

Can Central Banks Boost Corporate Investment? Evidence from ECB Liquidity Injections

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Liquidity injections by central banks have become frequent and massive, but their real effects on corporate investment remain unclear. We examine the longer-term refinancing operations (LTROs) of the European Central Bank (ECB) during the eurozone sovereign crisis and show that greater LTRO funding to banks is associated with lower corporate

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investment. Riskier banks received funds through the LTROs and subsequently increased their holdings of risky sovereign debt. Corporate investment reductions are associated with these banks. Further, concurrent fiscal and regulatory policies impeded the effectiveness of the ECB liquidity injections. Our findings identify the contributing factors for these failures of monetary policy. (JEL E52, E58, G32)

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Since the 2008 global financial crisis, many central banks around the world have undertaken the unconventional monetary policy of directly injecting liquidity into the banking system. Some of these liquidity injections were of significant size and scope and have attracted massive press coverage and academic attention. However, the question of whether these liquidity injections indeed helped the real economy, as intended, remains hotly debated. In this paper, we add to the discussion by empirically examining the relationship between unconventional liquidity interventions and corporate investment in the setting of the 3-year longer-term refinancing operations (LTROs) in the eurozone. Our findings have important policy implications for both ongoing interventions, such as those to fight the COVID-19 crisis, and the development of future monetary tools.

The eurozone provides an ideal laboratory to study the real effect of unconventional monetary policies due to its unique structure of a monetary union catering to diverse economies from the member states of the eurosystem with a common currency. Since 2010, several eurozone countries have experienced severe fiscal difficulties and financial problems. As a reaction to this heightened sovereign credit risk, the ECB engineered a series of interventions to improve market liquidity and real output. The largest of these interventions were the LTROs with a 3-year maturity that were implemented in December 2011 and February 2012.¹

The ECB used LTROs to inject more than one trillion euros into the commercial banks of eurozone countries. However, the efficacy of LTROs as prominent tools of unconventional monetary intervention remains a topic of active debate.

Prior studies have shown that *negative* credit supply shocks result in a reduction in corporate investment (e.g., Chava and Purnanandam (2011)). However, whether a *positive* credit supply shock can boost investment is an understudied open question. Corporations do not exclusively base their investment decisions on their current cost of funding: new investments tend to be driven by long-term plans. In general, under stochastic financing conditions,

¹ Figure 1 provides a detailed timeline of the recent unconventional monetary policies of the ECB, while the details of related ECB interventions are discussed in Internet Appendix Note 1. Dell'Ariccia, Rabanal, and Sandri (2018) provide an overview of major unconventional monetary policies in the euro area and the United Kingdom.

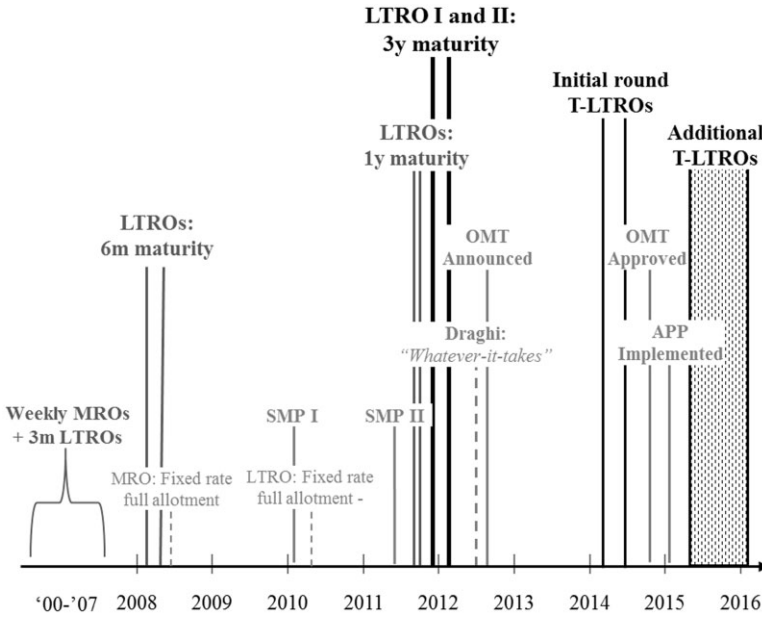


Figure 1
ECB's unconventional monetary policies

This figure outlines the timeline of recent unconventional monetary policies implemented by the European Central Bank (ECB). *MRO* labels the standard Marginal Refinancing Operations that are conducted on a weekly basis. The variable *LTROs* refers to longer-term refinancing operations, while the variable *T-LTROs* refers to targeted longer-term refinancing operations. *SMP*, the Securities Markets Program, was more recently replaced by the Outright Monetary Transactions (*OMT*) program. *APP* represents the most recently introduced Asset Purchase Program, that is still under way. The “whatever-it-takes” event refers to a speech made by Mario Draghi, the President of the ECB, at the Global Investment Conference, London, July 26, 2012.

corporate policies are affected by anticipation of a future financial downturn: corporations may even cut back their investments in good states in preparation for a future downturn (Bolton, Chen, and Wang (2013)). Hence, even theoretically, liquidity injections by central banks to *banks* do not necessarily translate into greater *corporate* investment.

Bank lending to corporations may respond weakly to unconventional liquidity interventions.² Even when banks increase their credit supply following an intervention, corporations’ own liquidity, financing, and investment policies may not fully align with those of the banks. On the one hand, unconventional monetary policies that aim at boosting bank liquidity may make corporations less concerned about their own future financing. On the other hand, corporations may interpret the high *LTRO* uptake of their respective banks as a sign of bank risk, including unobservable risk shifting incentives.

² Acharya et al. (2020) find that banks’ impaired balance sheets may have impeded the transmission of the ECB’s fixed-rate full allotment policy in 2008 (i.e., short-term liquidity provisions) through the loan markets.

Indeed, banks can borrow from the lender of last resort, and subsequently increase their investment in distressed sovereign debt.³ Because of concerns about future financing, corporations may reduce their investments. Thus, the extent to which macro-liquidity injections are converted into investment and economic output also depends on corporate expectations of future financing conditions, which can be affected by bank risk. Ultimately, the tradeoff between these complex effects can only be investigated in an empirical context.

It is, therefore, important and necessary to empirically examine the relationship between liquidity injections and the real economy. We do so by investigating investment and compensation policies in a large sample of eurozone corporations around the implementation of the LTRO. We build a comprehensive data set that combines monetary policy data from the ECB Statistical Data Warehouse, loan information on eurozone lenders from the Thomson Reuters Loan Pricing Corporation (LPC) DealScan database, corporate fundamental data from Compustat Global and S&P Capital IQ, credit ratings on nonfinancial corporations from CreditPro[®] by S&P Capital IQ, bank characteristics from Bankscope, credit default swaps (CDS) data from Markit, and relevant data from other sources. A unique feature of our research is that we capture the LTRO impact on corporate-specific policies using bank-level LTRO uptake information.

Based on our comprehensive data set, we find that, surprisingly, corporations connected with banks that had a higher LTRO uptake reduced their investment *more* than those associated with banks that had a lower or no LTRO uptake. The results are robust with alternative LTRO uptake measures and with more stringent *Time* \times *Country* \times *Industry* fixed effects (FE) to control for unobserved time-varying shocks to an industry in a country in a particular year, which may affect the investment demands of firms. To further control for the investment demand effect, we construct various matching samples based on country, industry, and size or Z-score, and conduct the investment analysis in the matching samples. Given that bank LTRO uptake is endogenously determined, to create some exogenous component of LTRO uptake, we compare similar firms based on the same industry and size or Z-score, with one from the eurozone and the other from a non-eurozone country in Europe. The non-eurozone-matched firms are more likely to borrow from non-eurozone banks that do not have access to the LTRO funds. We continue to find evidence that corporate investment is negatively associated with bank LTRO uptake in the matching sample analyses.

To better understand the counterintuitive result of lower investment associated with greater liquidity injection, we further explore the role of bank risk in explaining the decrease in corporate investment following the ECB's

³ Focusing on Italy, Carpinelli and Crosignani (2021) find that while private credit supply was increased after the LTRO liquidity injections, banks used most of the LTRO funds to buy domestic government bonds.

LTROs. By analyzing the determinants of a bank's LTRO uptake, we find evidence that high-risk banks are more likely to participate in the LTROs and take a greater amount, which is consistent with [Drechsler et al. \(2016\)](#). While past bank risk is positively related to banks' participation in the 3-year LTROs, the LTRO uptake itself can signal future bank risk-shifting incentives that cannot be easily observed. We explore further the signaling role of banks' LTRO uptakes by examining their risky sovereign debt holdings following the LTROs and find that banks with LTRO funds increased their risky sovereign debt holdings during the post-LTRO period, while their borrowers decreased investments proportional to their LTRO uptake amounts.

We also conduct additional firm-level analyses to provide more evidence for the channel. If firms interpret banks' LTRO uptakes as signals of bank risk and future financing constraints, we expect a more pronounced decrease in investments following bank LTRO uptake for firms with risky bank lenders and high rollover risk. We find evidence consistent with this prediction. Our findings are consistent with the LTRO's role in the revelation of unobservable bank risk, and underscore corporations' uncertainty about their own future financing conditions. Furthermore, we find that the banks' holding period for the LTRO funds plays a significant role in the transmission of unconventional monetary policies. Specifically, when banks repay their ECB funds early, their own corporate borrowers actually increased their investments. Thus, the investment reduction originated mainly from corporations connected to banks that retained the LTRO funds over a longer period. These findings reveal the distributional effects of unconventional monetary policies and cast doubt on the real benefits of the liquidity injection, as the countries that were most affected by the eurozone crisis did not experience an improvement in real economic performance.

Other regulatory policies that do not support monetary policies may have offset the positive liquidity shock created by the ECB. Recent discussions of the impact of central bank interventions in the face of anemic economic growth, even after many years of monetary easing, have shifted the debate to the role of fiscal policies. [Dixit and Lambertini \(2003\)](#) suggest that it is important to consider the interaction between monetary and fiscal policies, which can generate very different outcomes. Hence, we also investigate the role of fiscal policies in the effectiveness of the LTROs. This analysis is interesting because LTROs are eurozone-wide monetary policies, but corporations are also subject to disparate national fiscal policies. Analyzing the country-level fiscal policies in Europe concurrent with the liquidity injection, we show that when individual national governments increase their public investments or decrease their corporate taxes, the LTRO uptake of banks domiciled in those countries can decelerate the decrease in corporate investments therein. In addition to fiscal policies, the 2011 European Banking Authority (EBA) capital exercise may have induced banks to decrease lending to firms to meet their capital requirements ([Gropp et al. \(2019\)](#)). Indeed, we find evidence of an overlap between banks covered by the capital exercise and

banks that participated in the LTROs. These findings demonstrate the importance of coordinated policies of EU regulators for corporate investment, as there are limits to the efficacy of monetary policies implemented in isolation.

Our findings contribute to our understanding of the real effects of unconventional monetary policies. While many papers that focus on the United States, the bank-dominated financial system in Europe makes it a more interesting setting to understand monetary policy transmission through the banking sector and the ultimate effects on the real economy. During the recent European sovereign debt crisis, the ECB implemented various unconventional monetary policies.⁴ Focusing on the announcement of Outright Monetary Transactions (OMT) in the summer of 2012, which led to an indirect recapitalization of banks' balance sheets, especially for those with high sovereign debt, [Acharya et al. \(2019\)](#) find evidence of zombie lending by banks and firms receiving loans use these funds to build cash reserves rather than increase employment and investment. However, based on microlevel survey data by the ECB, [Ferrando, Popov, and Udell \(2019\)](#) document improved credit access, better loan terms, and capital investments and cash flows for small firms following the OMT announcement. We distinguish our study from theirs by focusing on *corporate* investment policies following the largest real liquidity injection, that is, 3-year LTROs, and emphasize the roles of bank risk and policy interactions.

In the setting of 3-year LTROs, in contrast to the country-specific studies (e.g., [Carpinelli and Crosignani \(2021\)](#); [Andrade et al. \(2019\)](#); [Arce, Mayordomo, and Gimeno \(2021\)](#)), we provide the first cross-country analyses of the real effect of the 3-year LTROs on corporate investments. Moreover, in contrast to the positive impacts of LTROs documented by those country specific studies, our results suggest that it is difficult to stimulate corporate investment simply by injecting liquidity into poorly capitalized banks. Our finding is broadly consistent with [Fabo et al. \(2021\)](#) regarding the effect of quantitative easing (QE) in the subsequent period. We also explore the role of banks' early repayment of their 3-year LTRO borrowing on corporations' decisions, as well as the interaction between these monetary policies and other regulatory policies. We suggest that it is important to consider monetary policies in tandem with banks' weak balance sheets, as well as the impact of potentially contractionary fiscal policies.⁵

1. Institutional Background and Literature Review

During the recent European sovereign debt crisis, the two 3-year LTROs were among the major efforts by the ECB to provide liquidity to the financial sector

⁴ [Internet Appendix Note 2](#) provides a categorized list of papers on the impact of unconventional monetary policies in the eurozone setting.

⁵ For example, during the recent pandemic, new international rules governing banks' capital requirements are to be deferred by a year following banks' argument that these rules would impede their ability to serve businesses hit by the pandemic.

and ease credit conditions. The LTROs were allotted on December 21, 2011 (“LTRO I”), and February 29, 2012 (“LTRO II”), with a total amount of 1,018.7 billion euros. The 3-year LTROs were attractive to eurozone commercial banks due to their long maturity, low interest rates, and option to repay the loans early without any penalty (after one year, either in part or in full). Subject to the provision of eligible collateral, banks were able to borrow unlimited funds for 3 years, with no restrictions on the use of the proceeds.⁶

The ECB’s LTROs are part of the unconventional monetary policies instituted by central banks worldwide in recent years. Other related policies include asset purchases (e.g., QE in the United States, the eurozone-wide Asset Purchase Programme [APP]), indirect bank balance sheet recapitalizations (e.g., the announcement effects of the ECB’s bailout funding program [OMT]), and yield curve flattening (e.g., the maturity extension program (MEP) in the United States). However, those other policies differ from *direct* central bank liquidity injections into commercial banks and may affect different banks and bank-dependent borrowers heterogeneously. The size and popularity of the 3-year LTROs make them an interesting policy intervention for understanding banks’ voluntary access to central bank liquidity injections and the responses of corporations’ when their own bank lenders tap liquidity through these liquidity injections. Hence, understanding and comparing different policies to stimulate the real economy can deliver valuable policy implications.⁷

The evidence on the impact of unconventional monetary policies on corporate investment and salaries and wages is mixed and depends on the particular characteristics of the intervention (e.g., Bergman, Iyer, and Thakor (2020); Berger and Roman (2017); Norden, Udell, and Wang (2020); Foley-Fisher, Ramcharan, and Yu (2016); Luck and Zimmermann (2020); Chakraborty, Goldstein, and MacKinlay (2020); Cong et al. (2019)). In the eurozone setting, Acharya et al. (2020) focus on the fixed-rate full allotment policy announced in October 2008 by the ECB that aimed to reduce the short-term funding risk in the banking system. They find that the transmission of monetary policy is not effective for bad banks and long-term loans, as evidenced by the resultant loan spreads and weak results for investment. In contrast to their work, we investigate firm investment following the 3-year LTROs with full allotment. Investment is a long-term decision for corporations, and is expected to be more positively affected by the availability of longer-term funding associated with the 3-year LTROs, if the transmission was indeed effective.

Acharya et al. (2019) and Ferrando, Popov, and Udell (2019) investigate the impact of OMT announcement in July 2012. While Acharya et al. (2019)

⁶ To further ease the credit conditions for the real economy, the ECB announced targeted LTROs (TLTROs) in 2014 that provided financing to credit institutions with a maturity of up to four years, with the bank borrowing amount being linked to their corporate lending.

⁷ Berger, Molyneux, and Wilson (2020) review research on the effects of banks on the real economy.

document the zombie lending following the OMT, Ferrando, Popov, and Udell (2019) document both improved credit access and loan terms for small firms after the OMT announcement based on microlevel survey data on SMEs. Different from these papers, we contribute by focusing on the 3-year LTROs, which is one of the largest interventions with injections of over one trillion euros, and by emphasizing the role of bank risk and policy interactions.

A few recent country-specific papers have shown that the LTRO liquidity injections by the ECB indeed had a positive, moderately sized effect on the supply of bank credit to corporations. For example, Carpinelli and Crosignani (2021) find a positive impact of LTROs on long-term credit supply in Italy, although banks used most of the additional money to increase their holdings of sovereign bonds. However, government guarantees improved Italian banks' access to the LTRO injections and promoted the transmission of monetary policy. Andrade et al. (2019) also document the positive effect of LTROs on French banks' credit supply. Focusing on Spanish corporations, Arce, Mayordomo, and Gimeno (2021) find that TLTROs did amplify the credit reallocation to smaller corporations following the ECB's Corporate Sector Purchase Programme. Different from these country-specific studies, we focus on a sample of eurozone corporations and emphasize the role of bank risk, early repayment options, and policy interactions in affecting corporate investment and employment compensation across countries. Thus, we are also able to document the differential effect of the LTROs across firms, banks, and countries.

Many papers that focus on the macroeconomic effects of unconventional policies by the ECB (e.g., Cahn, Matheron, and Sahuc (2017); Mouabbi and Sahuc (2019)). We contribute to this thread of the literature by using microeconomic data to investigate the impact of the 3-year LTROs introduced in the setting of the European sovereign debt crisis. In addition to the special features of 3-year LTROs, careful analysis using bank- and firm-level data can provide valuable insights (Kashyap, Stein, and Wilcox (1996)).

Our paper also relates to broader research on the impact of financial conditions on bank lending and corporate investment. In an investment-cash-flow sensitivity setting, Almeida and Campello (2007) document that financing frictions affect investment decisions. Investment-cash-flow sensitivity increases with the tangibility of firms' assets if firms are financially constrained. Harford and Uysal (2014) show that firms' access to debt markets has affected their ability to make investments as well as the quality of the investments. A substantial body of papers has shown that negative credit supply shocks reduce the various sources of lending and negatively affect corporate investment or employment (e.g., Duchin, Ozbas, and Sensoy (2010); Chava and Purnanandam (2011); Popov and Rocholl (2018); De Marco (2019); Beck, Da-Rocha-Lopes, and Silva (2021)).⁸ In addition, during

⁸ In contrast to the credit supply effect, Kahle and Stulz (2013) and Gennaioli, Ma, and Shleifer (2016) emphasize the influence of demand uncertainty and expectations on corporate policies during crisis periods.

the European sovereign debt crisis, banks tended to increase their domestic sovereign debt holdings (because of moral suasion or the banks' risk-shifting), which can generate "crowding-out" of bank lending to firms and households (e.g., Altavilla, Pagano, and Simonelli (2017); Becker and Ivashina (2018); Gennaioli, Martin, and Rossi (2018); Ongena, Popov, and van Horen (2019)). During the COVID-19 crisis, banks were able to meet corporate liquidity demand because of the Federal Reserve's liquidity injections, funds from depositors, and strong preshock bank capital (e.g., Li, Strahan, and Zhang (2020)), and firms increased their cash holdings (e.g., Acharya and Steffen (2020)). In contrast to these papers, we contribute to the literature by investigating the relationship between a major liquidity injection and corporate investments, in conjunction with policies of individual governments.

2. Data and Methodology

2.1 Data

We collect data from several databases that contain European data ranging from 2009 to 2014, thereby allowing us to examine differences in corporate financial policies during the European Sovereign Debt Crisis period and the subsequent periods characterized by ECB interventions. We use data on corporate fundamentals from the Compustat Global database. From this source, we identify a sample of European corporations with quarterly corporate financial and stock price data.⁹ Since financial and public utility corporations often have capital structures that are quite different from the average corporation, we exclude financial corporations (SIC codes 6000 to 6999), utility corporations (SIC codes 4900 to 4999) and corporations for which a SIC code is not available. Furthermore, because we are interested in active firms only, we follow Bates, Kahle, and Stulz (2009) and require corporations to have *both* a nonnegative asset (book) value and nonnegative sales to be included in a given year (quarter). We supplement the data from Compustat with corporate data from the Capital IQ database, which compiles, inter alia, detailed information on corporate debt structure using financial footnotes contained in corporations' financial reports. Finally, we use S&P credit ratings as a proxy for corporate credit risk.¹⁰ In addition to the corporate data, we collect country- and industry-specific data from several other sources, including 5-year sovereign CDS spreads from Markit and measures of a country's overall exposure to other countries' economic conditions from the World Bank.

⁹ The advantage of using data from Compustat instead of, for instance, Amadeus, is that we have quarterly, rather than only annual data, allowing for greater granularity in our analysis. The necessity of available corporate balance sheet information implies that our sample consists primarily of medium and large corporations. According to Andrade et al. (2019), large corporations benefited the most from the LTROs in terms of a positive credit supply shock.

¹⁰ To mitigate the effect of outliers, we winsorize the observations for our variables at the 1st and 99th percentiles. Furthermore, we follow the approach in related empirical research, and assume that a corporation has no R&D expenditure (or M&A activities) if it is reported as "missing" by Compustat.

We restrict our main sample to corporations located in countries that belong to the eurozone, that is, within the remit of the eurosystem, that were directly affected by the liquidity interventions.¹¹ To assess the relationship between liquidity interventions and corporate policies, we use the ECB's provision of unconventional 3-year LTROs. As presented in [Internet Appendix Figure IA1](#), these interventions turned out to be of significant size. Since we are interested in whether and how much of the ECB's liquidity injections flowed to individual banks, we specifically make use of hand-collected bank-level information on the eurozone banks' uptake of LTRO I and LTRO II.

[Table 1](#) outlines LTRO uptake in the eurozone by country. [Internet Appendix Figure A2](#) presents the corresponding graphical distribution. We find that banks from periphery countries were highly active in the program because of their actual capital needs, as the LTRO was their only option for accessing medium-term funding. However, participation in the unconventional LTROs also provided all eurosystem banks with an opportunity to replace their shorter-term borrowing with low-cost 3-year borrowing. Therefore, banks in even highly rated and safe eurozone countries, such as Germany and France, participated in the 3-year LTROs. In addition, the participation in and the uptake from the two LTROs were quite similar. Together, the two LTROs amounted to approximately 917.49 billion euro, with Italian and Spanish banks being the most active participants in terms of both the number of participating banks and amounts borrowed.¹² GIIPS countries had the highest total LTRO borrowings relative to their central government debt. The individual banks in the GIIPS countries also borrowed relatively more from the LTROs. Thus, the liquidity injection, as such, was greatest for the eurozone periphery, that is, those countries most affected by the European Sovereign Debt Crisis. We supplement these intervention-specific data with other eurozone-wide data obtained from the National Central Banks (NCBs), EBA stress testing reports, and the ECB Statistical Data Warehouse.¹³

2.2 Empirical design

To investigate the relationship between the 3-year LTROs on corporate investment, we conduct our main analyses in a bank-firm-linked sample in the eurozone during 2009 to 2014. Specifically, we create a sample of corporations with

¹¹ To exclude any potential biases, we include only corporations from countries that adopted the euro as a common currency in 1999 and joined the European Monetary System at its inception in 2001.

¹² Our total bank LTRO uptake amount (917.49 billion) covers over 90% of the publicly available total 3-year LTRO amount (1,018.7 billion). The slight difference between the two numbers is because of the lack of data on actual LTRO uptake by Greek and non-eurozone banks. Non-eurozone banks participated through their eurozone subsidiaries and accounted for approximately 5% of the total uptake. We do not count LTRO uptake by foreign subsidiaries for the country-specific LTRO uptake amount.

¹³ Sources: <https://sdw.ecb.europa.eu/home.do>, <https://eba.europa.eu/risk-analysis-and-data>, and <http://www.ecb.europa.eu/stats/monetary/res/html/index.en.html>. Note that the ECB does not provide detailed data on its intervention programs.

Table 1
Liquidity injection from the ECB's 3-year longer-term refinancing operations

Country	LTRO I: December 2011 EUR bn (1)	LTRO II: February 2012 EUR bn (2)	Total country LTRO borrowing EUR bn (3)	Country LTRO uptake percentage (4)	Average bank LTRO uptake percentage (5)
Austria	3.66	7.83	11.49	4.82	7.10
Belgium	45.28	43.71	88.99	25.02	12.30
France	5.59	6.52	12.12	0.61	3.40
Germany	12.25	13.13	25.38	1.67	6.70
Greece	60.94 [§]	n.a.	60.94	25.54	n.a.
Ireland	21.91	17.62	39.52	22.33	11.50
Italy	172.08	128.11	300.20	15.92	13.40
Netherlands	8.86	1.96	10.81	2.58	9.80
Portugal	24.54	24.76	49.30	29.37	11.80
Spain	153.21	165.53	318.74	51.44	15.70
Total	508.32	409.17	917.49		

This table presents data on the liquidity injections that eurozone countries obtained from the 3-year longer-term refinancing operations (LTROs) initiated by the European Central Bank (ECB) on December 21, 2011 (LTRO I), and February 29, 2012 (LTRO II), respectively. *Total country LTRO borrowing* refers to the total amount that banks in the respective country obtained through LTRO I and II, with the numbers given in billion EUR. In column 4, we scale the *Total country LTRO borrowing* for each country by the country's central government debt obligations, as of December 2011. In column 5, we report for each country the average bank-level LTRO borrowing, scaled by the respective banks' total assets in 2010. The information about the bank and country-specific LTRO uptake is based on hand-collected data from Bloomberg, as well as central bank announcements and public commentaries. The data on banks' total assets are obtained from Bankscope and available public financial reports, while the information for government debt by country is obtained from the World Bank Database. We do not report numbers for Finland, since Finnish banks did not participate in the 3-year LTROs. [§]In the case of Greece, we only have information about the total LTRO amount which, besides the 3-year LTROs, also includes the standard 1- and 3-month LTROs. As we cannot separate the latter, the number is not directly comparable to the uptake numbers for the other countries.

bank lender information based on LPC DealScan and our baseline eurozone corporations in Compustat Global as described in the previous subsection.¹⁴ We then use our bank-level LTRO uptake information to identify bank lenders with access to LTRO funds in the DealScan-Compustat-linked sample.¹⁵ We ultimately obtain a sample of 816 corporations in the linked sample, 416 of which have at least one borrowing relationship with an LTRO bank up to 5 years prior to the LTRO injections. Then, we estimate the following specification:

$$\text{Corporate investment}_{i,t} = \alpha + \beta \text{Bank LTRO uptake}_{i,t} + \gamma Y_{i,t} + \delta Z_{c,t} + \theta \text{Firm}_i + \eta \text{Time}_t + \epsilon_{i,t}, \quad (1)$$

where i refers to the corporation, t indicates the year-quarter, and c refers to the country. Our main measure of *Corporate Investment* is the ratio of capital expenditure to total assets. We also examine corporate investment in human

¹⁴ We match DealScan borrowers with Compustat corporations by using the link provided by Chava and Roberts (2008) and by hand-matching corporations by name and country of origin. Further, we only consider banks that are classified as lead lenders on a loan to address the concern that participating banks, relative to lead banks, may have a different or potentially lower impact on the borrower behavior.

¹⁵ Based on our sample of LTRO banks, we identify 89 of 109 banks as lead bank lenders in the LPC DealScan data set.

capital as measured by the logarithm of corporations' total salaries and wages (*Salaries and Wages*). To capture the liquidity injection impact of the 3-year LTROs, we mainly use the corporation-specific measure of *Bank LTR Ouptake*_{*i,t*}. The variable equals zero until the first round of the unconventional LTROs, 2011Q4, and thereafter equals the average LTRO borrowing amount of related banks (both LTRO I and LTRO II) of the corporation, scaled by total assets of each related bank as of 2011:

$$\text{Bank LTRO uptake}_{i,t} = \sum_{j=1}^{N_i} \left(\frac{\text{Bank LTRO borrowing}_{j,t}}{\text{Bank size}_{j,2011}} \right) / N_i, \quad (2)$$

where *j* refers to a related bank, and *N_i* refers to the total number of LTRO-bank relationships the corporation has. A high value of *Bank LTRO uptake* implies that the LTRO borrowing of banks with which the corporation has an existing lending relationship (compared to the size of the related banks), on average, was significant, which, all else being equal, makes it more likely that the corporation had access to additional funds stemming from the LTRO liquidity injections.¹⁶ As robustness checks, we construct an alternative LTRO uptake measure using the pre-LTRO firm borrowing from bank *j* as the weight when calculating the firm-level bank LTRO uptake measure. Rather than bank size, as that in Equation (2), we also scale bank LTRO borrowing with bank loan portfolio.

*Y_{*i,t*}* is a set of explanatory variables, including *Cash flow*, *Market to book*, *Firm size*, *Leverage*, and *Rated*. To control for sovereign credit risk and the diversification of the economy across markets, we also incorporate country-specific controls (*Z_{*c,t*}*), including the natural logarithm of sovereign CDS spreads (*Sovereign risk*) and the countries' export to gross domestic product (GDP) ratios (*Sovereign export*). We have also included firm (*Firm_{*i*}*) and time fixed effects (*Time_{*t*}*). As an alternative model specification, instead of sovereign risk controls, we add *Time × Country × Industry FE* to capture the unobserved time-varying shocks to an industry in a country for a particular year, which may affect the investment demands of firms. The appendix table A1 describes all variables. Table 2 shows the summary statistics for all the key measures in our DealScan-Compustat-linked corporate sample. A large degree of cross-country and time-series variation exists in *Sovereign risk*. The average corporation in our main sample invests 2.98% of its total assets in each quarter, with a mean bank debt to total asset ratio of 61.8%.

Our main results are based on the *Bank LTRO uptake* measure, as the LTROs provided liquidity to the banking sector, and the banks' incentives for participating in the LTROs are important to understand their transmission efficiency to the real economy. We also analyze the determinants of banks' LTRO borrowings using bank-level data from Bankscope and Markit and

¹⁶ For the average corporation with an LTRO-bank relationship, the median (mean) value of *Bank LTRO uptake* is 4.1% (15.9%), with a large degree of cross-corporation and cross-country variation.

Table 2
Summary statistics for eurozone sample with existing loan information from LPC DealScan

A. Corporate-specific measures

Country	AUT	BEL	DEU	ESP	FIN	FRA	GRC	IRL	ITA	NLD	PRT	Total
Corporate investment	5.51	3.28	3.45	2.36	2.96	2.95	2.34	2.41	2.70	2.65	5.14	2.98
Salaries and wages	3.91	3.12	3.31	3.78	3.99	3.90	2.54	2.07	3.39	4.03	4.26	3.55
Cash flow	3.61	3.58	4.05	4.66	3.89	2.81	1.19	2.44	2.68	3.84	2.74	3.32
Market to book	111.	108.	117.	104.	116.	110.	89.4	135.	107.	126.	106.	112.
Firm size	6.75	6.77	6.60	7.45	7.03	7.24	6.13	7.40	6.70	7.51	8.28	6.98
Leverage	27.1	25.5	22.5	35.5	27.8	23.9	45.2	28.2	30.8	24.9	38.0	26.8
Industry sigma	3.44	4.69	7.61	3.57	4.16	5.65	3.58	3.26	3.57	4.57	2.67	4.73
Net working capital	9.02	-3.3	4.51	-3.6	2.67	-3.6	-2.4	-0.4	-1.7	-0.6	-10.	-0.2
R&D/ sales	0.96	0.10	0.35	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Acquisition activity	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.10	0.00	0.05	0.00	0.00
Cash	8.49	7.21	9.65	7.39	6.38	9.05	4.93	10.0	7.55	6.69	5.79	8.19
Bank debt	65.7	57.6	61.6	85.1	49.2	56.8	47.3	51.7	80.6	64.4	21.6	61.8
Short-term debt	0.08	0.04	0.04	0.08	0.08	0.05	0.17	0.02	0.10	0.04	0.09	0.06
# N	491	949	4,979	1,324	1,181	4,424	950	574	1,668	1,617	189	18,346
# firms	23	41	222	61	50	193	40	25	77	76	8	816
# LTRO-bank rel.	10	24	113	41	18	92	9	13	48	41	7	416

B. Country-specific measures

Country	AUT	BEL	DEU	ESP	FIN	FRA	GRC	IRL	ITA	NLD	PRT	Total
Sovereign risk	50.2	58.6	31.5	135.	30.3	59.3	492.	216.	149.	46.5	368.	73.0
Sovereign export	0.53	0.81	0.44	0.28	0.38	0.27	0.25	1.03	0.26	0.77	0.34	0.38
Government debt	81.5	105.	75.5	64.8	48.2	83.9	155.	93.7	115.	59.9	103.	82.2

C. Bank-specific measures

Country	AUT	BEL	DEU	ESP	FIN	FRA	GRC	IRL	ITA	NLD	PRT	Total
Bank risk	2.05	2.85	1.47	1.71	-	1.24	1.36	1.90	2.12	2.00	2.20	2.10
Bank size	9.75	11.14	11.07	9.69	10.63	10.35	9.20	10.92	9.31	9.76	9.971	9.90
Borrower size	8.80	8.20	8.49	8.69	7.79	8.09	7.70	7.91	8.18	8.75	8.58	8.32
Borrower leverage	31.77	33.41	31.73	42.07	32.99	32.38	39.00	32.88	34.93	28.02	43.44	35.88
Borrower short-term debt	0.07	0.08	0.06	0.10	0.09	0.08	0.15	0.07	0.12	0.06	0.12	0.10
Borrower cash flow	3.85	4.05	4.93	3.40	4.77	3.93	2.82	3.64	4.24	3.37	3.20	3.91
# N	36	47	103	195	6	137	45	33	341	40	50	1,033
# banks	6	9	18	41	1	23	11	6	61	7	9	192

This table provides sample averages (medians) of corporate characteristics for each country in our samples of eurozone corporations. Panel A outlines the summary statistics for the corporate-specific measures. In panels B and C, we show summary statistics for the country-specific and bank-specific measures used in our main analysis. The sample period for each country is 2009–2014, and the variables are based on quarterly observations. For the specific definition of each variable, we refer readers to the appendix. The corporate fundamental data are obtained from Compustat Global, LPC DealScan, and Capital IQ, while country-specific and bank-specific data are obtained from Markit, BankScope, the World Bank, and the ECB Statistical Data Warehouse. For any data unavailable for a specific quarter, we replace the missing values with yearly observations. Ratios are given in percentages.

explore cross-sectional variations of the LTRO impact based on bank, firm, and country characteristics.¹⁷

3. Central Bank Liquidity Injections and Corporate Investment

In this section, we investigate the relationship between the unconventional liquidity intervention and the real economy. We focus on the 3-year LTROs implemented by the ECB on corporate investment in the eurozone. Within this examination, we pay particular attention to the role of bank risk and corporate rollover risk in interpreting the relationship.

3.1 Bank LTRO uptake and corporate investment: Baseline results

During the recent financial crisis, banks were undercapitalized and faced funding risk, which not only implied inadequate credit tightening on their part but also negatively affected corporate credit conditions more generally. To support bank financing and lending in the euro area, and to prevent a downturn in the real economy, the ECB designed 3-year LTROs. The resultant positive credit supply shock to the banking sector created by the ECB could have been extended to the corporate level through bank lending and thus may have positively affected corporations' investment policies. However, as there were no restrictions on the banks' use of the LTRO funding in the design of the program, banks also could have used the LTRO funding for other purposes rather than passing on the liquidity to the firm level. Accordingly, corporations may also have had concerns about their future access to financing because of the bank lenders' own impaired balance sheets or their risk taking. If LTRO uptake had been viewed as a signal of bank risk and future financing constraints, corporations may have even *decreased* their investments.

3.1.1 Baseline results. To investigate the relationship between the LTRO intervention and corporate investment and salaries and wages decisions, we utilize detailed bank-firm relationship data from LPC DealScan and bank-level LTRO uptake data from the ECB to measure the effects of liquidity injection at the corporate level. *Bank LTRO uptake* provides a corporation-specific measure of the total LTRO uptake of a corporation's bank lenders. If the LTROs were sufficiently effective, we would expect that corporations that had an existing borrowing relationship with banks that obtained a significant amount of the LTRO funds were more likely, in general, to be positively affected by the LTRO credit supply shock. In this spirit, we conduct our

¹⁷ We obtain data on bank characteristics from Bankscope and Markit by manually matching these data with the lender information from DealScan.

analyses in the sample of *all* corporations in the eurozone with the sample period of 2009 to 2014.

Our results are presented in [Table 3](#), panel A. In column 1, we use the ratio of capital expenditure to total assets as our proxy for corporate investment and add controls that may also affect the corporate capital expenditure decision. In column 2, we provide the same analysis by using the natural logarithm of total salaries and wage expenses as our proxy for corporate salaries and wages. As presented in [Table 3](#), panel A, columns 1 and 2, rather than a positive impact, we find a *negative* and statistically significant coefficient of *Bank LTRO uptake* for investment, whereas the coefficient is statistically insignificant for salaries and wages.¹⁸

Local demand factors and industry technological shocks may affect corporate investment decisions. Following [Acharya et al. \(2019\)](#), we add the interactions between country, industry, and time fixed effects (*Time* \times *Country* \times *Industry FE*) to capture the unobserved time-varying shocks to an industry in a country for a particular year, which may affect the investment demand of firms. In addition, as discussed in [Gormley and Matsa \(2014\)](#), where there are multiple unobserved heterogeneities, the interacted fixed effects may be used to arrive at consistent FE estimates without requiring as much memory. The results are presented in [Table 3](#), panel A, column 3. We continue to find a significantly negative coefficient for *Bank LTRO uptake* after adding the *Time* \times *Country* \times *Industry FE*.

In addition, our baseline *Bank LTRO uptake* measure is based on the simple average of the total number of LTRO-bank relationships the corporation has and scales the bank LTRO borrowing amount by bank size. We tried alternative *Bank LTRO uptake* measures, including scaling bank LTRO borrowing with bank loan portfolio or using the pre-LTRO firm borrowing from relevant banks as the weights when calculating the *Bank LTRO uptake* measure. Columns 4 to 6 in [Table 3](#), panel A, present the result. Our baseline finding remains the same. When we assign weights to bank LTRO borrowing based on pre-LTRO firm borrowing from relevant banks, we find the LTRO uptake measure is negative, but not statistically significant. Column 6 repeats the analysis in the GIIPS sample, and we again find a significant negative coefficient for the LTRO uptake measure.

We further conduct a set of robustness checks of our baseline results on investments. Since investments also may be determined by the lagged ratios of alternative investment measures, for example, R&D and acquisitions, along with profitability and the degree of competition in the considered industry, we use these controls for robustness checks. [Internet Appendix Table IA1](#), column 1, shows that our results are indeed robust to these additional controls. Rather than using the investment level, we measure corporate investment as

¹⁸ Given the insignificant results for salaries and wages, we focus on corporate investment throughout the rest of the paper.

Table 3
LTRO effect on investment and salaries and wages

A. Baseline sample

	Corporate investment	Salaries and wages	Corporate investment			
	(1)	(2)	(3)	(4)	(5)	(6)
Bank LTRO uptake	-0.157*	-0.034	-0.188**			
	(0.08)	(0.05)	(0.09)			
Bank LTRO uptake (scaled by loan pf.)				-1.232***		
				(0.17)		
Bank LTRO uptake (w. bank loan)					-0.113	-1.007***
					(0.10)	(0.25)
Cash flow	0.007**	0.004	0.003	-0.004	-0.001	-0.013
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)
Market to book	0.005***	0.001	0.004***	0.004***	0.004***	-0.001
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Firm size	0.167**	0.695***	0.377***	0.854***	0.615***	0.433
	(0.07)	(0.05)	(0.09)	(0.12)	(0.10)	(0.32)
Leverage	-0.016***	-0.001	-0.010***	-0.013***	-0.013***	-0.002
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Rated	0.017	-0.044	0.090	0.446**	0.214	-0.791
	(0.15)	(0.12)	(0.16)	(0.20)	(0.16)	(0.49)
Sovereign risk	-0.651***	-0.036				
	(0.05)	(0.04)				
Sovereign export	-0.057***	0.004				
	(0.00)	(0.00)				
Firm FE	Y	Y	Y	Y	Y	Y
Time FE	Y	Y				
Time x Country x Industry FE			Y	Y	Y	Y
Sample	Full	Full	Full	Full	Full	GIIPS
R-squared	.721	.744	.844	.880	.876	.850
N	16,351	12,483	16,574	11,031	12,512	3,275

B. Matched samples

	Corporate investment			
	Matched LTRO vs. non-LTRO:		Matched euro vs. non-euro:	
	Country, industry, size	Country, industry, Z-score	Industry, size	Industry, Z-score
	(1)	(2)	(3)	(4)
Bank LTRO uptake	-0.328**	-0.749***	-0.188*	-0.602***
	(0.14)	(0.17)	(0.10)	(0.20)
Cash flow	0.004	-0.008	0.020***	0.006
	(0.00)	(0.00)	(0.00)	(0.01)
Market to book	0.009***	0.006***	0.005***	0.006***
	(0.00)	(0.00)	(0.00)	(0.00)
Firm size	0.519***	0.981***	-0.230*	0.695***
	(0.14)	(0.18)	(0.12)	(0.19)
Leverage	-0.031***	-0.028***	-0.027***	-0.028***
	(0.00)	(0.00)	(0.00)	(0.00)
Rated	-0.248	0.858***	-1.226***	1.864***
	(0.30)	(0.31)	(0.26)	(0.49)
Firm FE	Y	Y	Y	Y
Time x Country x Industry FE	Y	Y	Y	Y

(continued)

Table 3
Continued*B. Matched samples*

	Corporate investment			
	Matched LTRO vs. non-LTRO:		Matched euro vs. non-euro:	
	Country, industry, size (1)	Country, industry, Z-score (2)	Industry, size (3)	Industry, Z-score (4)
R-squared	.864	.844	.904	.867
N	5,983	4,485	10,368	7,666

This table presents estimates of the effect of the liquidity uptake from the ECB's 3-year LTROs on corporate investment and salaries and wages in a sample of eurozone corporations with existing loan information in LPC DealScan. Our measure for *Corporate investment* is the corporations' capital expenditure, scaled by total assets. Our measure for salaries and wages is *Salaries and wages*, which is the corporations' total salaries and wages, given in logarithms. The variable *Bank LTRO uptake* is equal to zero until 2011Q4 and equal to the LTRO uptake amount of the corporate-related banks, scaled by the size of each bank thereafter. We classify eurozone banks as related if the corporation in the 5 years prior to the first LTRO intervention had a loan relation to the bank. The information about the bank-specific LTRO uptake is based on hand-collected data from Bloomberg, as well as central bank announcements and public commentaries. The loan information data have been obtained from LPC DealScan. In all models, we include base corporate-level financial variables in addition to macroeconomic variables. In panel A, we use our baseline corporate sample. The sample period is 2009–2014, based on quarterly observations. In panel B, columns 1 and 2, we use a sample of LTRO firms and their matched non-LTRO firms based on country, industry, and size or Z-score. In panel B, columns 3 and 4, we use a sample of eurozone firms and their matched non-eurozone firms based on industry and size or Z-score. The numbers in parentheses are standard errors. Time x Country x Industry FE represents Yr-qtr x Country x Two-digit SIC FE. * $p < .1$; ** $p < .05$; *** $p < .01$.

period-on-period growth in column 2. To avoid the seasonality impact, we calculate the change in investment based on annual data. We continue to find a negative coefficient for *Bank LTRO uptake*. Overall, the analyses in this section suggest that the average corporation did not increase its investments following the ECB's LTRO liquidity injections.

3.1.2 Matching samples. Demand uncertainty and expectations of lower future demand may affect corporate policies (e.g., Kahle and Stulz (2013); Gennaioli, Ma, and Shleifer (2016)). Corporations' investment demand is expected to be lower during a crisis period, particularly for small firms in countries with greater sovereign risk. In addition to the macroeconomic risk, industry technological shocks can affect corporate return on investment and relevant investment decisions. Thus, corporations may decrease their investments because of low investment demand rather than because of concerns about future financing.

To further address these concerns, we match corporations with an LTRO bank relationship against a corporation in the same country, industry, and of similar size or Z-score, but without a LTRO bank relationship. We then repeat the investment analysis in this matched sample with the expectation that corporations in this matched sample face similar country risk, industry shock,

and investment demand uncertainty. The difference in investments between LTRO firms and non-LTRO-matched firms is more likely because of financing differences following the LTROs. [Internet Appendix Table IA2](#) provides the summary statistics for the matched sample. As evidenced in the table, the matching ensures that there is no significant difference between LTRO firms and the matched non-LTRO firms in various aspects, such as leverage, market-to-book ratio, and Z-score. Columns 1 and 2 in panel B of [Table 3](#) present the investment regression analysis of the matched sample. We again find a decrease in investment for borrowers with a bank-LTRO relationship, confirming the importance of financing risk in explaining the negative association.

To isolate and separate the LTRO impact from other unconventional monetary policies, such as the OMT announcement in July 2012, we restrict our sample to 2011Q1 to 2012Q2, that is, three quarters before and three quarters after the LTRO liquidity injections. Although the sample size is much smaller due to the restriction, we continue to find a negative association between corporate investments and *Bank LTRO uptake*, as presented in columns 4 and 5 in [Internet Appendix Table IA1](#).¹⁹

Given that a bank's LTRO uptake is endogenously determined, to create some exogenous component of LTRO uptake, we compare similar firms based on the same industry and size or Z-score, but one in eurozone and the other one from non-eurozone. The non-eurozone matched firms are more likely to borrow from non-eurozone banks that do not have access to the LTRO funds. Then, we conduct the investment analysis in this matched sample. Columns 3 and 4 in [Table 3](#), panel B, presents the results. We continue to find that firms decrease investment following *Bank LTRO uptake*.

3.2 Bank choice of LTRO uptake

As banks' incentives for participating in the LTROs are important to understand the transmission efficiency from the ECB to the real economy, we next analyze the determinants of banks' LTRO uptake to understand the role of bank risk in explaining both LTRO uptake and the decrease in investment. To this end, we focus on all banks with loan information in LPC DealScan and lending relationships with eurozone corporations in our main sample and then investigate each bank's borrowing from the ECB's 3-year LTROs based on the hand-collected information on banks' participation in the LTRO interventions. Specifically, we define two measures: (1) an indicator variable that is equal to one if the bank participated in one of the LTROs and (2) the natural logarithm of one plus the bank's total borrowing in billion euro from LTRO I (Dec. 2011) and II (Feb. 2012).

¹⁹ In column 3 of [Internet Appendix Table IA1](#), we conduct a similar analysis with a shorter window in the full sample firms and find a negative coefficient for *Bank LTRO uptake*, although the coefficient is not statistically significant.

Drechsler et al. (2016) find that weakly capitalized banks took out more lender-of-last-resort loans. Thus, for our analysis of banks' LTRO borrowings, we use measures for bank risk as determinants of LTRO uptake. The variable *High-risk bank* is equal to one if, one year before the first 3-year LTRO intervention (i.e., 2010Q4), a bank had a 5-year CDS spread above the median 5-year CDS spread of the banks in our sample and zero otherwise. As larger banks may have had sufficient collateral to access the LTRO funds and may have had better access to liquidity injections because they were "too big to fail," we also add *Bank size* to capture a potential size effect. We measure *Bank size* as the natural logarithm of the bank's total assets at the end of 2010. Banks with greater sovereign debt holdings before the LTRO liquidity injection may be in greater need to participate in the LTRO and request a greater amount. Thus, we add *Bank sovereign debt holding* in the determinants of banks' LTRO borrowing model. In addition to bank characteristics, we add proxies for borrower and country risk, which may affect banks' access to and usage of LTRO funds. *Borrower size* refers to the average size (measured as the natural logarithm of total assets) of the banks' borrowers at the end of 2010. Likewise, *Borrower leverage*, *Borrower short-term debt*, and *Borrower cash flow* are the average leverage, short-term debt, and cash flow of the banks' borrowers at the end of 2010. Finally, we include *Sovereign risk*, which is the countries' CDS spread at the end of 2010, expressed as a natural logarithm.²⁰

We implement our test of the determinants of banks' LTRO uptake in a regression framework and present the results in Table 4. Panel A focuses on the probability of a bank participating in LTRO liquidity interventions, while panel B reports the determinants of the amounts of LTRO uptakes. The results in Model (1) in panels A and B indicate that risky banks (as proxied for by *High-risk bank*) are more likely to borrow and borrow a greater amount from the LTRO liquidity injections relative to low-risk banks. We also find that large banks accessed the LTRO injections much more than small banks, consistent with our prediction. However, banks' sovereign debt holdings before LTRO liquidity injections do not significantly affect their LTRO participation decisions. In addition, banks from riskier countries borrowed more through the LTROs. We further find some evidence that the borrowers' cash flows negatively affect bank lenders' LTRO uptake activities.

On October 26, 2011, the EBA announced a capital adequacy exercise implying that 61 banks were required to build additional capital buffers to reach a 9% core Tier 1 (CT1) ratio by June 2012. The selection of banks for the capital exercise was based on the banks' total assets as of the end of 2010 in each member state of the European Union. Given the timing of the EBA

²⁰ We collect the bank-level measures from Bankscope, Markit, and EBA Stress Test, while the borrower-related data are based on information in our main sample. After combining all bank-specific data, we ultimately obtain a sample of 185 banks with available information. Summary statistics for all bank-related measures can be found in Internet Appendix Table IA3.

Table 4
Determinants of banks' LTRO borrowing

A. Bank-level LTRO borrowing indicator

	LTRO indicator _{j,11/12}		
	(1)	(2)	(3)
High-risk bank _{j,10}	3.023** (1.26)	3.342*** (1.25)	2.4013** (1.03)
Bank size _{j,10}	0.592*** (0.14)	0.435*** (0.15)	0.918*** (0.20)
Bank sovereign debt holding _{j,10}	0.016 (0.03)	-0.014 (0.06)	0.021 (0.06)
Borrower size _{j,10}	-0.152 (0.28)	-0.271 (0.29)	-0.604* (0.34)
Borrower leverage _{j,10}	0.020 (0.03)	0.016 (0.03)	0.049 (0.03)
Borrower short-term debt _{j,10}	-8.305 (5.10)	-8.385 (5.24)	-18.092*** (6.79)
Borrower cash flow _{j,10}	-0.226** (0.12)	-0.206* (0.11)	-0.448** (0.18)
Sovereign risk ₁₀	1.495*** (0.42)	1.807*** (0.46)	0.745 (0.61)
EBA bank _{j,11}		1.654** (0.67)	
Non-GIIPS			-3.750*** (0.81)
High-risk bank _{j,10} x Non-GIIPS			0.547 (1.57)
Pseudo-R-squared	.272	.308	.456
N	155	155	155

B. Bank-level LTRO borrowing amount

	ln(1 + LTRO borrowing)		
	(1)	(2)	(3)
High-risk bank _{j,10}	1.024*** (0.38)	0.989*** (0.37)	0.807* (0.38)
Bank Size _{j,10}	0.267*** (0.04)	0.222*** (0.04)	0.258*** (0.03)
Bank sovereign debt holding _{j,10}	0.005 (0.01)	-0.003 (0.01)	0.005 (0.01)
Borrower size _{j,10}	0.055 (0.06)	0.086 (0.07)	-0.065 (0.06)
Borrower leverage _{j,10}	0.007 (0.00)	0.006 (0.00)	0.013 (0.00)
Borrower short-term debt _{j,10}	-1.661 (1.40)	-1.005 (1.41)	-3.964*** (1.34)
Borrower cash flow _{j,10}	-0.033 (0.03)	-0.035 (0.02)	-0.061** (0.02)
Sovereign risk ₁₀	0.554*** (0.12)	0.544*** (0.12)	0.170 (0.13)
EBA bank _{j,11}		0.570** (0.24)	
Non-GIIPS			-0.954*** (0.18)

(continued)

Table 4
Continued

B. Bank-level LTRO borrowing amount

	ln(1 + LTRO borrowing)		
	(1)	(2)	(3)
High-risk bank _{<i>t</i>,10} × Non-GIIPS			0.515 (0.36)
R-squared	.491	.510	.586
N	155	155	155

This table presents estimates of the effect of bank, country, and borrower measures on banks' borrowings from the ECB's 3-year longer-term refinancing operations (LTROs) in a sample of banks with borrowers located in the eurozone. In panel A, our measure for banks' LTRO borrowings is *LTRO indicator*, which is an indicator that is equal to one, if the bank participated in one of the LTROs. In panel B, our measure for banks' LTRO borrowings is $\ln(1 + \text{LTRO borrowing})$, which is the natural logarithm of one plus the banks' total borrowing from LTRO I (Dec. 2011) and II (Feb. 2012). We regress the bank LTRO borrowing measures on a set of control variables. *High-risk bank* is a dummy variable equal to one, if the bank at the end of 2010 had a CDS spread above the median CDS spread, and zero otherwise. *Bank size* is the banks' total assets at the end of 2010, given in natural logarithm. *Bank sovereign debt holding* is the banks' sovereign debt holding at the end of 2010. *Borrower size* refers to the average size (measured by total assets given in natural logarithm) of the banks' borrowers at the end of 2010. *Borrower leverage*, *Borrower short-term debt*, and *Borrower cash flow* are the average leverage, short-term debt, and cash flow of the banks' borrowers at the end of 2010. *Sovereign risk* is the countries' CDS spread at the end of 2010, given in natural logarithm. *EBA bank* is a dummy variable equal to one for banks which were a part of the EBA capital exercise as of 2011. The numbers in parentheses are standard errors.

* $p < .1$; ** $p < .05$; *** $p < .01$.

capital exercise, it is likely that there could be overlap between banks that were part of the capital adequacy exercise and LTRO banks in general. In column 2 of Table 4, we test whether banks that were covered by the EBA exercise were also more likely to participate in LTRO uptake or had higher LTRO uptake by adding a dummy for being a bank covered by the EBA capital exercise, *EBA bank*. We find a positive and significant coefficient for *EBA bank*. The results suggest a positive correlation between the banks covered by the EBA capital exercise and their use of the LTRO facility.

To further understand the role of bank risk, in column 3 of Table 4, we add the interaction terms of *High-risk bank* × *Non-GIIPS*. *Non-GIIPS* dummy is added to compare the difference between GIIPS and non-GIIPS banks regarding their participation in the LTRO program. We find that non-GIIPS banks indeed are less likely to participate in the LTRO program and take less LTRO money. While risky banks in non-GIIPS banks are more likely to participate in the LTRO program and take greater LTRO amounts, the results are not statistically significant. However, we continue to find a significant positive coefficient for *High-risk bank*. Overall, we find evidence that banks' participation in the LTROs and their LTRO uptake amounts are positively related to bank and country risks.

3.3 Bank risk and use of LTRO funds

In this section, we explore the role of bank behavior in explaining the decrease in corporate investment following the LTROs. If corporations interpret banks' LTRO uptakes as signals of bank risk and future financing constraints, we would expect a more pronounced decrease in investment for corporations with risky bank lenders. In addition, we examine the changes in bank risk following the LTRO liquidity injections in terms of the banks' risky sovereign debt holdings and the role of banks' early repayments of LTRO funds as a sign of their normalization.

3.3.1 The role of bank risk. The previous analysis of the determinants of banks' LTRO uptakes suggests that risky banks tend to take on more LTRO funds. To further understand the role of bank risk in explaining the decrease in investment following the LTROs, we construct a variable *High-risk bank* based on the average 5-year CDS spread of their respective bank lenders one year before the first 3-year LTRO intervention, that is, 2010Q4. Then, we add the interaction term of *Bank LTRO uptake* \times *High-risk bank* in the investment analysis. Column 1 of [Table 5](#) presents the results. We find a significant decrease in investments after the LTRO uptakes by banks for corporations with risky bank lenders, whereas the coefficient of *Bank LTRO uptake* is positive but statistically insignificant.

As the countries that were affected most by the Sovereign Debt Crisis were also the ones that had a higher country risk, ex ante, we also explore the interaction of bank and country risk and the resultant LTRO effect by adding the interaction terms of *Bank LTRO uptake* \times *GIIPS* and *Bank LTRO uptake* \times *High-risk bank* \times *GIIPS*. As evidenced by columns 2 and 3 in [Table 5](#), we find that the decrease in investments following banks' LTRO uptake is concentrated in corporations that are located in GIIPS countries and have risky lenders, that is, corporations with lending relationships with banks that used higher degrees of LTRO liquidity. Again, we find a positive sign for *Bank LTRO uptake*, although the changes are not statistically significant. These results are consistent with the corporations' precautionary demand for liquidity, and the signaling role of bank LTRO uptakes. The marginal value of liquidity is a major determinant of corporate financial policies ([Bolton, Chen, and Wang \(2011\)](#)): corporations tend to be more conservative and have a stronger response to bank LTRO uptakes when their marginal value of liquidity is high, that is, corporations in GIIPS countries with risky lenders.

The above findings suggest that bank risk helps explain the decrease in investment following the LTRO intervention. The decrease in investment following the LTROs is concentrated in the corporations with risky bank lenders. While past bank risk is positively related to banks' participation in the 3-year LTROs, LTRO uptake itself can signal future bank risk-shifting

Table 5
LTRO effect on investment: Bank risk

	Corporate investment		
	(1)	(2)	(3)
Bank LTRO uptake	0.061 (0.11)	0.049 (0.10)	0.044 (0.10)
Bank LTRO uptake x High-risk bank	-0.759*** (0.19)		
Bank LTRO uptake x GIIPS		-1.180*** (0.23)	
Bank LTRO uptake x High-risk bank x GIIPS			-1.154*** (0.23)
Cash flow	0.003 (0.00)	0.003 (0.00)	0.003 (0.00)
Market to book	0.004*** (0.00)	0.004*** (0.00)	0.004*** (0.00)
Firm size	0.368*** (0.09)	0.360*** (0.09)	0.360*** (0.09)
Leverage	-0.011*** (0.00)	-0.011*** (0.00)	-0.011*** (0.00)
Rated	0.098 (0.16)	0.082 (0.16)	0.085 (0.16)
Firm FE	Y	Y	Y
Time x Country x Industry FE	Y	Y	Y
R-squared	.845	.845	.845
N	16,574	16,574	16,574

This table presents estimates of the effect of bank characteristics and the liquidity uptake from the ECB's 3-year longer-term refinancing operations (LTROs), on corporate investment, in a sample of eurozone corporations with existing loan information in LPC DealScan. Our measure for *Corporate investment* is the corporations' capital expenditure, scaled by total assets. In Model (1), we investigate the impact of bank risk. *High-risk bank* is a dummy variable equal to one if the corporations' lenders one year before the first 3-year LTRO intervention, that is, 2010Q4, on average had a CDS spread above the median, and zero otherwise. In Models (2) and (3) we further investigate the impact of being located in *GIIPS* and *Non-GIIPS* countries, where *GIIPS* is a dummy variable equal to one for corporations that are located in either Greece, Ireland, Italy, Portugal or Spain. The variable *Bank LTRO uptake* is equal to zero until 2011Q4, and equal to the LTRO uptake amount of the corporate-related banks, scaled by the size of each bank, thereafter. The sample period is 2009–2014, based on quarterly observations. The numbers in parentheses are standard errors. Time x Country x Industry FE represents Yr-qtr x Country x Two-digit SIC FE.

* $p < .1$; ** $p < .05$; *** $p < .01$.

incentives, which cannot be easily observed. In the next subsection, we explore further the signaling role of banks' LTRO uptakes by examining their risky sovereign debt holdings following the LTROs.

3.3.2 Bank holdings of sovereign debt. To understand banks' holdings of risky sovereign debts and their role in explaining the decrease in corporate investment following the LTROs, we conduct additional tests based on the banks' sovereign debt holdings around the LTRO injections. If banks used the LTRO funds to finance their sovereign debt holdings, we would expect that LTRO banks would have increased their sovereign debt holdings following the LTROs. Considering the significant LTRO participation of banks from GIIPS, we expect that LTRO banks would have exhibited a greater increase in

risky GIIPS sovereign debt holdings. Furthermore, we expect a greater decrease in investment for corporations associated with banks that increased their GIIPS sovereign holdings following the LTRO intervention.

We test this prediction using data on banks' sovereign debt holdings from the EBA stress tests in 2011 and 2014.²¹ According to the EBA, the 90 (123) banks that were included in the 2011 (2014) stress test represent approximately 65% (70%) of bank assets in the EU banking sector. After linking the stress test data with our sample banks, we obtain, for 33 of our sample banks, end-of-year information on their sovereign debt holdings in 2010 and 2013.²² In Table 6, panel A, we first investigate the mean change in banks' sovereign debt holdings and compare the changes between LTRO and non-LTRO banks. In line with the literature, we find that banks, in general, increased their *total* sovereign debt holdings. However, the magnitude of the increase was much higher for LTRO banks (18.8%) than for non-LTRO banks (1.5%). We also compare the banks' holdings of risky and safe sovereign debt, where we define risky sovereign debt as banks' holdings in GIIPS sovereigns. As expected, we find that LTRO banks significantly increased (decreased) their holdings of risky, GIIPS (safe, non-GIIPS) sovereign debt. By contrast, non-LTRO banks reduced (increased) their holdings of GIIPS (non-GIIPS) sovereign debt. These findings are consistent with those of Krishnamurthy, Nagel, and Vissing-Jorgensen (2018).

In panel B, Table 6, we further regress the changes in bank sovereign debt holdings between 2010 and 2013 on banks' LTRO borrowing amount ($\ln(1 + \text{LTRO borrowing})$) and bank-level controls. The analysis is restricted to the sample of 30 banks with sovereign debt holding information from the EBA stress tests in both 2011 and 2014 and bank-level controls. In column 1, we measure the change in total sovereign debt holdings. In columns 2 and 3, we examine the change in risky sovereign debt holdings and safe sovereign debt holdings, respectively. We find that banks with greater LTRO borrowing amounts increase their total sovereign debt holdings, particularly their risky sovereign debt holdings. Furthermore, consistent with our expectation, we find that banks decrease their safe sovereign debt holdings when they have greater LTRO uptake. In column 4, we conduct the panel regression analysis of bank sovereign debt holdings based on sovereign debt holding data from Orbis Bank Focus (previously Bankscope) from 2009 to 2014. Since the Orbis Bank Focus provides only bank-level aggregate sovereign debt holding data, we focus on the impact of *Bank LTRO uptake* on total sovereign debt holdings in this analysis and again find that banks increase their sovereign debt holdings following their LTRO borrowing.

²¹ Source: <https://eba.europa.eu/risk-analysis-and-data/eu-wide-stress-testing>.

²² We have data for only 33 of the banks covered in the EBA Stress Test samples as we focus on eurozone banks and further require that the bank is covered in both the 2011 and 2014 stress tests and is also present in our DealScan-linked sample.

Table 6
LTRO effect on investment: Banks' post-LTRO sovereign debt holdings

A. Changes in bank-level sovereign debt holdings from 2010 to 2013

	Δ Total sovereign debt (1)	Δ Risky sovereign debt (2)	Δ Safe sovereign debt (3)
LTRO banks (n=19)	18.81%	11.29%	-27.26%
Non-LTRO banks (n=14)	1.51%	-36.79%	30.26%

B. Bank LTRO uptake and banks' sovereign debt holdings

	Δ Total sovereign debt (1)	Δ Risky sovereign debt (2)	Δ Safe sovereign debt (3)	$\ln(1 + \text{gov. securities}_t)$ (4)
$\ln(1 + \text{LTRO borrowing})_{j,12}$	0.089* (0.05)	0.114** (0.04)	-1.049* (0.58)	
High-risk bank $_{j,10}$	-0.336 (0.25)	0.052 (0.21)	2.880 (2.67)	
Bank size $_{j,10}$	-0.002 (0.00)	-0.028*** (0.00)	0.024 (0.09)	
$\ln(1 + \text{LTRO borrowing})_{j,t}$				0.238*** (0.08)
High-risk bank $_{j,t}$				-0.315 (0.32)
Bank size $_{j,t}$				1.316*** (0.01)
R-squared	.165	.341	.173	0.989
N	30	30	27	204

C. LTRO uptake effect on investment and bank lenders' risky sovereign debt holdings

	Corporate investment		
	(1)	(2)	(3)
Bank LTRO uptake	-0.365*** (0.08)	0.803 (2.11)	-0.126 (0.09)
Bank LTRO uptake x Bank increasing risky sov. debt		-1.163 (2.10)	
Bank LTRO uptake x Bank increasing risky sov. debt x GIIPS			-0.960*** (0.19)
Cash flow	0.009** (0.00)	0.009*** (0.00)	0.008* (0.00)
Market to book	0.005*** (0.00)	0.005*** (0.00)	0.005*** (0.00)
Firm size	0.391*** (0.10)	0.393*** (0.10)	0.373*** (0.10)
Leverage	-0.012*** (0.00)	-0.012*** (0.00)	-0.011*** (0.00)
Rated	0.356** (0.15)	0.356*** (0.15)	0.347** (0.15)

(continued)

Table 6
Continued

C. LTRO uptake effect on investment and bank lenders' risky sovereign debt holdings

	Corporate investment		
	(1)	(2)	(3)
Firm FE	Y	Y	Y
Time x Country x Industry FE	Y	Y	Y
R-squared	.989	.902	.903
N	10,168	10,168	10,168

This table presents the changes in bank lenders' sovereign debt holdings from 2010 to 2013 and the estimates of the effect of the liquidity uptake from the ECB's 3-year LTROs, on corporate investment. The sample of banks consists of all banks which are covered in the EBA stress test and which in the 5 years before the LTRO intervention had a lending relationship to at least one corporation in our sample of eurozone corporations with existing loan information in LPC DealScan. Panel A provides sample averages of the change in banks' sovereign debt holdings from December 2010 to December 2013, that is, around the LTRO intervention. *Risky Sovereign Debt* refers to banks' sovereign debt holdings in Greece, Ireland, Italy, Portugal and Spain, while *Safe Sovereign Debt* refers to banks' sovereign debt holdings in Germany, Austria, France, Netherlands, Belgium and Finland. Panel B provides estimates of the effect of the liquidity uptake from the ECB's 3-year LTROs on the change in banks' sovereign debt holdings from December 2010 to December 2013, that is, around the LTRO intervention (Models (1) to (3)), using data from the EBA stress tests, as well as the level of sovereign debt holdings post-LTRO intervention (Model (4)) using yearly data from Bankscope. Panel C shows the estimates of the effect of the liquidity uptake from the ECB's 3-year LTROs, on corporate investment in the sample of eurozone corporations for which we at least for one of its lenders have information from the EBA Stress Test. Our measure for *Corporate investment* is the corporation's capital expenditure, scaled by total assets. The variable *Bank LTRO uptake* is equal to zero until 2011Q4, and equal to the LTRO uptake amount of the corporation's related banks, scaled by the size of each bank, thereafter. *Banks increasing risky sovereign debt holdings* is a dummy equals to one if the corporations have a lending relationship to a bank that increased its holdings of risky sovereign debt from December 2010 to December 2013, and zero otherwise. The sample period is based on quarterly observations from 2009 to 2014. The numbers in parentheses are standard errors. Time x Country x Industry FE represents Yr-qttr x Country x Two-digit SIC FE.

* $p < .1$; ** $p < .05$; *** $p < .01$.

In panel C of Table 6, we investigate the relationship between the LTRO uptake of banks and investment, conditional on banks' holding of sovereign debt. Specifically, starting from the 33 banks for which we have sovereign debt holding information, we identify a sample of 576 corporations with lending relationships with at least one of those 33 banks in the 5 years before the LTROs. In column 1 of panel C, we confirm the negative association between banks' LTRO uptakes and corporate investment in this restricted sample. We then define the firm-level variable *Bank increasing risky sov. debt* based on whether we observe that the corporation had a lending relationship with a bank that increased its holdings of risky sovereign debt from December 2010 to December 2013. In columns 2 and 3 of panel C, we add the interaction terms of *Bank LTRO uptake* \times *Bank increasing risky sov. debt* and *Bank LTRO uptake* \times *Bank increasing risky sov. debt* \times *GIIPS* in the investment analysis. The results suggest that the negative relationship between banks' LTRO uptake and investments was concentrated in corporations whose bank lenders increased their risky sovereign debt holdings following the LTROs, particularly in GIIPS countries. Hence, we not only observe that

LTRO banks increased their holdings of risky assets following the LTROs in terms of GIIPS sovereign debt but also find that these banks' borrowers decreased their investment accordingly. The results are consistent with the signaling role of the banks' LTRO uptake as related to bank risk, which induced the decrease in corporate investment.

3.3.3 Early repayment of LTRO funds. While the uptake of central bank liquidity injections may signal bank risk, the ECB may believe that “a falling demand for liquidity can be seen as a sign of normalization.”²³ The LTROs provided a 3-year funding opportunity for eurozone banks. However, to increase the attractiveness of the unconventional LTROs, the program gave participating banks the option to repay, either in part or in full, the amount of their borrowings early after one year, without any penalty. Since banks are closely monitored by financial market participants, it is likely that LTRO-participating banks would have chosen to repay the 3-year LTRO funds at the earliest opportunity, either to signal improvements in their individual funding conditions or because of their decreased funding needs following the process of balance sheet adjustment.

To investigate the role of early repayment, we use end-of-year country-level LTRO data reported by the NCBs to proxy for country-specific LTRO early repayments by banks. Specifically, we measure early repayments of the 3-year LTROs across banks as the percentage changes in the country-level LTRO holdings between 2012 and 2013 (for details, see [Internet Appendix Table IA4](#)).²⁴ One interesting observation from this measure is that the bank repayments differed for non-GIIPS (core) versus GIIPS (periphery) countries. In general, the non-GIIPS countries in our sample had high LTRO repayment rates. At one extreme, German banks exhibited a 80% decrease in their reliance on LTRO funds from 2012 to 2013. Other non-GIIPS countries (i.e., Austria, the Netherlands, Belgium, and France) show a sharp decrease of approximately 64% in their balances of LTRO funding during this period. By contrast, there are mixed patterns of LTRO early repayment for GIIPS countries, with only modest amounts for banks in Portugal (13%) and Italy (20%), and larger repayments of approximately 45% in Spain and Ireland. Based on our proxy for banks' early LTRO repayments, we construct proxies for *Low early repayment* (Portugal and Italy), *Medium early repayment* (Spain, Ireland, Austria, the Netherlands, Belgium, and France), and *High early repayment* (Germany).

²³ See https://www.ecb.europa.eu/press/key/date/2011/html/sp111021_1.en.html.

²⁴ Although most of the LTROs were of a 3-year maturity, the NCBs' country-level LTRO data may contain LTROs of other maturities, that is, 3 months and 1 year. As discussed in the 2013 annual report of the Bank of Spain, “Most of the decrease in this balance took place in January when institutions availed themselves of the early redemption option offered by three-year refinancing operations” (Banco de España (2014)).

Table 7
LTRO effect on investment: Banks' early repayment of LTRO

	Corporate investment		
	(1)	(2)	(3)
Bank LTRO uptake	-0.112 (0.09)	-3.980*** (0.72)	-0.193** (0.09)
Bank LTRO uptake x Low early repayment	-4.636*** (0.75)		
Bank LTRO uptake x Medium early repayment		3.860*** (0.72)	
Bank LTRO uptake x High early repayment			6.645** (3.15)
Cash flow	0.003 (0.00)	0.003 (0.00)	0.003 (0.00)
Market to book	0.004*** (0.00)	0.004*** (0.00)	0.004*** (0.00)
Firm size	0.405*** (0.09)	0.397*** (0.09)	0.378*** (0.09)
Leverage	-0.012*** (0.00)	-0.012*** (0.00)	-0.011*** (0.00)
Rated	0.072 (0.16)	0.080 (0.16)	0.080 (0.16)
Firm FE	Y	Y	Y
Time x Country x Industry FE	Y	Y	Y
R-squared	.845	.845	.845
N	16,574	16,574	16,574

This table presents estimates of the effect of LTRO repayment policies and the liquidity uptake from the ECB's 3-year LTROs on corporate investment, in a sample of eurozone corporations with existing loan information in LPC DealScan. Our measure for *Corporate Investment* is the corporation's capital expenditure, scaled by total assets. In Models (1) through (3) we use dummy variables to separate corporations based on their location and the respective country's LTRO repayment policy, compared to the initial *Country LTRO uptake*. *Low (Medium, High) Early LTRO-repayment* is defined as a LTRO repayment ratio from 2012 to 2013, that is, at the first possible LTRO repayment date, that is below 30% (between 30% and 70%, above 70%). The variable *Bank LTRO uptake* is equal to zero until 2011Q4, and equal to the LTRO uptake amount of the corporate-related banks, scaled by the size of each bank, thereafter. We classify eurozone banks as related if the corporation in the 3 years prior to the first LTRO intervention had a loan relation to the bank. The sample period is based on quarterly observations from 2009 to 2014. In all models, we include base corporate-level financial variables in addition to macroeconomic variables. The numbers in parentheses are standard errors. Time x Country x Industry FE represents Yt-qtr x Country x Two-digit SIC FE.

* $p < .1$; ** $p < .05$; *** $p < .01$.

In Table 7, we examine the relationship between the LTRO intervention and corporate investment, by adding interaction terms of *Bank LTRO uptake* \times *Low early repayment*, *Bank LTRO uptake* \times *Medium early repayment*, and *Bank LTRO uptake* \times *High early repayment*. As shown in the table, the relationship between the LTRO intervention and corporate policies differed significantly across the three early LTRO-repayment groups. The decrease in investment is concentrated in corporations in countries in the low early LTRO-repayment group, that is, Portugal and Italy (column 1). Those with *Medium early repayment* and *High early repayment* increased their investments following their banks' LTRO uptakes (columns 2 and 3).

3.4 Corporate rollover risk

Thus far, our results suggest that corporate investments are negatively associated with their respective bank lenders' LTRO uptake. The potential channel for this effect could be firms' concern about future financing conditions since their bank LTRO uptake can be viewed as a signal of bank risk taking. Consistent with this prediction, we find evidence that banks with a greater LTRO uptake amount increase risky sovereign debt holdings during the post-LTRO period. To provide additional evidence on the channel, we conduct an analysis based on corporate rollover risk. Firms with high rollover risk are expected to have greater concern about future financing conditions. If firms decrease investments after their bank's LTRO uptake because of their concerns of future financing conditions, the decrease in investments should be greater for firms with high rollover risk associated with bank financing.

We measure corporate rollover risk prior to the LTRO liquidity injection based on various proxies. Small firms are, in general, more financially constrained and therefore face a greater rollover risk. Higher cash holdings may indicate a precautionary demand for liquidity and therefore greater concern about rollover risk. Tangible assets provide real liquidity and decrease their rollover risk. High cash flow volatility indicates liquidity risk and can generate more rollover risk concerns. Therefore, we expect that small firms, firms with high cash holdings, less tangible assets, and high cash flow volatility may have greater concerns about rollover risk. The bank LTRO effect should be greater for firms with high rollover risk concerns.

To test this prediction, we add the interaction terms of *Bank LTRO uptake* and rollover risk proxies prior to the LTRO liquidity injection in the investment analysis. The results are presented in Table 8. We find that firms decrease their investments following *Bank LTRO uptake* when they have high rollover risk before LTRO liquidity injections. The *Bank LTRO uptake* itself does not significantly decrease investments. The coefficient for *Bank LTRO uptake* is even significantly positive in column 3 when we use asset tangibility as a rollover risk proxy. The results in this section provide additional evidence that firms decrease investments following LTROs because of their concerns about future financing conditions.

4. Policy Interactions, Aggregate Effects, and Implications

Our evidence thus far suggests that corporate investment is negatively associated with their bank lenders' LTRO uptake. However, the effectiveness of these policies can also depend on policy interactions. For example, whereas in contrast to the numerous expansionary monetary interventions launched by the ECB since the onset of the European Sovereign Debt Crisis, many euro-zone member states implemented austerity plans to reduce government spending, thereby intending to reduce their fiscal deficits and sovereign debt

Table 8
LTRO effect on investment: Corporate rollover risk

	Corporate investment			
	(1)	(2)	(3)	(4)
Bank LTRO uptake	-0.034 (0.10)	0.021 (0.13)	0.306*** (0.11)	0.048 (0.10)
Bank LTRO uptake x Small firm	-0.761*** (0.23)			
Bank LTRO uptake x High cash holdings		-0.416** (0.19)		
Bank LTRO uptake x Low tangible assets			-1.417*** (0.18)	
Bank LTRO uptake x High cash flow risk				-1.191*** (0.23)
Cash flow	0.003 (0.00)	0.004 (0.00)	0.003 (0.00)	0.003 (0.00)
Market to book	0.004*** (0.00)	0.005*** (0.00)	0.005*** (0.00)	0.004*** (0.00)
Firm size	0.365*** (0.09)	0.373*** (0.09)	0.364*** (0.09)	0.361*** (0.09)
Leverage	-0.011*** (0.00)	-0.011*** (0.00)	-0.011*** (0.00)	-0.011*** (0.00)
Rated	0.087 (0.16)	0.071 (0.16)	0.086 (0.16)	0.083 (0.16)
Firm FE	Y	Y	Y	Y
Time x Country x Industry FE	Y	Y	Y	Y
R-squared	.845	.841	.842	.844
N	16,570	16,462	16,462	16,540

This table presents estimates of the effect of the liquidity uptake from the ECB's 3-year LTROs on corporate investment, in a sample of eurozone corporations with existing loan information in LPC DealScan. *Small firm* is a dummy variable equal to one if the corporation's total assets, given in logarithms, one year before the first 3-year LTRO intervention (2010Q4) is below the median, and zero otherwise. *High cash holdings* is a dummy variable equal to one if the corporation's cash holdings to total assets, one year before the first 3-year LTRO intervention (2010Q4) is above the median, and zero otherwise. *Low tangible assets* is a dummy variable equal to one if the corporation's tangible assets to total assets, 1 year before the first 3-year LTRO intervention (2010Q4) is below the median, and zero otherwise. *High cash flow risk* is a dummy variable equal to one if the corporation's cash flow risk, one year before the first 3-year LTRO intervention (2010Q4) is above the median, and zero otherwise. Our measure for *Corporate investment*, which is the corporation's capital expenditure, scaled by total assets. The variable *Bank LTRO uptake* is equal to zero until 2011Q4, and equal to the LTRO uptake amount of the corporate's related banks, scaled by the size of each bank, thereafter. We classify eurozone banks as related if the corporation in the 3 years prior to the first LTRO intervention had a loan relation to the bank. The sample period is based on quarterly observations from 2009 to 2014. The numbers in parentheses are standard errors. Time x Country x Industry FE represents Yr-qtr x Country x Two-digit SIC FE. * $p < .1$; ** $p < .05$; *** $p < .01$.

simultaneously. In this section, we further explore policy interactions, aggregate effects, and discuss the potential implications of these findings for policy design.

4.1 Country-specific policies

Fiscal and monetary policies interact closely in reality, and these interactions can lead to very different outcomes than those predicted by the analysis of each policy in isolation (Dixit and Lambertini (2003)). One feature of the eurozone economies is that although the ECB determines the common monetary policy for all member countries, each member state's government

decides its own fiscal policy. This feature limits the flexibility of economic policymaking and introduces greater complexity in economic policies overall, with attendant spillover effects on product supply and consumer demand in the eurozone. In particular, contractionary fiscal policy, such as decreasing government spending or increasing tax, can slow economic activity.²⁵ Decreasing government spending can reduce government purchases of goods and services from the private sector. Increasing corporate tax in a country can make investment less attractive in the region. For example, based on data from 85 countries, Djankov et al. (2010) find that a 10% increase in the effective corporate tax rate reduces the investment-to-GDP ratio by 2%. Fiscal policies that do not support the eurosystem-wide monetary policy may offset the positive liquidity shock created by the ECB. Therefore, we expect the decrease in investment to be more pronounced when coordination between monetary and fiscal policies is lacking, that is, an expansionary monetary policy through the LTROs accompanied by a contractionary fiscal policy in a particular country. On the contrary, when monetary and fiscal policies are more closely coordinated, we expect to observe increased corporate investment following the implementation of the ECB's unconventional monetary policy.

To investigate the role of fiscal policy, we analyze the impact of the changes in government investment expenditures and corporate taxation as proxies for country-specific fiscal policies. We define contractionary fiscal policies to involve decreasing government spending (investment expenditures) or increasing corporate taxation. Specifically, we measure governments' spending policies as the country-specific change in the government investment expenditures from one year before to one year after the first LTRO intervention, that is, the change from 2010Q4 to 2012Q4. To account for the government's tax policy, we again use the country-specific change in the corporate tax rate from one year before, to one year after, the first LTRO intervention, that is, the change from 2010Q4 to 2012Q4. During this period of time, Austria, Germany, Italy, Portugal, and Spain decreased their government investment, while France and Portugal increased corporate tax rates. We then add the interaction terms of *Bank LTRO uptake* × *Decreased government investment* or *Bank LTRO uptake* × *Increased corporate tax* to the investment analysis.

Table 9, columns 1 and 2, present the results of our analysis of fiscal policies. We find significant negative coefficients for *Bank LTRO uptake* × *Decreased government investment* and *Bank LTRO uptake* × *Increased corporate tax*. These results indicate that in countries with relatively contractionary fiscal policies (e.g., Austria, France, Germany, Italy, Portugal, and Spain), corporations decreased their investments following the LTRO

²⁵ See United States Congressional Research Service, Fiscal Policy: Economic Effects, by Lida R. Weinstock, January 21, 2021, available at <https://sgp.fas.org/crs/misc/R45723.pdf>.

Table 9
LTRO effect on investment: Policy interactions

	Corporate investment	
	(1)	(2)
Bank LTRO uptake	0.025 (0.10)	0.016 (0.12)
Bank LTRO uptake x Decreased gov. inv.	-1.053*** (0.23)	
Bank LTRO uptake x Increased corp. tax		-0.446** (0.19)
Cash flow	0.003 (0.00)	0.003 (0.00)
Market to book	0.004*** (0.00)	0.004*** (0.00)
Firm size	0.361*** (0.09)	0.380*** (0.09)
Leverage	-0.011*** (0.00)	-0.011*** (0.00)
Rated	0.086 (0.16)	0.093 (0.16)
Firm FE	Y	Y
Time x Country x Industry FE	Y	Y
<i>R</i> -squared	.845	.845
<i>N</i>	16,574	16,574

This table presents estimates of the effect of policy interactions on corporate investment in a sample of eurozone corporations. In Model (1), we use a dummy variable to separate corporations into those with increased and decreased government investment, based on the home countries' (relative) change in the government investment expenditures to GDP ratio between 2010Q4 and 2012Q4, that is, around the first LTRO. In Model (2), we use a dummy variable to separate corporations into those with increased and decreased corporate tax policies, based on the home countries' (relative) change in the corporate tax rate between 2010Q4 and 2012Q4, that is, around the first LTRO. Our measure for *Corporate investment*, which is the corporate capital expenditure, is scaled by total assets. The variable *Bank LTRO uptake* is equal to zero until 2011Q4 and equal to the LTRO uptake amount of the corporate's related banks, scaled by the size of each bank thereafter. In all models, we use the sample of corporations located in the eurozone for which we have loan information from LPC DealScan. The sample period is based on quarterly observations from 2009 to 2014. The numbers in parentheses are standard errors. Time x Country x Industry FE represents Yr-qtr x Country x Two-digit SIC FE.

* $p < .1$; ** $p < .05$; *** $p < .01$.

liquidity injection. Among countries with contractionary fiscal policies, Portugal both experienced a decrease in government investment and an increase in its corporate tax rate, which, in particular, limited the LTROs possibilities in supporting corporate investment.²⁶ However, when governments adopted accommodative fiscal policies in the face of substantial monetary stimulus, corporations did not decrease their investment along with their local banks' uptake of the LTRO liquidity injections. The coefficients for *Bank LTRO uptake* are positive albeit not statistically significant. Overall, the results in this section provide additional evidence about the potential for increased corporate investment in countries with coordinated policies.

²⁶ Together with our findings that the decrease in corporate investment following LTROs is concentrated in GIIPS countries (i.e., Greece, Italy, Ireland, Portugal, and Spain in Table 5) and is more pronounced in countries with low early repayment of LTROs (i.e., Portugal and Italy in Table 7), we conclude that GHPS countries, particularly Italy, Portugal, and Spain, are driving some of these results.

4.2 Aggregate effect of LTROs on investment

In this section, we conduct additional tests of the aggregate effect of the LTRO in terms of firm investment.²⁷ Our estimation approach is similar in spirit to that used in Acharya et al. (2018) and Chodorow-Reich (2014). Specifically, for each firm in our sample that exhibits a positive bank LTRO uptake, we estimate its counterfactual corporate investment if it had no lender with LTRO uptake (i.e., *Bank LTRO uptake* is zero). To determine the aggregate effect, we then employ a partial equilibrium analysis by assuming that the overall real effect equals the sum of the real effects at the firm level. We investigate the aggregate effect for the period after the LTRO intervention, that is, from 2011Q4 to 2013Q4.

We start by defining the counterfactual corporate investment of firm *i* if it had zero *Bank LTRO uptake* (denoted as *Bank LTRO uptake*_{0,t}):

$$\widetilde{\text{Corporate investment}}_{i,t} = \widehat{\text{Corporate investment}}_{i,t} - \widehat{\beta} \times [\text{Bank LTRO uptake}_{i,t} - \text{Bank LTRO uptake}_{0,t}]$$

where $\widehat{\text{Corporate investment}}_{i,t}$ denotes the fitted value from Model (1) in panel A, Table 3, and $\widehat{\beta}$ is the negative regression coefficient from the respective regression for *Bank LTRO uptake*.

The total investment decrease for firms with a positive *Bank LTRO uptake* during the post LTRO period (2011Q4 to 2013Q4) is then given by

$$\sum_{t \in \text{Post LTRO}} \left[\sum_{\text{Bank LTRO uptake} > 0} (\widetilde{\text{Corporate investment}}_{i,t} - \widehat{\text{Corporate investment}}_{i,t}) \right]$$

The fraction of the sample net corporate investment change during the post LTRO intervention period that is caused by bank lenders' LTRO uptake is then given by

$$\frac{\sum_{t \in \text{Post LTRO}} [\sum_{\text{Bank LTRO uptake} > 0} (\widetilde{\text{Corporate investment}}_{i,t} - \widehat{\text{Corporate investment}}_{i,t})]}{\sum_{\text{Bank LTRO uptake} > 0} (\text{Corporate investment}_{i,2011Q4} - \text{Corporate investment}_{i,2014Q4})}$$

For our sample firms in panel A of Table 3, we find that firm investment decreased by 10.5% during the post-LTRO period and that the LTRO effect accounts for 53.1% of this decline. To understand the size of the effect, we compare our numbers with those of Acharya et al. (2018), who find that firms in Italy, Ireland, Portugal, and Spain reduce investment by 20% on average during the crisis period of 2010 to 2012 based on investment data from the World Bank. In their sample of very large companies, they find a relatively

²⁷ We thank an anonymous referee for suggesting this test.

lower investment decline of 13%, of which 62% is explained by banks' lending behavior. Our sample firms are, in general, large firms, and thus, they exhibited a smaller investment reduction during the 2011Q4 to 2013Q4 period.

4.3 Implications for policy design

In general, the transmission of monetary policy to corporate liquidity and investment is not without challenges. The transfer mechanism is complex and depends on the longer-term funding risk, bank risk, and corporate financial risk management, etc. However, our evidence in this paper and findings from the previous literature suggest that the efficiency of the transmission can be facilitated by the *design* of the monetary policy (e.g., liquidity maturity, eligible collateral requirements, early repayment option, restrictions on banks' use of the liquidity) and *coordinated policies* from individual governments, NCBs, and other regulatory agencies (e.g., coordinated fiscal policies, government guarantee program to support banks' access to ECB liquidity).

Specifically, short-term and long-term central bank liquidity may have different effects on corporate liquidity and investment. Acharya et al. (2020) find impaired transmission of the fixed-rate full allotment policy in October 2008, which targeted reductions in banks' short-term funding risk. Compared with short-term liquidity injection, the longer maturity of central bank liquidity as in the LTROs may help banks restore their lending to corporations, especially when there is rollover risk of short-term liquidity (Carpinelli and Crosignani (2021)).

However, the maturity extension cannot itself solve the problem. Banks may have impaired balance sheet and risk-taking incentives that impede the transmission of monetary policies. In particular, banks' impaired balance sheets may inhibit their access to central bank liquidity injections. In this regard, programs such as the Additional Credit Claim (ACC) program, which was designed by the ECB and implemented by individual NCBs, may have helped to support banks' access to the ECB liquidity injections. In addition, banks' risk-taking behavior may have impeded the transmission of liquidity in terms of banks' usage of the additional liquidity, as argued by Carpinelli and Crosignani (2021), who find that Italian banks used most of the LTRO uptake to buy domestic government bonds.

Individual governments could do more to facilitate the transmission of monetary policy and stimulate corporate investment. For example, as discussed by Carpinelli and Crosignani (2021), banks with a higher exposure to drying up of liquidity before the liquidity injections may have had limited access to the 3-year LTROs because of their lack of collateral. Although the government guarantee program in Italy supported these high-exposure banks' access to the ECB liquidity, these same banks drove the increase in credit supply, particularly for low-profitability and high-risk corporations. However,

the involvement of governments in the guarantee program may have intensified the contagion loop between the sovereigns and the banks in the jurisdiction.

Finally, the corporations' own risk management may have impeded the stimulating effects of policies on investment. For example, the corporations may have had concerns about future financing risk (because of banks' impaired bank balance sheet and risk taking) or market demand risk. As a result, they may have decreased their investment even when their current liquidity conditions were good. Thus, a coordinated expansionary fiscal policy could have helped instill corporate confidence and stimulate investment. In this regard, the LTROs implemented in 2014 may have been a more effective way to restrict banks' risk taking and stimulate corporate investment, a question that can be explored further.

5. Summary and Conclusion

In this paper, we investigate whether and how corporate investment is affected by unconventional monetary policies by analyzing the largest central bank liquidity injections in history. Specifically, through the 3-year LTROs, the ECB provided over one trillion euros to commercial banks at very low rates and relatively long maturity. We find that nonfinancial corporations in the eurozone did not increase their investment even after these massive liquidity injections. On the contrary, the investment of these corporations was negatively associated with the amount of funds that their associated banks obtained from the ECB. This negative liquidity injection effect on corporate investment was concentrated in corporations whose lenders were risky and had weak balance sheets.

We emphasize the role of bank risk in explaining the decrease in corporate investment following the LTROs. Our analysis shows that riskier banks took on more funds from the ECB and subsequently increased their risky sovereign debt holdings. Their borrowers exhibited a greater decrease in investment during the post-LTRO period. The greater decrease in investment was likely related to borrowers' concern about future financing conditions as signaled by banks' uptakes from the ECB unconventional liquidity injection. Consistent with this channel, we find that the negative relationship between LTROs and investments is greater for firms with more rollover risk concerns. Furthermore, we find that the negative investment effect varied across banks' repayment choices, which could signal the normalization of bank balance sheets. In particular, we find that corporations whose lenders held the ECB funds for a longer period did, in fact, decrease their investment following their lenders' LTRO uptakes. These results suggest that bank risk and the signaling role of the banks' LTRO uptake may have impeded the transformation of liquidity injection into real economic output.

While some country-specific papers (e.g., [Carpinelli and Crosignani \(2021\)](#); [Andrade et al. \(2019\)](#); [Arce, Mayordomo, and Gimeno \(2021\)](#)) have documented positive impacts of LTROs on the real economy, such as bank credit supply, we contribute to the debate by providing cross-country analyses. LTRO uptakes are not random, and one must be careful in reaching conclusions about causality. However, our results suggest a negative association between bank LTRO uptakes and corporate investments, and the role of bank risk in explaining the negative relationship, which has important policy implications. Our results further suggest that it is difficult to stimulate corporate investment simply by injecting liquidity into poorly capitalized banks. We also show that it is important to have coherent policies that coordinate the central banks, regulators, and governments. Unconventional monetary policies are more effective if supported by regulatory and fiscal policies. This conclusion is based on the analysis of LTRO liquidity injections. Whether TLTROs, among other policies, render different conclusions requires further study.

Appendix

Table A1
Variable definitions

Main explanatory variables		Description
Bank LTRO uptake	Average (Bank LTRO borrowing/ Bank size ₂₀₁₁) of related bank lenders	The firm-level average of a related bank lenders' borrowings through the two 3-year LTROs (LTRO I and II), scaled by the size of the respective bank. Accordingly, the variable is equal to zero until time 2011Q4 (first round of 3-year LTRO) and afterward equal to the average of related banks' LTRO uptake. Quarterly corporate measure. <i>Sources:</i> Bloomberg and annual reports.
LTRO-bank relation	Dummy	Dummy variable equal to one for corporations that in the 3 years prior to 2011Q4 (first round of 3-year LTRO) had a loan relation to a eurozone bank that participated in the 3-year LTROs as of December 2011 and February 2012. Corporate measure. <i>Source:</i> LPC DealScan.
Country LTRO uptake	Total country LTRO borrowing/ Central government debt ₂₀₁₁	Country LTRO uptake is the sum of the euro amounts of the two 3-year LTROs (LTRO I and II) for each country. Accordingly, the variable is equal to zero until time 2011Q4 (first round of 3-year LTRO) and afterward equal to each country's total uptake, scaled by the central government debt holdings in the year 2011. Quarterly country measure. <i>Sources:</i> Bloomberg and the World Bank.

(continued)

Main explanatory variables		Description
Bank LTRO uptake (scaled by loan pf.)	Average (Bank LTRO borrowing/ Bank loan pf. ₂₀₁₁) of related bank lenders	The firm-level average of a related bank lenders' borrowings through the two 3-year LTROs (LTRO I and II), scaled by the total loan portfolio of the respective bank. Accordingly, the variable is equal to zero until time 2011Q4 (first round of 3-year LTRO) and afterward equal to the average of related banks' LTRO uptake. Quarterly corporate measure. <i>Sources:</i> Bloomberg and annual reports.
Bank LTRO uptake (w. bank loan)	Average (Bank LTRO borrowing/ Bank size ₂₀₁₁) of related bank lenders, weighted by the loan amount held by the respective bank	The firm-level average of a related bank lenders' borrowings through the two 3-year LTROs (LTRO I and II), scaled by the size of the respective bank, and weighted by the loan amount held by the respective bank. Accordingly, the variable is equal to zero until time 2011Q4 (first round of 3-year LTRO) and afterward equal to the average of related banks' LTRO uptake. Quarterly corporate measure. <i>Sources:</i> Bloomberg, BankScope, and annual reports.
Main corporate variables		Description
Corporate investment	Capital expenditures/ Total assets	Corporate capital spending. Quarterly corporate measure. <i>Source:</i> Compustat.
Salaries and wages	ln(Total salaries and wages)	The natural logarithm of total expenses related to salaries and wages. Quarterly corporate measure. <i>Source:</i> Compustat.
Cash flow	EBIT/ Total assets	Operating income before interest and taxes (after depreciation), scaled by total assets. Quarterly corporate measure. <i>Source:</i> Compustat.
Market to book	(Total liabilities + Market equity) / Total assets	Market value of total assets, scaled by book value of total assets. Market equity is the amount of shares outstanding times the share price as of the end of the fiscal quarter/year. Quarterly corporate measure. <i>Source:</i> Compustat.
Firm size	ln(Total assets)	Book value of assets, given in logarithms. Quarterly corporate measure. <i>Source:</i> Compustat.
Other corporate variables		Description
Short-term Debt	(Debt due in 1 year)/ Total assets	Fraction of long-term debt that is due in one year, scaled by total assets. Quarterly corporate measure. <i>Source:</i> Compustat.
Bank debt	Bank debt/ Total assets	Bank debt is the amount of debt from bank loans. Quarterly corporate measure. <i>Source:</i> Capital IQ.
Cash	Cash/ Total assets	Corporate cash holdings including marketable securities. Quarterly corporate measure. <i>Source:</i> Compustat.
Cash flow risk	SD (Cash flow/ Total assets)	Standard deviation of corporate cash flows within latest 3 years. Yearly corporate measure. <i>Source:</i> Compustat.
Tangible assets	Tangible assets/ Total assets	Tangible assets of corporate. Quarterly corporate measure. <i>Source:</i> Compustat.
Industry sigma	SD of cash flow	Average standard deviation of corporate cash flows within the same two-digit SIC code (minimum three observations). Quarterly industry measure. <i>Source:</i> Compustat.

(continued)

Main explanatory variables		Description
Net working capital	(Net working capital - Cash)/ Total assets	Corporate working capital net of cash holdings, scaled by total assets. Quarterly industry measure. <i>Source:</i> Compustat.
R&D/Sales	R&D/ Total sales	Costs related to research and development, scaled by corporate sales. Quarterly corporate measure. <i>Source:</i> Compustat.
Sales	ln(EBIT)	Operating income before interest and taxes (after depreciation), given in logarithms. Quarterly industry measure. <i>Source:</i> Compustat.
Acquisition activity	Acquisitions/ Total assets	The amount used for M&A activities, scaled by total assets. Quarterly corporate measure. <i>Source:</i> Compustat.
Dividends	Dummy	Dummy variable equal to one for corporations with positive dividends in a given quarter/year (zero otherwise). Quarterly corporate measure. <i>Source:</i> Compustat.
Other bank and country variables		Description
LTRO bank	Dummy	Dummy variable equal to one for banks that used funds from the 3-year LTROs. Bank-level measure. <i>Source:</i> Bloomberg.
Bank risk	ln(5-year CDS spread)	End-of-quarter observation of 5-year CDS spreads of banks. Quarterly bank measure. <i>Source:</i> Markit.
Δ Total sovereign debt	Δ Sovereign debt holdings ₂₀₁₀₋₂₀₁₃	The percentage change in banks' total holdings of sovereign debt from December 2010 to December 2013. The sovereign debt holdings are given in gross terms. Bank-level measure. " Δ Risky (safe) sovereign debt" similarly refers to the change in banks' holdings of sovereign debt in GIIPS (other eurozone countries) from December 2010 to December 2013. <i>Source:</i> EBA Stress Test (2011 and 2014 reports).
Early LTRO repayment	(Δ NCB LTRO holdings ₂₀₁₂₋₂₀₁₃)/ Country LTRO uptake _{2011/2012}	The change in National Central Banks' LTRO Holdings from 2012 to 2013, scaled by the total initial LTRO uptake in the respective country. Country measure. <i>Sources:</i> National Central Bank Reports and Bloomberg.
Sovereign risk	ln(5-year Sovereign CDS spread)	End-of-quarter observation of 5-year sovereign CDS spreads. Quarterly country measure. <i>Source:</i> Markit.
Sovereign export	Total exports/GDP	Exports of goods and services, scaled by GDP. Yearly country measure. <i>Source:</i> The World Bank.
GIIPS	Dummy	Dummy variable equal to one for corporations located in either Greece, Ireland, Italy, Portugal, or Spain. Country measure. <i>Source:</i> Compustat.
Government investments	Government investments/ GDP	Local government investment expenditures, scaled by GDP. Quarterly country measure. <i>Sources:</i> ECB Statistical Data Warehouse and The World Bank.
Government debt	Government debt holdings	The total debt amount held by the local government. Quarterly country measure. <i>Source:</i> ECB Statistical Data Warehouse.
Corporate tax	Corporate tax rate (%)	<i>Source:</i> The World Bank.

This table provides descriptions of all the variables used in the analyses. All financial variables are winsorized at the 1st and 99th percentiles.

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