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Credit-Supply Shocks and Firm Productivity in Italy[1]

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Abstract

The Italian economy has been struggling with low productivity growth and bank balance sheet strains. This paper examines the implications for firm productivity of adverse shocks to bank lending in Italy, using a novel identification scheme and loan-level data on syndicated lending. We exploit the heterogeneous loan exposure of Italian banks to foreign borrowers in distress, and find that a negative shock to bank credit supply reduces firms' loan growth, investment, capital-to-labor ratio, and productivity. The transmission from changes in credit supply to firm productivity relates to labor market rigidities, which delay or distort the adjustment of firms' desired labor and capital allocations, and thereby reduce firms' productivity. Effects are stronger for firms with higher capital intensity and external financial dependence.

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Contents Page

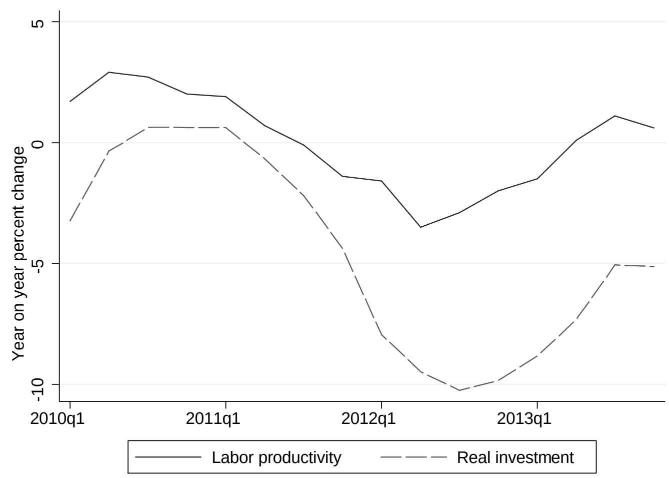
Figures

Tables

I. INTRODUCTION

Real business investment in Italy has underperformed in recent years, declining by over 12 percent during the 2010–2012 period (Figure 1). One of the contributing factors that has been cited in the literature is the role of tighter bank lending conditions, in particular, whether non-financial corporations were effectively rationed out by credit supply constraints. Credit supply rationing could have compounded the distress of firms that were already liquidity constrained and under balance-sheet pressures, exacerbating the retrenchment in investment spending and hampering productivity.

Figure 1. Labor Productivity and Real Investment



Source: Haver and authors' calculations.

This paper studies the effects of credit supply shocks on firms' productivity in Italy during the European sovereign debt crisis.[1] While the effect of a credit freeze on firms' investment or employment has been studied extensively for different countries, the literature on the effects of credit-supply shocks on firms' total factor productivity (its extent and channels of impact) is rather scarce. To the best of our knowledge, our paper is the first to study this link for Italy in the context of total factor productivity. To establish a causal link between bank-specific loan supply shocks and firm productivity, it is necessary to identify cases of financial distress that affect banks' balance sheets differently, but are uncorrelated with the level of economic activity, credit demand, and borrower risk. We rely on a large sample of matched bank-firm syndicated loan data over the period 2010Q1–2012Q2 and a novel scheme for identification. We use information on loans by individual banks to firms that borrow from multiple Italian banks, which are exposed to foreign borrowers in distress to different degrees. Results show

[1]The focus of this paper is on the productivity of average firm in Italy.

that contractions in loan supply to Italian firms reduce their productivity through a retrenchment in investment and sub-optimal capital-to-labor ratios.[2]

At the onset of 2010, some Italian banks had significant loan exposure to firms in financially-distressed euro area countries (i.e. Greece, Ireland, Portugal and Spain). For those banks, lending exposure to firms in such countries was about 8 percent of total loans. Over the following two years, a sharp rise in borrowing costs and default rates of non-Italian firms in financially-distressed euro area countries acted as an exogenous shock, adversely impacting Italian banks' balance sheets, and forcing affected banks to retrench from lending to Italian firms. On the loan level, we find that higher bank exposure to foreign borrowers in distress led to a significant contraction in loans to Italian firms. Aggregating across loans to non-financial corporations, we find that firms were unable to substitute from affected banks to healthy ones. Firms that borrowed more from troubled banks faced tighter credit constraints than firms that borrowed less from the affected banks.

Since Italy was involved in the European sovereign debt crisis, we need to ensure that our exposure variable is uncorrelated with credit demand factors. To do so, we follow Amiti and Weinstein (2016) in decomposing aggregate loan growth in Italy into bank-supply and firm-demand factors (See *Appendix B* for details). A major advantage of this approach is that one can identify credit supply shocks directly from loan data, rather than relying on instruments or proxies. We indeed find that our exposure variable is highly correlated with retrieved bank-supply factors, i.e. fluctuations in bank credit supply net of firm characteristics and general credit conditions, and is orthogonal to credit demand factors. Results are robust to the inclusion of time-varying fixed effects at the borrower level.

After establishing that credit supply shocks reduce firms' loan growth, we show that credit supply rationing has real effects.[3] Firms with higher exposure to troubled banks reduced their investment and employment more, and sub-optimally adjusted their capital-to-labor ratio due to labor market frictions. These firms experienced a significant fall in productivity. A one standard deviation increase in borrowing exposure to troubled banks reduced TFP by 5.8%. Firms with higher outstanding total debt were more adversely affected by the supply shock. The effect on firm productivity was stronger for firms that operated with higher capital

[2]The transmission from changes in credit supply to firm productivity relates to the decision to hold on to labor even in the face of adverse shocks, rather than to immediately adjust the capital-to-labor ratio. This could relate to labor market rigidities or labor-hoarding, both of which imply reduced firms' productivity.

[3]The syndicated loan market data comprises of mostly large enterprises and banks. Large firms could differ from small and medium-sized enterprises (SMEs) in terms of their access to alternative sources of finance (bonds, stock markets, etc.). However, the literature usually finds that the effects of a credit crunch are, if anything, stronger for smaller firms. This is especially true in bank-dependent systems such as Italy. Thus, while our sample suffers from the omission of SMEs, this should not fundementally change our findings. In terms of bank selection, the direction of the bias is unclear. While smaller banks could be less diversified, they might also have lower exposure to crisis countries.

intensity, because the inefficient adjustment in their capital-labor-ratio exerted a greater toll on them. We build a simple model featuring asymmetric labor adjustment costs to highlight the underlying channels driving our econometric results.[4] An important policy implication of our findings is to increase flexibility in allocation of labor within the firm—one of the main objectives of a recent labor market reform ("Jobs Act") in Italy, which is expected to yield benefits gradually over the long term.

Relative to the existing literature (see Section II.), this paper makes several contributions. First, as highlighted above, we add to the relatively scarce literature that examines the effects of credit-supply shocks on firms' productivity (its extent and channels of impact). Second, we identify a novel shock to the asset side of banks' balance sheet, and ensure its exogeneity by using the factor model of Amiti and Weinstein (2016). In the European context, several papers investigate the consequences of an interbank freeze or sovereign debt crisis on banks' lending behavior. However, in a single-country setting, it is more difficult to find appropriate proxies for credit supply shocks that are independent of loan demand factors. We construct such an exposure variable using syndicated loan data for many Italian banks.

The remainder of the paper is structured as follows. Section II. discusses how our paper relates to the existing literature. Section III. presents the dataset used for our analysis. Section IV. explains the methodology while Section V. presents the main results. Section VI. concludes.

II. Literature Review

This paper contributes to the growing literature that investigates the real effects of credit supply shocks. The key challenge is to disentangle firms' demand for credit from banks' supply of loans. Initial contributions were based on aggregate data and made use of geographical or economic borders; see Peek and Rosengren (2000). More recent studies use matched firm-bank data and employ information on loans from individual banks to firms that borrow from multiple banks to solve the identification problem. Most papers rely on finding suitable instruments to identify credit supply shocks and usually focuses on a particular episode. In a seminal paper, Khwaja and Mian (2008) carefully control for loan demand effects using micro-level data and show that an exogenous liquidity shock (an unanticipated nuclear test in Pakistan) forces affected banks to reduce lending, especially to small firms. Using a similar approach and data on loan applications in Spain, Jiménez et al. (2012) analyze how changes in aggregate macroeconomic variables and the interaction between these

[4] In the model, firms borrow to hire workers. Following a negative credit supply shock, they experience a tightening in their borrowing constraint. This forces them to reduce investment and labor. However, convex labor adjustment costs prevent firms from optimally adjusting employment. This leads to a decrease in their capital-to-labor ratio below the optimal level that would prevail without adjustment costs. Thus, a credit supply shock forces firms to work with an inefficient capital-labor mix, which reduces productivity.

variables and bank characteristics affect the likelihood of loans being granted. Bonaccorsi di Patti and Sette (2016) link banks' balance sheet conditions to the provision of credit and show that Italian banks that were more exposed to the interbank market or relied heavily on securitization prior to the subprime crisis curtailed lending more than other banks.

In a recent paper, Amiti and Weinstein (2016) develop a novel method to separate loan demand from loan supply shocks that does not rely on such instruments. Using a comprehensive, matched lender-borrower data set for Japan, they recover supply and demand components by imposing an additional constraint. The adding-up constraint states that changes in individual loan growth between banks and firms must add up to the overall, economy-wide change in loan growth. This consistency check allows one to efficiently recover each firms' loan demand and each banks' loan supply at each point in time. They show that their loan supply metric is strongly correlated with proxies previously used in the literature, and argue that changes in loan supply have significant effects on firm investment. Contemporaneous work to ours (Manaresi and Pierri (2016)) apply this methodology using Italian credit registry data and assesses the impact of credit constraints on input accumulation and value added productivity. Our paper combines both approaches and identifies a novel shock to the asset side of banks' balance sheet, while ensuring its exogeneity (to demand conditions) by using the factor model of Amiti and Weinstein (2016).

Our paper is also closely related to some recent contributions that investigate the effects of financial shocks on employment and investment at the firm level. Similar to ours, a number of these studies have used matched bank-firm syndicated loan data for their analyses. Chodorow-Reich (2014) concludes that for the US, following the Lehman bankruptcy, the reduction in lending explains around one third of total decline in firms' employment. For a sample of European firms active in the syndicated loan market, Acharya et al. (2016a) find that loan contractions by banks affected by the recent crisis depressed investment, job creation, and sales growth of the firms. Others have used credit registry data. In the context of Italy, Cingano et al. (2016) find a strong negative effect of the liquidity drought in interbank markets that followed the 2007 financial crisis on firm investment. They also find that credit shocks affect the firm's value added, employment and input purchases. Bottero et al. (2015) show that the Greek bailout in 2010 led to a fall in loan supply in Italy, which depressed investment and employment for smaller Italian firms. Berton et al. (2017) analyze the impact of financial shocks on employment using a matched data set of job contracts, firms and banks in one Italian region.

This paper also contributes to the literature that analyzes the effects of credit-supply shocks on firms' productivity—most of which has focused on labor productivity. Franklin et al. (2015) use pre-crisis lending relationships to establish that contractions in lending reduce labor productivity, wages and capital intensity of firms in the United Kingdom. Cette et al. (2016) use a cross-country sample of 14 OECD countries to show that stricter employment protection distorts firms' capital intensity, as firms perceive an increase in labor protection like a tax on labor costs. They substitute capital with labor. In another cross-country study, Borio et al. (2016) establish that during credit booms, capital and labor are misallocated towards unproductive sectors, which reduces aggregate labor productivity.

Most importantly, evidence for the impact of credit supply shocks on total factor productivity, one of the main contributions of our paper, has remained scarce. For Japan, Caballero et al. (2008) suggest that lax regulations allowed banks to keep lending to unproductive or insolvent borrowers (so-called zombies), which reduced TFP. They show that an increase in zombie lending depresses investment and employment growth of non-zombies and increases productivity dispersion. For a sample of EU countries, Acharya et al. (2016b) show that the Outright Monetary Transactions program implemented by the ECB encouraged zombie lending, as banks extended new loans mainly to low-quality and unproductive firms. Those firms, in turn, used the additional funds mainly to build up cash reserves and did not invest or create new employment.

III. Data Sources and Definition of Variables

A. Data

Data on syndicated loans by Italian banks at quarterly frequency are obtained from Dealogic over the period 2005 to 2016. Syndicated loans are issued jointly by a group of banks to one borrower, where one or more participants act as lead bank(s). Lead bank(s) screen the borrower and negotiate loan terms. We focus on non-financial borrowers and drop firms classified as financial corporations or special purpose vehicles. Dealogic provides detailed information on loan amount, interest spread over Libor/Euribor, and maturity of each loan. Additionally, it provides information on borrowers' and lenders' type, location, and industry.

Loans are split on a pro-rata basis among all participating banks in the syndicate. Transactions with deal status 'canceled' are removed. We define a loan as the total outstanding loan volume in a firm-bank pair. We keep each deal active until maturity and add up all deals of a firm-bank connection at each point in time. We merge our loan observations with data on Italian firms, provided by Orbis, as well as bank data from SNL Financial. We retrieve information on firms' total assets, fixed assets, return on assets, cash, value added, labor, labor costs, cash flow and income. For banks, we collect information on their assets, deposits, capital, tier-1 capital ratio, non-performing loans, liquid assets, and return on assets, consolidated at the group level. For robustness checks, we use data on firm borrowing costs, as well as long-term interest rates on sovereign debt. Both are provided by the ECB.

We define three samples. First, to recover demand and supply factors that drive loan growth following Amiti and Weinstein (2016), we use annual loan-level data from 2005 to 2016, where we take the yearly averages across quarters. In total, we have 47,205 firm-bank-year observations covering 39 banks and 814 firms. Second, to account for the possibility of firms switching between banks (exposed to euro area countries in distress, and not) and its impact, we focus on the period 2010Q1 to 2012Q2. Our sample period covers the start of the European sovereign debt crisis and ends before Mario Draghi delivered his "whatever it takes" speech. Over this period, we end up with a total of 12,238 firm-bank-quarter observations (loans) by 32 banks to 592 firms. Third, as firm data from Orbis are only available at the yearly level and to analyze the impact of bank loan supply shocks on firms' productivity, we aggregate the quarterly observations to the firm-year level. We end up with a total of 1132 firm-year observations including 316 firms.

B. Definition of Variables

For each firm-bank connection, we define loans/assets as the log of total outstanding loan volume extended by bank b to firm f at time t, scaled by its lagged total assets. As bank controls, we include size (log of total assets), liquid assets and capital (both standardized by total bank assets), return on assets (ROA), and nonperforming loans as share of total loans (NPL). When we aggregate to the firm level, the loan volume, interest spread (in basis points) and maturity (in years) are weighted averages across all lenders of each firm. We weigh by the share of lenders' loan volume out of firms' total outstanding borrowing. Loan growth is defined as the log difference in loan volume from $t-1$ to t. Firm controls are size (log of total assets), as well as log of debt, cash, and income, all standardized by total assets.

We define firm's labor productivity as the log of value added over labor, and estimate TFP using the Wooldridge (2009) methodology.[5] We impute missing values for value added as the sum of employment costs and EBITDA, see Gal (2013), and deflate the output values by the respective price indices for final, intermediate and investment goods. We then estimate the total factor productivity following the approach outlined in Wooldridge (2009), which builds on the method developed in Levinsohn and Petrin (2003), but is robust to the Ackerberg et al. (2006) critique. To highlight the underlying channels of impact, we require three additional variables: firms' investment, employment, and capital-to-labor ratio. Following the corporate finance literature, investment and employees are standardized by beginning of the sample period fixed assets. Investment is defined as net of depreciation. The capital-to-labor ratio is defined as log of fixed assets over employment. All variables are winsorized at the 1st and

[5]What we are usually after is physical productivity (denoted as "A" in most models). We would like to estimate productivity by dividing real value added by quantities of production inputs. However, without detailed price data P at the firm level, what we are actually measuring is revenue productivity TFPR = P*A. We are dividing the dollar-value of value added by the dollar value of production inputs. Prices reflect market power and supply, so when we estimate productivity, we are capturing a mixture of true productivity A and changes in market share affecting P. While in the short run A does not react to changes in the input mix or financial conditions, P does. A capital-labor ratio that does not maximize profits affects the price charged through the quantity produced, and thereby also TFPR. This also lies at the heart of our model.

99th percentile to avoid outliers driving our results.

C. Summary Statistics

Tables 1 and 2 report the summary statistics for our variables at the loan and firm level. As depicted in Table 1, average loan volume in our sample is around 18% of total firm assets, and average bank exposure to financially-distressed euro area countries is about 4%. The average bank in our sample has EUR 365 million in assets and a capital ratio of 7%. Return on assets is negative, on average during the period 2010–2012, and nonperforming loans make up 11% of total loans over the same period. Table 2 shows that while average investment is positive in our sample, it is negative for the median firm. Debt makes up 44% of firms' total assets, and the average firm has 2885 employees. This reflects the fact that syndicated loans are usually issued to large companies. Figure 2 plots the density of TFP for two groups of firms. It shows that TFP declined significantly from 2009 to 2012 for firms with high exposure to troubled banks (upper panel). However, TFP did not decline for firms with lower exposure (bottom panel). The next section will systematically investigate this hypothesis using a series of regressions.

Table 1. Loan Level Summary Statistics

	Mean	P50	SD	P25	P75
Loans/Assets	0.18	0.02	0.62	0.00	0.06
Bank Exposure	0.04	0.04	0.03	0.02	0.05
Bank Total Assets (million)	365	219	343	73	659
Bank Capital/Assets	0.07	0.07	0.01	0.06	0.08
Bank Liquid Assets/Total Assets	0.26	0.29	0.09	0.19	0.32
Bank Deposits/Assets	0.39	0.41	0.11	0.34	0.45
Bank ROA (%)	-0.56	-0.68	0.78	-1.25	0.13
Bank NPL (%)	0.11	0.11	0.04	0.09	0.13
Observations	12238				

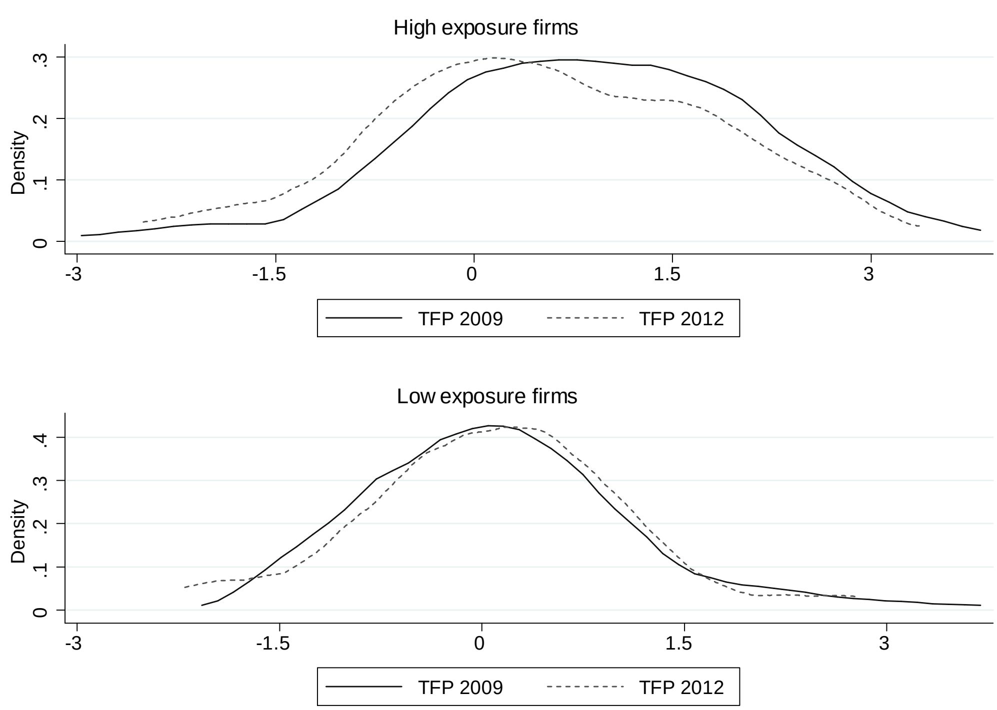
IV. Empirical Strategy

Establishing a causal link between (bank-specific) loan supply shocks and firm productivity poses an important identification challenge. The shock has to be exogenous with respect to the overall economic conditions and credit demand by firms. We satisfy this condition (and test for it formally in Section V.) by relying on varied patterns of credit extension to the same firm by multiple Italian banks that have been affected by the shock to different degrees. As a shock, we exploit the varied pre-crisis loan exposure of Italian banks to firms in financially-distressed euro area countries (excluding Italy) during the European sovereign

Table 2. Firm-Year Level Summary Statistics

	Mean	P50	SD	P25	P75
Firm Exposure	0.04	0.04	0.02	0.03	0.05
Investment	0.05	-0.01	0.35	-0.05	0.03
Employment	2885	277	10214	43	1325
Capital-Labor Ratio	4.19	0.23	13.61	0.09	1.15
Labor Productivity	0.22	-0.14	1.36	-0.61	0.71
Revenue TFP	2.19	2.18	1.12	1.46	2.84
Firm Total Assets (million)	1.39	0.15	4.95	0.04	0.48
Firm ROA (%)	-0.01	0.00	0.11	-0.01	0.03
Firm Debt/Assets	0.44	0.39	0.28	0.22	0.61
Firm Cash/Assets	0.06	0.04	0.08	0.01	0.09
Firm Income/Assets	0.07	0.07	0.08	0.03	0.11
Observations	1132				

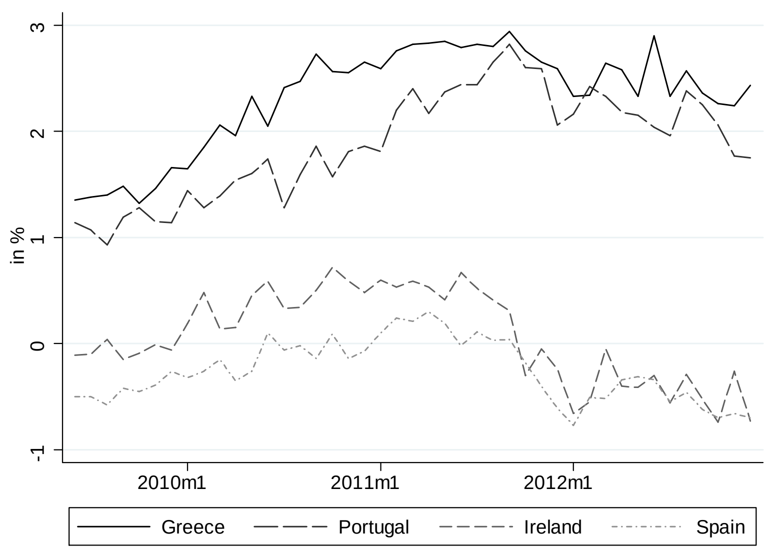
Figure 2. TFP Distributions



Source: Authors' calculations based on Orbis data.

debt crisis of 2010–2012. At the onset of the crisis, some Italian banks had strong syndicated loan exposure to borrowers in such countries — about 8% of total loans for exposed banks. Beginning in 2010, borrowing costs and corporate default rates rose sharply for firms in financially-distressed euro area countries (Figure 3) irrespective of the general economic condition in Italy. These events acted as a shock to the asset side of Italian banks' balance sheets, and provide a natural experiment for the analysis in this paper. We investigate, at the quarterly level, whether banks that had higher loan exposure to firms in distressed countries reduced their credit supply to Italian firms by more; to what extent firms managed to substitute their funding source to non-exposed Italian banks; and most importantly whether (and through which channels) bank credit supply shocks had real effects (using annual data).

Figure 3. Firm Borrowing Costs in Financially-Distressed Euro Area Countries (Spread Over Italy)



Source: Authors' calculations based on data from ECB.

For each bank, b, we define its exposure to financially-distressed euro area countries as the sum of all the loans extended to its borrowers, f, in troubled countries over the sum of all loans to borrowers in all countries. We record each bank's exposure at its pre-crisis level of 2009 to avoid contemporaneous changes in exposure during the crisis. Thus, exposure is calculated as

$$exposure_{b,09} = \frac{\sum_f GIPS_f \cdot L_{f,b,09}}{\sum_f L_{f,b,09}}, \tag{1}$$

where $GIPS_f$ is a dummy variable that takes the value of 1 if firm f is a borrower in Greece, Ireland, Portugal or Spain and zero otherwise; and $L_{f,b,09}$ is the outstanding loan volume extended by bank b to firm f in 2009.

To investigate the impact of loan supply shocks on banks' credit provision, we run loan level regressions on the firm-bank-quarter level. Our baseline specification is

$$l_{f,b,t} = \beta^l exposure_{b,09} + controls_{b,09} + \alpha^l_f + \alpha^l_{f,t} + \alpha^l_{i,t} + \varepsilon_{f,b,t}, \quad (2)$$

where $l_{f,b,t}$ is the log of total outstanding loan volume extended by bank b to firm f at time t, scaled by its lagged total assets. $exposure_{b,09}$ is bank b's exposure to financially-distressed euro area countries, as defined in Equation 1. To control for bank heterogeneity, we include the following standard bank characteristics in the regression: bank size, liquid assets, capital, return on assets, and nonperforming loans (all defined in Section III.). α^l_f, $\alpha^l_{f,t}$, and $\alpha^l_{i,t}$ denote firm, firm*time, and industry*time fixed effects (included in regressions one at a time). Standard errors are clustered at the bank*time level. We expect that banks with higher exposure to the troubled countries reduce their loan supply by more, so $\beta^l < 0$.

While the loan-level analysis allows for clean identification of the bank-lending channel, it does not assess whether changes in loan supply by banks materially affect firms' financing. If half of all banks in the sample (those with exposure) reduce their loan supply, firms could apply for new loans by the other half. This substitution across banks would mitigate or even undo any negative loan supply effects found on the loan level. To see whether firms can substitute across banks, we aggregate to the firm-quarter (fq) level and analyze the change in firms' overall loan growth across all banks. For each firm, we define its exposure as its share of loans by affected banks over total loans. Thus, for each borrower, we sum across all lenders, weighted by lenders' exposure to firms in the troubled countries. Exposure on the firm level is then defined as

$$exposure_{f,09} = \frac{\sum_b exposure_{b,09} \cdot L_{b,f,t}}{\sum_b L_{b,f,t}}. \quad (3)$$

To estimate the effect of higher exposure to affected banks on loan terms, we run variants of the following regression:

$$LT_{f,t} = \beta^{fq} exposure_{f,09} + controls_f + \alpha^{fq}_f + \alpha^{fq}_t + \alpha^{fq}_{i,t} + \epsilon_{f,t}, \quad (4)$$

where $LT_{f,t}$ is firm f's loan terms: loan growth across all lenders, its average interest spread weighted by loan volume, or its average maturity weighted by loan volume. $exposure_{f,09}$ denotes firms' exposure to affected banks as specified in Equation 3. To control for firm characteristics, we include a measure of firm size (log of total assets), as well as log of debt, cash, and income (see Section III.). We use robust standard errors. α^{fq}_f and α^{fq}_t denote firm and quarter fixed effects. We will also include time-varying fixed effects at the two-digit industry level, $\alpha^{fq}_{i,t}$, to absorb all unobserved changes in loan demand within each industry over time. The identifying assumption is that all firms within one industry change their loan demand in the same way. If there is imperfect substitution across banks, we expect that firms with stronger exposure to troubled banks see a stronger fall in loan growth, so $\beta^{fq} < 0$.

Since the Orbis database only provides firm-level data on an annual basis, we need to aggregate the loan observations to the firm-year (fa) level, taking averages across quarters, to study the real consequences of credit supply shocks. Specifically, the analysis tries to examine how shocks to loan supply by Italian banks affect firms' productivity and which channels are at work. *Appendix A* presents a simple model in which an adverse shock to bank loan supply, paired with labor market rigidities, can lead to inefficient adjustments in the capital-labor ratios by firms, thereby reducing their labor and revenue productivity. To test the validity of this model, we run two separate regressions:

$$y_{f,t} = \beta^{fa} exposure_{f,09} + controls_f + \alpha_f^{fa} + \alpha_{i,t}^{fa} + u_{f,t}. \tag{5}$$

At the first step, we use labor productivity and log total factor productivity as dependent variables $(y_{f,t})$. At the second step, we highlight the underlying channels and use firms' investment, employment and capital-to-labor ratio as dependent variables. All regressions include firm controls, robust standard errors, as well as firm and industry*time fixed effects.

V. RESULTS

This section reports the findings of the paper in three steps. First, at the quarterly level and focusing on the bank lending channel, we show that strained bank balance sheets during 2010Q1–2012Q2 (proxied by our exposure variable) forced banks to credit ration Italian firms. Second, this credit rationing was not only present at the loan level, but also when we aggregated across loans to the firm level. In other words, firms could not substitute their funding source from affected banks to healthy ones, and maintain their level of borrowing. Third and most importantly, at an annual frequency, we show that bank credit supply shocks had real effects in lowering investment, employment and productivity.

Before discussing the results, we need to ensure that our exposure variable is exogenous to credit demand conditions. We regress Amiti and Weinstein (2016) supply and demand factors over the period 2010Q1-2012Q2 (see *Appendix B*), on our exposure variable at the bank-firm-quarter level. Table 3 shows that our exposure variable is strongly negatively correlated with the bank supply factors—therefore it constitutes a significant supply shock. This is true with and without firm fixed effects, Columns (1) and (2). Furthermore, Columns (3) and (4) show that our exposure variable is uncorrelated with firm demand factors, implying exogeneity with respect to the overall economic conditions and credit demand by firms. Note that the inclusion of firm fixed effects increases the adjusted R^2 from 0.01 to 0.35 in columns 3 and 4 (for demand factors), while it has no effect on adjusted R^2 in columns 1 and 2 (for supply factors). If Amiti and Weinstein supply factors are indeed only driven by changes in banks' loan supply, while firm characteristics drive the loan demand component, this is exactly what we expect: including fixed effects should not lead to a better fit for supply factors, but should improve the fit for demand factors. To sum up, the retrieved Amiti and Weinstein factors are plausible and our shock is relevant for loan supply and exogenous to loan demand.[6]

Table 3. Retrieved Supply/Demand Factors and the Exposure Variable

VARIABLES	Supply Factors (1)	Supply Factors (2)	Demand Factors (3)	Demand Factors (4)
$exposure$	-0.150***	-0.149***	0.040	0.021
	(0.010)	(0.010)	(0.038)	(0.038)
Observations	11,575	11,575	11,575	11,575
Adjusted R-squared	0.038	0.031	0.010	0.353
α_f	-	Yes	-	Yes
α_t	Yes	Yes	Yes	Yes

Notes: *, ** and *** show statistical significance at 10%, 5% and 1% level, respectively. α_f and α_t denote firm and quarter fixed effects.

A. The Bank Lending Channel (Quarterly Loan Level Analysis)

We start the analysis by reporting the estimated coefficients from Equation 2. The results, depicted in Table 4, indicate that banks with higher exposure to firms in financially-distressed euro area countries reduce their loan supply to Italian firms by more. Column (1) shows the results of a simple pooled OLS regression (without controls or fixed effects). The estimated coefficient on the exposure variable, β^l, has a negative sign and is statistically significant. However, this result can be interpreted as either less lending by banks or lower borrowing by firms. To ensure that the change in bank lending to Italian firms is orthogonal to credit demand conditions by non-financial corporations or their riskiness, and is a pure supply shock, we include a range of fixed effects and controls in our regressions, Columns (2)–(5).

The estimated coefficient on the exposure variable remains negative and statistically significant when we add firm fixed effects to control for borrower characteristics, Column (2). Once we include bank controls (as of 2009) in Column (3), the magnitude of the estimated coefficient falls notably, but remains statistically significant. All the other coefficients in our regression are in line with the predictions of economic theory: banks holding more liquid

[6] In unreported regressions, we verify that loan supply factors show the correct sign and significance when we correlate them with proxies for loan supply shocks frequently used in the literature.

Table 4. The Impact of Credit-Supply Shocks on Loans

VARIABLES	$l_{f,b,t}$ (1)	$l_{f,b,t}$ (2)	$l_{f,b,t}$ (3)	$l_{f,b,t}$ (4)	$l_{f,b,t}$ (5)
$exposure_{b,09}$	-0.779***	-0.814***	-0.010**	-0.012***	-0.012***
	(0.159)	(0.142)	(0.004)	(0.004)	(0.004)
Size			-0.933***	-0.929 ***	-0.932 ***
			(0.005)	(0.005)	(0.005)
Liquid Assets			0.299***	0.196	0.194
			(0.113)	(0.128)	(0.119)
Capital			-0.258	-0.441	-0.549
			(0.666)	(0.709)	(0.693)
ROA			0.012	0.007	-0.001
			(0.007)	(0.009)	(0.010)
NPL			-0.321	-0.556**	-0.565**
			(0.254)	(0.261)	(0.253)
Observations	11,927	11,927	11,927	11,927	11,582
Adjusted R-squared	0.141	0.662	0.963	0.969	0.966
α_f^l	-	Yes	Yes	-	
$\alpha_{f,t}^l$	-	-	-	Yes	
$\alpha_{i,t}^l$					Yes

Notes: *, ** and *** show statistical significance at 10%, 5% and 1% level, respectively. Table reports the estimated coefficients from Equation (2).

assets have the capacity to extend more loans, while banks with higher non-performing loans tend to lend less. Finally, in Columns (4) and (5) we include time-varying or industry*time fixed effects at the borrower level to absorb any unobserved changes in loan demand by firms that vary over time and across industries. The coefficient of interest is still negative and significant at the 1% level. Moving a bank from the 10th to the 90th percentile in terms of its exposure to the troubled countries reduces its loan supply by -2.8%. To put this number into perspective, it is important to keep in mind the features of the syndicated loan market. Syndicated loans are larger and of longer maturity than the average loan. The mean and median loan in our sample amount to 77.4 and 25.2 million Euros. Thus, a 2.8 % reduction in loan supply amounts to a decrease of 2.2 million Euros for the average loan. To summarize, the results indicate that shocks to the asset side of banks' balance sheet during 2010Q1–2012Q2 forced them to reduce their loan supply to Italian firms significantly.

B. Financing Substitutability (Quarterly Firm Level Analysis)

The analysis in Section A. established that, following 2010, banks with high exposure to financially-distressed euro area countries significantly tightened their credit supply. This by itself does not imply that firms experienced a fall in their loan growth. If firms were able to substitute loans from exposed banks with those from non-affected ones, they could offset the loan supply contraction by a subset of banks. To investigate this hypothesis, we aggregate across loans to the firm level and analyze the change in firms' overall loan growth across all banks, see Equation 4. First, we show at the firm-quarter level that total loan growth fell for firms that were more exposed to banks with strained balance sheets. Including firm fixed effects and a range of control variables, Column (1) of Table 5 indicates that the estimated coefficient on the exposure variable, β^{fq}, is negative and statistically significant at 1% level.

Column (2) includes firm and quarter fixed effects to additionally absorb the common time trends. The coefficient of interest is similar in sign, magnitude and statistical significance. Column (3) involves the most demanding specification, where we use firm fixed effects, combined with time-varying fixed effects at the two-digit industry level. Any changes in firms' loan demand that vary over time within each two-digit industry are now accounted for. The effect of higher exposure to affected banks is negative and statistically significant at the 1% level. A one standard deviation increase in exposure reduces loan growth by 21%, or 0.9 standard deviations. Columns (4) and (5) look at the effect of exposure on loans' interest spread and maturity, weighted by loan volume. While a one-standard deviation increase in exposure increases the spread by 60 bps, the effect on maturity is not statistically significant. Overall, these results suggest that firms were unable to substitute across banks (at least in the syndicated loan market). The contraction in banks' loan volume is passed on to firms, which saw a fall in loan growth and a rise in borrowing costs.

Table 5. Credit-Supply Shocks and Financing Substitutability

VARIABLES	Loan Growth (1)	Loan Growth (2)	Loan Growth (3)	Spread (4)	Maturity (5)
$exposure_{f,09}$	-0.224***	-0.189**	-0.211***	59.092***	-0.209
	(0.083)	(0.077)	(0.074)	(20.887)	(0.226)
Size	-0.064	-0.019	0.018	2.191	-0.126*
	(0.057)	(0.052)	(0.052)	(2.762)	(0.074)
Income	0.010	-0.001	-0.003	0.951	-0.011
	(0.022)	(0.020)	(0.019)	(1.447)	(0.040)
Debt	0.036	0.039	0.045	1.565	-0.196*
	(0.030)	(0.028)	(0.028)	(2.121)	(0.103)
Cash	0.013*	0.015**	0.014*	0.087	0.013
	(0.007)	(0.007)	(0.008)	(0.481)	(0.018)
Observations	2,316	2,316	2,316	2,316	2,316
Adjusted R-squared	0.336	0.390	0.396	0.979	0.981
α_f^{fq}	Yes	Yes	Yes	Yes	Yes
α_t^{fq}	-	Yes	-	-	-
$\alpha_{i,t}^{fq}$	-		Yes	Yes	Yes

Notes: *, ** and *** show statistical significance at 10%, 5% and 1% level, respectively. Table reports the estimated coefficients from Equation (4).

C. Credit Supply and Productivity (Firm-Year Level Analysis)

To analyze the consequences of the contraction in loan supply on firm productivity, we proceed with the firm year level analysis as Orbis does not provide quarterly data (Equation 5). Our hypothesis is that a reduction in loan supply by banks forces firms to either invest less and/or shed workers. Since labor adjustment costs are particularly high in Italy, distortions in firms' optimal capital-labor ratio arise, thereby causing firms to experience lower productivity.[7] Table 6 provides some evidence to this effect. Columns (1) and (2) show that both labor productivity and TFP decline when exposure increases, although the effect is not statistically significant for TFP. Columns (3) and (4), which not only include firm fixed effects, but also sector-year fixed effects, confirm that labor productivity and TFP decrease significantly when exposure increases. In terms of magnitude, a one standard deviation increase in exposure reduces labor productivity by 10.9% (seventh percent of its standard deviation), and total factor productivity by 5.8% (five and half percent of its standard deviation). This is in line with the common finding in the literature that dispersion in labor productivity is higher than that of total factor productivity (Syverson (2011)). Additionally, as

[7]In addition to labor market frictions, labor hoarding could also distort firms' desired capital-to-labor ratio. If firms keep workers in adverse times to avoid rehiring costs when economic conditions improve, their labor stock exceeds the efficient level temporarily. One needs a dynamic panel data model and focus on the long-term impact of credit supply shocks to fully account for this possibility, something which is beyond the scope of this paper.

the effect of a credit crunch on productivity is driven by labor adjustment costs, a stronger impact of tightening credit supply on labor productivity than on TFP is reasonable.

Table 6. Credit Supply Shocks and Firm Productivity

VARIABLES	LP (1)	TFP (2)	LP (3)	TFP (4)
$exposure_{f,09}$	-0.100**	-0.047	-0.109***	-0.058*
	(0.041)	(0.031)	(0.041)	(0.031)
Size	0.333*	0.500***	0.342*	0.495***
	(0.178)	(0.161)	(0.190)	(0.166)
Income	0.447***	0.449***	0.432***	0.442***
	(0.059)	(0.056)	(0.054)	(0.053)
Debt	-0.055	-0.067	-0.040	-0.061
	(0.091)	(0.077)	(0.092)	(0.078)
Cash	0.001	0.011	0.015	0.017
	(0.023)	(0.018)	(0.025)	(0.019)
Observations	745	745	745	745
Adjusted R-squared	0.936	0.943	0.937	0.944
α_f^{fa}	Yes	Yes	Yes	Yes
$\alpha_{i,t}^{fa}$	-	-	Yes	Yes

Notes: *, ** and *** show statistical significance at 10%, 5% and 1% level, respectively. Table reports the estimated coefficients from Equation (5).

Having established that loan supply shocks adversely affect firm productivity, we take a closer look at the underlying channels of impact. Our model (sketched in *Appendix A*) predicts that a negative shock to bank credit supply forces firms to reduce their level of investment and adjust the employment/hours worked. Columns (1) and (2) in Table 7 show that investment declines significantly for firms with higher exposure to troubled banks, while the effect for employment is negative, but not statistically significant. Both regressions include firm fixed effects, as well as industry*year fixed effects. Column (3) shows that the impact of an increase in exposure to troubled banks on firms' capital to labor ratio is negative and statistically significant. Therefore, while firms reduce both their investment and employment levels, the reduction in the former is significantly stronger, thereby leading to an inefficient rise in their capital to labor ratio.

Next, we split firms according to their capital intensity, as measured by their lagged capital to labor ratio (above and below median), and investigate the differential effects of credit supply shocks on their productivity. We argue that a fall in credit supply forces firms to operate with an inefficient capital-labor mix, because they cannot adjust the employment level as desired due to labor market frictions. These rigidities act like a tax on labor costs, preventing their optimal downward adjustment. The hypothesis is that highly capital intensive firms are harder hit by labor market frictions, experience a more distorted input mix and lower productivity.

Table 7. Credit Supply Shocks and Firm Productivity (Channels of Impact)

VARIABLES	Investment (1)	Employment (2)	K/L (3)
$exposure_{f,09}$	-0.087**	-1.008	-0.110*
	(0.042)	(1.637)	(0.063)
Size	0.381**	5.620**	0.566**
	(0.159)	(2.683)	(0.225)
Income	-0.151***	0.846	-0.026
	(0.031)	(0.689)	(0.033)
Debt	0.005	0.400	-0.111
	(0.048)	(0.510)	(0.096)
Cash	-0.024*	-0.231	-0.054**
	(0.015)	(0.290)	(0.027)
Observations	834	693	753
Adjusted R-squared	0.133	0.981	0.973
α_f^{fa}	Yes	Yes	Yes
$\alpha_{i,t}^{fa}$	Yes	Yes	Yes

Notes: *, ** and *** show statistical significance at 10%, 5% and 1% level, respectively. Table reports the estimated coefficients from Equation (5) and focuses on the underlying channels of impact—uses firms' investment, employment and capital-to-labor ratio as dependent variables.

For a labor-intensive firm, a relatively small increase in the labor to capital ratio following a loan supply shock will have negligible effects on productivity. Table 8 shows that both for labor productivity and TFP, the estimated coefficient on the exposure variable is negative and statistically significant for firms with high capital-to-labor ratios (Columns (1) and (3)). Columns (2) and (4) show that while productivity falls for firms with low capital-to-labor ratios as well, the estimated coefficient on the exposure variable is smaller and not statistically significant.

Finally, a common finding in the literature is that credit tightening affects financially constrained firms by more. In Table 9 we split firms into financially constrained and unconstrained, according to their ratio of outstanding long-term debt over fixed assets. We take the median as the cutoff value. While the effect of a credit crunch on investment is significantly stronger for financially constrained firms (Column 1 versus 2), the effect on employment is not statistically significant for both types of firms. This suggests that neither financially constrained nor unconstrained firms could adjust labor optimally as they faced a decline in credit and investment.

Table 8. The Role of Capital Intensity

VARIABLES	High K/L Labor Productivity (1)	Low K/L Labor Productivity (2)	High K/L TFP (3)	Low K/L TFP (4)
$exposure_{f,09}$	-0.214**	-0.024	-0.123**	-0.006
	(0.091)	(0.038)	(0.060)	(0.028)
Size	0.162	0.465	0.497***	0.669***
	(0.190)	(0.284)	(0.120)	(0.222)
Income	0.674***	0.175***	0.664***	0.185***
	(0.079)	(0.036)	(0.074)	(0.038)
Debt	-0.075	0.129	-0.105	0.101
	(0.080)	(0.136)	(0.069)	(0.123)
Cash	0.011	-0.032	0.018	-0.034
	(0.029)	(0.026)	(0.020)	(0.023)
Observations	366	344	366	344
Adjusted R-squared	0.945	0.861	0.960	0.955
α_f^{fa}	Yes	Yes	Yes	Yes
$\alpha_{i,t}^{fa}$	Yes	Yes	Yes	Yes

Notes: *, ** and *** show statistical significance at 10%, 5% and 1% level, respectively. Table reports the estimated coefficients from Equation (5) while splitting firms according to their capital intensity, as measured by their lagged capital to labor ratio.

Table 9. The Role of Financial Constraints

VARIABLES	Constrained Investment (1)	Unconstrained Investment (2)	Constrained Employment (3)	Unconstrained Employment (4)
$exposure_{f,09}$	-0.094**	-0.088	0.954	-1.674
	(0.047)	(0.063)	(0.705)	(1.400)
Size	0.054	0.161	3.933***	5.154
	(0.110)	(0.271)	(1.443)	(5.351)
Income	-0.103***	-0.149**	0.251	0.186
	(0.039)	(0.072)	(0.459)	(0.829)
Debt	-0.095	0.123	0.308	-1.277
	(0.067)	(0.337)	(0.409)	(1.535)
Cash	-0.029	-0.026	-0.314	-0.396
	(0.025)	(0.026)	(0.232)	(0.372)
Observations	316	287	316	288
Adjusted R-squared	0.360	-0.044	0.985	0.994
α_f^{fa}	Yes	Yes	Yes	Yes
$\alpha_{i,t}^{fa}$	Yes	Yes	Yes	Yes

Notes: *, ** and *** show statistical significance at 10%, 5% and 1% level, respectively. Table reports the estimated coefficients from Equation (5) while splitting firms into financially constrained and unconstrained, according to their ratio of outstanding long-term debt over fixed assets.

VI. CONCLUDING REMARKS

We studied the relationship between bank lending shocks and firm productivity in Italy by exploiting the heterogeneous loan exposure of Italian banks to foreign borrowers in distress while using a novel identification scheme and loan level data on syndicated lending.

Our results indicate that banks' balance-sheets suffered from a shock to their asset side when firms' borrowing costs and default rates in Greece, Ireland, Portugal and Spain rose between 2010 and 2012. This forced banks with strained balance sheets to reduce lending to Italian firms. Aggregating across loans to non-financial corporations, we found that firms were unable to substitute from affected banks to healthy ones and thus became credit constrained. We also found that credit supply shocks had significant real effects on firms' investment and employment decisions, as well as productivity. Firms with higher exposure to troubled banks reduced their investment and employment more, and sub-optimally adjusted their capital-to-labor ratios due to labor market frictions. These firms experienced a significant fall in productivity. Firms with higher outstanding total debt and higher capital intensity were more adversely affected by the supply shocks.

These results point to a number of policy recommendations. First, use of enhanced flexibility in allocation of labor within the firm can limit the impact of credit-supply shocks on productivity. In this regard, the most recent labor market reform ("Jobs Act") is expected to yield benefits gradually over the long term. Second, the banking system's resilience against future shocks should be improved by an acceleration of financial sector repair. Decisive steps are needed, including through stricter supervisory oversight, to reduce faster the high nonperforming loans in the coming years.

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APPENDIX A

A model of asymmetric labor adjustment costs

In our model, firms own their capital stock k, but take up debt b at interest rate r to hire labor l on a competitive market at wage w. Wage and interest are taken as exogenous. Firms augment their capital stock through investment x and operate under monopolistic competition and produce output y. They face a downward sloping demand for their products, which is given by $y^{-1/\epsilon}$. Capital depreciates at rate δ and the production function is given by $y = Ak^{\alpha}l^{1-\alpha}$.

Firms face two constraints. First, they can only borrow a fraction θ of their future capital stock, so $b_{t+1} \leq \theta k_{t+1}$; and second, they face asymmetric labor adjustment costs of $\phi\frac{(l_t - l_{t-1})^2}{2l_{t-1}}$, where $\phi = 0$ if $l_t > l_{t-1}$ and $\phi > 0$ otherwise. This means when firms decide to decrease their labor force, they must pay an extra cost proportional to their adjustment. ϕ governs how high the costs is.

What we are interested in is the effect of tightening credit conditions on firms' capital-to-labor ratio k/l, and firm productivity. It is straightforward to show that a fall in credit supply (a decrease in θ) is conceptually similar to a rise in borrowing costs r. Thus, for the remainder of the analysis we set $\theta = 1$.

Firms solve

$$\max_{c,k',b',l} \mathcal{L} = \sum_{t=0}^{\infty} \beta^t \{u(c) + \lambda \left[(Ak^{\alpha}l^{1-\alpha})^{\frac{\epsilon-1}{\epsilon}} - wl + b' - c - k' + (1-\delta)k - (1+r)b - \phi\frac{(l_t - l_{t-1})^2}{2l_{t-1}} \right] \}. \tag{6}$$

Solving for first order conditions, we get

$$u'(c_t) = \lambda_t \tag{7}$$

$$\frac{\epsilon - 1}{\epsilon}\alpha\frac{p_{t+1}y_{t+1}}{k_{t+1}} = \delta + r_{t+1} \tag{8}$$

$$\frac{\epsilon - 1}{\epsilon}(1-\alpha)\frac{p_t y_t}{l_t} = w_t + \phi\left[\frac{l_t - l_{t-1}}{l_{t-1}} - \frac{1}{1+r_{t+1}}\frac{l_{t+1}^2 - l_t^2}{2l_t^2}\right] \tag{9}$$

Let us denote $\tau_t^l \equiv -\left[\frac{l_t - l_{t-1}}{l_{t-1}} - \frac{1}{1+r_{t+1}}\frac{l_{t+1}^2 - l_t^2}{2l_t^2}\right]$. With simple numerical examples, it is possible to show that if $l_t - l_{t-1} < 0$, then $\tau_t^l > 0$ (note that if $l_{t+1} - l_t > 0, \phi = 0$). Thus, labor adjustment costs act like a tax on labor. When firms decide to shed workers, they have to pay an extra cost.

The capital-to-labor ratio is then given by

$$\frac{k}{l} = \frac{\alpha}{\delta + r} \, \frac{w - \phi\tau_t^l}{1-\alpha}. \tag{10}$$

Thus, if firms reduce their labor force, adjustment costs bias the capital-labor ratio downwards. If there is a shock to borrowing conditions (rise in r), firms want to reduce capital. They also want to reduce labor, but to a lesser extent. The tax prevents firms from reducing labor enough, such that they operate with an inefficiently low capital intensity. To see the effect on productivity, lets define marginal revenue products as

$$MRPK_t = \frac{\epsilon - 1}{\epsilon} \alpha \frac{p_t y_t}{k_t} = \delta + r_t \tag{11}$$

$$MRPL_t = \frac{\epsilon - 1}{\epsilon} (1-\alpha) \frac{p_t y_t}{l_t} = w_t - \phi\tau_t^l \tag{12}$$

Now, we can write revenue productivity as

$$TFPR_t = \frac{p_t y_t}{k_t^{\alpha} l_t^{1-\alpha}} = \left(\frac{p_t y_t}{k_t}\right)^{\alpha} \left(\frac{p_t y_t}{l_t}\right)^{1-\alpha}. \tag{13}$$

This can be expressed as a function of the marginal revenue products, such that

$$TFPR_t = \frac{\epsilon}{\epsilon - 1} \left(\frac{MRPK_t}{\alpha}\right)^{\alpha} \left(\frac{MRPL_t}{1-\alpha}\right)^{1-\alpha} = \frac{\epsilon}{\epsilon - 1} \left(\frac{\delta + r_t}{\alpha}\right)^{\alpha} \left(\frac{w_t - \phi\tau_t^l}{1-\alpha}\right)^{1-\alpha}. \tag{14}$$

Thus TFP is a function of the labor wedge. If firms reduce their labor, adjustment costs prevent an optimal adjustment of the capital-to-labor ratio. Thus, changes in $MRPL$ can no longer be offset by optimal changes in $MRPK$. The wedge thus reduces firms' TFP.

Similar, for labor productivity we get

$$LP_t = \frac{p_t y_t}{l_t} = \frac{\epsilon}{\epsilon - 1} \frac{MPRL_t}{1-\alpha}, \tag{15}$$

so our wedge also reduces firms' labor productivity.

Appendix B

Decomposing Loan Growth into Demand and Supply Factors

Since our estimations in Section IV. resemble an instrumental variables regression in which the exposure variable is used as an instrument for credit supply shocks, we need to ensure its external validity (that the exposure variable is highly correlated with bank credit supply factors and orthogonal to firms' credit demand conditions). To decompose aggregate loan growth in Italy into supply and demand factors and correlate them with our exposure variable), we follow Amiti and Weinstein (2016). Identification of bank-supply and firm-demand factors is achieved by employing a large sample of matched bank-firm lending data (see Section III.) and imposing an adding up constraint that ensures the consistency of estimates obtained from the micro-lending data with those of aggregate lending and borrowing patterns in Italy. More specifically, we start from the standard equation postulated by Khwaja and Mian (2008)

$$\Delta L_{f,b,t} = \alpha_{f,t} + \beta_{b,t} + \epsilon_{f,b,t}, \tag{16}$$

where $\Delta L_{f,b,t} = \frac{L_{f,b,t} - L_{f,b,t-1}}{L_{f,b,t-1}}$ is the loan growth of firm f obtained from bank b at time t. The *firm borrowing channel* is captured by $\alpha_{f,t}$, and $\beta_{b,t}$ denotes the *bank lending channel*. Note that bank b's total loan growth $D^B_{b,t} = \sum_f \Delta L_{f,b,t} \cdot \frac{L_{f,b,t-1}}{\sum_f L_{f,b,t-1}}$ is a weighted sum of all the loans it extended to firms. The term $\frac{L_{f,b,t-1}}{\sum_f L_{f,b,t-1}}$ is the respective weight of firm f in bank b's total loan portfolio in year t, lagged by one year. Similarly, firm f's credit growth is a weighted sum of its total borrowings from all banks, or $D^F_{f,t} = \sum_b \Delta L_{f,b,t} \cdot \frac{L_{f,b,t-1}}{\sum_b L_{f,b,t-1}}$. Under a set of standard assumptions, Amiti and Weinstein (2016) show that it is possible to retrieve $\alpha_{f,t}$, and $\beta_{b,t}$ by solving the following system of $F + B$ equations up to a numeraire:

$$D^B_{b,t} = \sum_f \frac{L_{f,b,t-1}}{\sum_f L_{f,b,t-1}} \alpha_{f,t} + \beta_{b,t}, \tag{17}$$

$$D^F_{f,t} = \alpha_{f,t} + \sum_b \frac{L_{f,b,t-1}}{\sum_b L_{f,b,t-1}} \beta_{b,t} \tag{18}$$

Equation 17 states that bank b's loan growth is driven by a range of bank-specific credit-supply factors ($\beta_{b,t}$), as well as a weighted average of changes in loan demand by all its borrowing firms (the first term on the right-hand side). Similarly, equation 18 shows that firm f's loan growth is driven by its borrowing needs ($\alpha_{f,t}$), as well as a weighted average of credit-supply conditions in all lending banks to firm f (the second term on the right-hand side). Once we recovered $\alpha_{f,t}$ and $\beta_{b,t}$, we can decompose the *aggregate* loan growth D_t at time t into three components.

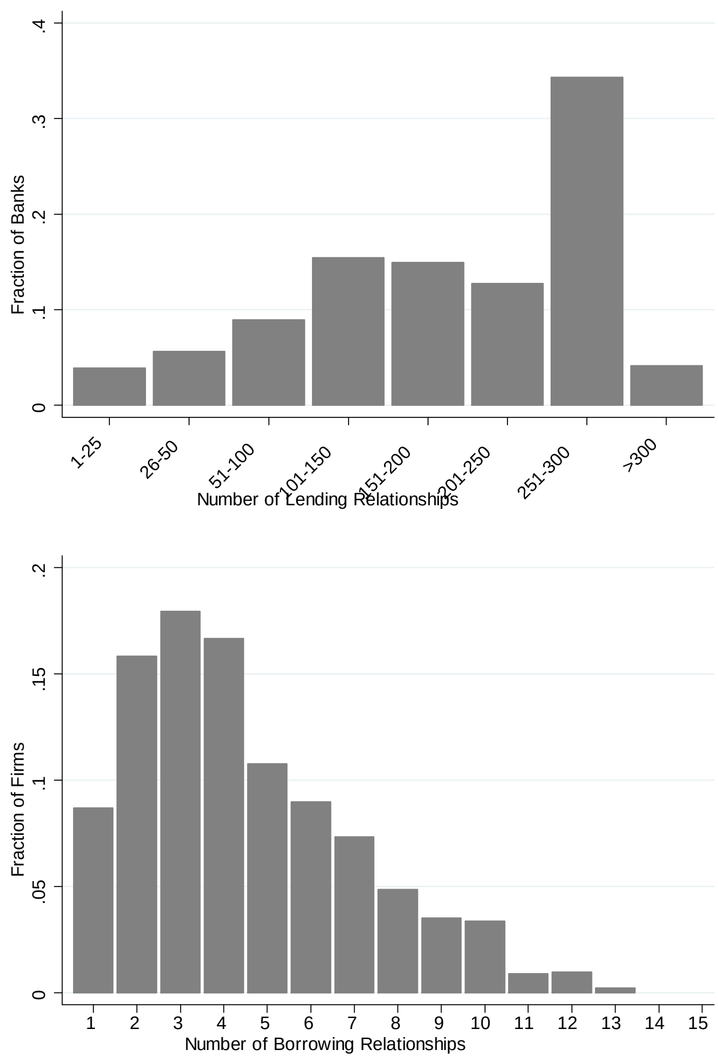
$$D_t = (\bar{A}_t + \bar{B}_t) + \mathbf{W^B_{t-1}} \mathbf{\Phi_{t-1}} \dot{\mathbf{A}}_t + \mathbf{W^B_{t-1}} \dot{\mathbf{B}}_t \tag{19}$$

The common factor $(\bar{A}_t + \bar{B}_t)$ which affects all banks and firms alike ($\bar{A}_t$ and $\bar{B}_t$ represent the median firm borrowing and bank supply conditions at each point in time). $\dot{\mathbf{A}}_t$ and $\dot{\mathbf{B}}_t$ are the two vectors that stack all the firm-borrowing and bank-supply factors, $\alpha_{f,t}$ and $\beta_{b,t}$. They are both expressed as deviations from $\bar{A}_t$ and $\bar{B}_t$. Finally, Φ_{t-1} is a weighting matrix, and $\mathbf{W^B_{t-1}}$

is the share of bank b's loan volume out of total lending by all banks in year t.

Note that for successful identification of $\alpha_{f,t}$ and $\beta_{b,t}$ in Equation 16, we need at least two connections for each bank or firm. Figure 4 shows the frequency of firm and bank relationships in our sample. Thanks to the syndicated nature of loans market in our paper, 92.5% of firms have more than one bank relationship per quarter, while the average bank lends to several hundred firms at each quarter. We only focus on those observations that satisfy the required number of connections. The resulting loss in sample size is minimal.

Figure 4. Distribution of Borrower and Lender Relationships



Source: Authors' calculations.
Notes: The top panel shows the number of borrowers per bank. The bottom panel shows the number of banks lending to a firm. Frequencies are displayed on the y-axis.