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Debt Overhang, Rollover Risk, and Corporate Investment: Evidence from the European Crisis
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ABSTRACT

We quantify the role of financial leverage behind the sluggish post-crisis investment performance of European firms. We use a cross-country firm-bank matched database to identify separate roles for firm leverage, bank balance sheet weaknesses arising from sovereign risk, and aggregate demand conditions. We find that firms with higher debt levels reduce their investment more after the crisis. This negative effect is stronger for firms holding short-term debt in countries with sovereign stress, consistent with rollover risk being an important channel influencing investment. The negative effect of firm leverage on investment is persistent for several years after the shock in the countries with sovereign stress. The corporate leverage channel can explain 40 percent of the cumulative decline in aggregate investment over four years after the crisis.

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1 Introduction

Investment expenditure in Europe experienced a dramatic collapse in the aftermath of the 2008 global financial crisis. Net corporate investment as a share of GDP in the euro area more than halved from its peak in 2008, with even sharper declines in the most affected periphery countries, and by the end of 2016 had still not recovered to pre-crisis levels (Figure 1, panel A). By contrast, the US recovered much faster over the same period, reaching its 2008 peak by 2014. This collapse in corporate investment in Europe followed a boom period during which the corporate sector borrowed heavily (Figure 1, panel B). Indebtedness of euro area non-financial corporations, measured as debt liabilities to GDP, increased 30 percentage points since 1999 on average, and 90 percentage points for the countries in the periphery.

Thus far both the theoretical and the empirical literatures have primarily focused on two channels to explain the depth of the crisis in Europe: a collapse in aggregate demand, partly induced by excessive household borrowing (e.g., Martin and Philippon, 2017) and weak bank-sovereign linkages, with bank balance sheets being weakened on account of large exposures to risky sovereign debt (e.g., Gennaioli et al., 2014; Acharya et al., 2014; Popov and Van Horen, 2015). We are the first to consider the role of firm leverage in explaining the decline in firm-level and aggregate corporate investment during the European crisis. We do so while simultaneously controlling for the aggregate demand and bank-sovereign channels. Specifically, we investigate whether corporate debt accumulated during the boom years holds back investment in the aftermath of the crisis. We refer to a situation where debt holds back investment as "debt overhang". Our debt overhang channel is distinct from the aggregate demand and bank-sovereign channels previously identified in the literature. Myers (1977) shows that debt overhang leads to under-investment by firms, as new capital cannot be raised when profits

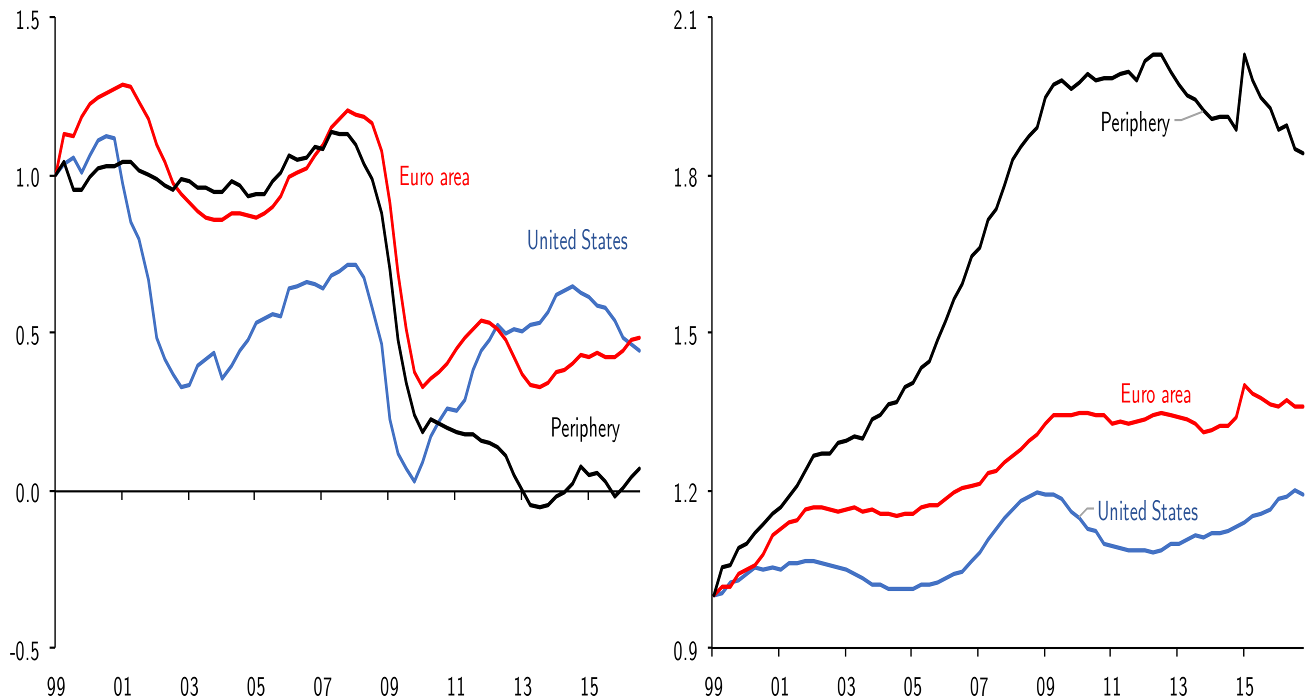


Figure 1: Evolution of Net Corporate Investment and Corporate Leverage

Notes: Net fixed capital formation of non-financial corporations, scaled by total economy GDP (left-hand side panel A) and credit to nonfinancial corporations granted by banks and non-banks, scaled by total economy GDP (right-hand side panel B). Quarterly data for the period 1999 to 2016. Values are indexed at 1 for 1999Q1. Periphery group of economies comprises Greece, Ireland, Italy, Portugal, and Spain.

Sources: Eurostat, BEA, and BIS.

primarily benefit existing debt holders, instead of the new investors. More generally, debt overhang can crowd out private investment in general equilibrium via higher borrowing costs (e.g. Krugman, 1988). Either way, the result will be a firm de-leveraging process during which firms cut down investment.

The ongoing COVID crisis highlights the dangers of firm debt overhang. What started as a liquidity shock to firms induced by a combination of demand and supply shocks due to the virus combined with lockdowns is quickly turning into solvency problems, especially for highly indebted firms (e.g., Gourinchas et al. (2020), Ding et al., 2020). Our results on the potentially strong persistent effects of firm debt overhang on firm investment, while based on a different type of crisis, can therefore be seen as informative for the evolution of firm investment going forward.

We show that the effect of firm leverage on investment is persistent and can explain the sluggish investment in Europe over 4 years, till the end of our sample, after the crisis. We run local projections a la Jordà (2005) using our firm panel dataset and obtain firm-level impulse response functions. Firms with high leverage in the periphery reduce investment rate by about 10 percentage points immediately after the shock, 8 percentage points after 1 year, and 4 percentage points after 4 years.[1] The differential responses of highly levered firms and lowly levered firms in the periphery is substantial: 5 percentage points on impact and 3 percentage points after 1 year and so on. These findings suggest that the debt overhang channel explains 40 percent of the aggregate decline.[2]

We use a firm-bank matched dataset since the deteriorations in firm and bank balance sheets have to be measured simultaneously to separate shifts in bank weakness and firm weakness. Our data is detailed in terms of financial position of firms including on the total amount of debt outstanding and on the maturity of this debt to capture the effects of debt overhang and rollover risk. A big advantage of our data set is its representative coverage of SMEs. SMEs tend to be informationally opaque and dependent on banks for their external financing, and therefore more likely to be affected by debt overhang (e.g. Kashyap et al., 1993, 1994a,b) and they make up more than 70 percent of the aggregate economic activity in Europe.

We use the Orbis-Bureau Van Dijk/Moody's database, also known as the AMADEUS database. The database has detailed firm-level balance sheet information on investment, indebtedness, debt service, and debt maturity across a large number of European countries. The database

[1] To the best of our knowledge, the only other papers using local projections in firm panels are Drechsel (2019), Cloyne et al. (2018), and Ottonello and Winberry (2018).

[2] We used the fact that cumulative decline in aggregate corporate sector investment as a ratio to aggregate capital stock is 20 percentage points over 4 years for this back-of-the-envelope calculation.

also incorporates information on each firm's main relationship bank(s), including the names and address of the bank, which we use to match firms and banks. For each bank, we obtain bank balance sheet information, including data on total sovereign bond holdings, from BANKSCOPE. In order to distinguish between banks' exposure to their *own* sovereign as opposed to other sovereigns, we use confidential ECB data which has nationality information on the sovereign exposure. A similar exercise would not be possible for the US where data on bank-firm relationships is generally not available, especially for privately held firms.[3]

We measure weakness in bank balance sheets during the crisis using the bank's holdings of risky sovereign bonds. In Europe, where banks hold sovereign bonds and firms depend on banks for their lending, sovereign risk can affect firm investment through bank-sovereign linkages. Following an increase in sovereign risk, banks with large exposures to risky sovereigns will experience a deterioration in their balance sheets, reducing the supply of loans to firms via a traditional bank lending channel. This will lead to an increase in debt overhang and rollover risk, especially for firms that financed themselves primarily with short-term debt during the boom years. It is also possible that weak banks continue to lend to risky borrowers in an effort to preserve relationships, consistent with loan evergreening/zombie lending.

We use a difference-in-difference approach to identify the effect of corporate debt overhang and rollover risk on investment, assessing the differential (relative) impact on investment of different levels of (short and long-term) leverage and between the pre-crisis and post-crisis periods. Consistent with the literature, we consider the year 2008 as the start of the financial crisis. We limit the analysis to firms in the euro area. The advantage of this setup is that

[3]In the US, even though private firms account for 74 percent of aggregate employment and 56 percent of aggregate gross output, they are not required to publicly disclose their financial data. In Europe, private firms also account for over 70 percent of aggregate employment and over 50 percent of aggregate output on average and in most European countries these (small) private firms are required to file their financial data with public registers. See Kalemli-Özcan et al. (2019) for data coverage in Europe and Dinlersoz et al. (2018) for the US.

we limit the analysis to firms that were subject to the same monetary policy but experienced diverging sovereign risk and banking conditions during the crisis. We measure leverage as the ratio of debt to total assets and distinguish between short-term and long-term debt. The analysis controls for the usual determinants of investment such as firm size and profitability and also for debt service to account for differences in payment terms on the debt.

To control for aggregate demand shocks we use four-digit industry$\times$country$\times$year fixed effects. These effects will absorb the impact of changes in credit demand for the four-digit sector that our firms operate in as well as any changes in country-level demand conditions, including those arising from changes in sovereign risk and general uncertainty conditions. We also control for bank fixed effects to capture the role of pre-existing bank relationships. We assume that most of the fluctuations in aggregate demand derive from the country and narrowly defined industry-specific factors, not idiosyncratic firm-specific factors. We control firm fixed effects to absorb permanent productivity differences across firms.

We run various panel regressions of corporate investment over the period 2000 to 2012, where we distinguish between the crisis period (2008-2012) and the pre-crisis period (2000-2007). Specifically, we run a panel regression of triple interactions, where we interact a crisis dummy that takes the value of one starting in 2008, with the interaction of a periphery dummy for firms in the periphery and a high-leverage indicator indicating whether firm leverage prior to the crisis was above the sample median. To mitigate concerns about reverse causality, we measure leverage and bank-firm relationships prior to the crisis. Because some firms deleveraged during and in the aftermath of the crisis, our conservative approach, if anything, underestimates the effect of high leverage on investment.

Our findings are as follows. First, high *ex ante* debt levels depress investment during crisis times, consistent with debt overhang. Second, the negative relationship between leverage and investment during the crisis is more pronounced for firms with high short-term leverage in the periphery, consistent with theories of shorter-term debt implying greater rollover risk. Third, the debt overhang effect remains when controlling for aggregate demand effects and the influence of sovereign-bank linkages, suggesting that debt overhang channel we focus on operates independently from aggregate demand and bank-sovereign channels. These results are economically significant. One standard deviation increase in firm leverage reduces investment by 20 percent and going from minimum to maximum level of leverage in our firm sample reduces investment by 57 percent. And last but not least, our effects are very persistent, explaining 40 percent of the decline in aggregate investment over a 4 year period.

We make three contributions to the literature. First, we identify the role of financial leverage in explaining the collapse in corporate investment during the European crisis. We show that this is an economically important channel over and above the aggregate demand and bank-sovereign channels previously identified in the literature, which are also very important channels. Second, our analysis shows that short-term debt exacerbates the debt overhang problem, as argued by Diamond and He (2014). And last but not least, we provide an explanation for the persistently low investment in the periphery of Europe, as shown by our dynamic response of firm-level investment to leverage after 4 years of the shock. These contributions are made possible by the uniqueness of our firm-bank-sovereign matched dataset, which features extensive coverage of small firms.[4]

We proceed as follows. Section 2 reviews related literature on corporate debt and firm investment. Section 3 presents the data used in the paper and reports descriptive statistics. Section 4 introduces the empirical framework and identification methodology. Section 5 presents

[4]Using a similar firm-level dataset encompassing small firms but without matching it to firms' banks' balance sheets, Gopinath et al. (2017) show the importance of firm leverage on misallocation and aggregate productivity dynamics during the boom period, whereas our focus is on investment dynamics during the bust period.

our empirical results. Section 6 concludes.

2 Literature

There is a large theoretical literature on debt overhang[5] and how financially distressed firms, when protected by limited liability, have an incentive to gamble by investing in risky projects (e.g., Jensen and Meckling, 1976; Admati et al., 2018). The empirical literature does not find strong results in either direction (under- or over-investment)[6]. Moreover, recent theoretical work by Aragón (2019) argues for mitigating factors arising from the firm losing access to credit when a creditor becomes insolvent. In his model, the bank can either liquidate the firm or continue lending. Funding new investment has the disadvantage that it will incentivize the firm to take more risk, decreasing the overall value for the bank. Hence, zombie-lending and under-investment can co-exist.[7]

Our paper also relates to an extensive empirical literature on corporate debt and firm investment. For instance, Whited (1992) shows that adding debt capacity variables to a standard investment model improves the model fit. Similarly, Bond and Meghir (1994) find an empirical role for debt in standard investment models. This literature generally finds a negative relationship between firm leverage and investment. For instance, for listed firms in the US, Lang et al. (1996) document a negative relationship between debt and investment for firms without valuable growth opportunities. More recently, Giroud and Mueller (2017) analyze the impact of firm leverage on employment using US establishment-level data. They find that firms that

[5]Hennessy (2004), Titman and Tsyplakov (2007), Moyen (2007), Diamond and Rajan (2011), and Occhino and Pescatori (2015).

[6]See De Jong and Van Dijk (2007), Eisdorfer (2008), and Gilje (2016).

[7]See Hoshi et al. (1990), Almeida et al. (2011) and Barnea et al. (1980) for theoretical models of zombie lending. The empirical literature on the significance of zombie lending in Europe during the recent crisis finds mixed results (e.g., Andrews and Petroulakis, 2019 and Schivardi et al., 2017). The literature that focuses on Japan finds strong results as in Peek and Rosengren (2000, 2005) and Caballero et al. (2008).

increased leverage experienced a larger decline in employment during the global financial crisis. Their work differs from us in at least two dimensions. First, they do not consider the role of maturity. Second, they focus on the US, not Europe, and therefore do not consider the role of bank-sovereign linkages and also do not have a firm-bank matched dataset.

Our work also relates to the theoretical literature on the maturity structure of debt. In the benchmark model of Myers (1977), short-term debt reduces the debt overhang problem, while in recent work by Diamond and He (2014), short-term debt can increase debt overhang. Darst and Refayet (2017) develops a model where a combination of short-term and long-term debt emerges as the optimal contract to deal with agency problems and bankruptcy costs. In their model, long-term debt insulates the firm from changes in credit spreads while short-term debt exposes the firm to credit spread fluctuations. However, short-term debt comes at the advantage of risk-free financing. Firms optimally choose the maturity structure of debt to intertemporally manage how much risky debt to issue. The sovereign debt literature has developed models of debt contracts with bankruptcy costs and agency costs for debtholders, where short-term debt will generally be preferred because it is cheaper, except when self-fulfilling rollover crises are probable (Chaterjee and Eyigungor, 2012). As debt accumulated during the boom period is mostly short-term, rollover risk will increase because lenders are reluctant to renew expiring credit lines during a crisis when collateral values drop (e.g. Diamond, 1991; Acharya et al., 2011).[8]

In related work on the implications of debt overhang, Lamont (1995) shows that the effect of debt overhang varies with economic conditions. Debt overhang binds when the economy

[8]Debt maturity may also affect the debt overhang by altering incentives to invest. According to Myers (1977), short-term debt reduces the debt overhang problem because the value of shorter debt is less sensitive to the value of the firm and thus receives a much smaller benefit from new investment. However, Diamond and He (2014) show that reducing maturity can increase debt overhang. For firms with future investment opportunities, shorter-term debt may impose stronger debt overhang in bad times since less risk is shared by shorter-term debt.

is in a downturn since investment returns are low. As a result, high levels of debt can create multiple equilibria in which the profitability of investment varies with economic conditions. Hennessy (2004) shows that debt overhang distorts the level and composition of investment, with a severe problem of underinvestment for long-lived assets. A significant debt overhang effect is found, regardless of firms' ability to issue additional secured debt. Hennessy et al. (2007) corroborate large debt overhang effects of long-term debt on investment, especially for firms with high default risk.

3 Data

In this section, we describe the data and variables used in the paper, before turning to the empirical framework and identification of the effects we are interested in.

3.1 Firm-Level Data

We use the Orbis global database, from Bureau van Dijk (BvD)—a Moody's Analytics company. Orbis is the largest cross-country firm-level database, covering over 200 countries and 200 million firms that can be used for research focusing on linking firms' financial accounts, ownership structure and production decisions. The database includes all industries and both private and public firms. BvD collects data from various sources, in particular, publicly available national company registries, and harmonizes the data into an internationally comparable format.

The coverage of firms varies both by country, industry, over time and across variables. The reason for variation in firm coverage by country is that different countries have different laws in terms of which firms are required to file their financial accounts.[9] For countries where the law requires every firm to file with the national company registry, the data obtained via Orbis will be identical to that contained in the country's financial accounts prepared by official statistical offices.[10]

The coverage of firms in Orbis database can vary by time and industry and this may be a source of discrepancy between various studies. The cause of this problem is the common practice in the literature of using a single vintage of Orbis database (or a single download from Wharton Research Data Services (WRDS)). As explained in detail in Kalemli-Özcan et al. (2019), the only way to get around this problem and have consistent coverage of firms over time and by industry is to use the historical vintages and match the firm data over time using unique firm identifiers. If a single vintage is used, firms will be missing since Orbis drops firms over a certain period of time from the database and also some variables, such as value-added and intermediate inputs, will be missing since every vintage does not cover all the variables. The industry classification will also be misleading since these classifications change over time due to firms' expanding their operations and/or firm and industry ID changes made by the national statistical offices. Due to such missing information, Orbis single vintage data will generally over-represent larger firms and under-represent smaller firms, requiring imputations and re-weighing of the data to ensure an adequate representation of small firms. As

[9] There is a common misconception that data from countries' national statistical offices always have better coverage than Orbis. If the country regulation is such that all firms have to file with the business registry then the coverage obtained from Orbis will be representative. For the other countries where the regulation is such that firms over a certain size threshold file their financial accounts, then the national statistical offices might have administrative surveys that can cover some of the differences in coverage of firms' financial accounts. A case in point is the United States, where private firms are not required to file financial accounts but there are select surveys covering certain set of firms in certain years such as the Federal Reserve Board of Governors' survey on "small business finance," which is a repeated cross-section that comes in four waves and covers only 3000-5000 firms and is not nationally representative.

[10] Country censuses are administrative datasets and will cover the universe of firms in a country; however, census datasets typically do not provide information on individual firms' financial accounts as company registries do.

shown in Kalemli-Özcan et al. (2019), there is no need to re-weigh and impute the data if the historical vintages are used, as this produces the nationally representative data mimicking the firm size distributions of the official statistics of each country.

We follow Kalemli-Özcan et al. (2019) to construct and clean our firm-level data. The main financial variables used in the analysis are total assets, sales, operating revenue (gross output), tangible fixed assets, intangible fixed assets, liabilities, and cash flow. We distinguish between short-term and long-term liabilities, with short-term liabilities being defined as debt liabilities with a remaining maturity of up to 1 year. A large fraction of short-term liabilities constitute trade credits that originate outside the financial system, we also construct a measure of short-term liabilities that excluded trade credits. We transform nominal financial variables into real variables using country-specific consumer price indices with 2005 base and converting to US dollars using the end-of-year 2005 US dollar/national currency exchange rate. In other words, the value of variables is expressed in constant prices at constant exchange rates. We drop financial firms and government-owned firms, and keep all the other sectors. As shown in Kalemli-Özcan et al. (2019), the coverage of our sample when compared to official statistics is extensive, ranging from roughly 70 to over 90 percent depending on the country.

3.2 Matching Firm- and Bank-Level Data

We create a novel data set of bank-firm relationships in Europe by matching our firm-level data to their banks. For each firm, there is a variable called BANK in our firm-level database showing the name(s) of the firm's main bank(s), which, following the literature on firm-bank lending relationships, we assume to be the main bank(s) that the firm borrows from. We obtain this information through our firm-level database but the original source is KOMPASS.[11] This

[11] KOMPASS provides the bank-firm connections in 70 countries including firm address, executive names, industry, turnover, date of incorporation and, most importantly the firms' primary bank relationships. KOMPASS

data has been used before by Giannetti and Ongena (2012), among others, to study bank-firm relationships. We use the 2013 data entries by firms of their main banks, including both the primary and secondary bank-firm relationships. We checked the stability of bank-firm relationships with the 2015 data entries and confirmed that bank-firm relationships are sticky and do not significantly change over short periods of time.[12]

For each main bank, we obtain bank balance sheet data from BANKSCOPE. This data set is also from Bureau Van Dijk, containing balance sheet information about more than 30,000 banks spanning most countries and data up to 16 years. Linking the main bank name to its equivalent in BANKSCOPE is a significant hurdle since there is no standardized procedure to match KOMPASS and BANKSCOPE bank names. We make use of the programs *OpenRefine* and *OpenReconcile* that offer several approximate-matching algorithms. We use these programs to match the BANK variable to the bank names in BANKSCOPE. Our match rate is very high: 87.6% of all bank name observations. Most of the unmatched observations correspond to small cooperative banks for which financial data is anyway not available in BANKSCOPE.

3.3 Matching Bank-Level Data to Sovereigns

Banks in the BANKSCOPE database are all recorded as domestic legal entities, including the subsidiaries of foreign parent companies. To determine the country of origin of each bank in our sample, we need to trace its ownership information to the ultimate owner. We set the country of origin of each bank equal to the country of origin of the ultimate owner of the bank, even if this entity is incorporated in a foreign country, under the assumption that it is

collects data using the information provided by chambers of commerce and firm registries, but also conducts phone interviews with firm representatives. Firms are also able to voluntarily register with the KOMPASS directory, which is mostly sold to companies searching for customers and suppliers.

[12] Giannetti and Ongena (2012) use both the 2005 and 2010 vintages and also find that bank-firm relationships are sticky. Other research has shown that these relationships are sticky also in the United States (see, for instance, Chodorow-Reich, 2014).

the strength of the parent bank that determines the strength of each subsidiary. We trace this information using the Global Ultimate Owner (GUO) variable. Then, we use its consolidated balance sheet reported directly in BANKSCOPE.

Whenever the GUO information is missing, a couple of criteria are used. First, some of the banks listed are actually branches of foreign banks. These are matched by hand to their GUO abroad. Second, some banks are reported to be independent or "single location" (i.e., they have only one branch). For these banks, the GUO is the bank itself. And finally, using the independence indicator provided by Bureau Van Dijk, for banks with a high degree of independence (i.e., values B-, B or B+), the GUO will be also the bank itself, as in the previous case. The sovereign of each bank is defined as the sovereign country of the entity that is the ultimate owner of the bank.

Data on total sovereign bond holdings come from BANKSCOPE. The limitation of these data is that they do not indicate the nationality of the sovereign. We therefore complement this data with data on *own* sovereign's holdings of the bank from the European Central Bank (ECB)'s proprietary database of Individual Balance-Sheet Items (IBSI). The difference between the two datasets is that the BANKSCOPE data captures all sovereign bonds while the IBSI data captures domestic bonds only. In practice, the difference between the two data series should be small since most of a bank's total sovereign bond holdings consist of domestic bonds. Indeed, according to the IBSI data for our sample of banks, around 70% of euro area banks' sovereign bond holdings are domestic, with an even higher percentage in the periphery.

3.4 Descriptive Statistics

Investment in real capital expenditures can be measured on a gross or net basis (i.e., with or without depreciation). If investment expenditures just match the depreciation of capital equipment, then gross investment is positive, but net investment remains unchanged. Therefore, net investment matters most for future productivity. Consequently, we use net investment rate in our empirical work, computed as the annual change in fixed tangible assets.[13]

We capture firm leverage using the ratio of total liabilities to total assets. Total liabilities are measured as the sum of long-term debt, loans, trade credit, and other current liabilities. To capture the drag on finances stemming from debt payments, we include the debt service ratio calculated as total interest paid by the firm over its earnings before taxes, depreciation and amortization of capital (EBITDA).

We distinguish between long-term and short-term liabilities. Long-term liabilities comprise all loans and bonds with residual maturities above one year. Short-term liabilities comprise all current liabilities, i.e., loans, trade credits and other current liabilities, with residual maturities up to 1 year. We also construct alternative measures of liabilities that exclude trade credits since these originate outside the financial system. When excluding trade credits, we lose about one-tenth of observations due to missing data on trade credits.

Previous literature has found that firm size is an important determinant of firm leverage. We thus use log of total assets as a control for firm size, labeled as "size."

Figure 2 shows the importance of including small and medium-sized firms (SMEs) in the sample when analyzing the maturity structure of debt. On average, SMEs have a short-term leverage ratio of 38.5 percent and a long-term leverage ratio of 30.5 percent, which adds up to a total leverage ratio of 68.5 percent. SMEs are also considerably more leveraged than large firms, both in terms of short-term and long-term debt, indicating the significance of including SMEs into the analysis.

[13]Using net investment is common in the literature; see, for example, Lang et al. (1996). We measure net investment rate as the ratio between net fixed capital stock increase and the initial net fixed capital stock, i.e., $\Delta K_t / K_{t-1}$. Fixed capital is measured as the firm's gross capital stock minus depreciation.

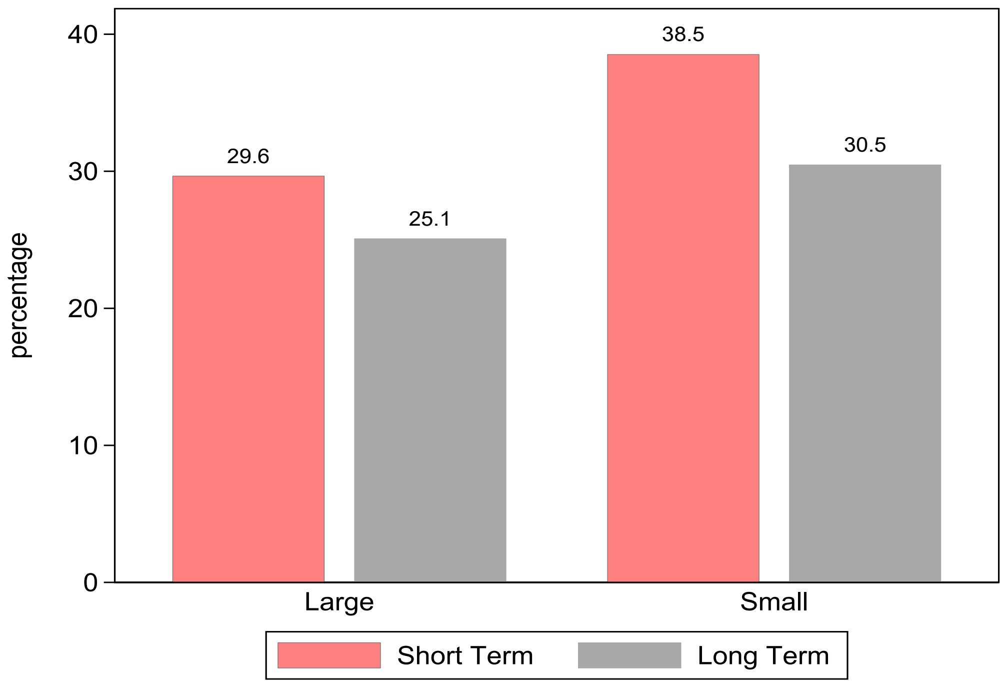


Figure 2: Firm Leverage by Size Class

Notes: This figure shows averages of the leverage (measured as a ratio of either short-term debt to assets or long-term debt to assets) of each firm for large firms and SMEs. Small and medium-sized firms (SMEs) are firms with fewer than 250 employees and/or firms with total assets lower than 43 million euros at 2005 prices.

We control for growth opportunities using net sales growth. We cannot use Tobin's Q or other market-based proxies for growth opportunities because market values are only available for listed firms which are less than 1% of our sample. We also control for cash flow as is standard in these regressions.

We measure bank weakness of the firm's main bank, WEAK BANK, using the share of total sovereign holdings of the bank over total assets of the bank. We use both BANKSCOPE and IBSI data on sovereign bond holdings to construct the variable WEAK BANK since IBSI data starts only in the fourth quarter of 2007 and covers fewer banks. In an extension, we only consider own sovereign exposure for banks in the periphery because exposure to own sovereigns in center (i.e., non-periphery) countries need not indicate weakness. While this is our preferred specification, it is also the most limited in terms of data coverage.

We also explored alternative measures of bank weakness based on bank leverage and total capital ratio. However given that most bank assets and liabilities are not marked to market, these balance sheet variables are very stable and do not register large enough movements over time to qualify as reliable measures of bank weakness. Moreover, sovereign bond holdings are a more direct measure of exposure to sovereign risk of each bank, and therefore more directly captures bank-sovereign linkages, which previous literature has shown to be an important channel through which bank weaknesses surfaced during the European financial crisis.

All firm-level variables are winsorized such that their kurtosis falls below a threshold of 10. This implies that net investment to lagged capital, (short-term/long-term) liabilities to assets ratio, interest paid to EBITDA, cash flow to assets, sales growth and log of capital stock are winsorized at the 5%, 3%, 3%, 2%, 2%, and 1% level respectively.

Table 1: Firm-Bank Relationships
(percentage of the total number of firms)

Country	With more than one bank[1] (percent)	Without any foreign bank[2] (percent)
Austria	20.4	99.5
France	0.0	100.0
Germany	32.2	99.8
Greece	50.4	99.9
Ireland	25.5	100.0
Netherlands	0.4	100.0
Portugal	37.9	97.9
Spain	40.3	99.0

[1] Share of firms in matched sample reporting more than one bank they have relationship with.
[2] Share of firms that report having relationships only with domestic banks.

Table 1 presents how many of the firm-bank relationships in the sample are multiple relationships (i.e., with more than one bank) and cross-border (i.e., with banks whose parent company is foreign). It is quite common for European firms to have multiple bank relationships although the data shows quite some variation across countries, with the fraction of firms having relationships with more than one bank ranging from a low of none in France to 50.4 percent Greece. Having a foreign bank is very rare in this sample. The one exception in our sample is Portugal but even there only 2.1 percent of firms have relationships with any foreign bank. In the case where multiple bank relationships are reported, the first listed bank is considered the main bank. For Italy, no firm reports its bank relationships so this country will be excluded from the analysis.

Table 2: Summary Statistics

Variables	Obs.	Mean	St. Dev.	Min.	Median	Max.
Net investment/Capital[1]	7,962,577	0.104	0.621	-0.539	-0.060	2.383
Liabilities/Assets	9,389,076	0.749	0.414	0.091	0.723	2.311
Fin.Expenses/EBITDA[2]	4,763,675	0.152	0.387	-1.188	0.083	1.566
Cash Flow/Assets	5,337,854	0.075	0.124	-0.600	0.065	0.534
Sales growth[3]	5,536,637	0.013	0.324	-1.410	-0.003	1.595
Size[4]	9,389,078	13.547	1.713	0.104	13.459	26.245
Banks' sovereign bonds/Assets	5,624,503	0.043	0.041	0	0.032	0.382
Periphery (banker)[5]	9,389,082	0.288	0.453	0	0	1
Periphery (firm)[5]	9,389,082	0.304	0.460	0	0	1

Notes: Based on unbalanced sample of matched firms (to their primary banks).
[1] Increase in real capital stock over lagged real capital stock.
[2] Interest paid scaled by EBITDA.
[3] Logarithmic change of real sales.
[4] Logarithm of total real assets.
[5] Binary variable equal to 1 if the firm (parent banker) comes from a peripheral economy.

Table 2 shows descriptive statistics for the main regression variables. Investment rates average about 10.4 percentage points during the sample period but declined by about 8.4 percentage points during the crisis period relative to the pre-crisis period. On average, debt liabilities account for about 75 percent of assets, and about 60 percent of total liabilities are short term (i.e., with a remaining maturity up to 1 year). Only a small fraction of short-term liabilities is made up of trade credits (about 14 percent). Financial expenses account for about 15 percent of EBITDA on average, with much variation across firms and over time. Exposures to sovereign bond holdings are modest on average, at about 4 percent of total assets, but there is much variation with some banks holding more than one-third of their assets in sovereign bonds. Firms in countries in the periphery comprise about 30 percent of the sample.

4 Empirical Framework and Identification

In this section we explain the framework and identification strategy we use to investigate the role of financial leverage in affecting corporate investment in Europe.

Our baseline model of corporate investment builds on a standard investment model with financial factors, similar to those used in Whited (1992), Bond and Meghir (1994), Lang et al. (1996), and Giroud and Mueller (2017). In these models, debt enters on account of bankruptcy and agency costs. Let the standard model for firm i be:

$$\left(\frac{\text{Investment}}{\text{Capital}}\right)_i = \beta\left(\frac{\text{Debt}}{\text{Assets}}\right)_i + \mathbf{X}_i{}'\gamma + \alpha + \varepsilon_i$$

where Investment/Capital is the net investment ratio, Debt/Assets is the ratio of total debt to total assets, capturing the financial leverage of the firm, and α is a constant. The vector $\mathbf{X}_i$ contains control variables, such as sales growth, cash flow ratio, and the debt service ratio. The model includes the usual determinants of investment as well as the debt service ratio since the debt to assets ratio may not fully capture the effects of lingering debt overhang when debt is measured at book value.

Our baseline model of corporate investment extends this standard model in several ways.

First, we estimate the above model using panel data, with all control variables lagged one period to mitigate reverse causality concerns. Second, we distinguish between post-crisis and pre-crisis periods by including interaction terms on the financial leverage variable using a post-crisis dummy variable. Third, we allow the effect of financial leverage to vary between peripheral countries and center countries. Fourth, we use a predetermined variable of financial leverage, constructed over the pre-crisis variable, to explain the evolution of investment in the post-crisis period to mitigate endogeneity concerns of the relationship between leverage and investment. Fifth, we include a host of fixed effects, including firm fixed effects, country-sector-year fixed effects, and main bank fixed effects.

Our baseline model of corporate investment is as follows:

$$\begin{aligned}\left(\frac{\text{Investment}}{\text{Capital}}\right)_{i,s,c,t} = \; & \beta_1 POST_t \times \text{Periphery}_c \times \text{High Leverage}_{i,s,c} + \\ & \beta_2 POST_t \times \text{High Leverage}_{i,s,c} + \\ & \mathbf{X}_{i,s,c,t-1}{}'\gamma + \alpha_i + \alpha_{s,c,t} + \alpha_b + \varepsilon_{i,s,c,t}\end{aligned} \quad (1)$$

Our main variable of interest is High Leverage$_i$ which is a dummy variable that is equal to one if the firm's average liabilities to assets ratio is greater than its sample median during the pre-crisis period 2000 to 2007. The reason why we use a dummy in this specification as opposed to a continuous variable is because we want to identify the effect of leverage from changes over time induced by the crisis shock. Hence we do not let firm leverage change with the shock but rather see how investment responds to the shock differentially for firms with high and low leverage ex-ante. This is a cleaner difference-in-difference exercise as it does not confound the effects of leverage with that of deleveraging.[14]

[14] We can also provide results upon request where we use the actual leverage ratio which will also capture de-leveraging of the firms after the crisis. These results are larger in magnitudes as they combine the effects of

Our main coefficients of interest are formed by the vector β. We expect β_1 and β_2 to be negative on account of debt overhang effects, that are more pronounced during the crisis period and for peripheral countries. $\mathbf{X}_{it-1}$ is the vector of control variables including sales growth, firm size, cash flow ratio, and debt coverage ratio. α_i are firm-specific fixed effects, and $\alpha_{s,c,t}$ are four-digit sector$\times$country$\times$year fixed effects. This specification allows to test for differential effects of financial leverage during the crisis, and the direct effect of leverage is absorbed by firm fixed effects as we define this variable as a time-invariant dummy at the firm-level. The direct effect of the crisis ($POST$) and the differential effect of crisis for periphery countries ($POST \times PERIPHERY$) will be absorbed by the time and time-country fixed effects, but we also show specifications without these fixed effects to establish the direct negative effects of crisis on firm investment. The baseline model boils down to a difference-in-difference approach to identify the effect of high leverage on investment by assessing the differential impact on investment of different levels of leverage between the pre- and post-crisis periods, where we define the pre-crisis period as 2000–2007 and the post-crisis period as 2008–2012. We also control for bank fixed effects to capture the role of pre-existing bank relationships.

Our identification approach is valid as long as any remaining variation in *ex post* firm-specific demand conditions does not vary systematically with the *ex ante* level of the firm's indebtedness. We think this is a reasonable assumption. After all, it is more likely that firms operating in the same four-digit sector tend to be hit by similar demand shocks over time. In addition, we limit the analysis to firms in the euro area. These firms were subject to the same monetary policy when they experienced diverging conditions in terms of banking and sovereign risk during the crisis.

As a robustness check, we incorporate the lagged investment rate as an explanatory vari-

pre-crisis leverage and de-leveraging during the crisis.

able and estimate using the Arellano and Bond (1991) two-step GMM procedure to account for Nickell (1981) bias. and transform the variables using forward deviations as in Arellano and Bover (1995) to reduce the amount of observations dropped from our sample.

In the first extension of the baseline model, we consider the role of weak banks where the "weakness" is time-varying and hence cannot be captured by the bank fixed effects. We do this by including the variable $\textit{Weak Bank}_{i,t-1}$ in the set of control variables $X_{i,t-1}$, where *Weak Bank* is the firm i's main bank's ratio of sovereign bond holdings to total assets, lagged one period. The *Weak Bank* variable captures the role of bank-sovereign linkages. These can affect firm investment via a bank lending channel when increases in sovereign risk weaken bank balance sheets, reducing the supply of loans to firms and increasing rollover risk.

In a second extension of the baseline model, we consider whether the effects are different for long-term liabilities as opposed to short-term liabilities. The benchmark model of Myers (1977) predicts that debt overhang effects are more pronounced for long-term debt, on account of higher agency costs. However, Diamond and He (2014) develop a model where debt overhang can increase with shorter term debt. Moreover, short-term debt could negatively affect investment on account of rollover risk, which manifests itself during bust periods.[15] In practice, there may be a possible tradeoff in the use of short-term debt, being cheaper than long-term debt during boom periods but turning costly during busts. The impact of debt maturity on investment during crises is therefore ultimately an empirical question. We define long-term liabilities as all bank loans and debt with a remaining maturity over 1 year and short-term liabilities as all loans, trade credits and other current liabilities with a remaining maturity of up to 1 year.

[15] See Chaterjee and Eyigungor (2012) for a model of self-fulfilling rollover crises.

5 Empirical Results

This section presents the results for the estimations outlined in the previous section. We will begin with the baseline dynamic investment model using annual data to explore how the crisis affects the relationship between investment and leverage. Then we will account for the role of weak bank balance sheets and consider the differential effects on short–term and long-term liabilities.

5.1 Debt Overhang and Rollover Risk

Table 3 shows our benchmark results with firm leverage. All regressions include firm fixed effects.

The results in Column 1 of Table 3 indicate that high leverage is a substantial drag on investment during the post-crisis period. Highly levered firms, defined as those with liabilities to assets above the sample average in the pre-crisis period, have a 3.3 percentage point lower investment rate during the crisis period compared to firms that are not highly levered. This is a large effect compared to the average investment rate of 10.4 percent. This result remains when accounting for aggregate demand effects and the average impact of weak banks through the inclusion of country-sector-year and bank fixed effects, as seen in Column 2. The coefficient estimate is slightly lower but still statistically significant. These results point to significant debt overhang during the crisis.

All control variables enter with the expected sign. We find that sales growth enters positively, as expected, signifying the positive effect of growth opportunities on firm investment. Firm size enters negatively, as expected, capturing the presence of decreasing returns to scale in investment, and the interest coverage ratio enters negatively indicating that firms with

Table 3: Benchmark Results with Total Firm Leverage

Dependent variable: (Net investment/Capital)$_{i,s,c,t}$

	(1)	(2)	(3)	(4)
$\text{Post}_t \times \text{Periphery}_c \times \text{High Leverage}_{i,s,c}$			-0.029***	-0.022***
			(0.003)	(0.003)
$\text{Post}_t \times \text{Periphery}_c$			-0.037***	
			(0.002)	
$\text{Post}_t \times \text{High Leverage}_{i,s,c}$	-0.033***	-0.028***	-0.017***	-0.017***
	(0.001)	(0.002)	(0.002)	(0.002)
Post_t	-0.020***		-0.002	
	(0.001)		(0.001)	
Fin. Expenses$_{i,s,c,t-1}$	-0.016***	-0.015***	-0.015***	-0.015***
	(0.001)	(0.001)	(0.001)	(0.001)
Cash Flow$_{i,s,c,t-1}$	0.280***	0.259***	0.277***	0.259***
	(0.006)	(0.006)	(0.006)	(0.006)
Sales$_{i,s,c,t-1}$	0.067***	0.058***	0.064***	0.058***
	(0.001)	(0.002)	(0.001)	(0.002)
Size$_{i,s,c,t-1}$	-0.235***	-0.243***	-0.234***	-0.242***
	(0.002)	(0.002)	(0.002)	(0.002)
Total effect: Post$_t$	-0.053***	-0.028***	-0.085***	-0.039***
	(0.001)	(0.002)	(0.001)	(0.002)
Total effect: Periphery$_c$			-0.066***	-0.022***
			(0.002)	(0.003)
Total effect: High Leverage$_{i,s,c}$	-0.033***	-0.028***	-0.046***	-0.039***
	(0.001)	(0.002)	(0.002)	(0.002)
Firm FE	Yes	Yes	Yes	Yes
Country-sector-year FE	No	Yes	No	Yes
Bank FE	No	Yes	No	Yes
Obs.	2,431,265	2,426,548	2,431,265	2,426,548
R^2	0.17	0.18	0.17	0.18
Within-R^2	0.03	0.02	0.03	0.02
Adjusted-R^2	0.03	0.03	0.03	0.03
Within-adjusted-R^2	0.03	0.02	0.03	0.02

Notes: Standard errors clustered at the firm level are in parentheses. Post is a dummy variable equal to 1 starting in 2008. Periphery is a binary variable equal to 1 if the firm comes from a peripheral economy, and 0 otherwise. High leverage is equal to 1 if the firm average of liabilities to assets is greater than the median of the sample until 2007. Financial expenses are equal to the ratio of interest paid to EBITDA. Sales are the change in the logarithm of sales. Size is measured by the logarithm of total assets. Cash flow is scaled by total assets.
$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

higher financial expenses invest less.

Next, we consider whether firms in peripheral countries are differentially affected by including interaction terms with a Periphery dummy variable. The results are presented in Columns 3 and 4, with the difference being that in Column 4 we also include fixed effects at the country-sector-year and bank levels. We find that the debt overhang effect is more pronounced for firms in peripheral countries. This is not surprising given that sovereign stress was concentrated in these countries. The investment rate of highly levered firms during the crisis is 2.2 percentage points lower for firms in peripheral countries as compared to firms in the center, and the total effect of high leverage for firms in peripheral countries during the crisis is 3.9 percentage points. However, the effect of high leverage during the crisis remains negative also for firms in center countries, being 1.7 percentage points lower than during pre-crisis times. These results indicate that there was significant debt overhang during the crisis in both peripheral and center countries but that the effects of debt overhang were more pronounced (i.e., at least two times larger) in peripheral countries.

5.2 Lagged Investment Rate

Table 4 shows results using the lagged investment rate as a dependent variable. The autocorrelation of the investment rate is relatively low across all specifications, in line with evidence from the literature on investment at the firm level. The significance of the rest coefficients in benchmark results is unchanged with respect to Table 3, and their magnitudes slightly revised upwards for the case of binary variables. In other words, when accounting for the low persistence of investment leads to a small upward revision of estimates of the negative effects from debt overhang problems, both for centre and periphery economies in the euro area.

Table 4: Lagged Investment Rate

Dependent variable: (Net investment/Capital)$_{i,s,c,t}$

	(1)	(2)	(3)	(4)
Post$_t$ $\times$ Periphery$_c$ $\times$ High Leverage$_{i,s,c}$			-0.031***	-0.032***
			(0.003)	(0.003)
Post$_t$ $\times$ Periphery$_c$			-0.024***	-0.023***
			(0.002)	(0.002)
Post$_t$ $\times$ High Leverage$_{i,s,c}$	-0.048***	-0.047***	-0.019***	-0.018***
	(0.001)	(0.001)	(0.002)	(0.002)
Post$_t$	-0.010***		-0.002	
	(0.001)		(0.001)	
(Net Investment/Capital)$_{i,c,s,t-1}$	0.030***	0.030***	0.030***	0.029***
	(0.001)	(0.001)	(0.001)	(0.001)
Fin. Expenses$_{i,c,s,t-1}$	-0.016***	-0.015***	-0.015***	-0.015***
	(0.001)	(0.001)	(0.001)	(0.001)
Cash Flow$_{i,c,s,t-1}$	0.287***	0.283***	0.283***	0.278***
	(0.006)	(0.006)	(0.006)	(0.006)
Sales$_{i,c,s,t-1}$	0.061***	0.060***	0.059***	0.059***
	(0.002)	(0.002)	(0.002)	(0.002)
Size$_{i,c,s,t-1}$	-0.241***	-0.245***	-0.240***	-0.243***
	(0.002)	(0.002)	(0.002)	(0.002)
Total effect: Post$_t$	-0.058***	-0.047***	-0.076***	-0.073***
	(0.001)	(0.001)	(0.001)	(0.002)
Total effect: Periphery$_i$			-0.055***	-0.055***
			(0.002)	(0.002)
Total effect: High Leverage$_{i,c,s}$	-0.048***	-0.047***	-0.050***	-0.050***
	(0.001)	(0.001)	(0.002)	(0.002)
Firm FE	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	Yes
Obs.	2,066,491	2,066,491	2,066,491	2,066,491
AR(1) test statistic	-261.49***	-261.78***	-261.45***	-261.74***
AR(2) test statistic	-1.60	-1.90*	-1.70*	-2.03**
Wald χ^2 statistic	35,218***	36,262***	36,429***	37,507***

Notes: Standard errors in parentheses. Estimation performed à la Arellano and Bond (1991), using two-step robust errors and a collapsed matrix of instruments, with forward-demeaned variables as in Arellano and Bover (1995). Post is a dummy variable equal 1 starting 2008. Periphery is a binary variable equal to 1 if the firm comes from a Periphery economy, and 0 from a Centre economy. High leverage is equal 1 if the firm average of liabilities to assets is greater than the median of the sample until 2007. Fin. Expenses is equal to the ratio of interest paid to EBITDA, and corresponds to the coverage ratio. Sales is the change in logarithm of sales. Size is measured by the logarithm of total assets. Cash flow is scaled by total assets.

$^{*}p < 0.10,^{**} p < 0.05,^{***} p < 0.01$

Table 5: Role of Weak Banks

Dependent variable: (Net investment/Capital)$_{i,s,c,t}$

	(1)	(2)	(3)	(4)
Post$_t$ $\times$ Periphery$_c$ $\times$ High Leverage$_{i,s,c}$			-0.034***	-0.026***
			(0.005)	(0.006)
Post$_t$ $\times$ Periphery$_c$			-0.041***	
			(0.004)	
Post$_t$ $\times$ High Leverage$_{i,s,c}$	-0.032***	-0.027***	-0.008*	-0.010**
	(0.003)	(0.003)	(0.004)	(0.005)
Post$_t$	-0.035***		-0.009***	
	(0.002)		(0.003)	
Fin. Expenses$_{i,s,c,t-1}$	-0.012***	-0.011***	-0.011***	-0.011***
	(0.001)	(0.001)	(0.001)	(0.001)
Cash Flow$_{i,s,c,t-1}$	0.298***	0.261***	0.293***	0.261***
	(0.009)	(0.009)	(0.009)	(0.009)
Sales$_{i,s,c,t-1}$	0.063***	0.052***	0.061***	0.052***
	(0.002)	(0.002)	(0.002)	(0.002)
Size$_{i,s,c,t-1}$	-0.312***	-0.319***	-0.311***	-0.319***
	(0.003)	(0.003)	(0.003)	(0.003)
Weak bank$_{i,t-1}$	-0.212***	0.037	-0.241***	0.038
	(0.022)	(0.030)	(0.022)	(0.030)
Total effect: Post$_t$	-0.067***	-0.027***	-0.091***	-0.036***
	(0.002)	(0.003)	(0.002)	(0.003)
Total effect: Periphery$_c$			-0.074***	-0.026***
			(0.004)	(0.006)
Total effect: High Leverage$_{i,s,c}$	-0.032***	-0.027***	-0.042***	-0.036***
	(0.003)	(0.003)	(0.003)	(0.003)
Firm FE	Yes	Yes	Yes	Yes
Country-sector-year FE	No	Yes	No	Yes
Bank FE	No	Yes	No	Yes
Obs.	1,052,146	1,048,091	1,052,146	1,048,091
R^2	0.26	0.28	0.26	0.28
Within-R^2	0.03	0.03	0.03	0.03
Adjusted-R^2	0.05	0.05	0.05	0.05
Within-adjusted-R^2	0.03	0.03	0.03	0.03

Notes: Standard errors clustered at the firm level are in parentheses. Post is a dummy variable equal to 1 starting in 2008. Periphery is a binary variable equal to 1 if the firm comes from a peripheral economy, and 0 otherwise. High leverage is equal to 1 if the firm average of liabilities to assets is greater than the median of the sample until 2007. Financial expenses are equal to the ratio of interest paid to EBITDA. Sales are the change in the logarithm of sales. Size is measured by the logarithm of total assets. Cash flow is scaled by total assets. Weak bank corresponds to the banker's average sovereign bondholdings scaled by total assets.
$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

5.3 The Role of Weak Banks

Table 5 accounts for the role of weak banks by including the Weak bank variable, which is time variant. The results in Column 1 of Table 5 show that investment is lower when the main banking relationship of the firm is with a weak bank (i.e., a bank with large exposure to sovereign bonds). This finding is consistent with the role of weak sovereign-bank linkages identified previously in the literature. Importantly, however, our main result on high leverage is robust to the inclusion of the Weak bank variable. We continue to find that highly levered firms have lower investment rates during the crisis. Results on our main variable of interest are unaltered when including country-sector-year and bank fixed effects in Column 2. However, the coefficient on the Weak bank variable turns insignificant upon the inclusion of bank fixed effects because there is not much variation over time in bank relationships. Our results on the more pronounced effects in peripheral countries also remain when controlling for the Weak bank variable, as seen in Columns 3 and 4, even though the size of the effect is somewhat reduced.

In Table 6, we consider whether the impact of weak banks differentially affects the investment of firms during the crisis and in peripheral countries through the inclusion of interaction terms of the Weak bank variable and the Post and Periphery dummy variables. Our main results on High leverage are robust to including these additional interaction terms. And the coefficients on these additional interaction terms do not enter with significant signs. Taken together, the results in Tables 5 and 6 show that the financial leverage effect we identify is robust to accounting for the weak bank channel identified in the literature.

Table 6: Additional Role of Weak Banks in Periphery Countries

Dependent variable: (Net investment/Capital)$_{i,s,c,t}$

	(1)	(2)	(3)	(4)
$\text{Post}_t \times \text{Periphery}_c \times \text{High Leverage}_{i,s,c}$			-0.034***	-0.027***
			(0.004)	(0.004)
$\text{Post}_t \times \text{High Leverage}_{i,s,c}$	-0.034***	-0.029***	-0.011***	-0.011***
	(0.002)	(0.002)	(0.003)	(0.003)
$\text{Post}_t \times \text{Periphery}_c$			-0.036***	
			(0.003)	
Post_t	-0.025***		-0.002	
	(0.001)		(0.002)	
$\text{Post}_t \times \text{Periphery}_c \times \text{Weak bank}_i$			-0.003	0.002
			(0.004)	(0.004)
$\text{Post}_t \times \text{Weak bank}_i$	-0.001	-0.002	-0.002	-0.003
	(0.002)	(0.002)	(0.003)	(0.003)
$\text{Fin. Expenses}_{i,s,c,t-1}$	-0.014***	-0.013***	-0.013***	-0.013***
	(0.001)	(0.001)	(0.001)	(0.001)
$\text{Cash Flow}_{i,s,c,t-1}$	0.251***	0.223***	0.246***	0.224***
	(0.007)	(0.007)	(0.007)	(0.007)
$\text{Sales}_{i,s,c,t-1}$	0.066***	0.056***	0.064***	0.056***
	(0.002)	(0.002)	(0.002)	(0.002)
$\text{Size}_{i,s,c,t-1}$	-0.231***	-0.239***	-0.230***	-0.239***
	(0.002)	(0.002)	(0.002)	(0.002)
Total effect: Post_t	-0.060***	-0.031***	-0.089***	-0.040***
	(0.002)	(0.003)	(0.002)	(0.003)
Total effect: Periphery_c			-0.074***	-0.025***
			(0.004)	(0.006)
Total effect: $\text{High Leverage}_{i,s,c}$	-0.034***	-0.029***	-0.045***	-0.039***
	(0.002)	(0.002)	(0.002)	(0.002)
Total effect: Weak bank_i	-0.001	-0.002	-0.005**	-0.001
	(0.002)	(0.002)	(0.002)	(0.002)
Firm FE	Yes	Yes	Yes	Yes
Country-sector-year FE	No	Yes	No	Yes
Bank FE	No	Yes	No	Yes
Obs.	1,582,082	1,577,267	1,582,082	1,577,267
R^2	0.18	0.20	0.18	0.20
Within-R^2	0.03	0.02	0.03	0.02
Adjusted-R^2	0.04	0.04	0.04	0.04
Within-adjusted-R^2	0.03	0.02	0.03	0.02

Notes: Standard errors clustered at the firm level are in parentheses. Post is a dummy variable equal to 1 starting in 2008. Periphery is a binary variable equal to 1 if the firm comes from a peripheral economy, and 0 otherwise. High leverage is equal to 1 if the firm average of liabilities to assets is greater than the median of the sample until 2007. Financial expenses are equal to the ratio of interest paid to EBITDA. Sales are the change in the logarithm of sales. Size is measured by the logarithm of total assets. Cash flow is scaled by total assets. Weak bank is equal to 1 if the firm's main banker's average sovereign bondholdings before 2008 is greater than its country-specific median until 2007. ${}^{*}p < 0.10$, ${}^{**}p < 0.05$, ${}^{***}p < 0.01$.

5.4 The Role of Debt Maturity

In Tables 7 and 8, we contrast the effects of short-term and long-term leverage. The regressions in Table 7, mirror those in Table 3 with the exception that we replace the High leverage variable based on total financial leverage with a High leverage variable based on short-term leverage. Similarly, in Table 8 we include a High leverage variable based on long-term leverage. In constructing the short-term leverage variable we abstract from trade credit. We find that the main result on the more negative effect of high leverage for peripheral countries during the crisis is mainly due to the presence of short-term debt, as seen when contrasting the results in Columns 3 and 4 of Tables 7 and 8. The difference is materially substantial. In the richest model specification presented in Column 4 where we include country-sector-year and bank fixed effects, the differential effect of high short-term leverage in peripheral versus center countries is -1.9 percentage points while it is not significant for long-term leverage. Firms with high short-term leverage in peripheral countries reduced investment more than those in center countries during the crisis. This is consistent with an increase in rollover risk during the bust period of peripheral countries and with theories in which short-term debt increases debt overhang problems during bust periods (such as Diamond and He, 2014). At the same time, the total effect of shocks in bust periods for the average country is more negative for long-term leverage (about -6.3 percentage points), compared to that of short-term leverage (-1.0 percentage points), within the group of highly leveraged firms in peripheral countries. To sum up, long-term debt has a bigger quantitative role in explaining overall debt overhang effects, whereas short-term debt accounts for differential effects between center and peripheral countries due to rollover risk.

Table 7: Benchmark Results with Firm's Short-Term Financial Leverage

Dependent variable: (Net investment/Capital)$_{i,s,c,t}$

	(1)	(2)	(3)	(4)
$\text{Post}_t \times \text{Periphery}_c \times \text{High Leverage}_{i,s,c}$			-0.034***	-0.019***
			(0.003)	(0.003)
$\text{Post}_t \times \text{Periphery}_c$			-0.033***	
			(0.002)	
$\text{Post}_t \times \text{High Leverage}_{i,s,c}$	-0.021***	-0.000	0.008***	0.010***
	(0.001)	(0.002)	(0.002)	(0.002)
Post_t	-0.026***		-0.013***	
	(0.001)		(0.001)	
$\text{Fin. Expenses}_{i,s,c,t-1}$	-0.016***	-0.015***	-0.015***	-0.015***
	(0.001)	(0.001)	(0.001)	(0.001)
$\text{Cash Flow}_{i,s,c,t-1}$	0.275***	0.253***	0.271***	0.253***
	(0.006)	(0.006)	(0.006)	(0.006)
$\text{Sales}_{i,s,c,t-1}$	0.067***	0.059***	0.065***	0.059***
	(0.001)	(0.002)	(0.001)	(0.002)
$\text{Size}_{i,s,c,t-1}$	-0.236***	-0.243***	-0.234***	-0.243***
	(0.002)	(0.002)	(0.002)	(0.002)
Total effect: Post_t	-0.047***	-0.000	-0.072***	-0.010***
	(0.001)	(0.002)	(0.001)	(0.002)
Total effect: Periphery_c			-0.067***	-0.019***
			(0.002)	(0.003)
Total effect: $\text{High Leverage}_{i,s,c}$	-0.021***	-0.000	-0.026***	-0.010***
	(0.001)	(0.002)	(0.002)	(0.002)
Firm FE	Yes	Yes	Yes	Yes
Country-sector-year FE	No	Yes	No	Yes
Bank FE	No	Yes	No	Yes
Obs.	2,420,571	2,415,809	2,420,571	2,415,809
R^2	0.17	0.18	0.17	0.18
Within-R^2	0.03	0.02	0.03	0.02
Adjusted-R^2	0.03	0.03	0.03	0.03
Within-adjusted-R^2	0.03	0.02	0.03	0.02

Notes: Standard errors clustered at the firm level are in parentheses. Post is a dummy variable equal to 1 starting in 2008. Periphery is a binary variable equal to 1 if the firm comes from a peripheral economy, and 0 otherwise. High leverage is equal to 1 if the firm average of short-term liabilities to assets (excluding trade credit) is greater than the median of the sample until 2007. Financial expenses are equal to the ratio of interest paid to EBITDA. Sales are the change in the logarithm of sales. Size is measured by the logarithm of total assets. Cash flow is scaled by total assets.
$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table 8: Benchmark Results with Firm's Long-Term Leverage

Dependent variable: (Net investment/Capital)$_{i,s,c,t}$

	(1)	(2)	(3)	(4)
$\text{Post}_t \times \text{Periphery}_c \times \text{High Leverage}_{i,s,c}$			-0.011***	0.001
			(0.003)	(0.003)
$\text{Post}_t \times \text{Periphery}_c$			-0.037***	
			(0.002)	
$\text{Post}_t \times \text{High Leverage}_{i,s,c}$	-0.063***	-0.064***	-0.049***	-0.065***
	(0.001)	(0.002)	(0.002)	(0.002)
Post_t	-0.005***		0.010***	
	(0.001)		(0.001)	
Fin. Expenses$_{i,s,c,t-1}$	-0.016***	-0.015***	-0.015***	-0.015***
	(0.001)	(0.001)	(0.001)	(0.001)
Cash Flow$_{i,s,c,t-1}$	0.277***	0.258***	0.274***	0.258***
	(0.006)	(0.006)	(0.006)	(0.006)
Sales$_{i,s,c,t-1}$	0.067***	0.058***	0.065***	0.058***
	(0.001)	(0.002)	(0.001)	(0.002)
Size$_{i,s,c,t-1}$	-0.235***	-0.242***	-0.234***	-0.242***
	(0.002)	(0.002)	(0.002)	(0.002)
Total effect: Post_t	-0.068***	-0.064***	-0.087***	-0.063***
	(0.001)	(0.002)	(0.001)	(0.002)
Total effect: Periphery_c			-0.048***	0.001
			(0.002)	(0.003)
Total effect: High Leverage$_{i,s,c}$	-0.063***	-0.064***	-0.060***	-0.063***
	(0.001)	(0.002)	(0.002)	(0.002)
Firm FE	Yes	Yes	Yes	Yes
Country-sector-year FE	No	Yes	No	Yes
Bank FE	No	Yes	No	Yes
Obs.	2,430,249	2,425,533	2,430,249	2,425,533
R^2	0.17	0.19	0.17	0.19
Within-R^2	0.03	0.02	0.03	0.02
Adjusted-R^2	0.03	0.03	0.03	0.03
Within-adjusted-R^2	0.03	0.02	0.03	0.02

Notes: Standard errors clustered at the firm level are in parentheses. Post is a dummy variable equal to 1 starting in 2008. Periphery is a binary variable equal to 1 if the firm comes from a peripheral economy, and 0 otherwise. High leverage is equal to 1 if the firm average of long-term liabilities to assets is greater than the median of the sample until 2007. Financial expenses are equal to the ratio of interest paid to EBITDA. Sales are the change in the logarithm of sales. Size is measured by the logarithm of total assets. Cash flow is scaled by total assets.
$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

5.5 Threats to Identification

An important assumption underlying the use of the difference-in-difference methodology is that there is a parallel trend in the dependent variable for different cross sections of the data over which the difference in explanatory variables is taken, and that this difference diverges after the shock (in our case, after the crisis starting in 2008). Figure 3 shows the behavior of the average net investment rate for firms with high and low leverage over time, before and after the crisis shock. A firm is considered to have high leverage if its leverage before the shock in 2008 is above the median of the sample. It is clear that the investment behavior of these different sets of firms was similar before the crisis (until the last observation in 2007) but diverged after the crisis (starting with the first observation in 2008) in favor of our results such that high leverage firms reduced investment more. This provides evidence in support of the parallel trend assumption and the empirical approach we take.

5.6 Sluggish Investment: Dynamic Persistent Effects

To investigate the dynamic responses in the baseline model, we run the following regressions by local projections (Jordà, 2005):

$$\begin{aligned}\left(\frac{\text{Investment}}{\text{Capital}}\right)_{it+h} =& \beta_{1h} POST_t + \\ & \beta_{2h} POST_t \times \text{Periphery}_i + \\ & \beta_{3h} POST_t \times \text{High Leverage}_i + \\ & \beta_{4h} POST_t \times \text{Periphery}_i \times \text{High Leverage}_i + \\ & \mathbf{X}_{it-1}{}'\boldsymbol{\beta_h} + \alpha_i + \alpha_{c,s} + \alpha_b + \epsilon_{it}\end{aligned} \quad (2)$$

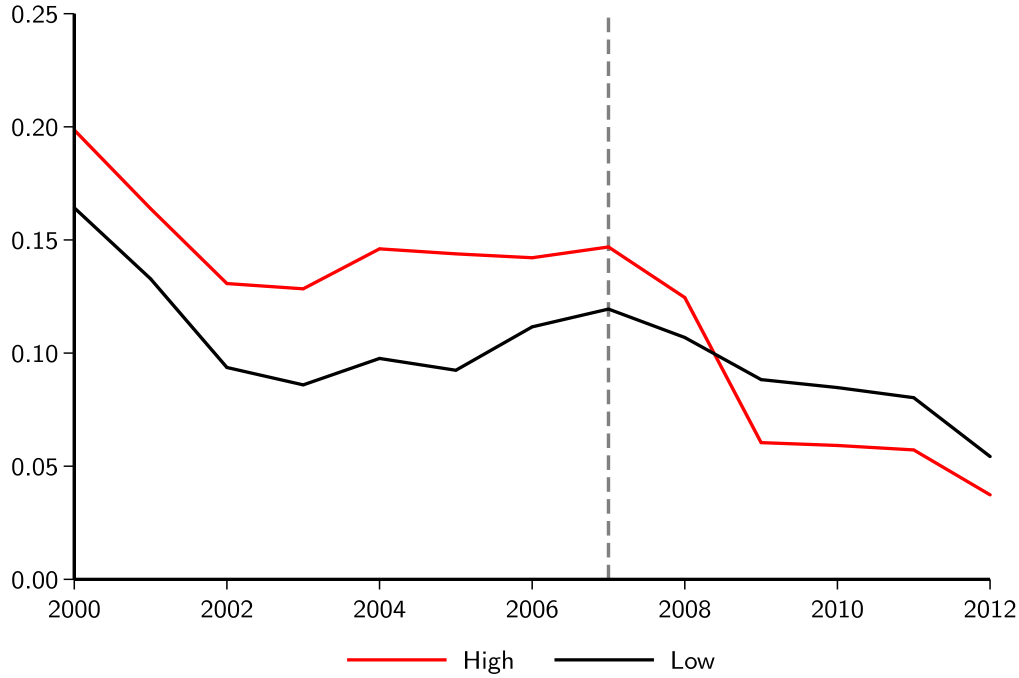
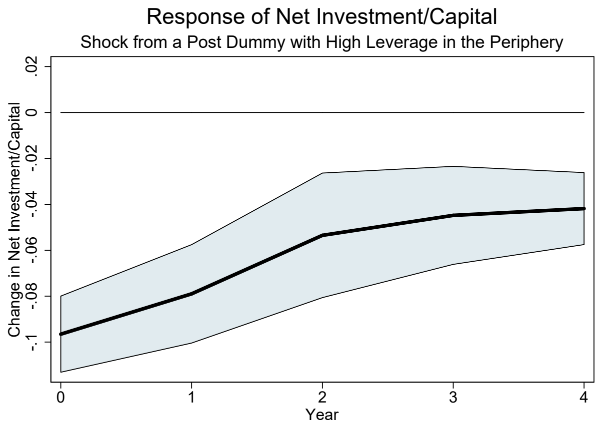


Figure 3: Evolution of Average Net Investment Rate by Leverage

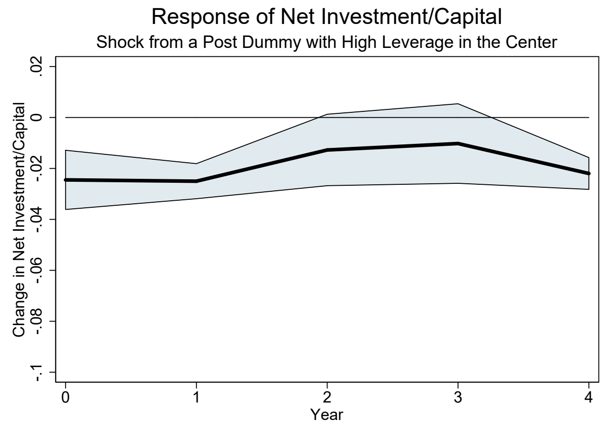
Note: A firm is considered to have high leverage if its ratio of total debt to total assets before 2008 is above the median.

where horizons are given by $h = 0, 1, 2, 3, 4$; α_i and α_b are firm and bank fixed effects, respectively; and $\alpha_{c,s}$ are country×industry fixed effects. $\mathbf{X}_{it-1}$ includes a lagged investment rate $(\frac{\text{Investment}}{\text{Capital}})_{it-1}$ and other controls (sales growth, firm size, cash flow ratio, and debt coverage ratio). We do not include year fixed effects since we are interested in how the crisis affects firm investment differentially, depending on the level of firm leverage and country status. The High Leverage and Periphery dummies are absorbed by firm fixed effects. We use two-way clustered standard errors by firm and year. The estimated impulse coefficient $\hat{\beta}_{1h} + \hat{\beta}_{2h} + \hat{\beta}_{3h} + \hat{\beta}_{4h}$ is a response of investment to the crisis for highly leveraged firms in the periphery. Similarly, we estimate impulse coefficients $\hat{\beta}_{1h} + \hat{\beta}_{2h}$ for lowly leveraged firms in the periphery, $\hat{\beta}_{1h} + \hat{\beta}_{3h}$ for highly leveraged firms in the center, and $\hat{\beta}_{1h}$ for lowly leveraged firms in the center.

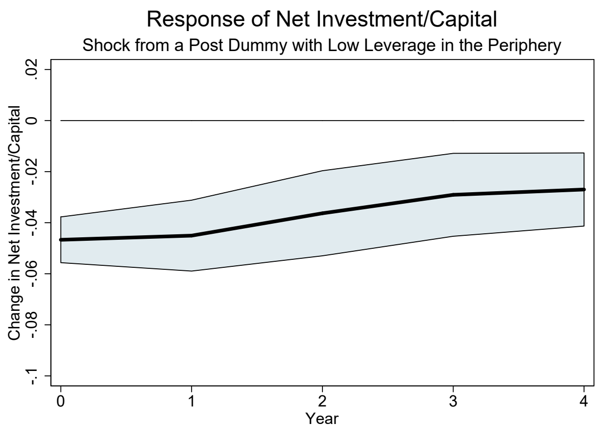
Figure 4 plots estimated impulse coefficients of each group for each horizon h. We find that firms with high leverage in the periphery reduce investment more for up to 4 years after the crisis than firms with low leverage in the center. Panel (a) shows that firms with high leverage in the periphery reduce their investment rate by about 10 percentage points on impact, 8 percentage points after 1 year, and 4 percentage points after 4 years. Magnitudes of the impulse coefficients are smaller in firms with high leverage in the center (panel (b)), low leverage in the periphery (panel (c)), and low leverage in the center (panel (d)) compared to those reported in panel (a). The estimated cumulative impact on investment of high leverage in the periphery over the first 5 years since the crisis (including the crisis year) is very large: a decline of about 32 percentage points. In order to quantify the corporate leverage channel, we use this differential responses of highly levered firms and lowly levered firms in the periphery. As the cumulative decline in aggregate corporate sector investment as a ratio to aggregate capital stock is 20 percentage points over 4 years, the corporate leverage channel explains 40 percent of the aggregate decline.



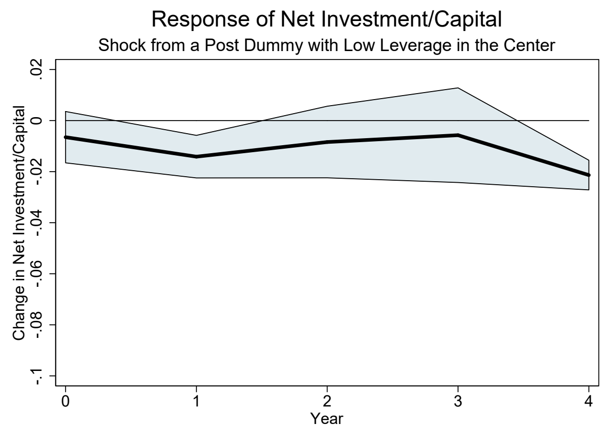
(a) High Leverage, Periphery



(b) High Leverage, Center



(c) Low Leverage, Periphery



(d) Low Leverage, Center

Figure 4: Impulse Responses of Investment

Notes: We apply the local projections method by Jordà (2005) to run the following regressions: $(\frac{\text{Investment}}{\text{Capital}})_{it+h} = \beta_{1h}POST_t + \beta_{2h}POST_t \times \text{Periphery}_i + \beta_{3h}POST_t \times \text{High Leverage}_i + \beta_{4h}POST_t \times \text{Periphery}_i \times \text{High Leverage}_i + \mathbf{X}_{it-1}{}'\boldsymbol{\beta_h} + \alpha_i + \alpha_{c,s} + \alpha_b + \epsilon_{it}$, where horizons are given by $h = 0, 1, 2, 3, 4$; α_i and α_b are firm and bank fixed effects, respectively; and $\alpha_{c,s}$ are country×industry fixed effects. $\mathbf{X}_{it-1}$ includes a lagged investment $(\frac{\text{Investment}}{\text{Capital}})_{it-1}$ and other controls (sales growth, firm size, cash flow ratio, and debt coverage ratio). For each horizon h, this figure plots estimated impulse coefficients $\hat{\beta}_{1h} + \hat{\beta}_{2h} + \hat{\beta}_{3h} + \hat{\beta}_{4h}$ for highly leveraged firms in the periphery, $\hat{\beta}_{1h} + \hat{\beta}_{2h}$ for lowly leveraged firms in the periphery, $\hat{\beta}_{1h} + \hat{\beta}_{3h}$ for highly leveraged firms in the center, and $\hat{\beta}_{1h}$ for lowly leveraged firms in the center. We plot 95 percent confidence interval (calculated using two-way clustered standard errors by firm and year) as a shaded area.

6 Conclusions

We quantify the role of financial factors that have contributed to sluggish investment in Europe in the aftermath of the 2008–2009 crisis. We use a very large pan-European firm-bank-time level dataset, in which we match the firms to their banks based on banking relationships in 8 countries over time. Our identification relies on a difference-in-difference estimation approach, where we compare the investment of high debt firms with low debt firms between crisis and normal times, while absorbing demand shocks through country-four-digit industry-year fixed effects. Furthermore, we distinguish between short-term and long-term debt to account for the effect of debt maturity on debt overhang and rollover risk, and use confidential ECB data on the exposures of banks to (own) sovereign debt together with information on the main bank relationship of each firm to identify the role of sovereign-bank linkages in driving the effect of debt overhang and rollover risk. Regressions also include bank fixed effects alongside firm fixed effects to abstract from any unobserved bank and firm characteristics.

Our results highlight the important role of firm leverage and debt maturity in determining firm investment following a crisis. Firms with higher leverage reduce investment more and this effect is stronger for firms in peripheral countries. Firms from peripheral countries that borrowed more short-term suffer from rollover risk and decrease investment relatively more. However, this effect is dominated for the average firm by the negative effect of long-term debt. These results are robust to accounting for weak bank and aggregate demand effects. The negative effect of firms leverage on investment is persistent for up to four years after the crisis in countries with sovereign stress, resulting in a cumulative decline in investment for these firms of about 32 percentage points. A simple back of the envelope calculation based on our firm-level estimates suggests that the debt overhang channel explains about 40 percent of the actual decline in aggregate corporate investment during the crisis.

Our results are complementary to the existing explanations in the literature that have focused on aggregate demand, banking health, and sovereign-bank linkages to explain the severity of the crisis. Our results also point to the dangers of the rise in corporate financial distress during the ongoing COVID crisis. While governments have provided ample liquidity to cash-strapped firms during the lockdown periods, it can be expected that these liquidity problems will turn into solvency problems for many firms, especially highly indebted firms. Our findings imply that an increase in firm debt overhang can have strong persistent negative effects on firm investment going forward. Our findings suggest that growth-enhancing policies that more directly target and improve the financial conditions of firms may be needed to reduce the debt overhang and stimulate the real economy. The results also point to the dangers of an overreliance on short-term debt to finance investment during good times, especially in countries that are prone to sovereign risk.

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