics, Aarhus University.

GARICANO, L. (2000): "Hierarchies and the Organization of Knowledge in Production," *Journal of Political Economy*, 108.

GARICANO, L. AND E. ROSSI-HANSBERG (2004): "Inequality and the Organization of Knowledge," *American Economic Review*, 94, 197–202.

GREENSTONE, M., A. MAS, AND H.-L. NGUYEN (2014): "Do Credit Market Shocks affect the Real Economy? Quasi-Experimental Evidence from the Great Recession and 'Normal' Economic Times," Working Paper 20704, National Bureau of Economic Research.

GRILICHES, Z. (1969): "Capital-Skill Complementarity," *The Review of Economics and Statistics*, 51, 465–468.

GUADALUPE, M. AND J. WULF (2008): "The Flattening Firm and Product Market Competition: The Effect of Trade Liberalization," *NBER Working Paper*, 14491.

GUMPERT, A. (2018): "The Organization of Knowledge in Multinational Firms," *Journal of the European Economic Association*, 16, 1929–1976.

HSIEH, C.-T. AND P. KLENOW (2009): "Misallocation and Manufacturing TFP in China and India," *The Quarterly Journal of Economics*, 124, 1403–1448.

HUBBARD, T. AND L. GARICANO (2007): "The Return to Knowledge Hierarchies," Working Papers 07-01, Center for Economic Studies, U.S. Census Bureau.

ICHNIOWSKI, C., K. SHAW, AND G. PRENNUSHI (1997): "The Effects of Human Resource Management Practices on Productivity: A Study of Steel Finishing Lines," *The American Economic Review*, 87, 291–313.

IYER, R., J.-L. PEYDRÓ, S. DA ROCHA-LOPES, AND A. SCHOAR (2014): "Interbank Liquidity Crunch and the Firm Credit Crunch: Evidence from the 2007–2009 Crisis," *Review of Financial Studies*, 27, 347–372.

JIMÉNEZ, G., M. M. ATIF, J.-L. PEYDRO, AND J. SAURINA SALAS (2011): "Local Versus Aggregate Lending Channels: The Effects of Securitization on Corporate Credit Supply," *Available at SSRN: https://ssrn.com/abstract=1939774 or http://dx.doi.org/10.2139/ssrn.1939774*.

JIMÉNEZ, G., S. ONGENA, J.-L. PEYDRÓ, AND J. SAURINA (2014): "Hazardous Times for Monetary Policy: What Do Twenty-Three Million Bank Loans Say About the Effects of Monetary Policy on Credit Risk-Taking?" *Econometrica*, 82, 463–505.

KHWAJA, A. I. AND A. MIAN (2008): "Tracing the Impact of Bank Liquidity Shocks: Evidence from an Emerging Market," *American Economic Review*, 98, 1413–42.

KRUSELL, P., L. E. OHANIAN, J.-V. RÍOS-RULL, AND G. L. VIOLANTE (2000): "Capital-Skill Complementarity and Inequality: A Macroeconomic Analysis," *Econometrica*, 68, 1029–1053.

LIBERTI, J. M. (2017): "Initiative, Incentives, and Soft Information," *Management Science*, 0, null.

LOURENÇO, R. AND P. M. RODRIGUES (2015): "House prices: bubbles, exuberance or something else? Evidence from euro area countries," *Working Papers*.

MARISCAL, A. (2018): "Firm Organization and Information Technology: Micro and Macro Implications, year=2018," 2018 Meeting Papers 1076, Society for Economic Dynamics.

MARTINS, P. S. (2009): "Dismissals for Cause: The Difference That Just Eight Paragraphs Can Make," *Journal of Labor Economics*, 27, 257–279.

MION, G. AND L. D. OPROMOLLA (2014): "Managers' mobility, trade performance, and wages," *Journal of International Economics*, 94, 85–101.

MION, G., L. D. OPROMOLLA, AND A. SFORZA (2016): "The Diffusion of Knowledge via Managers' Mobility," *CEPR working paper*.

PARAVISINI, D. (2008): "Local Bank Financial Constraints and Firm Access to External Finance," *The Journal of Finance*, 63, 2161–2193.

PARAVISINI, D., V. RAPPOPORT, AND P. SCHNABL (2017): "Specialization in Bank Lending: Evidence from Exporting Firms," Working Paper 21800, National Bureau of Economic Research.

PARAVISINI, D., V. RAPPOPORT, P. SCHNABL, AND D. WOLFENZON (2015): "Dissecting the Effect of Credit Supply on Trade: Evidence from Matched Credit-Export Data," *The Review of Economic Studies*, 82, 333–359.

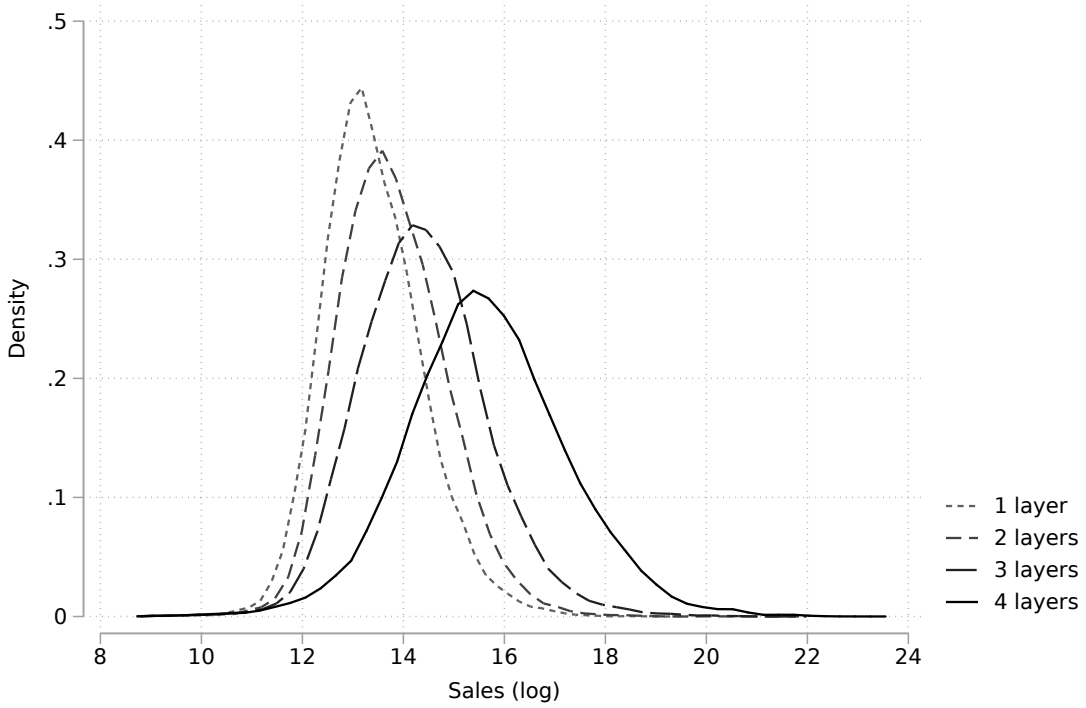
PARRO, F. (2013): "Capital-Skill Complementarity and the Skill Premium in a Quantitative Model of Trade," *American Economic Journal: Macroeconomics*, 5, 72–117.

SCHNABL, P. (2012): "The International Transmission of Bank Liquidity Shocks: Evidence from an Emerging Market," *The Journal of Finance*, 67, 897–932.

SPANOS, G. (2019): "Firm organization and productivity across locations," *Journal of Urban Economics*, 112, 152 – 168.

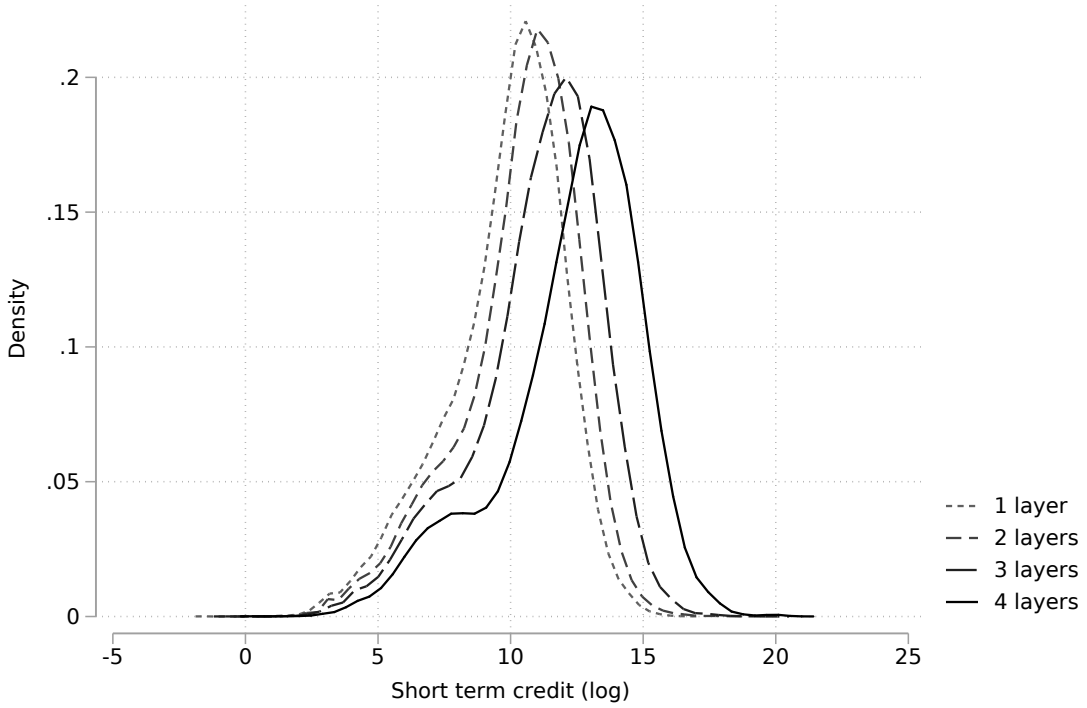
WOOLDRIDGE, J. M. (2009): "On estimating firm-level production functions using proxy variables to control for unobservables," *Economics Letters*, 104, 112 – 114.

Figure 1: Distribution of firms' hierarchy by sales



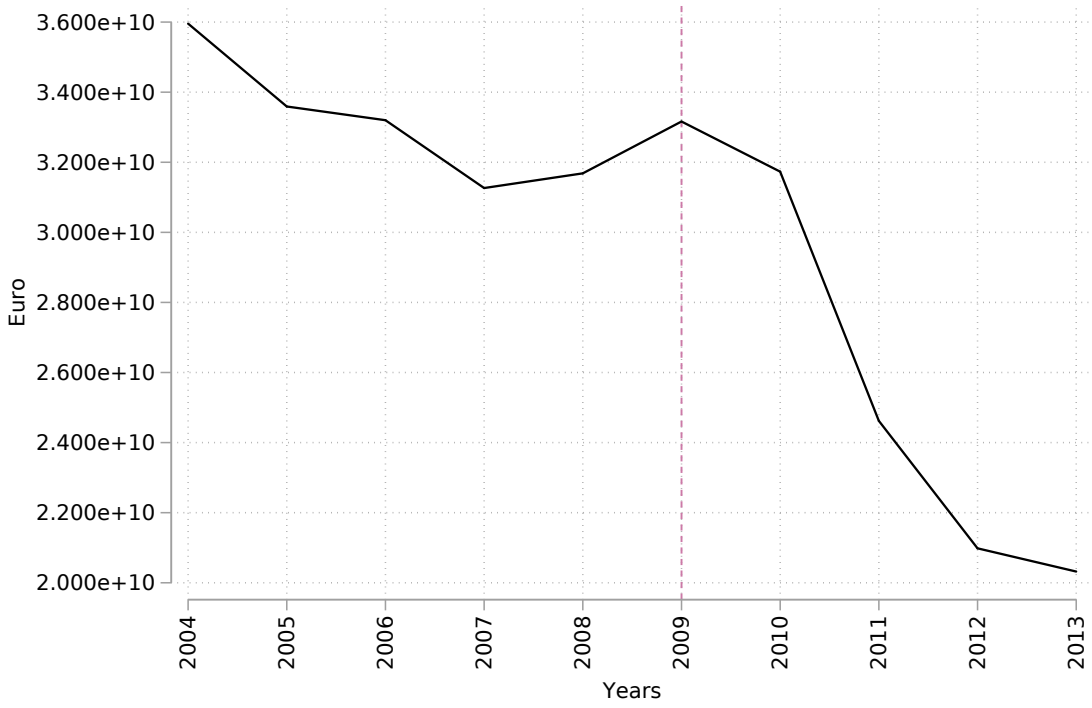
Notes: This figure report kernel density estimates of the distribution of log sales by number of layers in the firm. One density is estimated for each group of firms with the same number of layers.

Figure 2: Distribution of firms' hierarchy by credit



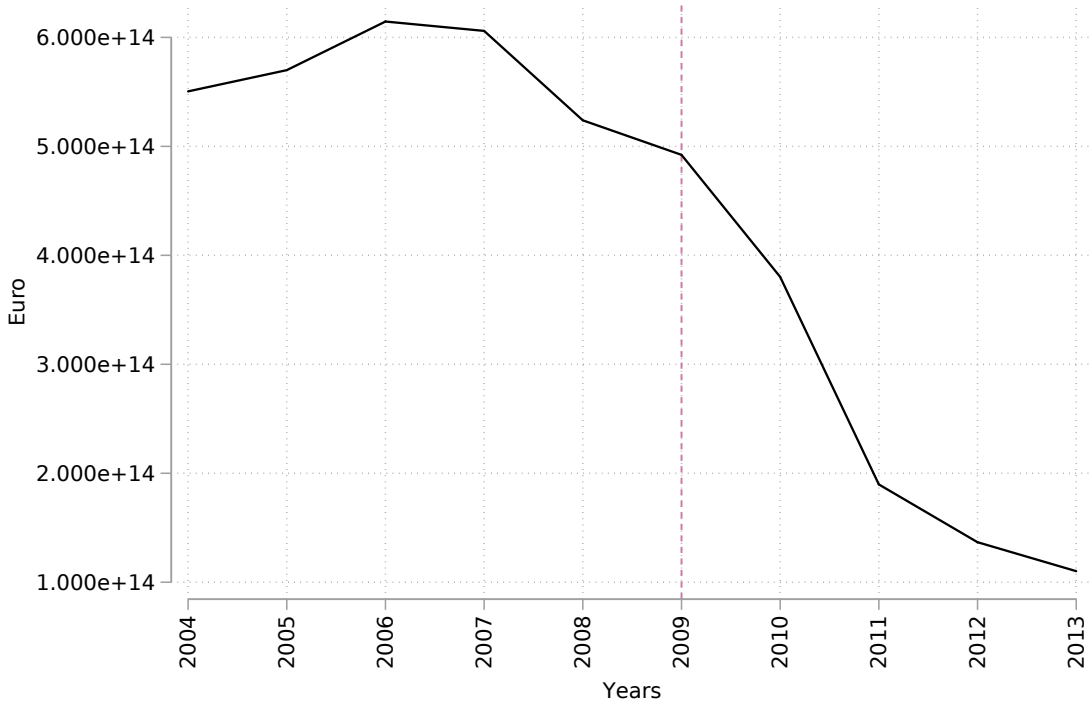
Notes: This figure report kernel density estimates of the distribution of log short term credit by number of layers in the firm. One density is estimated for each group of firms with the same number of layers.

Figure 3: Credit shock



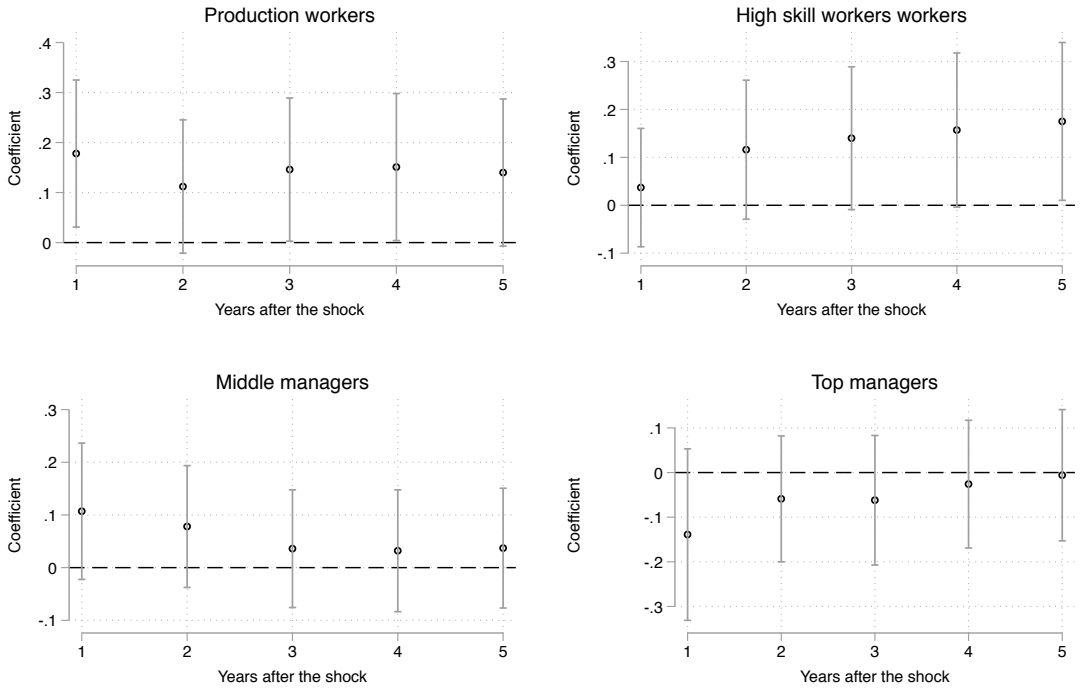
Notes: This figure report the total amount of short term credit with maturity up to one year lended lended in the Portuguese economy for the firms and banks in the sample. The red dotted vertical line in correspondence to year 2009 is the Lehman shock. Values on the vertical axis are in Euros.

Figure 4: Interbank market shock



Notes: This figure report the total exposure of Portuguese banks to the foreign interbank borrowing market. The red dotted vertical line in correspondence to year 2009 is the Lehman shock. Values on the vertical axis are in Euros.

Figure 5: Dynamics



Notes: This figure report the evolution of the estimated elasticities (and the corresponding confidence interval) of each layer to credit, respectively 1, 2, 3, 4 and 5 years after the shock in 2009. Values on the vertical axis are in percentages.

Table 1: Firm-level descriptives

	Mean	*S.d*	*Min*	*Max*	*Firm-year*
Wage bill	522,801	4066829	5615.441	2.93e+08	1,471,063
# workers	30.28	191.25	1	15359	1,471,063
Tot. Sales	6,648,312	6.20e+07	5011.533	1.05e+10	1,471,063
# management layers	1.24	1.07	0	3	1,471,063
Tot. credits	294,582	3,488,805	0	1.03e+09	1,471,063
Short term Credit	208,165	2,280,285	0	7.11e+08	1,471,063
Bank x firm	2.23	1.57	1	8	1,471,063

Notes: This table reports descriptive statistics for all the variables used in the regressions. All the values in the table are an average over all the firms in the sample and all the years, from 2004 to 2013. The wage bill is calculated adding the monthly base and overtime wages plus regular benefits and multiplying by 14. I apply a trimming of the top and bottom 0.5 per cent within each year. A firm wage bill is the sum of the annual wages of all its workers. The number of workers is the sum total number of workers in the firm in the year. A firm reporting c occupational categories will be said to have L = c − 1 layers of management: hence, in our data we will have firms spanning from 0 to 3 layers of management (as in Caliendo et al. (2015a)). In terms of layers within a firm we do not keep track of the specific occupational categories but simply rank them. Hence a firm with occupational categories 2 and 0 will have 1 layer of management, and its organization will consist of a layer 0 corresponding to some skilled and non-skilled professionals, and a layer 1 corresponding to intermediary executives and supervisors. Short term credit computed summing all the bank credit with maturity up to 1 year for a firm in a given calendar year. Bank per firm is the number of bank relationships each firm has.

Table 2: Percentage of firms that satisfy hierarchy in wages

# *layers*	$w_L^l \leq w_L^{l+1}$ all l	$w_L^0 \leq w_L^1$	$w_L^1 \leq w_L^2$	$w_L^2 \leq w_L^3$
1	0.82	0.82		
2	0.70	0.85	0.85	
3	0.61	0.90	0.87	0.82

Notes: This table reports the fraction of firms that satisfy a hierarchy in hours, grouping firms by their number of layers of management (# number of layers). Hours N_L^l is the number of hours reported in layer l in an L layers of management firm. For $L = 1, 2, 3$, and $l = 0, ..., L-1$ we say that a firm satisfies a hierarchy in hours between layers number l and $l+1$ in a given year if $N_L^l \geq N_L^{l+1}$, i.e. if the number of hours worked in layer l is at least as large as the number of hours worked in layer $l+1$; moreover, we say that a firm satisfies a hierarchy at all layers if $N_L^l \geq N_L^{l+1}\ \forall l = 0, ..., L-1$, i.e. if the number of hours worked in layer l is at least as large as the number of hours in layer $l+1$, for all layers in the firm. Following these definitions, the top panel reports, among all firms with $L = 1, 2, 3$ layers of management, the fraction of those that satisfy a hierarchy in wages at all layers (first column), and the fraction of those that satisfy a hierarchy in wages between layer l and $l+1$, with $l = 0, ..., L-1$ (second to fourth column). All the values in the table are an average over all the firms in the sample and all the years, from 2004 to 2013

Table 3: Firm-level descriptives by number of layers

		Mean				
# layers	*Firm-year*	*Sales*	*Hours*	*Hourly wage*	*Short term credit*	*Long term credit*
0	6,830	1,856,666	36,014	5.36	83,927	322,388
1	31,518	3,389,909	43,170	5.73	163,575	462,767
2	50,637	6,912,070	67,747	6.66	337,968	782,710
3	47,454	28,893,688	235,215	7.81	1,386,366	2,585,667

Notes: This table reports descriptive statistics by number of layers. Each row shows the average sales, hours worked, hourly wage and short term (maturity below 1 year) and long term (maturity above 1 year) credit for firms with a certain hierarchical structure ($L = 0, 1, 2, 3$). All the values in the table are an average over all the firms in the sample and all the years, from 2004 to 2013.

Table 4: Distribution of layers at $t+1$ conditional on layers at t

		# *of layers in* $t+1$					
		Exit	0	1	2	3	Total
# *layers t*	0	32.16	45.20	18.85	3.44	0.35	100.00
	1	27.55	6.20	52.78	12.20	1.27	100.00
	2	21.41	1.06	12.80	55.96	8.77	100.00
	3	13.74	0.21	2.00	14.48	69.57	100.00
	New	87.26	2.62	5.46	3.41	1.24	100.00

Notes: This table reports the distribution of the number of layers of management at time t+1, grouping firms according to the number of layers of management at time t. Among all firms with L layers of management (L = 0,...,3) in any year from 2003 to 2012, the columns report the fraction of firms that have layers 0, ..., 3 the following year (from 2004 to 2013), or are not present in the dataset, Exit. The table also reports, in the bottom row, the distribution of the new firms by their initial number of layers. The elements in the table sum to 100% by row.

Table 5: Credit shock OLS - firm level

	(1)	(2)	(3)	(4)
Δ *ln*	# *workers*	*wage bill*	*wage bill det.*	# *layers*
Δ *ln (Credit)*	0.038***	0.040***	0.041***	0.012***
	(0.003)	(0.003)	(0.003)	(0.001)
Observations	13,618	13,618	13,618	13,618
Sector FE	Yes	Yes	Yes	Yes

Notes: This table reports the results of the within firm estimation of equation 2. The independent variable, $\Delta ln(Credit)$ is the log change of short term credit with maturity up to one year between a pre-period, namely from 2004 to 2009 and a post period, from 2009 to 2013. The dependent variables are log changes of the averages before and after the shock. The number of workers employed in the firm is the total amount of workers employed by the firm in the calendar year, the wage bill is the total amount of wages (base plus overtime) payed by the firm in each calendar year, the wage bill de-trended is the total amount of workers employed by the firm in the calendar year de-trended using a standard linear de-trending methodology to take out normal business cycle variation, while the number of layers is the number of management layers in the firm. A firm reporting c occupational categories will be said to have L = c − 1 layers of management: hence, in our data we will have firms spanning from 0 to 3 layers of management (as in **?**). Robust standard errors in parenthesis.

Table 6: Credit shock OLS - layer level

Panel A: change in the number of workers in each layer				
	(1)	(2)	(3)	(4)
Δ *ln (number)*	*Production workers*	*Team leaders*	*Middle managers*	*Top managers*
Δ *ln* (C_i)	0.026***	0.041***	0.025***	0.016***
	(0.004)	(0.005)	(0.004)	(0.005)
Panel B: change in the average wage in each layer				
	(1)	(2)	(3)	(4)
Δ *ln (wage)*	*Production workers*	*Team leaders*	*Middle managers*	*Top managers*
Δ *ln* (C_i)	0.002*	0.001	0.002	0.001
	(0.001)	(0.001)	(0.002)	(0.003)
Observations	13,618	13,119	10,322	5,253
Firm FE	Yes	Yes	Yes	Yes

Notes: This table reports the results of the within firm estimation of equation 7 at the layer level. The independent variable, Δ *ln* (C_i) is the log change of short term credit with maturity up to one year between a pre-period, namely from 2004 to 2009 and a post period, from 2009 to 2013. In panel A I look at the quantities, and the dependent variables are log changes of the averages number of workers in each managerial layer before and after the shock, while in panel B I look at the prices and the dependent variable is the average wage in each managerial layer. The production workers are workers dealing with simple well defined tasks, mainly manual or mechanical (no intellectual work) with low complexity, usually routine and sometimes repetitive. Workers in layer 1, namely higher-skill workers or team leaders, deal with complex or delicate tasks, usually not repetitive, and defined by the superiors. Middle managers deal with the organization and adaptation of the guidelines established by the superiors and directly linked with the executive work while workers in the top layer are in charge of the definition of the firm general policy or consulting on the organization of the firm; strategic planning; creation or adaptation of technical, scientific and administrative methods or processes. Robust standard errors in parenthesis.

Table 7: Identification of the credit supply shock

	$\Delta\ ln\ (C_{ib})$		
	(1)	*(2)*	*(3)*
FD_b	-1.831***		
	(0.108)		
$FD_b > p50(FD_b)$		-0.616***	
		(0.02)	
$FD_b > mean(FD_b)$			-0.480***
			(0.02)
Observations	36,459	36,459	36,459
R^2	0.467	0.475	0.470
Firm FE	Yes	Yes	Yes

Notes: This table reports the estimation of equation 3 in first differences for the period 2004-2013. FD_b is the measure of foreign dependence of bank b to the interbank borrowing market as a share of total assets of the bank in a pre-sample year, 2003. I estimate equation 3 using both a linear function of FD, FD_b as well as indicators for banks that have an exposure to the foreign interbank borrowing market above the median of the banks in 2003, $FD_b > p50(FD_b)$ or above the mean of the banks in 2003, $FD_b > mean(FD_b)$. The dependent variable, $\Delta ln(Credit)$ is the log change of short term credit with maturity up to one year between a pre-period, namely from 2004 to 2009 and a post period, from 2009 to 2013. Robust standard errors in parenthesis.

Table 8: Credit shock - first stage

	$\Delta\ ln\ (C_i)$			
	(1)	(2)	(3)	(4)
$\sum_b w_{ib} * \{FD_b > p50(FD_b)\}$	-0.107***			
	(0.027)			
$\sum_b w_{ib} * \{FD_b > mean(FD_b)\}$		-0.143***		
		(0.020)		
$\sum_b w_{ib} * FD_b$			-1.233***	3.25***
			(0.204)	(0.90)
$\sum_b w_{ib} * FD_b^2$				-17.56***
				(3.63)
$\sum_b w_{ib} * FD_b^3$				14.72***
				(3.41)
Observations	12,657	12,657	12,657	12,657
F-Statistic	10.17	15.77	36.38	35.40
Firm FE	Yes	Yes	Yes	Yes

Notes: This table reports the estimation of the first stage as defined in equation 6 in first differences for the period 2004-2013. FD_b is the measure of foreign dependence of bank b to the interbank borrowing market as a share of total assets of the bank in a pre-sample year, 2003. I estimate equation 6 using both a linear function of FD, FD_b as well as indicators for banks that have an exposure to the foreign interbank borrowing market above the median of the banks in 2003, $FD_b > p50(FD_b)$ or above the mean of the banks in 2003, $FD_b > mean(FD_b)$. w_{ib} are the shares of funding from each bank over the total loans of firm i. The dependent variable, $\Delta ln(Credit)$ is the log change of short term credit with maturity up to one year between a pre-period, namely from 2004 to 2009 and a post period, from 2009 to 2013. Robust standard errors in parenthesis.

Table 9: Credit shock IV - span of control

	(1)	(2)	(3)
Δ *ln*	*Team leaders* / *Prod. workers*	*Middle manager* / *Team leaders*	*Top manager* / *Middle manager*
Δ *ln* $\widehat{C}_i$	0.215*	-0.156	0.065
	(0.129)	(0.118)	(0.124)
Observations	11,123	8,506	5,533
Sector FE	Yes	Yes	Yes

Notes: This table reports the results of the within firm estimation of equation 7. The independent variable, Δ *ln* $\widehat{C}_i$ is the predicted change in credit to firm i instrumented using a linear function of FD, FD_b to construct the instrument. The dependent variables are log changes of the averages before and after the shock. The ratios are computed using the total number of workers in each occupation category. In column 1 the dependent variable is the log change in the ratio of team leaders to production workers; in column 2 is the log change in the ratio of middle managers to team leaders; in column 3 is the log change in the ratio of top managers to middle managers. Robust standard errors in parenthesis.

Table 10: Credit shock IV - layer level

Panel A: change in the number of workers in each layer				
	(1)	(2)	(3)	(4)
Δ *ln (number)*	*Production workers*	*Team leaders*	*Middle managers*	*Top managers*
Δ *ln* $\widehat{C}_i$	0.140*	0.175**	0.037	-0.006
	(0.075)	(0.084)	(0.058)	(0.075)
Panel B: change in the average wage in each layer				
	(1)	(2)	(3)	(4)
Δ *ln (wage)*	*Production workers*	*Team leaders*	*Middle managers*	*Top managers*
Δ *ln* $\widehat{C}_i$	0.01	0.032	0.022	-0.016
	(0.013)	(0.028)	(0.030)	(0.039)
Observations	12,657	12,657	12,657	12,657
First stage F-Stat	34.30	34.30	34.30	34.30
Firm FE	Yes	Yes	Yes	Yes

Notes: This table reports the estimation of the second stage as defined in equation 7 in first differences for the period 2004-2013 at the layer level. Δ *ln* $\widehat{C}_i$ is the predicted change in credit to firm i instrumented using a linear function of FD, FD_b to construct the instrument. In panel A I look at the quantities, and the dependent variables are log changes of the averages number of workers in each managerial layer before and after the shock, while in panel B I look at the prices and the dependent variable is the average wage in each managerial layer. The production workers are workers dealing with simple well defined tasks, mainly manual or mechanical (no intellectual work) with low complexity, usually routine and sometimes repetitive. Workers in layer 1, namely higher-skill workers or team leaders, deal with complex or delicate tasks, usually not repetitive, and defined by the superiors. Middle managers deal with the organization and adaptation of the guidelines established by the superiors and directly linked with the executive work while workers in the top layer are in charge of the definition of the firm general policy or consulting on the organization of the firm; strategic planning; creation or adaptation of technical, scientific and administrative methods or processes. Robust standard errors in parenthesis.

Table 11: Credit shock IV - firm level

	(1)	(2)	(3)	(4)
Δ *ln*	*# workers*	*wage bill*	*wage bill det.*	*# layers*
Δ *ln* $\widehat{C}_i$	0.182***	0.199***	0.189***	0.137**
	(0.049)	(0.052)	(0.053)	(0.059)
Observations	12,657	12,657	12,657	12,657
First stage F-Stat	42.63	42.63	42.63	42.63
Firm FE	Yes	Yes	Yes	Yes
Sector FE	Yes	Yes	Yes	Yes

Notes: This table reports the estimation of the second stage as defined in equation 7 in first differences for the period 2004-2013. Δ *ln* $\widehat{C}_i$ is the predicted change in credit to firm i instrumented using a linear function of FD, FD_b to construct the instrument. The dependent variables are log changes of the averages before and after the shock. The number of workers employed in the firm is the total amount of workers employed by the firm in the calendar year, the wage bill is the total amount of wages (base plus overtime) payed by the firm in each calendar year, the wage bill de-trended is the total amount of workers employed by the firm in the calendar year de-trended using a standard linear de-trending methodology to take out normal business cycle variation, while the number of layers is the number of management layers in the firm. A firm reporting c occupational categories will be said to have L = c − 1 layers of management: hence, in our data we will have firms spanning from 0 to 3 layers of management (as in Caliendo et al. (2015a)). Robust standard errors in parenthesis.

Table 12: Trade shock OLS - firm level

	(1)	(2)	(3)	(4)
Δ *ln*	# *workers*	*wage bill*	*wage bill det.*	# *layers*
Δ *ln* $(Sales_i)$	0.254***	0.271***	0.271***	0.134***
	(0.014)	(0.014)	(0.014)	(0.006)
Observations	12,285	12,285	12,285	12,285
Sector FE	Yes	Yes	Yes	Yes

Notes: This table reports the results of the within firm estimation of equation 11. The independent variable, $\Delta ln(Sales_i)$ is the log change of de-trended sales between a pre-period, namely from 1998 to 2001 and a post period, from 2002 to 2004. The dependent variables are log changes of the averages before and after the shock. The number of workers employed in the firm is the total amount of workers employed by the firm in the calendar year, the wage bill is the total amount of wages (base plus overtime) payed by the firm in each calendar year, the wage bill de-trended is the total amount of workers employed by the firm in the calendar year detrended using a standard linear de-trending methodology to take out normal business cycle variation, while the number of layers is the number of management layers in the firm. A firm reporting c occupational categories will be said to have L = c − 1 layers of management: hence, in our data we will have firms spanning from 0 to 3 layers of management (as in Caliendo et al. (2015a)). Robust standard errors in parenthesis.

Table 13: Trade shock OLS - layer level

Panel A: change in the number of workers in each layer				
	(1)	(2)	(3)	(4)
Δ *ln (number)*	*Production workers*	*Team leaders*	*Middle managers*	*Top managers*
$\Delta ln\ (Sales_i)$	0.227***	0.194***	0.129***	0.089***
	(0.015)	(0.014)	(0.013)	(0.014)
Observations	12,285	11,629	8,280	3,961
Sector FE	Yes	Yes	Yes	Yes
Panel B: change in the average wage in each layer				
	(1)	(2)	(3)	(4)
Δ *ln (wage)*	*Production workers*	*Team leaders*	*Middle managers*	*Top managers*
$\Delta\ ln\ (Sales_i)$	0.010***	0.015***	0.015***	0.027***
	(0.003)	(0.003)	(0.005)	(0.006)
Observations	12,285	11,629	8,280	3,961
Sector FE	Yes	Yes	Yes	Yes

Notes: This table reports the results of the within firm estimation of equation 11 at the layer level. The independent variable, $\Delta ln(Sales_i)$ is the log change of de-trended sales between a pre-period, namely from 1998 to 2001 and a post period, from 2002 to 2004. The dependent variables are log changes of the averages number of workers in each managerial layer before and after the shock. The production workers in column 1 are workers dealing with simple well defined tasks, mainly manual or mechanical (no intellectual work) with low complexity, usually routine and sometimes repetitive. Workers in layer 1, namely higher-skill workers or team leaders, deal with complex or delicate tasks, usually not repetitive, and defined by the superiors. Middle managers deal with the organization and adaptation of the guidelines established by the superiors and directly linked with the executive work while workers in the top layer are in charge of the definition of the firm general policy or consulting on the organization of the firm; strategic planning; creation or adaptation of technical, scientific and administrative methods or processes. Robust standard errors in parenthesis.

Table 14: Trade shock IV - span of control

	(1)	(2)	(3)
Δ *ln*	*Team leaders* / *Prod. workers*	*Middle manager* / *Team leaders*	*Top manager* / *Middle manager*
Δ ln $\widehat{Sales_i}$	-0.826***	-0.142	-0.469***
	(0.129)	(0.124)	(0.171)
Observations	10,785	7,164	4,268
Sector FE	Yes	Yes	Yes

Notes: This table reports the results of the within firm estimation of equation 13. The independent variable, $\Delta ln(\widehat{Sales_i})$ is the log change of de-trended sales between a pre-period, namely from 1998 to 2001 and a post period, from 2002 to 2004. The dependent variables are log changes of the averages before and after the shock. The ratios are computed using the total number of workers in each occupation category. In column 1 the dependent variable is the log change in the ratio of team leaders to production workers; in column 2 is the log change in the ratio of middle managers to team leaders; in column 3 is the log change in the ratio of top managers to middle managers. Robust standard errors in parenthesis.

Table 15: Trade shock IV - layer level

Panel A: change in the number of workers in each layer

	(1)	(2)	(3)	(4)
Δ *ln (number)*	*Production workers*	*Team leaders*	*Middle managers*	*Top managers*
Δ *ln* $(\widehat{Sales}_i)$	1.395***	0.604***	0.238***	-0.020
	(0.125)	(0.078)	(0.077)	(0.102)
Observations	12,285	11,629	8,280	3,961
Sector FE	Yes	Yes	Yes	Yes

Panel B: change in the average wage in each layer

	(1)	(2)	(3)	(4)
Δ *ln (wage)*	*Production workers*	*Team leaders*	*Middle managers*	*Top managers*
Δ *ln* $(\widehat{Sales}_i)$	0.125***	0.037	0.128***	-0.089
	(0.025)	(0.032)	(0.044)	(0.068)
Observations	12,285	11,629	8,280	3,961
Sector FE	Yes	Yes	Yes	Yes

Notes: This table reports the results of the within firm estimation of equation 11 at the layer level. The independent variable, $\Delta ln(\widehat{Sales}_i)$ is the log change of de-trended sales between a pre-period, namely from 1998 to 2001 and a post period, from 2002 to 2004. The dependent variables are log changes of the averages number of workers in each managerial layer before and after the shock. The production workers in column 1 are workers dealing with simple well defined tasks, mainly manual or mechanical (no intellectual work) with low complexity, usually routine and sometimes repetitive. Workers in layer 1, namely higher-skill workers or team leaders, deal with complex or delicate tasks, usually not repetitive, and defined by the superiors. Middle managers deal with the organization and adaptation of the guidelines established by the superiors and directly linked with the executive work while workers in the top layer are in charge of the definition of the firm general policy or consulting on the organization of the firm; strategic planning; creation or adaptation of technical, scientific and administrative methods or processes. Robust standard errors in parenthesis.

Table 16: Trade shock IV - firm level

	(1)	(2)	(3)	(4)	(5)
	Δ *ln (sales)*	Δ *ln*			
		# workers	*wage bill*	*wage bill det.*	*# layers*
$\Delta IP_{s,t}^{Other}$	-0.177***				
	(0.016)				
Δ *ln* $(\widehat{Sales}_i)$		1.572***	1.631***	1.626***	0.040
		(0.129)	(0.134)	(0.134)	(0.082)
F-test	118.99	118.99	118.99	118.99	118.99
Observations	12,285	12,285	12,285	12,285	12,285

Notes: In column 1 the table reports the first stage regression as defined in equation 12; the independent variable is $\Delta IP_{s,t}^{Other}$ and the dependent variable is the change in log sales. From column 2 to column 5 I report the estimation of equation 13. The independent variable, $\Delta ln(Sales_i)$ is the log change of de-trended sales between a pre-period, namely from 1998 to 2001 and a post period, from 2002 to 2004 and is instrumented using the definition of import penetration in equation 10. The dependent variables are log changes of the averages before and after the shock. The number of workers employed in the firm is the total amount of workers employed by the firm in the calendar year, the wage bill is the total amount of wages (base plus overtime) payed by the firm in each calendar year, the wage bill de-trended is the total amount of workers employed by the firm in the calendar year de-trended using a standard linear de-trending methodology to take out normal business cycle variation, while the number of layers is the number of management layers in the firm. A firm reporting c occupational categories will be said to have L = c − 1 layers of management: hence, in our data we will have firms spanning from 0 to 3 layers of management (as in Caliendo et al. (2015a)). Robust standard errors in parenthesis.

Table 17: Credit shock IV - temporary contracts

	(1)	(2)	(3)	(4)
Δ *ln*	# *workers*	*wage bill*	*wage bill det.*	# *layers*
Δ *ln* $\widehat{C}_i$	0.241***	0.266***	0.257***	0.119*
	(0.054)	(0.057)	(0.059)	(0.070)
Temporary	-0.040*	-0.047**	-0.045*	-0.009
	(0.022)	(0.023)	(0.024)	(0.029)
Δ *ln* $\widehat{C}_i$ * *Temporary*	0.200*	0.233**	0.228**	-0.037
	(0.104)	(0.111)	(0.115)	(0.139)
Observations	13,225	13,225	13,225	13,225
Sector FE	Yes	Yes	Yes	Yes

Notes: This table reports the estimation of the second stage as defined in equation 7 in first differences for the period 2004-2013 interacting the instrument with the measure of intensity in temporary contracts as defined in equation 14. FD_b is the measure of foreign dependence of bank b to the interbank borrowing market as a share of total assets of the bank in a pre-sample year, 2003. I estimate 7 with the interaction for the intensity in temporary contracts using a linear function of FD, FD_b to construct the instrument. The dependent variables are log changes of the averages before and after the shock. The number of workers employed in the firm is the total amount of workers employed by the firm in the calendar year, the wage bill is the total amount of wages (base plus overtime) payed by the firm in each calendar year, the wage bill de-trended is the total amount of workers employed by the firm in the calendar year de-trended using a standard linear de-trending methodology to take out normal business cycle variation. Robust standard errors in parenthesis.

Table 18: Credit shock IV - temporary contracts

	(1)	(2)	(3)	(4)
Δ *ln (number)*	*Production workers*	*Team leaders*	*Middle managers*	*Top managers*
Δ *ln* $\widehat{C}_i$	0.204**	0.327***	0.109	-0.015
	(0.087)	(0.093)	(0.077)	(0.104)
Temporary	-0.026	-0.094*	-0.018	0.034
	(0.036)	(0.038)	(0.031)	(0.043)
Δ *ln* $\widehat{C}_i$ * *Temporary*	0.196	0.578***	0.318**	0.005
	(0.175)	(0.186)	(0.155)	(0.203)
Observations	13,225	12,247	10,080	5,167
Sector FE	Yes	Yes	Yes	Yes

Notes: This table reports the estimation of the second stage as defined in equation 7 in first differences for the period 2004-2013 interacting the instrument with the measure of intensity in temporary contracts as defined in equation 14 at the layer level. FD_b is the measure of foreign dependence of bank b to the interbank borrowing market as a share of total assets of the bank in a pre-sample year, 2003. I estimate 7 with the interaction for the intensity in temporary contracts using a linear function of FD, FD_b to construct the instrument. The dependent variables are log changes of the averages number of workers in each managerial layer before and after the shock. The production workers in column 1 are workers dealing with simple well defined tasks, mainly manual or mechanical (no intellectual work) with low complexity, usually routine and sometimes repetitive. Workers in layer 1, namely higher-skill workers or team leaders, deal with complex or delicate tasks, usually not repetitive, and defined by the superiors. Middle managers deal with the organization and adaptation of the guidelines established by the superiors and directly linked with the executive work while workers in the top layer are in charge of the definition of the firm general policy or consulting on the organization of the firm; strategic planning; creation or adaptation of technical, scientific and administrative methods or processes. Robust standard errors in parenthesis.

Table 19: Placebo using 2005

	$\Delta \ln (C_i)$
$\sum_b w_{ib} * FD_b$	-0.159
	(0.163)
Observations	13,534
F-test	0.94
Sector FE	Yes

Notes: This table reports the estimation of the first stage as defined in equation 15 in first differences for the period 2004-2007. I use the instrument constructed using information in 2003 to test if it has predictive power when used to a different period of time and a placebo shock defined in the year 2005. FD_b is the measure of foreign dependence of bank b to the interbank borrowing market as a share of total assets of the bank in a pre-sample year, 2003. The dependent variable, $\Delta ln(Credit)$ is the log change of short term credit with maturity up to one year between a pre-period, namely from 2004 to 2005 and a post period, from 2006 to 2007. Robust standard errors in parenthesis.

Table 20: Credit shock IV - span of control - manufacturing only

	(1)	(2)	(3)
Δ *ln*	*Team leaders* / *Prod. workers*	*Middle manager* / *Team leaders*	*Top manager* / *Middle manager*
Δ *ln* $\widehat{C}_i$	0.401*	-0.190	0.017
	(0.230)	(0.185)	(0.141)
Observations	4,825	3,627	2,303
Sector FE	Yes	Yes	Yes

Notes: This table reports the results of the within firm estimation of equation 7. The independent variable, Δ *ln* $\widehat{C}_i$ is the predicted change in credit to firm i instrumented using a linear function of FD, FD_b to construct the instrument. The dependent variables are log changes of the averages before and after the shock. The ratios are computed using the total number of workers in each occupation category. In column 1 the dependent variable is the log change in the ratio of team leaders to production workers; in column 2 is the log change in the ratio of middle managers to team leaders; in column 3 is the log change in the ratio of top managers to middle managers. Robust standard errors in parenthesis.

Table 21: Credit shock IV - layer level - manufacturing only

Panel A: change in the number of workers in each layer				
	(1)	(2)	(3)	(4)
Δ *ln (number)*	*Production workers*	*Team leaders*	*Middle managers*	*Top managers*
Δ *ln* $\widehat{C}_i$	0.163*	0.298*	0.102	-0.037
	(0.095)	(0.166)	(0.084)	(0.080)
Panel B: change in the average wage in each layer				
	(1)	(2)	(3)	(4)
Δ *ln (wage)*	*Production workers*	*Team leaders*	*Middle managers*	*Top managers*
Δ *ln* $\widehat{C}_i$	0.061**	0.128**	0.089*	0.017
	(0.028)	(0.056)	(0.050)	(0.049)
Observations	5,340	5,166	4,116	2,195
First stage F-Stat	18.83	18.83	18.83	18.83
Firm FE	Yes	Yes	Yes	Yes

Notes: This table reports the estimation of the second stage as defined in equation 7 in first differences for the period 2004-2013 at the layer level. Δ *ln* $\widehat{C}_i$ is the predicted change in credit to firm i instrumented using a linear function of FD, FD_b to construct the instrument. In panel A I look at the quantities, and the dependent variables are log changes of the averages number of workers in each managerial layer before and after the shock, while in panel B I look at the prices and the dependent variable is the average wage in each managerial layer. The production workers are workers dealing with simple well defined tasks, mainly manual or mechanical (no intellectual work) with low complexity, usually routine and sometimes repetitive. Workers in layer 1, namely higher-skill workers or team leaders, deal with complex or delicate tasks, usually not repetitive, and defined by the superiors. Middle managers deal with the organization and adaptation of the guidelines established by the superiors and directly linked with the executive work while workers in the top layer are in charge of the definition of the firm general policy or consulting on the organization of the firm; strategic planning; creation or adaptation of technical, scientific and administrative methods or processes. Robust standard errors in parenthesis.

Table 22: Credit shock IV - firm level - manufacturing only

	(1)	(2)	(3)	(4)
Δ *ln*	*# workers*	*wage bill*	*wage bill det.*	*# layers*
Δ *ln* $\widehat{C}_i$	0.190***	0.249***	0.232***	0.020
	(0.068)	(0.078)	(0.079)	(0.085)
Observations	5,340	5,340	5,340	5,340
First stage F-Stat	18.83	18.83	18.83	18.83
Firm FE	Yes	Yes	Yes	Yes
Sector FE	Yes	Yes	Yes	Yes

Notes: This table reports the estimation of the second stage as defined in equation 7 in first differences for the period 2004-2013. Δ *ln* $\widehat{C}_i$ is the predicted change in credit to firm i instrumented using a linear function of FD, FD_b to construct the instrument. The dependent variables are log changes of the averages before and after the shock. The number of workers employed in the firm is the total amount of workers employed by the firm in the calendar year, the wage bill is the total amount of wages (base plus overtime) payed by the firm in each calendar year, the wage bill de-trended is the total amount of workers employed by the firm in the calendar year de-trended using a standard linear de-trending methodology to take out normal business cycle variation, while the number of layers is the number of management layers in the firm. A firm reporting c occupational categories will be said to have L = c − 1 layers of management: hence, in our data we will have firms spanning from 0 to 3 layers of management (as in Caliendo et al. (2015a)). Robust standard errors in parenthesis.

Table 23: Trade shock IV - span of control - manufacturing only

	(1)	(2)	(3)
Δ *ln*	*Team leaders* / *Prod. workers*	*Middle manager* / *Team leaders*	*Top manager* / *Middle manager*
Δ ln $\widehat{Sales_i}$	-1.168***	0.083	-0.830
	(0.413)	(0.356)	(0.506)
Observations	4,878	3,263	1,875
Sector FE	Yes	Yes	Yes

Notes: This table reports the results of the within firm estimation of equation 13. The independent variable, $\Delta ln(\widehat{Sales_i})$ is the log change of de-trended sales between a pre-period, namely from 1998 to 2001 and a post period, from 2002 to 2004. The dependent variables are log changes of the averages before and after the shock. The ratios are computed using the total number of workers in each occupation category. In column 1 the dependent variable is the log change in the ratio of team leaders to production workers; in column 2 is the log change in the ratio of middle managers to team leaders; in column 3 is the log change in the ratio of top managers to middle managers. Robust standard errors in parenthesis.

Table 24: Trade shock IV - layer level - manufacturing only

Panel A: change in the number of workers in each layer				
	(1)	(2)	(3)	(4)
Δ *ln (number)*	*Production workers*	*Team leaders*	*Middle managers*	*Top managers*
Δ *ln* $(\widehat{Sales}_i)$	1.141***	0.139	-0.158	-0.200
	(0.348)	(0.195)	(0.212)	(0.263)
Observations	5,572	5,217	3,744	1,807
Sector FE	Yes	Yes	Yes	Yes
Panel B: change in the average wage in each layer				
	(1)	(2)	(3)	(4)
Δ *ln (wage)*	*Production workers*	*Team leaders*	*Middle managers*	*Top managers*
Δ *ln* $(\widehat{Sales}_i)$	0.315***	0.124	0.099	-0.294
	(0.116)	(0.096)	(0.122)	(0.204)
Observations	5,572	5,217	3,744	1,807
Sector FE	Yes	Yes	Yes	Yes

Notes: This table reports the results of the within firm estimation of equation 11 at the layer level. The independent variable, $\Delta ln(\widehat{Sales}_i)$ is the log change of de-trended sales between a pre-period, namely from 1998 to 2001 and a post period, from 2002 to 2004. The dependent variables are log changes of the averages number of workers in each managerial layer before and after the shock. The production workers in column 1 are workers dealing with simple well defined tasks, mainly manual or mechanical (no intellectual work) with low complexity, usually routine and sometimes repetitive. Workers in layer 1, namely higher-skill workers or team leaders, deal with complex or delicate tasks, usually not repetitive, and defined by the superiors. Middle managers deal with the organization and adaptation of the guidelines established by the superiors and directly linked with the executive work while workers in the top layer are in charge of the definition of the firm general policy or consulting on the organization of the firm; strategic planning; creation or adaptation of technical, scientific and administrative methods or processes. Robust standard errors in parenthesis.

Table 25: Trade shock IV - firm level - manufacturing only

	(1)	(2)	(3)	(4)	(5)
	Δ *ln (sales)*	Δ *ln*			
		# workers	*wage bill*	*wage bill det.*	*# layers*
$\Delta IP_{s,t}^{US}$	-0.203***				
	(0.060)				
Δ *ln* $(\widehat{Sales}_i)$		1.690***	1.864***	1.700***	0.490
		(0.479)	(0.526)	(0.479)	(0.382)
F-test	13.65	13.65	13.65	13.65	13.65
Observations	5,572	5,572	5,572	5,572	5,572

Notes: In column 1 the table reports the first stage regression as defined in equation 12; the independent variable is $\Delta IP_{s,t}^{Other}$ and the dependent variable is the change in log sales. From column 2 to column 5 I report the estimation of equation 13. The independent variable, $\Delta ln(Sales_i)$ is the log change of de-trended sales between a pre-period, namely from 1998 to 2001 and a post period, from 2002 to 2004 and is instrumented using the definition of import penetration in equation 10. The dependent variables are log changes of the averages before and after the shock. The number of workers employed in the firm is the total amount of workers employed by the firm in the calendar year, the wage bill is the total amount of wages (base plus overtime) payed by the firm in each calendar year, the wage bill de-trended is the total amount of workers employed by the firm in the calendar year de-trended using a standard linear de-trending methodology to take out normal business cycle variation, while the number of layers is the number of management layers in the firm. A firm reporting c occupational categories will be said to have L = c − 1 layers of management: hence, in our data we will have firms spanning from 0 to 3 layers of management (as in **?**). Robust standard errors in parenthesis.

Table 26: Trade shock IV long term credit - firm level

	(1)	(2)	(3)	(4)
	Δ *ln*			
	# workers	*wage bill*	*wage bill det.*	*# layers*
$\Delta ln(LongTermCredit)$	-2.534	-3.027	-2.854	-1.824
	(8.275)	(9.858)	(9.319)	(6.031)
First stage F-test	0.10	0.10	0.10	0.10
Observations	9,766	9,766	9,766	9,766

Notes: This table reports the estimation of the second stage as defined in equation 7 in first differences for the period 2004-2013. The independent variable $\Delta ln(LongTermCredit)$ is the predicted change in long term credit to firm i instrumented using a linear function of FD, FD_b to construct the instrument. The dependent variables are log changes of the averages before and after the shock. The number of workers employed in the firm is the total amount of workers employed by the firm in the calendar year, the wage bill is the total amount of wages (base plus overtime) payed by the firm in each calendar year, the wage bill de-trended is the total amount of workers employed by the firm in the calendar year de-trended using a standard linear de-trending methodology to take out normal business cycle variation, while the number of layers is the number of management layers in the firm. A firm reporting c occupational categories will be said to have L = c − 1 layers of management: hence, in our data we will have firms spanning from 0 to 3 layers of management (as in **?**). Robust standard errors in parenthesis.

A Construction of the dataset

One of the innovation of the paper is to bring together several data sources and construct an harmonized dataset on banks, credit relationships, firms and workers. In this appendix I describe in detail each dataset and the procedure followed to select the sample and construct the variables used in the analysis.

A.1 Credit registry (CRC)

CRC is the credit registry of the Central bank of Portugal. The dataset has a monthly frequency and records all the loans conceded to firms and individuals with value greater than 50 Euros from each bank in the Portuguese territory. It does not report credit given by foreign banks residing abroad to firms in the Portuguese territory, while it does record credit conceded to foreign owned firms residing in Portugal. The dataset includes several informations on each loan which I use to select a my sample.

I select regular credit to firms, excluding credit not yet materialized (potential) or any type of credit for which there is no expectation of being reimbursed or the expectation of being reimbursed is low (Overdue in a legal dispute or written-off in legal dispute for example).

The distinction between long and short term loans is made using a combination of two different variables: from 2009 onwards (2009 included) the dataset has precise information on loan maturity and allows me to select credit up to 1 year maturity. Before 2009, the dataset does not contain information on credit maturity, but instead reports the credit categories. Indeed, credit is categorized into commercial, discount funding, other funding and short term, medium and long term funding and other residual categories. I define a loan to be short term credit before 2009 if it is reported as a commercial, discount funding and other funding and short term. The structural difference in the way short term credit is defined does not create a mechanical drop in the supply of credit; in fact, looking at figure 3 the total amount of short term credit supplied in the economy starts decreasing between 2009 and 2010, while it still increases for the first year of the new classification, namely 2009. [45] Long term credit is calculated as the residual category, subtracting the value for short term credit from the total amount of credit received by the firm in a month.

The CRC dataset reports monetary values in current euros for each loan: I deflate all monetary values to 2013 euros using the monthly (aggregated to annual) Consumer Price index (CPI - Base 2008) by Special Aggregates from Statistics Portugal.

I select non financial corporations[46] and aggregate values to yearly level by taking the average

[45] I double check that the categorization is meaningful by checking that the series of loans for a randomly selected sample of firms across the years 2008 and 2009 does not mechanically drop because of the structural change in the dataset.

[46] To select non financial corporations I use the first digit of the tax identifier and match the dataset with the full list of non financial corporations identified using the sector of activity from the matched employer-employee dataset (QP).

of total short and long term firm credit across months.

A.2 Central do balancos (BBS)

The bank balance sheet dataset (Central do balancos) includes the monthly balance sheet of all the financial institutions based in Portugal. For each institution, the dataset reports a detailed classification of assets and liabilities together with their characteristics and monetary values (in millions of Euros). I deflate all monetary values to 2013 euros using the monthly (aggregated to annual) Consumer Price index (CPI - Base 2008) by Special Aggregates from Statistics Portugal.

To construct the measure of exposure to the interbank borrowing market I proceed as follows: from the liability part of each bank balance sheet, I sum short term deposits with maturity up to 1 year and repos contracts where the counterpart is a foreign financial institution and divide the sum by the total assets of the bank. I exclude intra-group funding by flagging the transaction in which the counterpart is the the ultimate owner of the Portuguese affiliate.[47] I construct an alternative measure excluding the ECB as a counterpart and perform the estimation using this definition; results are qualitatively the same. The measure of foreign interbank borrowing is the average of the monthly borrowing for each bank across the 12 months.

A.2.1 Mergers & Acquisitions

Mergers and acquisitions have been very frequent in the Portuguese banking system in the last 2 decades. Many institutions, both big and very small ones, were involved in a process that led a consolidation of the banking system; the consolidation had its peak around 2000 with four of the top seven credit institutions in Portugal involved in mergers or acquisition processes.

The event per se does not alter the analysis of this paper, but the problem arises when the M&A events are accounted differently in bank balance sheet database and in the credit registry. To make the two dataset consistent, I have checked all the M&A events happened between 1998 and 2013 that involved institutions with at least 1% of total credit in a given month.

A.3 Matched employer-employee (Quadros de Pessoal)

Quadros de Pessoal, is a longitudinal dataset matching virtually all firms and workers based in Portugal.[48] Currently, the data set collects data on about 350,000 firms and 3 million employees

[47] This happens only in 3 cases and for small banks that account for less that 1% of the total credit in a year. Details on the name of the bank or the business group are not included due to confidentiality.

[48] Public administration and non-market services are excluded. Quadros de Pessoal has been used by, amongst others, Cabral and Mata (2003) to study the evolution of the firm size distribution; by Blanchard and Portugal (2001) to compare the U.S. and Portuguese labour markets in terms of unemployment duration and worker flows; by Cardoso and Portugal (2005) to study the determinants of both the contractual wage and the wage cushion (difference between contractual and actual wages); by Carneiro et al. (2012) who, in a related study, analyze how wages of newly hired workers and of existing employees react differently to the business cycle; by Martins (2009) to study the effect of

from 1998 to 2013. The data are made available by the Ministry of Employment, drawing on a compulsory annual census of all firms in Portugal that employ at least one worker. Each year, every firm with wage earners is legally obliged to fill in a standardized questionnaire. Reported data cover the firm itself, each of its plants, and each of its workers. Variables available in the dataset include the firm's location, industry, total employment, sales, ownership structure (equity breakdown among domestic private, public or foreign), and legal setting. The worker-level data cover information on all personnel working for the reporting firms in a reference week. They include information on gender, age, occupation, schooling, hiring date, earnings, hours worked (normal and overtime), etc. The information on earnings includes the base wage (gross pay for normal hours of work), seniority-indexed components of pay, other regularly paid components, overtime work, and irregularly paid components.[49] It does not include employers' contributions to social security. Each firm entering the database is assigned a unique, time-invariant identifying number which we use to follow it over time. The Ministry of Employment implements several checks to ensure that a firm that has already reported to the database is not assigned a different identification number. Similarly, each worker also has a unique identifier, based on a worker's social security number, allowing us to follow individuals over time. The administrative nature of the data and their public availability at the workplace—as required by the law—imply a high degree of coverage and reliability. The public availability requirement facilitates the work of the services of the Ministry of Employment that monitor the compliance of firms with the law (e.g., illegal work).

A.4 Combined dataset and data processing

Central do balancos (BBS) and the credit registry (CRC) are merged by means of bank identifiers, while the matched employer-employee dataset is merged to CRC using the firm identifier. As in Cardoso and Portugal (2005), I account for sectoral and geographical specificities of Portugal by restricting the sample to include only firms based in continental Portugal while excluding agriculture and fishery (Nace rev.1, 2-digit industries 1, 2, and 5) as well as minor service activities and extra-territorial activities (Nace rev.1, 2-digit industries 95, 96, 97, and 99). Concerning workers, I consider only single-job, full-time workers between 16 and 65 years old, and working between 25 and 80 hours (base plus overtime) per week. Each worker in Quadros de Pessoal (QP) has a unique identifier based on her social security number. We drop from the sample a minority of workers with an invalid social security number and with multiple jobs. If a worker is employed in a particular year, we observe the corresponding firm identifier for that year. Since worker-level

employment protection on worker flows and firm performance. See these papers also for a description of the peculiar features of the Portuguese labour market.

[49] It is well known that employer-reported wage information is subject to less measurement error than worker-reported data. Furthermore, the Quadros de Pessoal registry is routinely used by the inspectors of the Ministry of Employment to monitor whether the firm wage policy complies with the law

variables are missing in 2001, I follow Mion and Opromolla (2014) and Mion et al. (2016) and assign a firm to workers in 2001 in the following way: if a worker is employed by firm A in 2002 and the year in which the worker had been hired (by firm A) is before 2001 or is 2001, then I assign the worker to firm A in 2001 as well; for all other workers, we repeat the procedure using 2003. In case neither 2002 nor 2003 allow us to assign a firm to a worker in 2001, we leave the information as missing. All the information in QP is collected during the month of November of each year. Worker-level variables refer to October of the same year. To control for outliers, I apply a trimming based on the hourly wage and eliminate 0.5 percent of the observations on both extremes of the distribution. Firm-level variables refer to the current calendar year (except firm total sales that refer to the previous calendar year). The location of the firm is measured according to the NUTS 3 regional disaggregation.

A.5 Definitions

Layer number. In the matched employer-employee data set, each worker, in each year, has to be assigned to a category following a (compulsory) classification of workers defined by the Portuguese law (see Mion and Opromolla (2014) and **?**). Classification is based on the tasks performed and skill requirements, and each category can be considered as a level in a hierarchy defined in terms of increasing responsibility and task complexity. On the basis of the hierarchical classification and taking into consideration the actual wage distribution, we partition the available categories into occupations. We assign "Top executives (top management)" to occupation 3; "Intermediary executives (middle management)" and "Supervisors, team leaders" to occupation 2; "Higher-skilled professionals" and some "Skilled professionals" to occupation 1; and the remaining employees, including "Skilled professionals", "Semi-skilled professionals", "Non-skilled professionals", and "Apprenticeship" to occupation 0. The position of the workers in the hierarchy of the firm, starting from 0 (lowest layer, present in all firms) to 3 (highest layer, only present in firms with 3 layers of management).

Number of layers of management. A firm reporting c occupational categories will be said to have L = c − 1 layers of management: hence, in our data we will have firms spanning from 0 to 3 layers of management (as in CMRH). In terms of layers within a firm we do not keep track of the specific occupational categories but simply rank them. Hence a firm with occupational categories 2 and 0 will have 1 layer of management, and its organization will consist of a layer 0 corresponding to some skilled and non-skilled professionals, and a layer 1 corresponding to intermediary executives and supervisors.

Reorganization. Firms can reorganize by changing the hierarchical structure or not. In fact, in line with the hierarchy model described in Caliendo and Rossi-Hansberg (2012), firms might decide to drop(add) a management layer if the shock to the production scale is sufficiently large to make the fixed cost of an additional management layer high(low) compared to the benefit of

the reduction in marginal cost due to the increase in productivity that the new manager brings to the firm by making the production workers more productive. On the other hand, if the shock to the production scale is not big enough, firms might chose to change the internal organization without changing the hierarchical structure. In the latter case, the firm might decide to decrease the number of employees in a specific layer or in any layers or decrease the wages of the workers to decrease the total wage bill of the firm.

Contract types.

Wage bill. A worker annual wage is computed adding the monthly base and overtime wages plus regular benefits and multiplying by 14. We apply a trimming of the top and bottom 0.5 per cent within each year. A firm wage bill is the sum of the annual wages of all its workers that satisfy the criteria listed above.

OLS TFP. Log total factor productivity computed from a standard three factors (labour, capital and materials) Cobb-Douglas production function model where output is measured by firm sales and the model is estimated via OLS. Separate estimations have been carried for each industry.

Wooldridge revenue-based productivity. Log total factor productivity computed from a standard two factors (labour and capital) Cobb-Douglas production function model where output is measured by firm value-added. [50]

Short term credit. Short term credit computed summing all the bank credit with maturity up to 1 year for a firm in a given calendar year.

B Additional results

B.1 Productivity

To better understand the impact of credit supply shocks to the economy through the lenses of the organization of the firm, this section presents a description of the impact of credit shock on firm organization and productivity. The decision to reorganize production by adding or dropping a layer of management has been shown to be an important determinant of firm productivity (see **?**). Indeed, **?** show that when firms reorganize by adding a layer of management they are more productive, but they also increase the quantity produced to an extent that lowers the price charged by the firm and that in turns leads to a drop in revenue-based productivity. However, the decision to reorganize is endogenous as well as the amount of credit the firm uses; if one wants to study the impact of credit supply on firm productivity needs two different instrument, one for the credit supply and one for the reorganization itself. In absence of such an instrument, I report descriptive results of productivity changes correlated with firm reorganizations and negative credit supply shocks.

[50] See Wooldridge (2009).

Table A.1 presents results for the estimation of productivity for firms that drop a management layer: a 10% drop in the supply of short term credit is correlated with a 0.48% increase in revenue productivity (column 1) and a 2.24% increase in sales per worker (column 3) while no effect is found on markup (column 2). Results are consistent with the findings in **?**: when firms are hit by a negative credit supply shock and reorganize by dropping a layer of management their productivity increases compared to firms that do not reorganize. It is crucial to notice that in this specification we are comparing two firms hit by a shock with the same intensity but with different reorganizational reaction: one of the two firms reorganizes by changing the hierarchical structure and dropping one management layer, while the other firm keeps constant the hierarchical structure while potentially reorganizing on the extensive and intensive margin within each layer—by changing the number of workers within each layer and its composition.

A formal test of the mechanism described by **?** in this set-up would require data on quantity and prices as well as an additional instrument for change in the number of layers. Moreover, the general equilibrium effect is non trivial and it is difficult to argue that more flexibility in the labour market immediately translates into a more responsive reaction of firms to exogenous shocks that in turns leads to reorganizations and to an average increase in productivity in the economy. More investigation to deal with the selection problem in the estimation of the productivity effects and a framework that incorporates the organization of the firm and the credit constraint into a general equilibrium model are needed to understand the welfare implications of reorganizations.

B.2 Accounting for bank specialization

A major concern for the identification strategy presented in section B.2 is bank specialization. The identifying assumption behind the approach described in section B.2 is that—in expectation—changes in firms' credit demand are equally spread across all banks lending to the firm.[51]

If banks have advantages in specializing in a specific sector of activity and supply disproportionately more in the specialized sector compared to all others, a negative shock to that bank can have stronger effects for the firms in the sector in which the bank is specialized. Moreover, if a demand shock hits a sector more than other sectors at the same time as the credit shock, the assumption that the changes in firms' credit demand are equally spread across all banks lending to the firm does not hold. Both effects would lead to an additional reduction in the credit supply for the firms in the sector of the bank's specialization and ultimately bias the estimates of the elasticity of firm organization to credit supply.

I follow Paravisini et al. (2015) and construct an index of bank specialization by exploiting information on the universe of loans granted by each bank and the sector of activity of the firms

[51] This approach is standard in the literature that empirically identifies bank credit supply shocks by controlling for demand shocks by mean of firm-time fixed-effects (see for example Khwaja and Mian (2008), Paravisini (2008), Schnabl (2012), Paravisini et al. (2015), Chodorow-Reich (2014) and Jiménez et al. (2014))

receiving the loan. The index of banks specialization for each bank is equal to 1 if a bank i has an above the average exposure of loans in a two digit sector in the *Pre* period compared to all active banks in the *Pre* period in Portugal. To test if bank specialization is a major concern in my set-up, I augment specification 1 interacting the measure of credit supply C_i with the measure of bank specialization and estimate equations 6 and 7 with the new terms. The new equation that I estimate is the following:

$$L_{ist} = \eta * ln(C_{it}) * Bankspecialization_i + \delta_i + \gamma_{st} + \epsilon_{ist} \tag{16}$$

Equation 16 is estimated in first difference instrumenting the supply of credit as in equation 7. Table A.2 shows that the results of the estimation of equation 16; in the first column 1 re-estimate the first stage regression for the augmented specification. The coefficient and the size of the f-test confirm the existence of a robust first stage even if one accounts for bank specializing in a specific sector of activity. In columns 2, 3 and 4 I estimate second stage for the three main outcomes, namely the wage bill of the firm and the wage bill de-trended and the number if employees. The coefficients on the instrumented credit supply confirm the results obtained in section 3.5 both in magnitudes and in significance, predicting an elasticity of 1.8% to a 10% reduction in short term credit for the wage bill of the firm and of 1.7% for the total number of workers. However, the row below shows the coefficients of the interaction between the supply of credit and the measure of bank specialization; interestingly, none of the interaction is significant and the signs are the opposite we would expect.[52]

[52]This is a test of bank specialization at 2 digit sectoral level which does not exclude the existence of bank specialization at a finer level of aggregation. More data would be needed to compute further test in the spirit of the paper by Paravisini et al. (2017).

Table A.1: Productivity

	(1)	(2)	(3)
Δ *ln*	*TFP*	*Markup*	*Sales/worker*
Δ *ln* $\widehat{C}_i$	-0.048**	0.017	-0.224**
	(0.024)	(0.016)	(0.100)
Observations	1,533	1,533	1,533
Firm FE	Yes	Yes	Yes
Sector-time FE	Yes	Yes	Yes

Notes: This table reports the estimation of the second stage as defined in equation 7 in first differences for the period 2004-2013 conditional on dropping a layer of management; the table compares firms that drop a layer of management in response to the shock with firms that either keep the same organizational structure or add a management layer. FD_b is the measure of foreign dependence of bank b to the interbank borrowing market as a share of total assets of the bank in a pre-sample year, 2003. I estimate 7 using a linear function of FD, FD_b to construct the instrument. The dependent variables are log changes of the averages before and after the shock. In column 1, TFP is estimated using a standard procedure as defined by Levinson and Petrin. Robust standard errors in parenthesis.

Table A.2: Bank specialization

	(1)	(2)	(3)	(4)
Δ *ln*	C_i	*Wage bill*	*Wage bill det.*	*# workers*
$\sum_b w_{ib} * FD_b$	-1.228***			
	(0.204)			
Δ *ln* $\widehat{C}_i$		0.185***	0.173***	0.169***
		(0.049)	(0.053)	(0.055)
Δ *ln* $\widehat{C}_i$ * *Bank specialization*		-0.005	-0.004	-0.004
		(0.012)	(0.013)	(0.013)
Observations	12,657	13,266	13,266	13,266
First stage F-Stat	33.67	33.67	33.67	33.67
Sector FE	Yes	Yes	Yes	Yes

Notes: Notes: This table reports the estimation of the second stage as defined in equation 7 in first differences for the period 2004-2013 interacting the instrument with the measure of intensity is measure of bank specialization equal to one if the bank is above the median of specialization in a sector compared to the other banks in a pre-sample year, namely 2003. FD_b is the measure of foreign dependence of bank b to the interbank borrowing market as a share of total assets of the bank in a pre-sample year, 2003. I estimate 7 with the interaction for bank specialization using a linear function of FD, FD_b to construct the instrument. The dependent variables are log changes of the averages before and after the shock. The number of workers employed in the firm is the total amount of workers employed by the firm in the calendar year, the wage bill is the total amount of wages (base plus overtime) payed by the firm in each calendar year, the wage bill de-trended is the total amount of workers employed by the firm in the calendar year de-trended using a standard linear de-trending methodology to take out normal business cycle variation. Robust standard errors in parenthesis.