



**ECB UNCONVENTIONAL LIQUIDITY INJECTIONS: DID THEY AFFECT
CORPORATE LEVERAGE AND INVESTMENT BEHAVIOUR?**

Key points

- *This study examines the efficacy of the unconventional Longer-Term Refinancing Operations (LTROs) through which the European Central Bank (ECB) provided long-term funding to commercial banks. Of particular interest is whether the unconventional LTROs helped promote credit to non-financial corporations and facilitated real economic activities.*
- *Using a panel fixed effect model on euro area firm-level data from 2010 to 2018, our study suggest the ECB's unconventional LTROs are effective in promoting corporate leverage and cash-holding ratios. For the average firm in a country in the upper quartile of LTRO uptake, the leverage and cash ratios are 0.3% (0.1%) higher than a firm in a country in the lower quartile of LTRO uptake.*
- *Given its fine-tuning design, the Targeted LTRO (TLTRO) is more successful than its predecessor, the three-year LTRO, in increasing the leverage and cash-holdings of non-financial corporations. Further analysis indicates this is particularly the case for small firms.*
- *The LTROs, however, do not significantly boost real activities, such as corporate investment. While the findings demonstrate that unconventional central bank liquidity injections help in supporting liquidity supply in the euro area, they also show that both the LTROs and the TLTRO were difficult to stimulate corporate investment, likely due to heightened economic uncertainty.*

Prepared by: Muiyang Wu

Economic Research Division, Research Department

Hong Kong Monetary Authority

The views and analysis expressed in this paper are those of the authors, and do not necessarily represent the views of the Hong Kong Monetary Authority.

* The author would like to thank Jason Wu and Ip-wing Yu for their comments and suggestions

I. INTRODUCTION

The Longer-Term Refinancing Operations (LTROs) are a key part of the ECB's unconventional monetary policy toolkit, first launched in response to the sovereign debt crisis and liquidity tightening in the euro area since 2011. The primary purpose of the unconventional LTROs is to improve credit accessibility and ease lending standards through the provision of long-term funding to commercial banks.

This study examines the efficacy of the unconventional LTROs in stimulating credit creation and facilitating the real economy in the euro area, utilising a panel fixed effect model on euro area firm-level data from 2010 to 2018. After controlling for demand-side factors, the results show that the two types of unconventional LTROs, especially the Targeted LTROs (TLTRO) first launched in 2014, are effective in helping to increase leverage and cash holdings of firms. On the other hand, there is no evidence the unconventional LTROs boosted firms' investments.

Most existing studies that assess the effectiveness of unconventional LTRO programmes are mainly conducted on a country-by-country basis, and cover only the first unconventional LTRO (the three-year LTROs). Studies conducted for enterprises in France, Spain and Italy found that the three-year LTRO programme had a limited positive impact on firm-level credit growth¹.

Unlike previous studies that focused on individual countries, this study examines the policy effectiveness across 10 EU countries (Austria, Belgium, France, Germany, Greece, Ireland, Italy, the Netherlands, Portugal and Spain)², as it is valuable to cover both the core and peripheral countries and to better differentiate

¹ Andrade et al (2015) showed that in France, the transmission rate of three-year LTRO lending into corporate lending is around 9.5%. Garcia and Marchetti (2016) found that the three-year LTRO led to a 0.8% to 1% increase in the annual firm lending growth in Spain. Another study by Carpinelli and Crosignani (2017) indicated that for Italy, total credit expanded roughly 2% with the three-year LTROs.

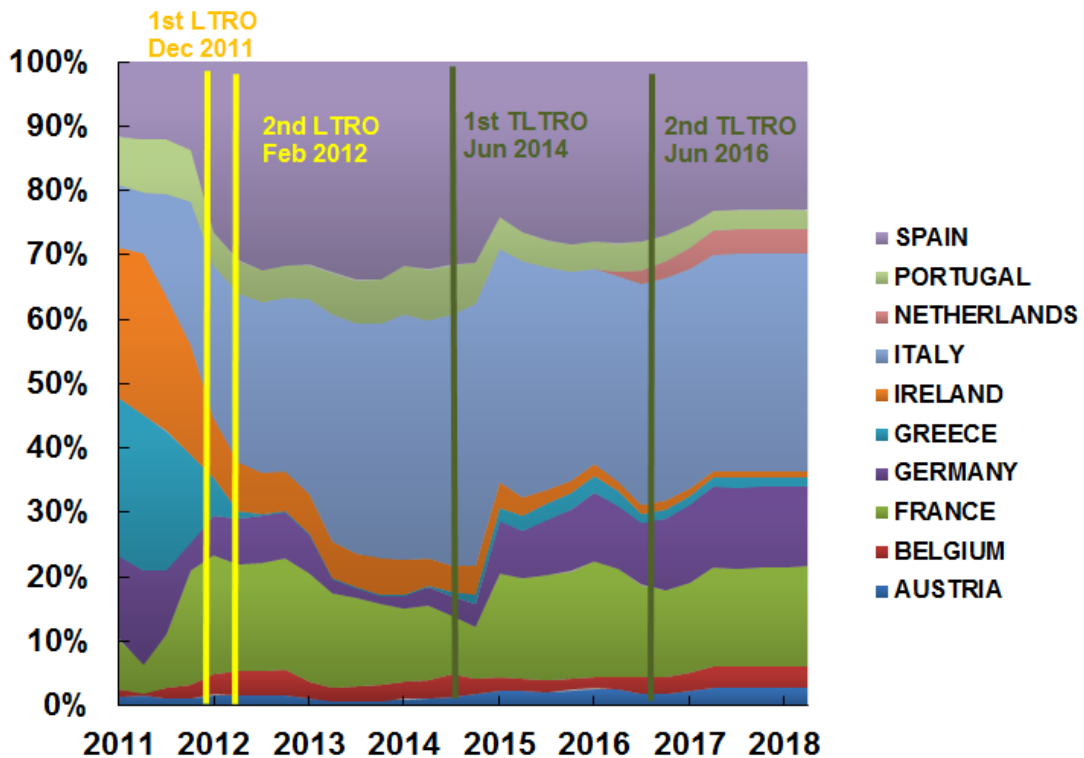
² To exclude any potential bias or country-specific reasons, such as later adoption of the euro by some countries, only those that adopted the euro as a common currency in 1999 and joined the EMU since inception in 2001 are included, following the practice in Daetz, Tang and Wang (2017).

between the impact on the transmission mechanism from macro liquidity to local corporate liquidity. In addition, for a more comprehensive evaluation of the unconventional LTROs, this research covers both the three-year LTROs and the TLTROs, as the latter has a specific mandate and design to promote lending to non-financial corporates and households. Indeed, we hope to close the gap by elucidating whether the unconventional LTROs have real effects on credit generation and investment stimulation, distinguishing between different rounds of the operations.

II. BACKGROUND

The unconventional LTRO operation consists of four rounds of liquidity injections, including two rounds of the three-year LTRO in late 2011 and early 2012, and two rounds of the Targeted LTRO (TLTRO) in 2014 and 2016. The loans were granted on a full allotment basis and came with a significantly longer maturity compared to the ECB's regular LTRO loans. The unconventional LTROs were significant in terms of size and scope with around €1 trillion gross injection under the three-year LTRO, and €876 billion gross injection under the TLTROs, which reached over 800 credit institutions in the euro area (Alvarez et al, 2017).

Chart 1: Country share of total LTRO uptake



Note:

Apart from the unconventional LTRO programmes, the ECB maintains its regular three-month LTRO operations and releases statistics on the combined uptake of regular three-month LTRO and the unconventional LTROs, as shown in Chart 1 above

Source: ECB

The exact design and credit allocation mechanism are different for the three-year LTRO programme and the TLTRO programme. Under the three-year LTROs, launched in Dec 2011 and Feb 2012, credit institutions were allowed to borrow unlimited amounts (as long as they provided eligible collateral) with a three-year maturity. Banks were not limited on the usage of borrowed funds and had the option to repay part or full amount of the proceeds after one year. The interest charged was the average of the Main Refinancing Operation (MRO) rate over the maturity of loans (2011-2015), which was below 1%³.

Loans under the TLTROs (launched in Jun 2014 and Jun 2016) have a

³ As a comparison, the average lending rate from Monetary Financing Institutions to non-financial corporations between 2011 and 2015 was around 2.95% in the euro area, according to ECB statistics on the cost of borrowing indicators.

longer maturity of four years and a different credit allotment design, based on the programme's targeted nature. This targeted nature is reflected in the linkage between borrowing limits and banks' eligible corporate lending. In the initial round of the TLTRO (TLTRO-I conducted between Jun 2014 and Jun 2016), banks were allowed to borrow up to 7% of their lending to non-financial corporations and households, while the allowance was raised to 30% in the second round of TLTRO (TLTRO-II conducted in Jun 2016). Under TLTRO-I, banks that did not meet their eligible net lending target would be subject to a penalty of mandatory early repayment in September 2016, two years before maturity⁴. This penalty system was introduced to stimulate credit supply by banks and, conceivably, to put a halt to bank's home-currency sovereign bond purchases using the low-cost funding of the three-year LTROs.

Aside from the borrowing limits, the TLTRO programme also introduced a reward system on the interest rates charged. For TLTRO-I, the interest charged was initially fixed at the Main Refinancing Operation (MRO) rate at the time of loan take-up plus a spread of 10bps; the spread was subsequently eliminated in January 2015. In TLTRO-II, if a bank's eligible net lending exceeded the calculated benchmark, it would enjoy a more attractive interest rate, which could be as low as the prevailing deposit facility rate (-0.4% at the time⁵). By linking the cost of borrowing and the lending amount of banks, the reward system was also aimed at motivating credit creation of financial institutions.

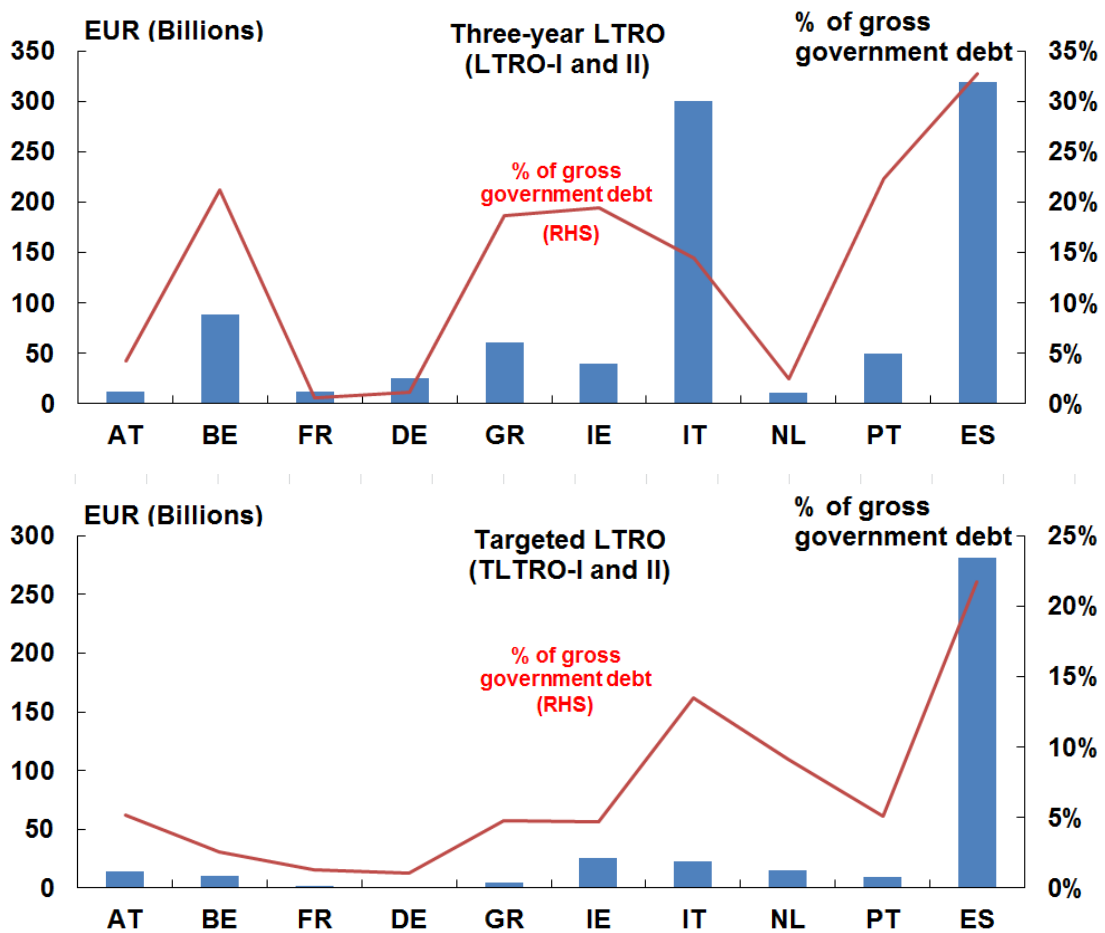
Both the three-year LTROs and the TLTROs saw high levels of participation by the banks, as they were attracted by the relatively low funding costs. The distribution of funds was asymmetric across the euro area, with peripheral countries having higher participation rates in both rounds due to tightening local credit conditions. Chart 2 shows a country breakdown of the three-year LTRO and TLTRO total uptake estimated by Bloomberg using individual bank sources as the ECB does not publish official statistics that

⁴ https://www.ecb.europa.eu/press/pr/date/2014/html/pr140729_updated_modalities.pdf

⁵ For details on benchmark and interest calculation, see https://www.ecb.europa.eu/ecb/legal/pdf/celex_32016d0010_en_txt.pdf

differentiate between the unconventional LTROs uptake and the regular three-month series⁶.

Chart 2: Total Three-year LTRO and TLTRO country uptake (estimated)



Notes:

Gross government debt was averaged between 2011 and 2016 for Austria (AT), Belgium (BE), France (FR), Germany (DE), Greece (GR), Ireland (IE), Italy (IT), the Netherlands (NL), Portugal (PT) and Spain (ES)

Source: Bloomberg and World Bank database

Given the primary purpose of the unconventional LTROs is to stimulate credit, it is important to understand whether the policy has achieved its intended outcome. The ECB itself is reflecting on the use of unconventional LTROs and may plan to further extend or renew the TLTROs in the wake of recent softening economic data. According to the January 2019 Monetary Account, the

⁶ The ECB publishes monthly statistics on the amount of Long-term Refinancing Operations (LTRO), which provides only the grand total of the three-month maturity loan and the unconventional ones. Thus it is difficult to obtain the amount of unconventional LTROs on a monthly basis.

ECB mentioned that suggestions were made to revisit the TLTROs' contribution to the monetary policy stance⁷. Indeed, an examination of the effectiveness of unconventional LTROs could be useful if the Bank decides to deploy new rounds of the TLTRO in the future.

III. DATA AND METHODOLOGY

3.1 Data

Following previous studies of LTRO effectiveness⁸, firm-level data was collected from Capital IQ based on quarterly financial filings for the period from 2010 Q1 to 2018 Q2, covering both the normal and sovereign debt crisis periods, together with the unconventional LTRO intervention periods. This information enables a comprehensive analysis of corporate borrowing and investment behaviour under different macroeconomic environments.

In selecting the firms for our study, those utility and financial firms based on SIC codes are excluded because large periodic infrastructure investments for the utilities sector and banking regulations, such as Basel II and III for the financial sector, lead to a significantly different capital structure of firms in these sectors. Selected firms also need to have their primary operating location within the EU10 countries (Austria, Belgium, France, Germany, Greece, Ireland, Italy, the Netherlands, Portugal and Spain). To avoid the issue of non-active firms, we follow the practice in Daetz, Tang and Wang (2017), by only including firms with a non-negative asset value in all given quarters in the sample period. The final sample includes 1,344 listed firms across eight sectors within the EU10 countries. Detailed explanations of the firm-level variables and other country-specific controls used in the empirical analysis are described in Table 1.

⁷ <https://www.ecb.europa.eu/press/accounts/2019/html/ecb.mg190110.en.html>

⁸ See Andrade et al (2015), Crosignani et al (2017) and Garcia-Posada and Marchetti (2016)

Table 1: Summary of Model Variables

Categories	Variables	Description	Note
Dependent Variables	$Leverage_{f,t}$	(Book Value of Long Term Debt ⁹ + current liabilities) / total assets	Used as dependent variables in three separate models
	$Investment_{f,t}$	Capital Expenditure /Assets	
	$Cash_{f,t}$	(Cash + Short-term investment ¹⁰) /total assets	
Independent Variables: LTRO variables	Total LTRO uptake $(X_{country(f),t}^{LTRO})$	(Regular three-month LTRO operation uptake + unconventional LTRO uptake of the country of firm f)/ Gross government debt averaged between 2011 and 2016 ¹¹	The interaction variables $X_{country(f),t}^{threeyrLTRO}$ and $X_{country(f),t}^{TLTRO}$ are used to gauge the effect of specific terms and conditions attached to the three-year and targeted LTROs. The level amount of unconventional LTROs is not used due to data limitations (see footnote 6.)
	Three-year LTRO indicator $(X_{country(f),t}^{threeyrLTRO})$	Interaction term between total LTRO uptake $X_{country(f),t}^{LTRO}$ and the dummy variable for 3-year LTRO injection time (i.e. this dummy equals 1 for 2011 Q3, 2011 Q4, 2014 Q3 and 2014 Q4, and zero for all other periods)	

⁹ According to the IFRS standard, long-term debt refers to debt that will not be due for the next 12 months, while current liability refers to debt that will be due within the next 12 months.

¹⁰ According to the IFRS standard, short-term investment refers to any investment that is readily realisable and intended not to be held for more than one year.

¹¹ This specification follows the practice in Daetz, Tang and Wang (2017). In their research, they used a country's LTRO uptake scaled by GDP as a check, and the results were robust to this alternative specification.

	<p>TLTRO indicator</p> <p>$(X_{country(f),t}^{TLTRO})$</p>	<p>Interaction term between total LTRO uptake variable $X_{country(f),t}^{LTRO}$ and the dummy variable for Targeted LTRO injection time (i.e. this dummy equals 1 for 2015 Q1 – 2017 Q1 and zero for all other periods)</p>	<p>The LTRO variables are country-level uptakes mapped onto individual firms according to their primary operation locations.</p>
<p>Independent Variables: Firm-level control variables</p> <p>$Z_{f,t}$</p>	<p>Industry sigma</p>	<p>Log of cash flow volatility for a specific industry (based on SIC code)</p>	<p>Firm level financial statement items are used as control of idiosyncratic risks and to isolate the impact of macro liquidity injections on micro borrowing and investing behaviour.</p>
	<p>Cash Flow (CF)</p>	<p>Earnings Before Interest and Tax /total assets</p>	
	<p>M/B</p>	<p>Price to Book ratio</p>	
	<p>Size</p>	<p>Log(total assets)</p>	
	<p>Sales</p>	<p>Sales/total assets</p>	
	<p>Net working capital (NWC)</p>	<p>(Current asset – current liability net of cash) / total assets</p>	
	<p>RDSales</p>	<p>R&D Expenditure/Sales</p>	
	<p>Acquisition</p>	<p>Acquisition/ total assets</p>	
	<p>LT Debt</p>	<p>(Book value of long-term debt)/ total assets</p>	
	<p>ST Debt</p>	<p>Current liabilities / total assets</p>	

Independent variables: Country-level control variables ¹² $W_{country(f),t}$	SovCDS	5-year CDS spread for the country (in decimal points)	Controlling for individual country characteristics and sovereign risks
	SovExport	Export to GDP ratio	
	Loan demand conditions (BLS)	From bank lending survey by ECB Overall enterprise loan demand (forward-looking 3 months, index in percentage) for each country in the sample A positive value implies higher loan demand	Controlling for loan demand situations. Only used in models with Leverage being the dependent variable
	Country-specific sentiment (ESI)	=ln(Economic Sentiment Index) ESI by European Commission for each country	Controlling for domestic demand and uncertainty. Only used in models where Cash and Investment being the dependent variable
Independent Variables: Other control variables V_t	Corporate bond spread (BAA10Y)	Spread between Moody's BAA corporate bond yield and 10 year US Treasury (end of period)	Stand-alone control for credit market sentiments

Note: All data are winsorised at 1st and 99th percentiles to mitigate the impact of outliers, following Daetz, Tang and Wang (2017).

¹² Country control variables in $W_{country(f),t}$ are mapped onto a specific firm according to its primary country of operation

3.2 Empirical Framework

This study employs a panel regression model with firm fixed effects, focusing on the transmission channel of unconventional LTRO injections to the real economy.

$Leverage_{f,t}$

$$\begin{aligned} &= \alpha_{fixed\ effect} + \beta_1^{Leverage} X_{country(f),t}^{LTRO} + \beta_2^{Leverage} X_{country(f),t}^{threeyrLTRO} \\ &+ \beta_3^{Leverage} X_{country(f),t}^{TLTRO} + (B_4^{Leverage})' Z_{f,t} \\ &+ (B_5^{Leverage})' W_{country(f),t} + (B_6^{Leverage})' V_t + \varepsilon_{f,t} \end{aligned}$$

$Investment_{f,t}$

$$\begin{aligned} &= \alpha_{fixed\ effect} + \beta_1^{Investment} X_{country(f),t}^{LTRO} + \beta_2^{Investment} X_{country(f),t}^{threeyrLTRO} \\ &+ \beta_3^{Investment} X_{country(f),t}^{TLTRO} + (B_4^{Investment})' Z_{f,t} \\ &+ (B_5^{Investment})' W_{country(f),t} + (B_6^{Investment})' V_t + \varepsilon_{f,t} \end{aligned}$$

$$\begin{aligned} Cash_{f,t} &= \alpha_{fixed\ effect} + \beta_1^{Cash} X_{country(f),t}^{LTRO} + \beta_2^{Cash} X_{country(f),t}^{threeyrLTRO} \\ &+ \beta_3^{Cash} X_{country(f),t}^{TLTRO} + (B_4^{Cash})' Z_{f,t} + (B_5^{Cash})' W_{country(f),t} \\ &+ (B_6^{Cash})' V_t + \varepsilon_{f,t} \end{aligned}$$

Where $X_{country(f),t}^{LTRO}$ is the total LTRO variable, and $X_{country(f),t}^{threeyrLTRO}$

and $X_{country(f),t}^{TLTRO}$ is the threeyrLTRO variable and TLTRO variable respectively.

The key regressors of interest are $X_{country(f),t}^{threeyrLTRO}$ and $X_{country(f),t}^{TLTRO}$, which are constructed by interacting the total LTRO uptake $X_{country(f),t}^{LTRO}$ and the injection time of unconventional LTROs. The use of interaction terms rather than the level amount for unconventional LTROs is mainly due to the fact that the ECB does not provide an official breakdown of the amount of unconventional LTROs and the regular three-month LTROs on a monthly basis. In addition, this interaction term approach helps to capture the effects of specific lending requirements attached to

the unconventional LTROs as well as the penalty/reward system embedded in the programmes, features which are absent from the regular three-month LTROs. For controls, $Z_{f,t}$ is the vector for the group of firm control variables, $W_{country(f),t}$ is the vector for the group of country control variables and V_t is the vector for the group of other control variables as shown in Table 1. B'_4 , B'_5 and B'_6 stand for vectors of coefficients of $Z_{f,t}$, $W_{country(f),t}$ and V_t respectively. Equations with full details of control variables can be found in Appendix A.2.

The leverage model examines whether the unconventional LTRO liquidity injections have translated into higher corporate leverage by analysing the impact of the three-year LTROs and TLTROs on firms' leverage ratio. As the main purpose of unconventional LTRO injections is to stimulate bank lending to the real economy¹³, it is worth examining whether firms have increased their borrowing under the scheme. The cash and investment models evaluate whether the unconventional LTROs have affected the investment and cash-holding decisions of firms, as their access to debt financing has an impact on cash holding behaviour and real activities, such as investment (Harford and Uysal, 2014).

Apart from the general firm-level controls, this study tries to add new country-level controls (variables in $W_{country(f),t}$ group) to control for loan demand and economic uncertainty. In general, an unfavourable economic outlook and lower demand could lead to corporates increasing their cash holdings for precautionary purposes and postponing their new investment.

Aside from the baseline model mentioned above, Section IV also investigates the granular impact of the unconventional LTRO schemes. Subsample analysis based on the characteristics of firms, such as size, is conducted to better understand the impact of a macro liquidity injection into the micro behaviour of local firms. More details on the subsample analysis will be explained in the following section.

¹³ <https://www.ecb.europa.eu/mopo/implement/omo/tltro/html/index.en.html>

IV. EMPIRICAL RESULTS

4.1 *Leverage*

This section examines how the unconventional LTRO programmes have affected the corporate leverage ratio. The results from Table 2 show that in terms of corporate borrowing (Model 1), the TLTRO programme leads to a small but positive increase in the corporate leverage ratio (0.3% higher for firms in countries in the upper quartile of the TLTRO uptake than firms in countries in the lower quartile)¹⁴, while the three-year LTRO does not have a significant impact on leverage.

As discussed in Andrade et al (2015), the presence of unconventional LTRO as the first opportunity for low-cost long-term funding amid tightening liquidity conditions may have encouraged firms to borrow long-term funding to pay back their short-term debts. To examine this, another leverage regression, Model 2, was conducted with long-term debt (LT Debt) used as the dependent variable. The results show that TLTRO leads to an increase in the long-term debt ratio. One possibility for this is that corporations may be involved in replacing their short-term borrowings with long-term ones. However, in Model 3, the sign of the coefficient for TLTRO implies that firms may have decreased their short-term debt holdings under the TLTRO scheme, but the impact was not statistically significant. Thus, it is not clear whether firms have swapped short-term debt into long-term debt.

¹⁴ The difference between the 25th percentile and the 75th percentile of TLTRO country uptake is 6.59%, implying that the leverage is $6.59\% * 0.045 = 0.3$ percentage points higher for corporations in the upper quartile of TLTRO uptake countries than firms in lower quartile countries.

Table 2: Leverage model results

	Leverage (LT Debt +ST Debt)	Leverage (LT Debt)	Leverage (ST Debt)
	Model 1	Model 2	Model 3
$X_{country(f),t}^{LTRO}$	-0.008* (0.00)	0.005 (0.00)	-0.015 (0.003)
$X_{country(f),t}^{threeyearLTRO}$	0.006 (0.01)	-0.007 (0.01)	0.011 (0.006)
$X_{country(f),t}^{TLTRO}$	0.045** (0.01)	0.030** (0.01)	-0.001 (0.008)
Constant	0.719** (0.02)	0.120** (0.02)	0.545** (0.020)
Firm controls	YES	YES	YES
Country controls	YES	YES	YES
N	33850	29228	33850
R-square	0.861	0.761	0.813

Robust standard errors in parentheses and *, ** denote significance at 5% and 1%.

LT debt is defined as the book value of long-term debt over total assets of a firm, while ST debt is defined as the current liabilities over total assets of a firm. $X_{country(f),t}^{LTRO}$, $X_{country(f),t}^{threeyearLTRO}$ and $X_{country(f),t}^{TLTRO}$ are variables for country-level (mapped to individual firms) total LTRO uptake, three-year LTRO uptake and TLTRO uptake, respectively.

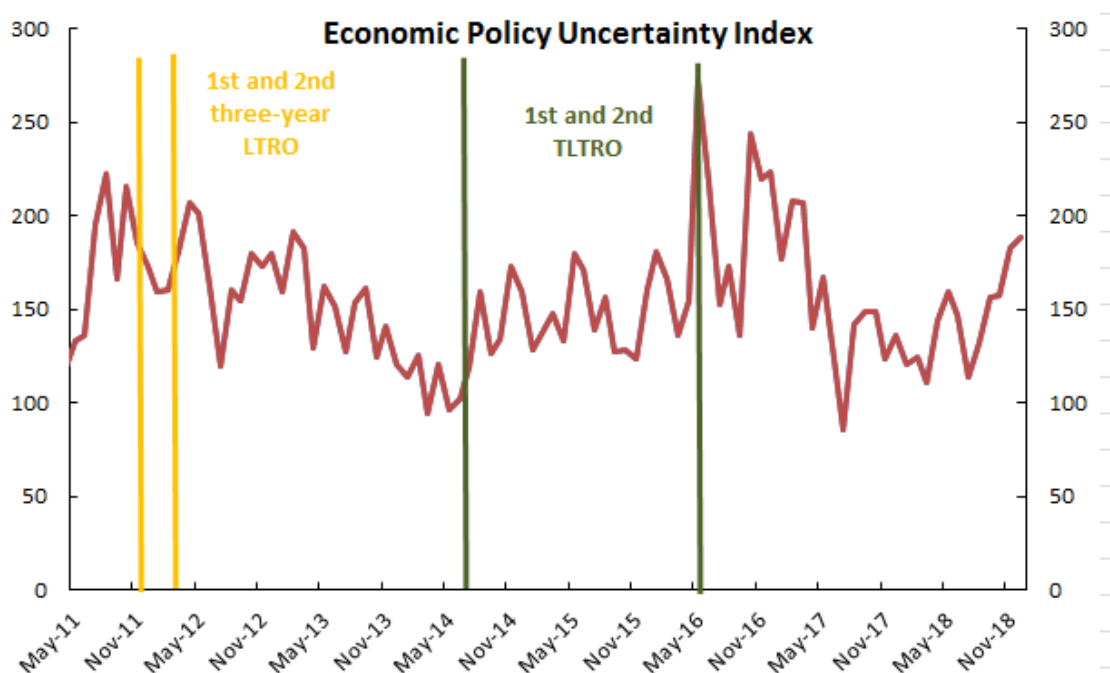
4.2 Investment

This section examines whether increased leverage was transmitted fully into real activities (i.e. investment) for both rounds of unconventional LTROs. In Model 4, only the three-year LTRO programme has a positive impact on investment by firms. On average, the three-year LTROs lead to a small increase in the corporate investment ratio (0.04% more for firms in countries in the upper quartile of the three-year LTRO uptake than firms in countries in the lower quartile¹⁵). Overall, the magnitude indicates that both the three-year LTRO and the TLTRO do not have a significant quantitative impact on corporate investment, suggesting firms were hesitant to launch new investment projects, perhaps due to heightened uncertainty (see Chart 3), when the programmes were introduced¹⁶.

¹⁵ The difference between the 25th percentile and the 75th percentile of three-year LTRO country uptake is 19%, implying that investment is $19\% \times 0.002 = 0.04$ percentage points higher for corporations in the upper quartile of the three-year LTRO uptake countries than firms in the lower quartile countries.

¹⁶ See Black, Hashimzade and Myles (2016) who argue the elasticity of corporate investment in relation to fundamentals is lower in high uncertainty periods. Thus, monetary interventions of a more

Chart 3: Average Economic Policy Uncertainty Index for sampled countries



Notes:

Monthly data for the EPU index of France, Germany, Greece, Ireland, Italy, the Netherlands and Spain were collected and averaged. Other sampled countries (Austria, Belgium and Portugal) were omitted due to data availability.

Source: Economic Policy Uncertainty Index website

It should be noted that firms in some cases tend to make investment and borrowing decisions upfront, while the actual expenditure is spread out across periods and can be quite lumpy. To avoid the impact of this investment lumpiness, a robustness check was carried out using a four-quarter ahead moving average of the investment ratio as the dependent variable for investment in the Model 4 regression. The results were not statistically different from the original model and can be found in Appendix A.3.

substantial magnitude are needed to boost investment in recession periods. Bloom (2009) also argues that a macro uncertainty shock could lead to firms pausing investment and hiring.

Table 3: Investment Model Results

	Investment Model 4
$X_{country(f),t}^{LTRO}$	0.001 (0.00)
$X_{country(f),t}^{threeyearLTRO}$	0.002** (0.00)
$X_{country(f),t}^{TLTRO}$	-0.001 (0.00)
Constant	0.005 (0.00)
Firm controls	YES
Country controls	YES
N	32761
R-square	0.518

Robust standard errors in parentheses and *, ** denote significance at 5% and 1%.

Investment is defined as capital expenditure over total assets of a firm. $X_{country(f),t}^{LTRO}$, $X_{country(f),t}^{threeyearLTRO}$ and $X_{country(f),t}^{TLTRO}$ are variables for country-level (mapped to individual firms) total LTRO uptake, three-year LTRO uptake and TLTRO uptake, respectively.

4.3 Cash

For cash holdings, the full sample results suggested by Model 5, show that both the three-year LTRO and the TLTRO do not have a significant impact on corporate cash holdings at the 5% significance level. Therefore, it seems the unconventional LTRO programmes do not affect cash holdings.

However, the full sample result could mask some important distinction among firms, as some could have different access to funding amid heightened uncertainty depending on their relationship with banks¹⁷. If these

¹⁷ A related discussion of the negative relationship between bank debt and cash holdings in the EMU can be found in Ferreira and Vilela (2004). A high bank debt before the intervention in theory suggests that the firm has a closer bank relationship, and thus having less need to hoard precautionary cash and consequently lower cash holdings.

banking relationships did affect their motive for precautionary cash holdings, it is vital to distinguish between firms based on the strength of their banking connections.

Table 4: Cash model results

	Cash		Cash	
	Full Sample Model 5	High Bank Debt Model 6	Low Bank Debt Model 7	
$X_{country(f),t}^{LTRO}$	0.008* (0.00)	-0.004 (0.01)	0.014** (0.00)	
$X_{country(f),t}^{threeyearLTRO}$	0.008 (0.01)	0.002 (0.01)	0.012 (0.01)	
$X_{country(f),t}^{TLTRO}$	0.014 (0.01)	0.002 (0.01)	0.031** (0.01)	
Constant	0.173** (0.04)	-0.140* (0.06)	0.472** (0.06)	
Firm controls	YES	YES	YES	
Country controls	YES	YES	YES	
N	13308	6278	7030	
R-square	0.695	0.692	0.702	

Robust standard errors in parentheses and *, ** denote significance at 5% and 1%.

Cash is defined as cash and short-term investments over total assets of a firm. $X_{country(f),t}^{LTRO}$, $X_{country(f),t}^{threeyearLTRO}$ and $X_{country(f),t}^{TLTRO}$ are variables for country-level (mapped to individual firm) total LTRO uptake, three-year LTRO uptake and TLTRO uptake, respectively.

To investigate whether banking relationship matters for cash-holdings, Model 6 and Model 7 examine the cash-holding behaviour of firms with high bank debt and low bank debt, using the level of bank debt as a proxy for bank-firm relationship. The bank debt is defined as bank debt obligations of the firm one quarter before the first unconventional LTRO intervention (2011 Q3). The high bank debt group consists of firms with a bank debt level higher than the median. According to Table 4, Model 6 and Model 7 show that firms with lower bank debt tend to hoard more cash under the TLTROs (0.2% higher for low bank debt firms in countries in the upper quartile of the TLTRO uptake than firms in countries in the

lower quartile¹⁸), while firms with high bank debt do not exhibit such behaviour. This result is in accordance with the literature that a low bank debt level (hence limited relationship with banks) leads to more precautionary cash holdings in high uncertainty periods¹⁹. This further suggests that unconventional LTRO liquidity, especially TLTRO liquidity, has partially translated into precautionary cash holdings for firms with limited bank financing access, thus implying that unconventional LTROs are successful in providing liquidity to firms amid heightened uncertainty.

4.4 TLTRO vs three-year LTRO

Compared with the three-year LTROs, the TLTROs have a much greater impact on corporate leverage and cash-holding decisions, while the impact on investment is largely muted. The three-year LTROs shown in Tables 2 to 4, carry mostly insignificant regression coefficients.

The differences in the impact could be due to the fact that the TLTRO is designed with a more targeted purpose. The TLTRO was introduced with a borrowing limit and interest rates linked to the amount of corporate lending extended by banks. There is also an early repayment penalty mechanism, if banks fail to sufficiently increase their lending to the private sector. In contrast, the three-year LTRO scheme has neither a penalty system nor restrictions on the use of funds. A considerable share of participating banks used liquidity from the three-year scheme to purchase home-currency sovereign bonds, particularly in peripheral countries, such as Italy, Spain and Portugal²⁰. In the absence of an effective incentive mechanism to direct the use of funds, it is not surprising that a large fraction of the three-year LTRO liquidity went into the purchase of sovereign bonds and, thus, had a limited impact on corporate level liquidity and leverage (Krishnamurthy, Nagel and Vissing-Jorgensen, 2017).

¹⁸ The difference between the upper quartile and lower quartile of TLTRO country uptake is 6.5% in the low bank debt group, implying that cash is $6.5\% \times 0.031 = 0.2$ percentage points higher for low bank debt firms in the upper quartile of TLTRO uptake countries.

¹⁹ Study by Ferreira and Vilela (2004) on firms in the EMU suggested the existence of a negative relationship between bank debt level and firms' cash holdings.

²⁰ Studies found that Portuguese banks significantly increased domestic sovereign bond holdings during the three-year LTRO allotment, as in Crosignani, Faria-e-Castro and Fonseca. (2015).

4.5 *Firm Size*

While firm size could be a factor in determining the effectiveness of monetary policy shocks, the relationship is not clear from the literature²¹. Thus, the following section aims to shed light on the relationship between the effectiveness of unconventional LTROs and the size of firms. In this section, firms are categorised into small and large groups, with those in the small group in the lower 5th percentile of firm size in 2011 Q3, and those in the large group in the upper 5th percentile in 2011 Q3²². The firm size is defined as the natural logarithm of total assets. Then a subsample analysis is conducted for the two groups, focusing on the impact of unconventional LTROs on corporate leverage, investment and cash-holding decisions.

As shown in Model 7-9 (Table 5), small firms experienced a larger increase in leverage and cash holdings, with a 1.1% rise in the leverage ratio and a 3.4% rise in the cash ratio for firms in countries in the upper quartile of the TLTRO uptake than firms in countries in the lower quartile²³. On the other hand, large firms were not significantly affected by the TLTRO in any of the three aspects. While the three-year LTRO had no significant impact on firms in either of the two groups. Given that small firms have an average leverage ratio of 53% and a cash ratio of 19%, the effects from TLTROs is economically meaningful.

²¹ Audretsch and Elston (2002) argue that firm size is significant for the effectiveness of monetary transmission in Germany, while Ehrmann (2005) found firms' size to be uninformative in monetary policy effectiveness.

²² To examine whether the cut-off at 2011 Q3 affects the subsample constituents, a robustness check using a rolling sample of lower 5th percentile and upper 5th percentile of firm size is conducted. The results are not statistically different from the results in Table 5.

²³ The difference between the upper quartile and lower quartile of TLTRO country uptake is on average, 6.7% in the small firm group, implying that leverage is $6.7\% \times 0.171 = 1.1$ percentage points higher for small firms in the upper quartile of TLTRO uptake countries. The same calculation applies for the cash ratio (cash ratio is $6.7\% \times 0.507 = 3.4$ percentage points higher for small firms in the upper quartile of TLTRO uptake countries).

Table 5: Small firm and large firm subsample results

	Small Firms			Large Firms		
	Leverage	Investment	Cash	Leverage	Investment	Cash
	Model 7	Model 8	Model 9	Model 10	Model 11	Model 12
$X_{country(f),t}^{LTRO}$	0.040 (0.03)	0.001 (0.00)	0.047* (0.02)	0.015 (0.01)	-0.005** (0.00)	0.027* (0.01)
$X_{country(f),t}^{threeyearLTRO}$	0.001 (0.05)	-0.008 (0.01)	0.039 (0.05)	-0.000 (0.01)	0.000 (0.00)	-0.001 (0.01)
$X_{country(f),t}^{TLTRO}$	0.171* (0.08)	-0.015* (0.01)	0.507** (0.07)	-0.013 (0.02)	-0.004 (0.00)	0.001 (0.00)
Constant	0.389** (0.10)	-0.021 (0.03)	0.684** (0.22)	0.535** (0.03)	0.007 (0.01)	0.078 (0.06)
Firm control	YES	YES	YES	YES	YES	YES
Country control	YES	YES	YES	YES	YES	YES
N	1198	1165	1151	1972	1922	1869
R-square	0.864	0.358	0.797	0.909	0.622	0.745

Robust standard errors in parentheses and *, **denote significance at 5% and 1%.

Small and large firms are the ones in the upper and lower 5th percentile of firm size in 2011 Q3. Leverage is the book value of long-term debt plus current liabilities over total assets. Investment is defined as capital expenditure over total assets. Cash is defined as cash and short-term investments over total assets of a firm.

$X_{country(f),t}^{LTRO}$, $X_{country(f),t}^{threeyearLTRO}$ and $X_{country(f),t}^{TLTRO}$ are variables for country-level (mapped to individual firms) total LTRO uptake, three-year LTRO uptake and TLTRO uptake, respectively.

The TLTRO is likely to have stronger effects on small firms' leverage and cash holdings due to the fine-tuning nature of the programme. With the penalty mechanism punishing insufficient lending and the preferential interest rate treatment encouraging lending, participating banks may have engaged in granting loans to the farther end of the borrower spectrum. This may have benefitted some previously excluded firms, many of which could conceivably be small in size. The increase in leverage and cash holdings for small firms suggests that small and medium enterprises benefitted more from the TLTROs than large enterprises.

The analysis in this section is done by separating sampled firms into small and large sizes accordingly, which inevitably imposes restrictions on all regression coefficients. To examine the additional impact of being a small firm on

the effectiveness of unconventional LTROs, another interaction term approach²⁴ is conducted as a robustness check. This yields very similar results to the subsample approach. Details can be found in Appendix A.4

V. CONCLUSION

Since the onset of the sovereign debt crisis, the ECB has expanded its unconventional monetary policy tools to increase liquidity supply and stimulate the real economy. Existing studies mainly focused on unconventional policies, such as asset purchase programmes (APP) and negative interest rates, to investigate their impact on asset markets and commercial banks. Limited research has looked into macro liquidity injection tools such as the three-year LTROs and the TLTROs, especially at the firm level. This study fills the void by analysing how non-financial corporations in the euro area have reacted to the unconventional LTROs, thus providing estimates of the impact of central bank liquidity injections on the corporate sector.

The empirical results show that non-financial corporations in the euro area increased their leverage ratio and cash holdings after the introduction of TLTROs, while investment was little affected by both the TLTROs and the three-year LTROs. This implies increased liquidity passed through from commercial banks to the corporate sector, but failed to translate into more real economic activities, potentially due to heightened economic uncertainty that supported more precautionary cash holdings. Overall, the targeted LTRO (TLTRO) was more effective in terms of stimulating credit creation and increasing firms' leverage compared with the three-year LTROs. This could be due to the fine-tuned nature of TLTROs with their inbuilt penalty system which punishes insufficient lending growth and restricts bank's use of TLTRO funding on investment activities other than bank lending. In addition, the results indicate that small firms benefitted more from the unconventional LTROs, as their leverage and cash holding increased

²⁴ A dummy variable named Small (equals 1 if the size of the firm belongs to the lower 5th percentile in the sample, and equals 0 otherwise) is created and is interacted with the TLTRO and the three year LTRO variable.

more in percentage terms compared with that of large firms under the TLTRO scheme.

Indeed, the findings suggest the macro liquidity injection from unconventional LTROs reached enterprises in the euro area for leverage and cash holdings. However, the lack of stimulus to real economic activities implies that the ECB is only partially successful in its intention of promoting credit and improving the real economy. In summary, the unconventional LTROs can be deemed effective in easing credit conditions (especially the Targeted LTROs), but may not be regarded as successful in stimulating real economic output. To this end, more carefully designed and fine-tuned monetary policy tools, together with policies that could alleviate economic uncertainty, would be more useful in promoting real economic activities.

REFERENCE

Audretsch, D. B., & Elston, J. A. (2002). Does firm size matter? Evidence on the impact of liquidity constraints on firm investment behaviour in Germany. *International Journal of Industrial Organisation*, 20(1), 1-17.

Alvarez, I., Casavecchia, F., De Luca, M., Duering, A., Eser, F., Helmus, C., ... & Pasqualone, F. (2017). *The use of the Eurosystem's monetary policy instruments and operational framework since 2012* (No. 188). ECB Occasional Paper.

Andrade, P., Cahn, C., Fraisse, H., & Mésonnier, J. S. (2015). Can the Provision of Long-term Liquidity Help to Avoid a Credit Crunch? Evidence from the Eurosystem's LTRO. *Journal of the European Economic Association*.

Bloom, N. (2009). The impact of uncertainty shocks. *Econometrica*, 77(3), 623-685.

Crosignani, M., & Carpinelli, L. (2017). The Effect of Central Bank Liquidity Injections on Bank Credit Supply. *New York University, Working Paper*.

Daetz, S. L., Subrahmanyam, M. G., Tang, D. Y., & Wang, S. Q. (2017). Did ECB Liquidity Injections Help the Real Economy in Europe? *The 43rd European Finance Association Annual Meeting (EFA 2016)*.

Ehrmann, M. (2005). Firm size and monetary policy transmission—evidence from German business survey data. *Ifo Survey Data in Business Cycle and Monetary Policy Analysis* (pp. 145-172). Physica-Verlag HD.

Ferreira, M. A., & Vilela, A. S. (2004). Why do firms hold cash? Evidence from EMU countries. *European Financial Management*, 10(2), 295-319.

Fonseca, L., Faria-e-Castro, M., & Crosignani, M. (2015). *Central Bank Interventions, Demand for Collateral, and Sovereign Borrowing Costs* (No. w201509).

Garcia-Posada, M., & Marchetti, M. (2016). The bank lending channel of unconventional monetary policy: The impact of the VLTROs on credit supply in Spain. *Economic Modelling*, 58, 427-441.

Harford, J., & Uysal, V. B. (2014). Bond market access and investment. *Journal of Financial Economics*, 112(2), 147-163.

Krishnamurthy, A., Nagel, S., & Vissing-Jorgensen, A. (2017). ECB policies involving government bond purchases: Impact and channels. *Review of Finance*, 22(1), 1-44.

Black, J., Hashimzade, N., & Myles, G. (2016). The impact of uncertainty on activity in the euro area. *Economic Bulletin, Issue 8 2016*, 1-20.

APPENDIX

A.1

Table A1 Summary statistics for sampled non-financial corporations

Variable	Obs	Mean	SD	Min	Max
Size	44,523	6.096	2.349	1.693	11.869
Cash	44,278	0.111	0.108	0.002	0.583
Investment	38,072	0.009	0.011	-0.005	0.071
Leverage	44,523	0.594	0.223	0.104	1.378
NetDebt	44,278	0.483	0.271	-0.322	1.296
STDebt	44,382	0.350	0.188	0.037	0.983
LTDebt	38,334	0.180	0.148	0.000	0.679
BankDebt	28,752	0.174	0.165	0.000	0.789
PB	41,932	2.131	2.317	0.000	14.826
CF	43,537	0.012	0.026	-0.103	0.094
NWC	44,367	0.104	0.171	-0.321	0.591
Sales	43,407	0.235	0.150	0.012	0.837
RDSales	45,662	0.055	0.180	0.000	1.167
Acquisitions	45,662	0.002	0.009	-0.003	0.073
Industrysigma	45,458	6.942	1.173	3.574	9.499
ESI	41,752	4.583	0.084	4.357	4.759
BLS	44,064	0.076	0.151	-0.380	0.380
SovCDS	44,268	0.000	0.001	0.000	0.007
SovExport	44,064	0.567	0.234	0.175	1.140
BAA10Y	45,662	0.027	0.004	0.018	0.034
# Corp	1,342				

Note: All numbers in decimals. Data covers 2010 Q1 to 2018 Q2

Source: Capital IQ, ECB, Bloomberg, World Bank database and European Com

Table A2 Country uptake of unconventional LTRO funding (estimated)

	Three-year LTRO	Three-year LTRO Country Uptake	TLTRO	TLTRO Country Uptake
	Nov 2011 and Feb 2012 EUR (billions)	% of gross government debt	Jun 2014 and Jun 2016 EUR (billions)	% of gross government debt
Country	(1)	(2)	(3)	(4)
AUSTRIA	11.49	4.20%	14.22	5.19%
BELGIUM	88.99	21.20%	10.75	2.56%
FRANCE	12.12	0.61%	1.57	1.26%
GERMANY	25.38	1.17%	0.93	1.06%
GREECE	60.94	18.68%	4.30	4.75%
IRELAND	39.52	19.42%	25.05	4.67%
ITALY	300.20	14.41%	23.05	13.51%
NETHERLANDS	10.81	2.50%	15.49	9.15%
PORTUGAL	49.30	22.29%	9.50	5.06%
SPAIN	318.74	32.77%	281.37	21.74%

Source: Bloomberg estimations and World Bank

Note: Gross government debt is defined as total gross central government debt averaged between 2011 and 2016, and is obtained from the World Bank database

A.2 Full model specifications

$Leverage_{f,t}$

$$\begin{aligned}
&= \alpha_{FE} + \beta_1^{Leverage} LTRO_{country(f),t} \\
&+ \beta_2^{Leverage} threeyrLTRO_{country(f),t} + \beta_3^{Leverage} TLTRO_{country(f),t} \\
&+ \beta_4^{Leverage} LnIndustrySigma_{f,t} + \beta_5^{Leverage} CF_{f,t} \\
&+ \beta_6^{Leverage} \frac{M}{B}_{f,t} + \beta_7^{Leverage} Size_{f,t} + \beta_8^{Leverage} Sales_{f,t} \\
&+ \beta_9^{Leverage} NWC_{f,t} + \beta_{10}^{Leverage} Investment_{f,t} + \beta_{11}^{Leverage} Cash_{f,t} \\
&+ \beta_{12}^{Leverage} R\&D/sales_{f,t} + \beta_{13}^{Leverage} Acquisition_{f,t} \\
&+ \beta_{14}^{Leverage} SovCDS_{country(f),t} + \beta_{15}^{Leverage} SovExport_{country(f),t} \\
&+ \beta_{16}^{Leverage} BAA10Y_{country(f),t} + \beta_{17}^{Leverage} BLS_{country(f),t} + \varepsilon_{f,t}
\end{aligned}$$

$Investment_{f,t}$

$$\begin{aligned}
&= \alpha_{FE} + \beta_1^{Investment} LTRO_{country(f),t} \\
&+ \beta_2^{Investment} threeyrLTRO_{country(f),t} \\
&+ \beta_3^{Investment} TLTRO_{country(f),t} \\
&+ \beta_4^{Investment} LnIndustrySigma_{f,t} + \beta_5^{Investment} CF_{f,t} \\
&+ \beta_6^{Investment} \frac{M}{B}_{f,t} + \beta_7^{Investment} Size_{f,t} + \beta_8^{Investment} Sales_{f,t} \\
&+ \beta_9^{Investment} NWC_{f,t} + \beta_{10}^{Investment} Leverage_1_{f,t} \\
&+ \beta_{11}^{Investment} R\&D/sales_1_{f,t} + \beta_{12}^{Investment} Acquisition_1_{f,t} \\
&+ \beta_{13}^{Investment} SovCDS_{country(f),t} \\
&+ \beta_{14}^{Investment} SovExport_{country(f),t} \\
&+ \beta_{15}^{Investment} BAA10Y_{country(f),t} + \beta_{16}^{Investment} LnESI_{country(f),t} \\
&+ \varepsilon_{f,t}
\end{aligned}$$

$Cash_{f,t}$

$$\begin{aligned}
&= \alpha_{FE} + \beta_1^{Cash} LTRO_{country(f),t} + \beta_2^{Cash} threeyrLTRO_{country(f),t} \\
&+ \beta_3^{Cash} TLTRO_{country(f),t} + \beta_4^{Cash} LnIndustrySigma_{f,t} \\
&+ \beta_5^{Cash} CF_{f,t} + \beta_6^{Cash} \frac{M}{B}_{f,t} + \beta_7^{Cash} Size_{f,t} + \beta_8^{Cash} Sales_{f,t} \\
&+ \beta_9^{Cash} NWC_{f,t} + \beta_{10}^{Cash} Investment_1_{f,t} + \beta_{11}^{Cash} Leverage_1_{f,t} \\
&+ \beta_{12}^{Cash} R\&D/sales_{f,t} + \beta_{13}^{Cash} Acquisition_{f,t} \\
&+ \beta_{14}^{Cash} SovCDS_{country(f),t} + \beta_{15}^{Cash} SovExport_{country(f),t} \\
&+ \beta_{16}^{Cash} BAA10Y_{country(f),t} + \beta_{17}^{Cash} LnESI_{country(f),t} + \varepsilon_{f,t}
\end{aligned}$$

Table A3 Investment (four-quarter ahead moving average) model results

	Investment
	Model A3
$X_{country(f),t}^{LTRO}$	0.001 (0.00)
$X_{country(f),t}^{threeyearLTRO}$	0.000 (0.00)
$X_{country(f),t}^{TLTRO}$	-0.003** (0.00)
Constant	0.003 (0.00)
Firm controls	YES
Country controls	YES
N	27227
R-square	0.647

Robust standard errors in parentheses and *, ** denote significance at 5% and 1%.

Investment is defined as the four-quarter ahead moving average of capital expenditure divided by the total asset of a firm. $X_{country(f),t}^{LTRO}$, $X_{country(f),t}^{threeyearLTRO}$ and $X_{country(f),t}^{TLTRO}$ are variables for country-level (mapped to individual firm) total LTRO uptake, three-year LTRO uptake and TLTRO uptake, respectively.

Table A4: Small firm and large firm interaction term results

	Small Firms		
	Leverage	Investment	Cash
	Model A4.1	Model A4.2	Model A4.3
$X_{country(f),t}^{LTRO}$	-0.007* (0.00)	0.001 (0.00)	0.014** (0.00)
$X_{country(f),t}^{threeyearLTRO}$	0.007 (0.01)	0.002** (0.01)	-0.004 (0.00)
$X_{country(f),t}^{TLTRO}$	0.035** (0.01)	-0.001 (0.00)	0.004 (0.01)
$X_{country(f),t}^{threeyearLTRO}$ * <i>small</i>	0.048 (0.05)	-0.011 (0.01)	0.030 (0.04)
$X_{country(f),t}^{TLTRO}$ * <i>small</i>	0.176* (0.07)	-0.008 (0.01)	0.471** (0.07)
Constant	0.572** (0.01)	0.007 (0.00)	0.129** (0.03)
Firm control	YES	YES	YES
Country control	YES	YES	YES
N	33157	32130	31481
R-square	0.858	0.518	0.784

Robust standard errors in parentheses and *, **denote significance at 5% and 1%.

Small is a dummy variable that equals 1 if the firm is in the lower 5th percentile of firm size as of 2011 Q3 and equals 0 otherwise. Leverage is the book value of long-term debt plus current liabilities over total asset. Investment is defined as capital expenditure over total assets. Cash is defined as cash and short-term investments over total assets of a firm.

$X_{country(f),t}^{LTRO}$, $X_{country(f),t}^{threeyearLTRO}$ and $X_{country(f),t}^{TLTRO}$ are variables for country-level (mapped to individual firms) total LTRO uptake, three-year LTRO uptake and TLTRO uptake, respectively.