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Who takes the ECB's targeted funding?

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Who takes the ECB's targeted funding?

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Abstract

This paper investigates motives of banks to borrow funds from the ECB through its first two series of targeted longer-term refinancing operations (TLTROs) allotted between September 2014 and March 2017. We quantify that the top-three parameters that determine banks' take-up decisions are the price of the operation, the amount of eligible collateral of the bank, and the composition of that collateral. In particular, the opportunity for banks to transform their less liquid assets partly into liquid central bank reserves by pledging these assets as collateral with the central bank is a strong motive for take-up and suggests that accepting a broad set of collateral was important for the monetary easing provided by TLTROs. In addition, we find that the conditions attached to TLTRO participation and take-up played an important role in creating broad-based participation across banks of different financial strength and size.

JEL: C23, C24, E52, E58, G21.

Keywords: monetary policy operations, funding for lending, targeted longer-term refinancing operations, take-up behaviour, dynamic Tobit panel.

Non-technical summary

In 2014 the European Central Bank (ECB) launched a new non-standard measure in the form of targeted longer-term refinancing operations (TLTROs) to “reinforce the ECB’s accommodative monetary policy stance and to strengthen the transmission of monetary policy by further incentivising bank lending to the real economy.” Under this programme, banks that fulfil certain conditions receive an allowance to borrow longer term funds from the central bank against collateral.

This paper asks what characterises and incentivises individual banks to take this “funding for lending” which peaked at EUR 762 billion and what role the parameters of the scheme play. Understanding these aspects is important for several reasons. First, there is the public concern whether such funds dominantly end up with financially weak banks. Second, as targeted operations are a new monetary policy instrument, understanding better what determines take-up can allow the central bank to fine tune the parameters of any future scheme in view of its objectives. Third, as a first step in the transmission of the conditions of the scheme to the real economy, the distribution of take-up contains information about the transmission of monetary policy.

The study employs a unique data set of individual banks’ take-up per quarterly operation that was allotted as part of the first two TLTRO programmes between September 2014 and March 2017. Panel data methods are applied to these data to test a wide range of potential drivers of take-up and participation at the bank level. The subsequent third TLTRO programme that started in September 2019 is not subject of the study.

The main contributions are the following. First, we identify the parameters of the TLTRO programme that banks care about the most when deciding on their take-up. We find that the top-3 of drivers of take-up consists of the price of the operation, the amount of eligible collateral available at the level of the bank, and the composition of that collateral. The result confirms that the operations were attractively priced and that banks tend to dedicate a share of their collateral buffer to take-up. We also notice that these are exactly the parameters that the ECB changed when it made its third TLTRO programme more attractive during the Covid-19 crisis in March-April 2020, namely lowering the TLTRO interest rate and expanding the amounts and types of eligible collateral.

Second, we provide empirical evidence that banks activate a share of their non high quality liquid assets (non-HQLA) to raise the overall liquidity of their balance sheet. The mechanism is a form of liquidity transformation by which banks pledge non-HQLA as collateral with the ECB to obtain HQLA in the form of central bank reserves. Furthermore, as regulatory liquidity ratios can benefit from this liquidity transformation, the result also hints at regulatory motives for take-up. This finding suggests

that the Eurosystem collateral framework had an important role in the monetary stimulus that TLTROs provided.

As regards the distribution of the funds, in contrast to the common perception about take-up in central bank operations in crisis times, we do not find strong evidence that TLTRO funds end up importantly with financially weak banks. If anything, banks with a larger capital buffer take up more. The finding is important in view of the aim of the programme to steer new lending and not merely to provide access to funding. The finding is also interesting in view of the fact that the programme incentivises deleveraging banks to participate and that this does not need to mean that financially weak banks will dominate take-up. Instead take-up appears broad-based across deleveraging and non-deleveraging banks, financial weaker and stronger banks and small and large banks. We conclude that the conditionality of the TLTROs played an important role in facilitating broad-based participation across banks of different financial strength and size.

The results entail lessons for the design of future funding for lending schemes. First, setting a lower TLTRO interest rate helps offsetting the dampening effect of weak loan demand on take-up. Also, a lower interest rate incentivises participation when banks already hold excess reserves and are reluctant to take-up more central bank reserves via TLTROs. Second, applying different lending requirements to deleveraging versus non-deleveraging banks when determining their borrowing allowance performs well in neutralising the effect of deleveraging pressures on take-up. Namely, the share of non-performing loans held on bank balance sheets, as a proxy for bank deleveraging pressures, is found to matter little economically in explaining take-up. Furthermore, the four-year maturity which most operations carried appears to have served participation and take-up well. In addition, the importance of collateral availability and its composition as drivers of take-up shows that sizeable longer-term refinancing operations better go hand in hand with a broad collateral framework to support participation.

Finally, the fact that the price and maturity of the operations are important drivers of take-up suggests that the attractive conditions of those parameters are passed on to banks. Together with the signs that the funds were borrowed by a large and broad set of banks, we conclude that the very first stage of the transmission of the TLTRO conditions to the real economy looks promising. A study of the use of the TLTRO funds would provide more direct insights about the likely impact on the real economy, but goes beyond the scope of this paper.

1. Introduction

In the aftermath of the global financial crisis and the euro area sovereign debt crisis, the euro area experienced a sharp contraction in credit to the real economy. By March 2014, euro area bank lending to non-financial corporations and to households for non-house purposes contracted at annual rates of 3.0% and 1.9%, respectively.¹ To some extent the contraction reflected a healthy correction from the excessive lending and misallocation of funds in the run-up to the crises, but the debt deflation pressures that these crises triggered required intervention by central banks to prevent a downward economic spiral (Fisher, 1933). The European Central Bank (ECB), like other major central banks, aimed to avoid severe economic contraction by cutting its policy rates and by launching several non-standard measures to safeguard the transmission of monetary policy and the supply of credit to the economy.

In June 2014 the ECB announced its targeted longer-term refinancing operations (TLTRO) programme as a new non-standard measure. This programme is a “funding for lending” scheme whereby banks that fulfil certain conditions receive an allowance to borrow longer term funds from the central bank against collateral in order to boost bank lending to the real economy. The second TLTRO programme started as of June 2016 and both programmes together comprised twelve TLTROs. Although these operations are novel and complex in their design they have dominated take-up in the ECB’s refinancing operations for several years. The design was inspired by the funding for lending scheme of the UK who was the first to launch such a scheme as a credit easing measure.² The design of both programmes differed, however, as the ECB set different conditions and parameters largely reflecting economic and financial differences between both regions.

This paper asks which banks take funding for lending and why. It studies the incentives of banks to take up EUR 762 billion by the time of the last operation in March 2017, what characterises participants and what role the parameters of the scheme play. Understanding these aspects is important for several reasons. First, the central bank has an interest for total take-up can be large and involve a broad set of counterparties that expand the size of the central bank balance sheet and the risks it carries. Although the ECB is protected thanks to the collateralisation of the operations there is a public concern whether funds dominantly end up with financially weak banks. Second, as central bank communication suggests that these schemes are considered to be effective, they are likely to be used again in the future when central banks find it is again time for credit easing policies.³ Understanding better what determines take-up should allow the central bank to fine tune the parameters of any future scheme in view of its objectives. Third, as a first step in the transmission of the conditions of the scheme to the real economy, the distribution of take-up contains information about the transmission of monetary policy. For example, Andrade et al. (2018)

¹ These figures compare to the high annual growth rates before the crisis of e.g. 15% and 2.1%, respectively, in March 2008.

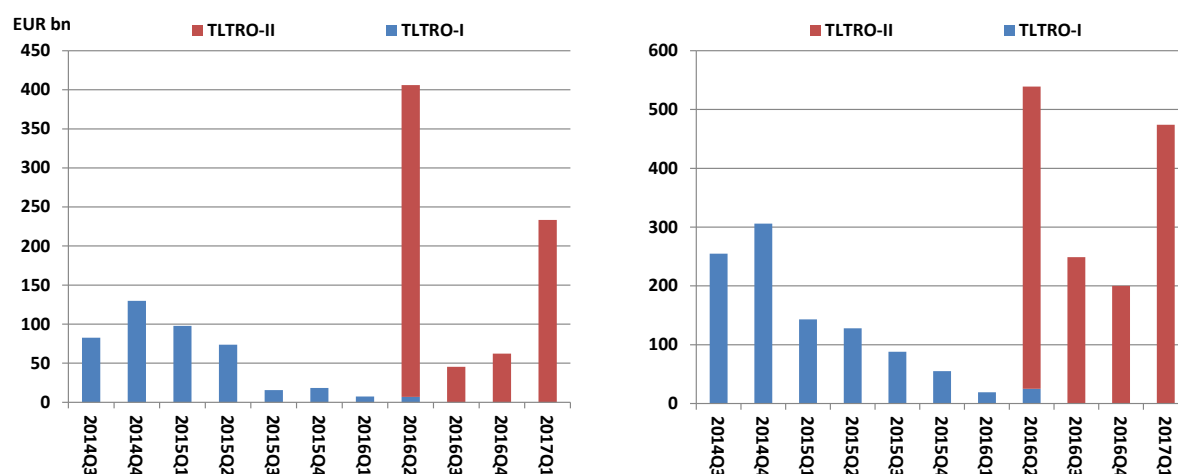
² As of 2012, banks and building societies were offered cheap funding linked to additional lending to the real economy. The scheme was designed to reduce funding costs for banks and building societies so that they can make loans cheaper and more easily available.

³ See ECB (2015b), Churm et al (2015) and Andreeva and García-Posada (2019) for early views on the macroeconomic impact.

find that banks that took up more in the ECB's 3-year longer-term refinancing operations (LTROs) provided more bank lending. The paper does not assess the impact of the operations on lending or the broader economy which would require a study of the use of the funds. While that is a relevant research topic, analysing the impact of the TLTRO take-up is fraught with difficult identification issues and addressing those would go beyond the scope of this paper. Nevertheless, the findings on who takes the ECB funding provide indirect insights of the likely intended use of these funds.

The study employs a unique data set of individual banks' take-up in the first two TLTRO programmes per quarterly operation allotted between September 2014 and March 2017. The proprietary information on participation and take-up is matched with publicly available data on characteristics of the operations, bank balance sheet items, business model indicators, and macroeconomic conditions. Chart 1 presents the total take-up and number of bidders per operation, while also distinguishing between two parts of the programme. The aim is to explain this take-up and participation at the micro level using panel data methods. The ECB has started a third TLTRO programme of seven quarterly operations as of September 2019 which is on-going and not subject of this study.

Chart 1: Take-up (lhs) and number of bidders (rhs) per operation and quarter



Source: ECB.

The main findings of the paper are the following. First, we identify the parameters of the TLTRO programme that banks care about the most when deciding on their take-up. We find that the top-3 of drivers of take-up consists of the price of the operation, the amount of eligible collateral available at the level of the bank, and the composition of that collateral. In order to make funding for lending schemes attractive, we therefore conclude that the central bank should pay particular attention to those three parameters. We notice that these are exactly the parameters which the ECB has changed when it made its third TLTRO programme more attractive during the Covid-19 crisis in March-April 2020. Therefore, we expect these changes to support take-up significantly in the third programme.

The cost advantage of the operation, i.e. the TLTRO interest rate versus that of alternative market funding, contributed the most to take-up. For example, a forty basis points cut in the TLTRO interest rate, which equalled the spread between the ECB policy rate and deposit facility rate for most of the

sample period, boosts the likelihood of participation by 15 pp and take-up over assets per operation by 0.33 percentage points (pp). The latter is economically significant in view of the average take-up over assets of 0.58% per bank and operation in the sample. Collateral availability is the second most important driver. For example, ten percent more of ECB-eligible collateral available on the balance sheet, boosts the participation likelihood by 36 pp and take-up over assets by 0.8 pp per operation. The result suggests that banks dedicate a share of their available collateral to take-up.

Second, we provide empirical evidence that banks activate a share of their non high quality liquid assets (non-HQLA) to raise the overall liquidity of their balance sheet. The mechanism is a form of liquidity transformation by which banks pledge non-HQLA as collateral with the ECB to obtain HQLA in the form of central bank reserves. Although the incentive for liquidity transformation has been described in the literature, we provide evidence that this driver is important as it is the third strongest driver of take-up. We find that ten percent more of non high quality liquid securities on the balance sheet boosts the participation likelihood by 21 pp and take-up over assets per operation by 0.8 pp. Furthermore, as regulatory liquidity ratios can benefit from this liquidity transformation, the result also hints at regulatory motives for take-up.

Third, the results suggest that the conditionality of the TLTROs played an important role in facilitating broad-based participation. For instance, in contrast to other studies on take-up in central bank operations, we do not find strong evidence that TLTRO funds end up importantly with financially weak banks. If anything, banks with a larger capital buffer take up more. The finding is important in view of the aim of the programme to steer new lending and not merely to provide access to funding. And, the finding differs from that of e.g. Drechsler et al. (2016) who find that weakly capitalised banks took out more ECB loans and used riskier collateral during the European sovereign debt crisis. The finding is also interesting in view of the fact that the programme incentivises deleveraging banks to participate via a less strict lending benchmark and that this does not need to mean that financially weak banks will dominate take-up. Instead take-up appears broad-based across deleveraging and non-deleveraging banks, financial weaker and stronger banks and small and large banks. As regards the latter, studies on bidding in other Eurosystem operations conducted under the variable rate tender procedure had typically found that larger bidders were more active; see e.g. Bruno et al. (2005). The simplicity of the full allotment procedure that applies in Eurosystem refinancing operations, whereby bank demand is fully satisfied at the fixed price rather than determined in an auction, may contribute to the finding as it may not provide information advantages to certain larger and more sophisticated market participants.

Literature. Our paper contributes to the literature modelling banks' participation in open market operations of central banks. As regards funding for lending schemes, the literature is currently limited to descriptive reports such as ECB (2017) and Churm et al. (2012). In comparison, the literature on participation in other types of operations is more extensive. The closest related studies are those analysing take-up under the ECB's full allotment tender procedure such as Drechsler et al. (2016). The larger part of that literature focuses on explaining bid rates and volumes that result from variable rate tenders of bank reserves, and thus focus on pre-crisis episodes when that procedure was used by the ECB in the main refinancing operations (MROs) and 3-month longer-term

refinancing operations (LTROs). Those studies already deviate more from our purposes as they investigate drivers of strategic behaviour in bid prices that are largely irrelevant under full allotment and may require a different consistent estimator in the presence of endogenous sample selection. However, at least their analysis of the role of bank size and interest rate uncertainty remains relevant.⁴

The finding that liquidity transformation plays an important role for participation in the operations contributes to the literature on the market impact of the central bank collateral framework and the interaction with liquidity regulation. These points of interaction of collateral with financial markets and the regulatory arbitrage are described by e.g. Bindseil (2014). Several theoretical models have been developed to explain related aspects. For example, Ewerhart and Tapping (2008) and Bindseil (2013) show that higher quality collateral is preferred for private transactions and lower quality collateral is pledged with the central bank. Koulischer and Struyven (2014) study the relationship between the quantity and quality of collateral and interest rates in the economy. However, empirical evidence has remained scarce, apart from e.g. Cassola and Koulischer (2019) showing that an increase in the haircut of low rated collateral reduces the use of this collateral.

The study is related to the literature analysing the effect of central bank liquidity provision on bank credit supply, or in other words whether there is a bank lending channel for non-standard monetary policy measures.⁵ On the theoretical side, models by Stein (1998) and Ritz and Walther (2015) provide microfoundations for the role of bank funding availability and liquidity risk within this channel. On the empirical side, the literature has expanded fast with evidence of how liquidity strains impact credit supply.⁶ As regards the provision of central bank liquidity at early stages of the crisis, Iyer et al. (2014) find limited positive overall effects on the credit supply by banks in Portugal and therefore suggest the design of alternative public policies that try to increase the supply of credit to firms. The three-year funds offered by the ECB in two operations at the end of 2011 and the beginning of 2012 are such a measure aiming to prevent a credit crunch. Andrade et al. (2018), Carpinelli and Crosignani (2018), and García-Posada and Marchetti (2016) find positive moderate-sized effects of these two operations on the credit supply to firms in France, Italy and Spain, respectively. That impact did not prevent that credit growth underwent a significant correction in those countries, but the operations are broadly seen to have helped preventing an outright credit crunch where liquidity constrained banks see themselves forced to deleverage and enter a downward spiral. Andreeva and García-Posada (2019) study responses to the ECB's bank lending survey to assess the TLTROs and find that margins of loans to relatively safe borrowers are adjusted

⁴ See e.g. Bindseil et al. (2004), Bruno et al. (2005), Cassola et al. (2013), Craig and Fecht (2007), Craig et al. (2015), Eisenschmidt et al. (2009), Eisenschmidt and Holthausen (2010), Ewerhart et al. (2010), Fecht et al. (2011), Linzert et al. (2005), Linzert et al. (2007), Nautz and Oechssler (2003).

⁵ Through this channel, monetary policy can shift the supply of bank loans, which affects the external finance premium of firms and this way influences interest rates. For discussions of the bank lending channel see in particular Kashyap and Stein (1994) and Bernanke and Gertler (1995).

⁶ On how bank liquidity stress led banks to hoard liquidity to protect themselves and cut lending during the US financial crisis see Ivashina and Scharfstein (2010) and Cornett et al. (2011) among others. Similar findings are reported for the euro area countries by e.g. Puri et al. (2011) and Iyer et al. (2014). On emerging markets see in particular Paravisini (2008), Khwaja and Mian (2008) and Schnabl (2012).

as a direct effect, but they also identify indirect effects and spillovers to non-targeted loan categories. Bats and Hudepohl (2019) find that the lending benchmark of the TLTRO-II was an effective credit easing instrument.

This paper is structured as follows. Section 2 introduces the targeted longer-term refinancing operations. Section 3 presents the data and the empirical strategy. In Section 4, the estimates for the drivers of take-up amounts are presented. Section 5 assesses the robustness of the results and Section 6 concludes.

2. The operations

By participating in the ECB's refinancing operations, banks can borrow reserves from the central bank against collateral at a certain interest rate. The TLTROs provided central bank reserves at longer maturity of two to four years depending on the operation. The TLTROs were targeted in the sense that they restricted who can borrow, namely banks that already lend to the real economy, and how much they can borrow, by setting a limit based on their lending performance. This section recalls the main features of the operations and Annex 1 lists further details. An interesting development is that the ECB changed some of the parameters over time and such variation can inform our estimations.

This study focuses on the first two series of TLTROs that were launched. A first series of eight operations (TLTRO-I) was announced on 5 June 2014 and a second series of four operations (TLTRO II) on 10 March 2016. In each of the twelve operations, counterparties were entitled to borrow up to a bid limit which was set per counterparty based on its recent lending performance to the euro area non-financial private sector. The definition of that allowance has varied over time depending on the operation as explained in Annex 1, but overall, as a first condition for participation, counterparties needed to have sufficient eligible loans.

The TLTROs were conditional in the sense that the lending performance of banks had to beat a certain benchmark for them to fully benefit from the attractive conditions of the programme. TLTRO-I applied the 'stick' approach by threatening with mandatory repayment if the benchmark was not reached by a specific moment in time. It also provided a 'carrot' approach as the bid allowance for operations 3 to 8 was based on the recent additional net lending. TLTRO-II applied a different carrot approach by lowering the interest rate on the operation down to the deposit facility rate if the benchmark were beaten. The programmes foresaw two types of benchmarks for banks to beat: for banks that recently showed positive net lending, the benchmark was set to zero and hence required banks to show positive net lending henceforth, and for banks that deleveraged their loan portfolio a negative benchmark applied that required banks to deleverage at least at a lower rate.

The interest rate on the TLTROs was generally the rate that prevailed on the MROs at the time of the allotment of the TLTRO. However, for the first two TLTRO-I operations an add-on of 10 basis points applied and TLTRO-II included the possibility that the interest rate could be as low as the deposit facility rate depending on the lending performance. When the lending was assessed in 2018, it

turned out that the large majority of banks beat their benchmark and obtained the deposit facility rate.

In both programmes, counterparties could participate individually or, subject to certain conditions, on a group basis. In the latter case, the calculation of the TLTRO group's benchmark and borrowing allowances were based on aggregated loan data for the TLTRO group. The advantage for members of such a group is that the eligible loans of one bank could count to obtain a bidding allowance and funds for the entire group, while the bidding expertise/infrastructure of another bank in the group could be relied on to place bids. In practice, 75 TLTRO groups were established which participated through a lead institution.

TLTRO-I operations matured in September 2018, implying that the initial maturity of the quarterly operations declined from four years for the first operation to two years and one quarter for the last operation, while all four TLTRO-II operations had a maturity of four years maturing between June 2020 and March 2021.

The tender procedure is the fixed rate full allotment (FRFA) procedure. This implies that bid amounts are fully accommodated at the interest rate of the operation. The ECB has implemented this procedure in almost all refinancing operations since October 2008. Before, the variable rate tender procedure had applied in the refinancing operations, whereby counterparties submit both bid rates and volumes to compete for a pre-set amount of central bank reserves.

In parallel to TLTROs, the ECB continued to offer one-week funds via MROs and 3-month funds via monthly longer-term refinancing operations using the FRFA procedure. The take-up in those regular operations declined to historically low levels as banks switched into TLTROs. At the time of the first TLTROs, certain banks still had amounts outstanding in the 3-year LTROs that matured early 2015, i.e. they had not fully taken use of the early repayment options attached to the 3-year LTROs. Among those banks those with access to the TLTROs could roll over outstanding amounts into the first TLTROs. Also the injection of bank reserves that resulted from the ECB's asset purchase programme that ran in parallel to TLTROs as of March 2015 contributed to lower demand in refinancing operations.

According to the press releases, TLTROs intend "to reinforce the ECB's accommodative monetary policy stance and to strengthen the transmission of monetary policy by further incentivising bank lending to the real economy." To the extent that the operations offer attractive long-term funding conditions to market participants, the intention is that banks pass these on to their credit conditions and stimulate credit creation. With respect to monetary policy transmission, the ECB stressed the easing of borrowing conditions and the signalling channel (ECB, 2015b). This way the monetary policy stance is eased further and the bank lending channel of monetary policy is supported. At the same time, the programme wants to prevent that financially constrained banks cut their credit provision excessively, which would tighten the effective monetary stance and dampen economic activity.

The conditionality of the operations implies that TLTROs are not pure lender-of-last-resort (LOLR) instruments. The LOLR function prescribes that the central bank offers funding to banks in exchange

of good collateral without further conditions during a liquidity crisis to stop bank runs; see the literature going back to Bagehot (1873). Such support prevents that solvent banks need to enter fire sales that trigger knock-on effects and prevent banks from lending. In contrast, TLTROs aim to channel the funds to credit institutions that lend to the real economy as the central bank identified a need to support that sector. Such conditionality finds support in findings as those by Abbassi et al. (2016) indicating that even financially strong banks may be tempted to invest in securities rather than lending to the real economy. However, setting conditions on who can get how much and against which conditions deviates from this LOLR principle.

3. Data and empirical strategy

3.1 Data

The study starts from a set of 940 banks that participated or could have participated in TLTROs. That sample excludes several banks for which the matching with balance sheet item information delivered unrealistic figures. A further 21 institutions were excluded that are classified as government sponsored banks, development banks, or government financial institutions, because they face different incentives than entirely private banks. Among the 940 banks, 812 have bid at least once in the operations. In fact most banks participated once or twice, leaving a concentrated and sporadic trace of participation across banks and time (Chart 2). Among those that never bid, 52 banks did not apply for participation in the TLTRO programmes, while data on their loan portfolio suggests that they held eligible loans and hence could have joined the programme had they chosen to do so. We include those banks as they add information on banks with zero take-up. After matching with the various data sets described below, the estimates are typically based on 630 banks.

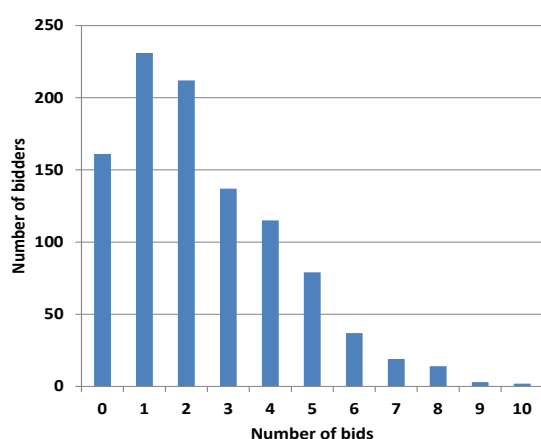
The sample period covers eleven quarters from 2014Q3 until 2017Q1 and eleven of the twelve TLTRO operations executed in that period. The last TLTRO-I operation is left out of the analysis, because it was conducted at the same time as the first TLTRO-II operation in June 2016 and this allows us to preserve the quarterly panel data structure. Ignoring that operation should not impact the results as the operation had become largely obsolete given its worse rate and maturity conditions and attracted only tiny take-up from a few banks that wanted to take-up more than what they would be allowed to take up in TLTRO-II.

The dataset matches ECB proprietary data with information from private providers. Bank level data on TLTRO participation, participation in other Eurosystem refinancing operations, pledged collateral including (non) high quality liquid asset holdings and forthcoming redemptions of bank bonds, excess liquidity holdings, and bank lending survey results are taken from databases of the European Central Bank. These are matched with bank balance sheet, CDS and rating data provided by S&P Global Market Intelligence.⁷ The pricing of ECB policy rate expectations and EURIBOR-OIS spreads are derived from Bloomberg market data. Covered bond yields at the country level are provided by

⁷ The balance sheet indicators include the amount of wholesale funding, profit, non-performing loans, tier-1 capital, equity, (short-term) loans, a subsidiary indicator, and total assets.

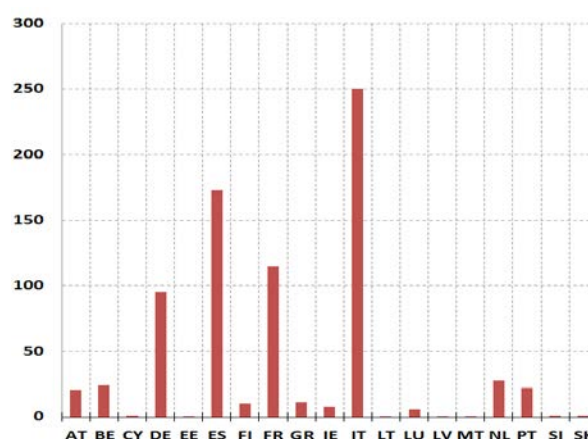
Markit iBoxx and are checked for consistency against averages of yields on individual bonds observed on the Thomson Reuters platform. For countries that lack a liquid covered bond market, a proxy of the covered bond yield is computed by adding the spread on sovereign bonds to Germany to the German covered bond yield using Bloomberg data on generic government bond yields. Senior unsecured bank bond yields at the country level are calculated as averages of yields on individual bonds based on Thomson Reuters data. For countries that lack such bonds, a proxy yield is computed by adding the spread on sovereign bonds to Germany to the German senior unsecured bank bond yield using Bloomberg data. Interest rate uncertainty is derived from option-implied densities extracted from ICE Futures data. Unemployment rates are provided by Eurostat. In case of data available at daily frequency, which concerns all explanatory variables except the bank balance sheet items, the variables are measured on the dates of the deadlines by which banks need to submit TLTRO bids to the Eurosystem. For bank balance sheet items, data of the latest quarter before each operation is used. Annex 2 provides descriptive statistics while Section 4 elaborates on the definition of each explanatory variable.

Chart 2: Histogram of number of bids across all operations



Source: ECB.

Chart 3: Take-up outstanding in longer-term refinancing operations per country (as of 1 April 2017; EUR bn)



Note: longer-term refinancing operations include 3-month LTROs and Targeted LTROs, because take-up in TLTROs per country is confidential information.

Source: ECB.

For TLTRO groups, we focus on the bank characteristics of the lead institution. This is an approximation as in principle the TLTRO take-up may be motivated by the other group members and TLTRO funds may also flow to them. However, as the lead institution is typically a large member it should also be representative of the group. The alternative approach of attempting to aggregate information at TLTRO group level appears fraught with difficulties.

3.2 Empirical strategy

Panel data estimation techniques are applied to identify the drivers of participation and take-up in the operations. The probability for a bank to participate in an operation is modelled by a dynamic Probit panel data model where the functional form ensures that probability predictions fall within the feasible 0-100% space. For bank i and operation $t = 1, 2, \dots, 11$:

$$P(y_{i,t} = 1 | y_{i,t-1}, \dots, y_{i,0}, \mathbf{x}_i, \mu_i) = \Phi(\alpha + \boldsymbol{\beta}' \mathbf{x}_{i,t} + \gamma y_{i,t-1} + \mu_i), \quad (1)$$

where $y_{i,t}$ is the indicator variable for whether the bank participated in the operation, $\mathbf{x}_{i,t}$ is the matrix of observations on the explanatory variables, and μ_i is the unobserved bank specific effect.

The amounts banks take up in the operations are modelled by a dynamic Tobit panel data model where the functional form accounts for the fact that in case of non-participation take-up is censored at zero. Consider

$$y_{i,t} = \max[0, \alpha + \boldsymbol{\beta}' \mathbf{x}_{i,t} + \gamma y_{i,t-1} + \mu_i + v_{i,t}], \quad (2)$$

$$v_{i,t} | y_{i,t-1}, \dots, y_{i,0}, \mathbf{x}_i, \mu_i \sim N(0, \sigma_v^2),$$

for $t = 1, 2, \dots, 11$. Note that this study focuses on explaining a bank's take-up as a ratio of the size of the bank. The reason is simply that larger banks can be expected to have larger funding needs and hence their size should be accounted for. Some studies have focused on explaining the absolute level of take-up, which is equivalent to explaining the ratio as long as the size of the bank is included as an explanatory variable (Linzert et al., 2007). Others do not include bank size as an explanatory variable which should imply that the estimation will focus mainly on explaining the take-up by large banks (Drechsler et al., 2016).

The dynamic non-linear panel data model estimator of Wooldridge (2005) is applied to the data. The persistence in the panel data calls for the dynamic specification as in (1) with the first lag of the dependent variable proving to be statistically significant in most cases. The estimator is essentially a random effects estimator which for consistency requires that the composite error, $\mu_i + v_{i,t}$, is uncorrelated with the explanatory variables. As that assumption will typically not hold in practice and because the fixed effects estimator does not apply to dynamic non-linear models, the unobserved heterogeneity is instead modelled by including time-constant controls giving rise to the correlated random effects models as discussed by e.g. Greene (2015). The need to control for unobserved heterogeneity is addressed by the Wooldridge (2005) approach which models μ_i as a linear function of the initial condition $y_{i,1}$ and $\mathbf{z}_i$ the row vector of all (nonredundant) explanatory variables in all time periods, as originally suggested by Chamberlain (1980). In addition, time series averages of not included explanatory variables are included as originally suggested by Mundlak (1978). Wald tests show that those control variables are always jointly significant, but as their coefficients are not of interest the below estimate tables do not present them.

The regressions include a number of quadratic and interaction explanatory variables to allow and test for non-linearity in the effects. However, interaction variables that are not significant at the 10% significance level in t-tests and F-tests are left out of the specifications. This keeps the list of interaction variables contained and avoids collinearity issues. Allowing for these effects in the regressions supports unbiased inference of the coefficients on the linear variables and the average partial effects. The results present Hubert-White robust standard errors for the Probit models and jack-knife resampling is applied to obtain robust standard errors for the Tobit models.

4. Estimation results

A broad range of explanatory variables are considered covering parameters of the operations, banks' financial strength, bank asset and liability items, business model characteristics and macroeconomic and financial conditions. This way, many potential drivers can be tested and ranked along the size of their impact while controlling explicitly for other potential drivers. In addition, a broad set of explanatory variables allows constructing a significant set of Chamberlain-Mundlak variables that support the inference in correlated random effects models. The correlation between the explanatory variables is limited and multicollinearity is not a concern.

Tobit results for seven regressions are presented in Table 1. The coefficient estimates of each regression are presented in panels (a) and (b), with (a) listing the coefficients on the linear variables and (b) the coefficients for the interaction variables. The statistically significant interaction variables in panel (b) show that the drivers of take-up often reinforce or dampen each other's effect.

As the coefficients of the non-linear Probit and Tobit models are poor indicators of the marginal effects of the explanatory variables, we need additional estimates to obtain a view on the economic significance of the drivers. For that purpose, panel (c) of Table 1 presents estimates of the average partial effects (APE) per explanatory variable for the Tobit estimates presented in panels (a) and (b), where the APE is the average change in the observed take-up when each bank's value for the explanatory variable is raised by one unit. The discussion focuses mainly on the APEs.

4.1 Main drivers of take-up

If we focus on the three drivers with the largest impact, then we notice that these are the pricing of the operations, the amount of available collateral of the bank and the amount of non-HQLA the bank holds. Table A summarises the economic significance for the main drivers.

4.1.1 Cost advantage

As regards TLTRO pricing, what should matter for take-up is not the TLTRO rate, but its difference to the cost of alternative funding in the market.⁸ As covered bond issuance is the closest alternative to TLTRO participation, covered bond yields of comparable maturity are used to proxy the opportunity cost of TLTRO participation.⁹ Chart 4 presents the resulting TLTRO cost advantage for selected countries per operation. We observe significant level differences across countries in line with liquidity and credit risk spread differentials in the market, while there is a strong correlation across time of the cost advantages. The cost advantage roughly reveals a U-shaped time pattern as the advantage declined on average towards the end of the TLTRO-I programme and then rose again with

⁸ Annex 1 describes how the rates applicable to the operations changed over time.

⁹ The cost advantage derivation follows the approach by Will and von Koss (2016). Namely, a new issuance premium of five basis points is added to the covered bond yields. Next, this opportunity cost is compared to the all-in cost of TLTROs, which takes into account that haircuts are applied by the Eurosystem and that this part needs to be funded on an unsecured basis, where senior unsecured bank bond yields serve as a proxy for that cost. For euro area countries that lack a liquid covered bond market, a proxy of the covered bond yield is computed by adding the spread on sovereign bonds to Germany to the German covered bond yield.

the conditions offered by the TLTRO-II programme as well as the rise in market yields.¹⁰ We define this explanatory variable at the country level because covered bond yields or other funding cost variables for individual banks are not available for our large sample of banks. In terms of robustness of the results, note that including country dummies in the regressions does not change the results and the cost advantage variable is hence not simply loading on country specific characteristics.

Table A: Effects of the main drivers of take-up and participation

	Take-up over assets		Probability of participation	
	Effect of 1 st.dev. increase	As a % of the st.dev. of take-up over assets	Effect of 1 st.dev. increase	As a % of the st.dev. of the probability of participation
Cost advantage (%)	0.80 pp	42%	37 pp	88%
Available collateral over assets	0.43 pp	23%	19 pp	44%
Non-HQLA holdings over assets	0.42 pp	22%	11 pp	26%

Note: Based on the average partial effects reported in Table 1(c), this table summarises the economic significance of the three drivers with the largest effects on take-up over assets and the probability of participating in TLTROs.

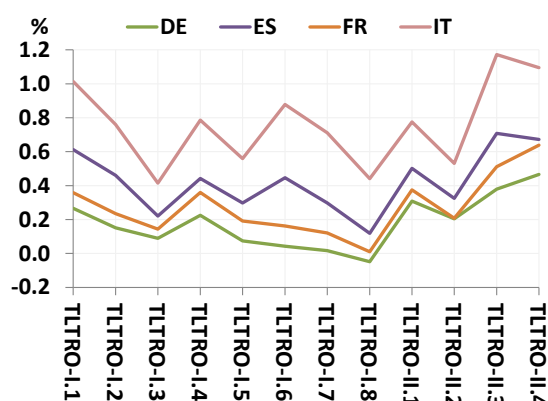
The results show that the pricing of the operation has a significant impact on take-up. In particular, the APE of the cost advantage in the base regression (1) suggests that a one percentage point cost advantage, which happens to be close to the standard deviation of the cost advantage, raises the take-up over assets by 0.83 pp (Table 1(c)). The effect is economically significant, accounting for 42% of the standard deviation of the take-up over assets (Table A). Equivalently, a 10 bps cut in the TLTRO rate would all else equal raise take-up by 0.08 pp. Taking into account that the mean take-up over assets in the sample is 0.58% per bank and operation, a 10 bps rate cut could raise take-up by roughly 14% ($=0.08/0.58*100$). The result is consistent with the euro area bank lending survey where banks put forward the attractive TLTRO conditions (i.e. profitability motive) as the dominant driver of participation in their replies; see e.g. ECB (2015a) and ECB (2017b).

As simultaneity cannot be ruled out, the effect of the cost advantage may in fact be underestimated. In principle, the (anticipated) take-up in the Eurosystem operations or simply the possibility for banks to participate could ease funding costs in the market, which would imply that the regressions underestimate the effect of the cost advantage variable.

The interaction effects with other explanatory variables show that when banks face a weak macroeconomic situation then the cost advantage would need to be significantly higher to entice the same take-up as other banks. Chart 5 presents the APE for the cost advantage at specific values for non-performing loans (NPLs) and unemployment, using the base regression (1). The cost advantage has a much larger effect on take-up of up to 1.6 pp when there is no unemployment (i.e. loan demand is high) and declines to 0.6 pp when unemployment reaches 20%. The curve flattens as NPLs increase, but not in statistically significant ways.

¹⁰ Most studies on bidding behaviour consider opportunity costs, e.g. Bindseil et al. (2004) and Cassola et al. (2013) find that the opportunity cost variable played a role in the context of MROs.

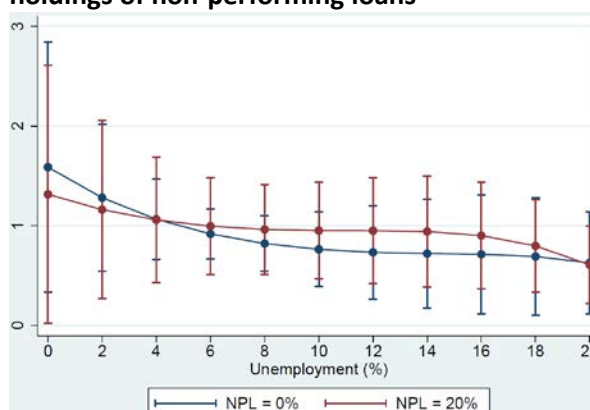
Chart 4: Cost advantage of participation in TLTRO operations for selected countries



Source: IBoxx, Thomson Reuters, ECB.

Note: Shown is the difference between the cost of covered bond issuance and the all-in cost of TLTROs.

Chart 5: Average partial effect of the cost advantage as a function of unemployment and holdings of non-performing loans

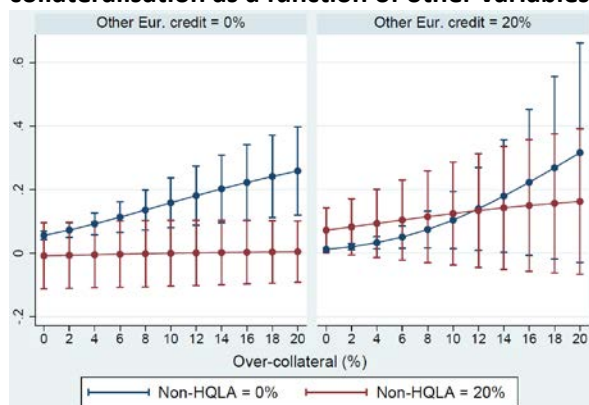


Note: APEs are calculated at different levels of the unemployment rate (x-axis) and non-performing loans (NPL) to assets (curves). The box plots indicate 95% confidence intervals.

4.1.2 Available collateral

Banks pledge their collateral with the Eurosystem in ‘a pool’, which is typically larger than the amounts they use to borrow in refinancing operations at a given point in time. Our hypothesis is that this amount of over collateralisation could play a role in considering additional take-up in TLTROs. On the one hand, it has to play a role because to the extent that it reflects the total collateral available to the bank, it creates a physical limit on how much the bank can borrow. On the other hand, it could play an economic role if banks determine their take-up as a function of that amount of available collateral. As an explanatory variable, the value of collateral pledged with the Eurosystem (after haircuts) minus the amount already encumbered by outstanding Eurosystem credit enters the regressions.

Chart 6: Average partial effect of the over-collateralisation as a function of other variables



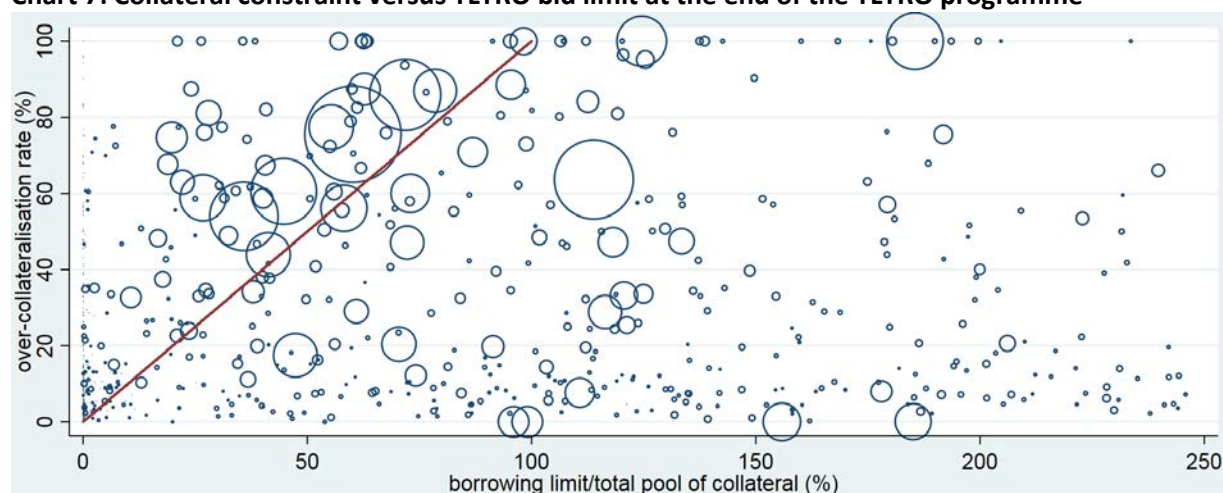
Note: APEs are calculated at different levels of the interaction variables. The box plots indicate 95% confidence intervals.

The effect of collateral availability is economically strong in promoting take-up. Having 10% more of collateral on the balance sheet is found to boost the take-up by 0.8 pp (Table 1(c)). Or, a one standard deviation increase in this variable accounts for 23% of the standard deviation of take-up over assets (Table A). Chart 7 shows that only few banks can be considered to be collateral constrained in the sample as few banks are located on the x-axis. Therefore, the result is not driven by mere shortages. Instead, banks appear to reserve a share of their available collateral for take-up in

the TLTROs. In this context, Carpinelli and Crosignani (2018) also found that collateral availability played an important role in the take-up of 3-year LTROs.

The APE of over-collateral as a function of other variables tentatively suggests that over-collateral incentivises take-up the most when the bank has high levels of over-collateral, collateral that is liquid and of high quality, and has no other Eurosystem credit outstanding (Chart 6). In particular, the APE curves are upward trending in most cases, suggesting large amounts of over-collateral make it attractive to use some for TLTRO take-up. High levels of non-HQLA holdings dampen the effect by flattening the curve from the blue to the red curve, suggesting that those benefiting from liquidity transformation attach a lower weight to over-collateral in their decision. Also, judging from the difference between the two panels of Chart 6, if the amount of other Eurosystem credit outstanding is high, then non-HQLA has less of a dampening impact, suggesting the liquidity transformation may already partly be satisfied in other Eurosystem operations and over-collateral matters again more for TLTRO take-up. Note, however, that the confidence intervals often suggest that interaction effects are not significantly different from each other or from zero.

Chart 7: Collateral constraint versus TLTRO bid limit at the end of the TLTRO programme



Note: The size of the circles denotes the amount of the borrowing limit that is not used as of 30 March 2017. The red line indicates the 45-degree line below which counterparties have a borrowing limit that is larger than their over-collateral. The over-collateral rate is defined here as total collateral minus outstanding Eurosystem credit as a percentage of total collateral, where the collateral is the value after haircuts.

Source: ECB.

4.1.3 Liquidity transformation and regulatory incentives

The share of non high quality liquid assets (non-HQLA) in the total assets of banks is found to have a strong economic effect. In particular, having 10% more non-HQLA on the balance sheet is found to boost take-up by 0.8 pp (Table 1(c)). Or, a standard deviation increase in this variable accounts for 22% of the standard deviation of the take-up over assets (Table A).

The holdings data that we use to construct the explanatory variable reflect the amount of non-HQLA collateral pledged by individual banks with the Eurosystem.¹¹ As a caveat, note that the collateral variables that we employ are proxy variables for the total amounts of collateral available at banks, because banks do not necessarily place all their collateral with the Eurosystem. Nevertheless, since

¹¹ The actual liquidity ratios of those banks might offer a better measure, but are not available for such a large sample of banks. Furthermore, note that the non-HQLA holdings are not highly correlated with the over-collateral holdings, reflecting how the collateral composition differs significantly across banks and time.

the amounts banks pledge with the Eurosystem are typically large we are confident they contain sufficient information about the collateral availability of banks.

In addition, it cannot be excluded that banks place more collateral with the Eurosystem in anticipation of future take-up, which could support the relation found between collateral and take-up. Nevertheless, even if this were the case the conclusion would remain that those able to pledge more collateral are found to take up more TLTRO funding. An investigation of the collateral management of banks would be interesting in this context but goes beyond the scope of this study.

We interpret our finding in the way that refinancing operations of the Eurosystem can be of interest to banks simply to borrow liquid central bank reserves in return for pledging less qualitative and less liquid securities with the Eurosystem. Namely, if part of a bank's assets is difficult to monetise in financial markets it could be attractive to make it liquid if it is accepted as collateral by the central bank. This particularly applies to the euro area, where the Eurosystem accepts a broad set of collateral types. Although the Eurosystem asks for a larger amount of collateral than what it provides in amount of reserves to protect itself against credit risk, i.e. so-called haircuts apply, the liquidity transformation could nevertheless be attractive to banks (Bindseil et al., 2017).

In addition, this liquidity transformation can boost banks' liquidity ratios if they participate in TLTROs. In particular, take-up can raise the liquidity coverage ratio (LCR) and net stable funding ratio (NSFR), two requirements that were put forward as part of the regulatory framework agreed by the Basel Committee on Banking Supervision in its third instalment (i.e. Basel III). To have a positive effect on the ratios, banks particularly need to pledge non-HQLA as collateral with the central bank. The remainder of the section explains the effects on both ratios in more detail.

Effect on the liquidity coverage ratio

The LCR promotes the short-term resilience of a bank's liquidity risk profile. It does this by ensuring that a bank has an adequate stock of unencumbered high-quality liquid assets (HQLA) that can be converted into cash easily and immediately in private markets to meet its liquidity needs for a 30 calendar day liquidity stress scenario. As such, the ratio is defined as the bank's holdings of HQLA over the net outflows expected over the next 30 days.

When a bank borrows TLTRO funds, the central bank reserves obtained count as level-1 HQLA for the fulfilment of the ratio. At the same time, the collateral mobilized becomes encumbered and can no longer be considered for the purpose of the LCR. The overall effect on the LCR depends on the type of collateral pledged. As long as that collateral is non-HQLA (or level-2 HQLA with smaller haircuts at the central bank), the bank improves its overall HQLA holdings and thus the numerator of the ratio.¹²

Effect on the net stable funding ratio

The NSFR promotes resilience over a longer time horizon by creating incentives for banks to fund their activities with more stable sources of funding on an ongoing basis. It is defined as the ratio of

¹² For more details on HQLA categories see BIS (2013): "Basel III: Liquidity Coverage Ratio and Liquidity Risk Monitoring Tool", Basel Committee on Banking Supervision.

available stable funding (ASF) to required stable funding (RSF) of a bank, which must equal or exceed 100%. For both the numerator and denominator, bank balance sheet items receive specific weights depending on the liquidity character of the source of funding and exposures. Although the requirement becomes binding only in mid-2021, it had initially been expected to be implemented much earlier and banks have aimed to fulfil the ratio for window dressing reasons towards investors and rating agencies in advance. In other words, even though supervisors only monitor the progress of banks towards achieving the target in the future, market pressure is widely seen as already pushing banks to comply much before the deadline.

The NSFR can be supported by TLTRO participation, in particular if less liquid securities are pledged as collateral. For the calculation of the ratio, bank liabilities with residual maturity above one year receive an ASF weight of 100%. Therefore, TLTRO funds classify for 100% as ASF for the fulfilment of the NSFR as long as they have a residual maturity of above one year, while the central bank reserves obtained are assigned a 0% weight for the RSF. At the same time, the collateral mobilised by the bank becomes encumbered and receives a higher RSF weight because it can now no longer be monetised. Depending on the type of collateral, different RSF weights apply with pledging of less liquid assets such as credit claims boosting the NSFR the most, while pledging of government bonds generally does not improve the NSFR. The positive effect on the NSFR is dampened by the haircuts that the central bank applies to the pledged collateral, because it means that the bank needs to pledge a higher amount of collateral than the reserves it receives. For lower quality and less liquid collateral, higher haircuts apply that will hence dampen the positive effect on the NSFR.¹³

4.2 Additional drivers of take-up

This section presents the results for the explanatory variables that are found to play a smaller role in explaining take-up. For instance, it allows us to test drivers that were found relevant in other studies of take-up in refinancing operations. The results allow us to extract a few policy relevant lessons as summarised in Section 6.

4.2.1 Characteristics of the operations

Apart from the pricing of the operations, certain operations might have been perceived more special than others and it appears important to control for that in the estimations.

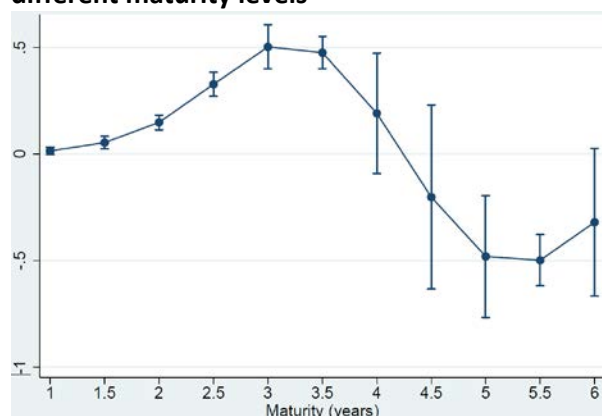
Maturity. Long-term funding is typically attractive to banks, because at least from a regulatory perspective a maturity of above one year fully counts as stable funding for the fulfilment of the Basel-III net stable funding ratio requirement, as explained above. In addition, access to longer-term funding facilitates the match with longer-term loans on the bank's asset side. In this context, Andrade et al. (2018) found that the long maturity of the 3-year LTROs was important in explaining the amount that banks would lend to firms.

The maturity of the operations (measured in years) is statistically and economically significant as apparent from regression (7). On average, raising the maturity of the operation by one year boosts

¹³ For more details on ASF and RSF factors see BIS (2014): "Basel III: The Net Stable Funding Ratio", Basel Committee on Banking Supervision.

participation by 0.27 pp (Table 1(c)). The maturity effect is presented in a separate regression in the tables, because the variable is competing empirically with the cost advantage variable, as the most attractively priced operations happen to be the ones offering the longest maturity. Note that the collinearity of the cost advantage and maturity suggests that the effect of the cost advantage largely relies on its variation across time.

Chart 8: Average partial effect of the maturity at different maturity levels



Note: APEs are calculated at different levels of the maturity. The box plots indicate 95% confidence intervals.

A maturity of three or three-and-half years appears optimal for take-up. This is apparent from Chart 8 which shows that the APE reaches a maximum for those maturities, while it is already declining at four years of maturity. Reportedly, the ECB set the maturity of most TLTROs to four years as that roughly matched the average maturity of relevant loans to the real economy. However, the results suggest that banks may take up more had the maturity been somewhat shorter.

Switch opportunity. The first TLTRO-II operation is special, because the ECB created the opportunity in June 2016 for banks to repay take-up in all TLTRO-I operations and switch into the first TLTRO-II operation. Therefore, for explaining the relatively large take-up in TLTRO-II.1, it is important to control for this opportunity that was offered in June 2016. As an explanatory variable, the amount outstanding in TLTRO-I that could be switched into TLTRO-II (over assets) is included in the regressions. Also, the repayment options offered in the subsequent quarters for specific TLTRO-I operations provided similar switch opportunities and are therefore included in the variable, but involved much smaller amounts.

As expected, the results show that the opportunity to switch to TLTRO-II supported take-up figures. As Table 1(c) shows, one percentage point more of TLTRO-I funds over assets that could be switched to TLTRO-II boosts take-up by 0.22 pp. Economically, that effect appears limited suggesting also other drivers determined the take-up in the first TLTRO-II operations. The interaction effects with other explanatory variables suggest that the opportunity to switch sizeable amounts into TLTRO-II reduced the effects of non-performing loan (NPL) holdings, non-HQLA holdings and capital, suggesting those three drivers were somewhat over-ruled when the opportunity appeared (Table 1(b)). At the same time, the opportunity enforced the supportive effect of the amount of available collateral.

Last opportunity. Including a dummy variable for the last operation shows that the last opportunity to participate in TLTROs made that operation particularly attractive. The take-up in the last TLTRO operation is estimated to be about 1.16 pp higher than the other TLTRO operations. This finding appears consistent with the market perception at that time suggesting that comments by ECB President Draghi that the ECB was not planning to introduce additional liquidity operations made the

last TLTRO attractive.¹⁴ The finding is also consistent with the replies to the euro area bank lending survey where more banks reported “precautionary motives” played a role at the time of the last operation, i.e. “to reduce current and/or prevent future funding difficulties” (ECB, 2017b).

The impression that opportunistic behaviour contributed to the take-up in the last operation finds some further support. Namely, the estimates suggest that the higher the amount of available ECB-eligible collateral, the more non-performing loans are held and the higher the country’s unemployment, the higher the participation in the last operation. Furthermore, this operation caused a significant upward jump in excess liquidity by EUR 204 bn to EUR 1,543 bn in contrast to previous operations which were either smaller in size and/or reflected significant substitution effects from outstanding take-up in other operations. Also, market analysts appear to have significantly underestimated the aggregate take-up of EUR 233 bn at that time, while they were closer in predicting outcomes for previous operations.

In addition, note that the total take-up in the TLTRO programmes may also be influenced by characteristics of the programme that we do not manage to quantify. In particular, the operations appear to have benefited from positive reputational effects as media reported on participating banks as ‘supporting the real economy’ while absence from the operations could attract criticism. This effect can also be deducted from the fact that several banks made their take-up amount public. Bloomberg gathered the take-up amounts revealed by individual banks totalling EUR 277 bn for TLTRO-II out of a total take-up of EUR 740 bn. Also, certain banks have referred to TLTRO conditions when advertising new lending schemes.¹⁵ In contrast, participating in the 3-year LTRO programme was often associated with negative reputational effects, ex ante since borrowing from the central bank at the height of the crisis may signal balance sheet weakness, and, ex post as banks were suspected of investing the funds importantly in government bonds and earning the spread; see e.g. Fonseca et al. (2015).

4.2.2 Financial strength

Capital. The TLTRO funds do not dominantly end up with weakly capitalised banks. Including the tier-1 capital ratio of banks as an explanatory variable, which compares core equity capital to total risk-weighted assets, shows that its APE is not statistically significant (Table 1(c)). If one nevertheless wants to assess the effect e.g. based on its significance in Table 1(a-b), then notice that the APE estimate is positive suggesting that banks with a higher tier-1 capital ratio tend to have larger take-up.¹⁶ This signals that those with more balance sheet capacity would take up more, e.g. for new loan issuance that would raise risk weighted assets, compared to those with lower capital that may face higher market funding costs. The literature often came to the opposite conclusion when studying take-up in other Eurosystem operations during the crisis with riskier banks taking up relatively more;

¹⁴ Maraffino, G., “The Final TLTRO: too good to miss”, Euro Money Market Weekly, Barclays, 28 March 2017.

¹⁵ E.g. the prospect of one bank reads “the money that [the bank] borrowed at a discount belonged to the TLTRO programme of the ECB. [The bank] has chosen to fully pass-through this advantage to its customers as a discount on the interest rate.”

¹⁶ The coefficient on the linear variable of the tier-1 capital ratios is not statistically significant based on t-tests (Table 1(a)), but the variable is jointly significant with the interaction terms (Table 1(b)) based on F-tests.

e.g. Drechsler et al. (2016).¹⁷ Interaction effects show that any positive effect of the tier-1 capital ratio on take-up is strengthened somewhat by higher NPLs (Table 1(b)). This suggests that banks with larger NPLs particularly take the opportunity of higher TLTRO take-up (and new investment) as soon as the tier-1 capital ratio allows.

Non-performing loans. In the aftermath of the global financial crisis and the sovereign debt crisis in the euro area, the level of non-performing loans (NPL) that banks held received considerable attention in the first place by bank supervisors but also by the central bank as a concern for monetary policy transmission. The level of NPLs may signal that banks face deleveraging pressure and are not keen on an expansion through new funding, but may also signal financial weakness where TLTROs may be seen as an attractive funding opportunity. Furthermore, as the sample period in which the impact of capital is assessed is rather particular because banks were in the process of raising their capital to well above the regulatory requirement, it appears important to also control for NPL holdings.

The evidence suggests that banks holding more NPLs take up more in TLTROs but the effect is limited in size. The APE of NPLs is slightly positive but not always statistically significant at the 10% significance level (Table 1(c)). The APE is small in size, with one percentage point raising take-up by only 0.02 pp, and a one standard deviation increase accounting only for 4.4% of the standard deviation of take-up over assets.¹⁸

Profit. The profitability of banks is not found to be a driver. A priori either sign could be expected for the profitability: do less profitable banks see this as an attractive funding opportunity or do highly profitable banks see more opportunities to make use of the funds? As a variable the net income over total assets is used, but is not statistically significant in regression (2). Alternative variables capturing various return definitions do not alter that conclusion.

4.2.3 Asset side

Apart from the collateral holdings discussed among the main drivers, other assets may be important for the take-up of banks.

Excess liquidity. The amount of central bank reserves that banks hold in excess of their reserve requirements is found to have a dampening impact on take-up. The effect is limited in economic terms with one percentage point of excess liquidity over assets reducing take-up by 0.03 pp, and a one standard deviation increase accounting only for 6.6% of the standard deviation of take-up over assets.

¹⁷ While funding support to financially constrained banks may raise the credit risk absorbed by the central bank, it may support bank lending in an important way. Andrade et al. (2018) found that 3-year LTRO liquidity injections were more efficient for less capitalised banks in supporting loan supply. They interpret this as the positive bank funding shock having a stronger impact on bank lending when banks are ex ante financially constrained.

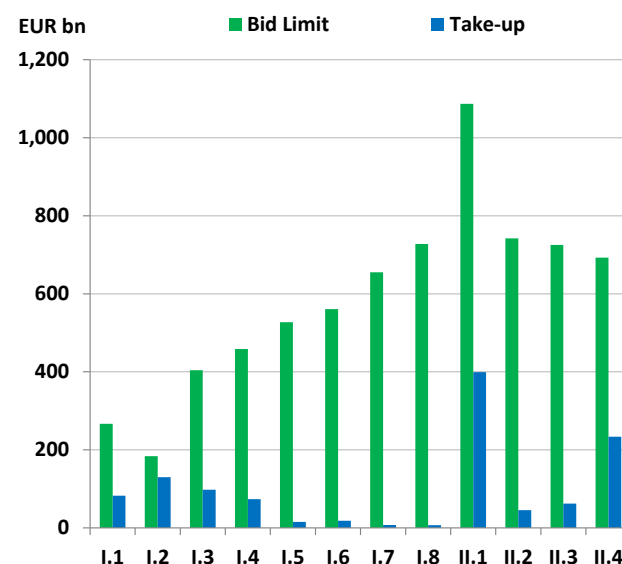
¹⁸ The coefficient on the linear variable in Table 1(a) is negative, suggesting banks facing deleveraging pressure may have taken up relatively less, but economically this tentative effect is over-ruled by the mostly statistically insignificant positive APE in Table 1(c).

A priori it may not be entirely clear if such holdings should matter, because from a pure portfolio allocation perspective banks evaluate these holdings against any other potential investment. However, the result of a dampening impact on take-up may at least partly be driven by the asset purchase programme that the ECB ran in parallel to TLTROs as of March 2015. The central bank reserves that the purchases inject lead to higher excess liquidity that needs on aggregate to be held by banks and thus reduces their demand for liquidity transformation through refinancing operations with the central bank. Baldo et al. (2017) show that excess liquidity holdings are highly concentrated with certain countries and banks and our regression results suggest that those banks are less keen on take-up.

Bid limits. Take-up was generally not censored by the conditionality of the TLTROs as bid limits turned out to be rather generous. In theory, take-up is censored by the bid limit each bank had received and that can complicate inference. In practice, however, the bid limits of the TLTROs acted as a constraint on take-up only in few cases such that the censoring can be ignored not to complicate the regressions.¹⁹ Chart 9 presents the aggregate bid limit per operation, which equals the sum of the allowance each bank received minus previous take-up. The allowance was calculated according to three different definitions over time; see Annex 1 for info on the conditionality that applied to each operation. Overall, bid limits were rather generous and grew over time during TLTRO-I as eligible lending grew and take-up in previous TLTROs was contained. The allowance for TLTRO-II was set above EUR 1 trillion and remained generous throughout that programme as take-up remained significantly below the bid limits.

For most banks the borrowing limit is larger than the over-collateralisation, as shown in Chart 7 by the bubbles below the 45-degree line. These banks would rather be constrained by the amount of collateral available, although they may also have more collateral that they had not yet pledged with the Eurosystem. Another large share of banks appears above the 45-degree line indicating that the borrowing limit is tighter than the over-collateralisation.

Chart 9: Aggregate bid limit and take-up per operation



Source: ECB.

¹⁹ Thus, bid limits are not included as an explanatory variable, also because that info would not exist for the group of banks in our sample that did not register for the TLTRO programmes or that did not submit loan templates for certain operations.

4.2.4 Liability side

Wholesale funding. Banks that rely more on wholesale funding are not found to show different take-up behaviour. Wholesale funding is generally considered to be a less stable funding source which banks may be more inclined to replace with TLTRO funding than the deposit base. We find no role for such a funding structure effect as the explanatory variable is not statistically significant at the 10% significance level.²⁰

Outstanding TLTRO and other Eurosystem credit. As expected, the amount of outstanding TLTRO take-up and the amount of outstanding take-up in other Eurosystem operations (MRO, 3-month LTROs and 3-year LTROs) each have a dampening impact on TLTRO participation. The dampening effects are strong with one percentage point of TLTROs outstanding over assets and other Eurosystem credit over assets reducing further take-up by 0.17 pp and 0.06 pp, respectively (Table 1(c)). The explanatory variable for amounts outstanding in other Eurosystem credit operations is measured just after the allotment of TLTRO operations such that any switching from other operations into a TLTRO is taken into account.²¹

The dampening impact suggests that banks have a certain limit for total Eurosystem reliance in mind such that already outstanding amounts lower the probability of further take-up. As rating agencies and bank supervisors reportedly pay more attention to the Eurosystem exposure of banks since the global financial crisis, this driver may have gained relevance. Furthermore, interaction effects suggest that the dampening effect of other Eurosystem credit on TLTRO take-up is smaller if: 1) there is more collateral available, hence the bank is not approaching that type of constraint; or 2) if TLTRO take-up was already sizeable, which signals that the bank already expressed little preference for keeping short-term operations.

Redemptions. Funding pressures are not found to be a significant driver to the extent that banks may want to systematically replace maturing bonds with TLTRO funding. As an explanatory variable, the regressions include the value of bonds banks see maturing in the coming year. Regression (3) shows this variable is not statistically significant, which is somewhat surprising because forthcoming redemptions could be seen as an obvious occasion to switch to TLTRO funding. Section 5 discusses this aspect further.

Future participation in funding for lending schemes is also likely to be dampened by total loss absorbing capacity (TLAC) requirements and the minimum requirement for eligible liabilities (MREL). These regulations will require banks to keep a certain share of bail-in-able funding, which TLTROs do not qualify for. As these regulations were neither active, nor clarified, at the time of the TLTRO allotments they are unlikely to be significant dampening factors on TLTRO participation in this sample.

²⁰ In a similar fashion, Carpinelli and Crosignani (2018) found that take-up in 3-year LTROs was uncorrelated with banks' exposure to the foreign wholesale market in 2011.

²¹ Andrade et al. (2018) found that the bulk of the stimulus to bank lending associated with bids in the first 3-year LTRO came from a substitution of short-term Eurosystem refinancing for participation in the longer-term operations.

4.2.5 Business model

Equity and the funding model. Banks that rely less on equity are found to materially rely more on TLTRO take-up. In particular, one percentage point more of equity reduces take-up by 0.06 pp. We interpret the equity ratio effect more as a funding model effect than a financial strength or leverage effect. The reason is that the regressions already control for credit risk indicators such as tier-1 capital ratio and NPLs, which were found to have little impact on take-up. Higher equity may thus simply signal that banks that rely less on debt funding will also rely less on Eurosystem credit. The equity variable is not highly correlated with tier-1 capital and the results show that it takes on a different role in the estimations with a different sign.

As regards interaction effects of the equity variable, banks with higher equity ratios are found to take more use of the switch opportunity, but take up less when demand is weak (i.e. unemployment is high). This suggests equity-reliant banks are not using all occasions to take up TLTRO funding, but when they did participate in TLTRO-I they were particularly keen on switching to TLTRO-II.

Loan specialisation, corporate structure and bank size. These business model properties do not add value in explaining take-up. In particular, subsidiaries do not take-up significantly less, while bank size and the share of loans to assets are also not found to play a role; see regression (4). Bank size could drive take-up when it reflects experience and sophistication in bidding (Bindseil et al. 2004), better market access, or a larger need for steady liquidity (Craig and Fecht, 2007).²² However, the total assets variable is not statistically significant in the context of TLTROs, possibly because take-up bids are fully accommodated and there is no need for competitive strategies. It also suggests that small banks find TLTROs equally accessible and participation is broad based.²³ Furthermore, the extent to which banks have a loan-based business model, as measured by total net loans over assets, is not statistically significant. The finding by Kashyap and Stein (2000) that the impact of monetary policy on lending is stronger for banks with less liquid balance sheets could have predicted a significantly positive coefficient, because it suggests that banks with the largest benefit from central bank intervention can be expected to take up more. One reason why the variable may not be significant is that the sample mainly focuses on banks with a loan business model leaving limited variation in the variable. In particular, banks in the sample on average hold 59% of loans on the asset side and the 5% lower-percentile also hold 26% of loans on the balance sheet.

4.2.6 Macro conditions

The operations take place against a specific macroeconomic background with for instance the demand for credit, interest rate expectations, interest rate uncertainty and the level of funding stress potentially determining take-up.

Loan demand. The larger the loan demand banks experience or expect to materialise, the more funding they may seek to meet that demand and expand their business. In this context, market

²² Bruno et al (2005) find that large bidders participate more regularly in variable rate tenders. Linzert et al (2007) find that a bank's participation probability in an LTRO increases with its size.

²³ We are underestimating the size of the TLTRO groups in our data, which leaves the possibility that if we would be able to correct for this issue that small individual banks are found to take up relatively more.

participants often found credit demand to be subdued at the time of the operations which might explain lower take-up on aggregate in the TLTROs.

As a proxy variable for loan demand at the time of each operation, a country's unemployment rate is used. The variable is kept part of the base specification in the regressions even though it is not always statistically significant to make sure there is a control variable for demand conditions. A priori, one may expect higher unemployment and the associated weaker loan demand to dampen take-up. However, the variable may also load on country risk that is not yet captured by other explanatory variables as it also shows a positive sign in certain regressions. Regression (5) includes also the indicator from the ECB bank lending survey capturing banks' sentiment about their expected loan demand.²⁴ The variable is found to be statistically significant, but carrying the wrong sign, and is therefore left out of the base specification.

Funding stress. Funding stress was low in the sample period and played no role economically. The spread between the 3-month EURIBOR and 3-month OIS rate serves as a proxy for bank funding stress in the regressions. This variable has commonly been used as a measure of liquidity and credit risk in the interbank market during the crisis and has been tested by e.g. Cornett et al. (2011). The negative sign on the coefficient suggests that the higher the aggregate funding stress, the lower the take-up. However, the spread was already below 13 bps by the time of the first TLTRO and declined to about 1 bp at the time of the last TLTRO. Thus, the spread stood at modest levels in general and the counterintuitive result has little economic significance. The fact that banks in their replies to the euro area bank lending survey reported "absence of funding constraints" as the main reason for non-participation supports this conclusion (ECB, 2017b). As a caveat, simultaneity may be affecting the estimation to the extent that take-up in the operations could dampen market stress, in which case the impact of funding stress is underestimated.

While the 3-year LTROs are seen as crisis measures that brought funding relieve to troubled banks at the height of the sovereign debt crisis, it cannot be argued that TLTROs were a continuation of that same policy. This can already be concluded from the fact that half of the TLTRO participants never participated in the 3-year LTROs, suggesting both type of operations to a significant extent attracted a different set of customers (Table 4). In addition, there were banks which had never joined the ECB credit operations that utilised TLTROs this time, which is also different from the 3-year LTROs.

Rate cut expectations. A variable capturing the probability that the ECB will cut rates by the end of the TLTRO programme carries the wrong sign. As the interest rate for TLTROs was fixed at the policy rate level at the time of each operation, any expectations of future policy rate cuts could support later take-up compared to today's take-up. As an explanatory variable, the market-implied probability of a 10 bps rate cut in the deposit facility rate by the time of the last TLTRO-I (and later the last TLTRO-II) is included. The wrong sign of the estimated effect may be explained by the fact that rate cut expectations only really appeared at the time the TLTRO-II was launched which nevertheless saw large initial take-up.

²⁴ This variable equals the net percentage of respondents to the euro area bank lending survey indicating that expected demand for loans to enterprises rose. As a robustness test, the indicator was replaced by the one summarising bank perceptions about the recent change in demand, but the conclusion remains the same.

Interest rate uncertainty. Uncertainty about future short-term interest rates is not found to be a driver of take-up. This variable has often been tested in other studies on participation in variable rate tenders although its expected sign is not clear a priori. On the one hand, the winner's curse would predict more cautious participation as interest rate uncertainty rises. On the other hand, it could be that banks do not want to lose out on the current attractive rate and take up more now. As an explanatory variable, the implied volatility (in bps) of 3-month EURIBOR in one year's time at the time of the operation is used. The coefficient is not statistically significant and carries a positive sign. The sign may reflect that at the effective lower bound a rise in interest rate uncertainty normally goes hand in hand with a rise in average interest rate expectations, making it attractive to participate now.²⁵ The insignificance would indicate that the cost of rescheduling TLTRO participation or bond issuance was higher than the cost of potential changes in the TLTRO rate.

Carry trade. Banks may participate in TLTROs and invest the funds in higher yielding securities rather than new lending.²⁶ This strategy needs to account for the risk of not meeting the lending benchmark and facing mandatory repayment under TLTRO-I or a higher interest rate under TLTRO-II. Several studies argue that banks used the ECB's 3-year LTROs for carry trade purposes, in particular because an increase was observed in the government bond exposures of banks reported by the European Banking Authority (EBA).²⁷ This paper does not apply the same test for carry trade motives as it is not clear if the EBA exposure measures are still comparable across time and in any case cover only a limited set of banks. However, we are convinced that carry trade motives played a limited role since government bond spreads declined to small levels compared to the 3-year LTRO period, making such strategies much less profitable. For instance, the spread on 2-year Italian, Portuguese and Spanish government bonds to Germany declined from 449, 1587, and 310 basis points to 39, 85 and 27 basis points between January 2012 and September 2014.²⁸

²⁵ Linzert et al (2007) find evidence of the winner's curse in 3-month LTROs with banks decreasing their participation significantly as interest rate volatility increases. In contrast, Bindseil et al. (2004) find that increased volatility leads to higher bids in MRO variable rate tenders, hence banks try to raise the chance of obtaining an allotment. Also Eisenschmidt et al. (2009) find that banks wish to secure their funds during financial turmoil and with greater interest rate uncertainty bid at higher rates in MROs. Bruno et al (2005) find that interest rate volatility lowers the probability of bidding in variable rate tenders, but also leads to higher bid interest rates.

²⁶ Note that the motive does not need to be entirely profit driven. It could also reflect a precautionary and regulatory motive of investing in liquid securities while lengthening the funding maturity. In addition, banks may park the TLTRO funds temporarily in securities before gradually channelling them towards new loan contracts which take time to establish.

²⁷ Evidence reported by Fonseca et al. (2015) suggests that Portuguese banks participating in the second 3-year LTRO bought significant amounts of high yielding short-term domestic government bonds for carry trade or liquidity parking motives. Acharya et al. (2017), Angeloni and Wolff (2012) and Drechsler et al. (2016) illustrate how banks tended to raise their holding of domestic government bonds.

²⁸ Market commentary also points to the limited carry trade incentives; see e.g. Mary-Dauphin, C., "TLTROII.2 Review", European Macro Strategy, Royal Bank of Scotland, 22 September 2016; Rieger, C. and Rack, J., "TLTRO II: Game Changer or Damp Squib?", Ahead of the Curve, Commerzbank, 16 June 2016.

5. Robustness

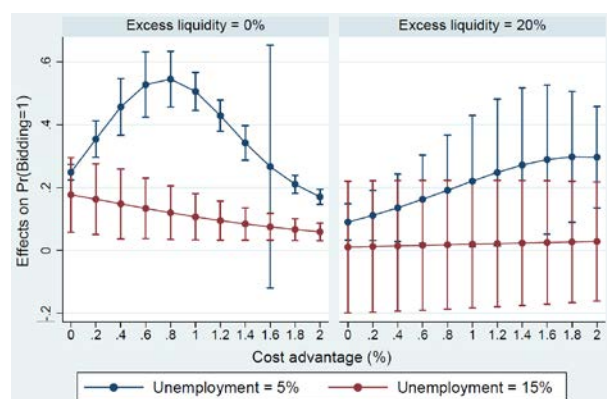
In order to assess the robustness of the Tobit results we place them next to those of the Probit specifications that model the decision to participate in the operations. Subsequently, alternative proxy variables are tested for certain potential drivers within the Tobit specification, and we also discuss the linear probability model.

5.1 Drivers of participation

Before banks decide on take-up amounts they decide whether to participate in TLTROs. As the drivers of the binary participation decision are unlikely to be fully detached from those that determine take-up amounts, this section discusses the estimates of the dynamic Probit models as a robustness check. It turns out that the results are indeed broadly consistent with those of the Tobit estimates as most drivers of the decision to participate are also those of the decision on the take-up amount over assets. At the same time, we should not expect the drivers to be fully the same or to play the same role. Therefore, this section focuses on the areas where the participation decision appears to differ from the take-up decision. Panels (a), (b) and (c) of Table 2 report the linear variable, interaction variable and average partial effect estimates, respectively.

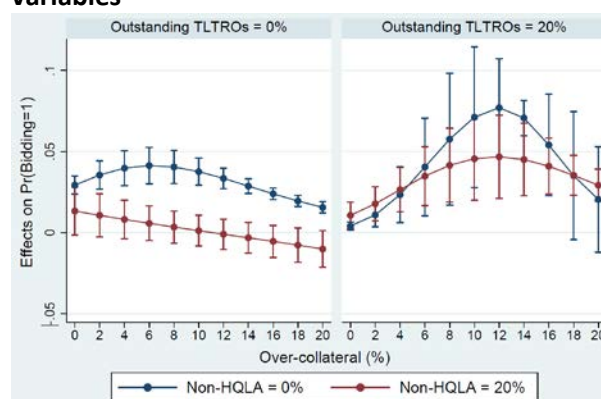
As regards the specifications of the Probit model, the explanatory variables differ only in a few spots compared to the Tobit specifications (Table 2). Firstly, the switch opportunity variable is re-defined as a dummy variable since the variable in absolute amounts creates convergence issues for the estimator. The variable therefore indicates that there were amounts that could be switched into TLTRO-II. Second, the estimates suggested that the redemptions variable is more relevant for the participation decision and therefore becomes part of the base regression. On the other hand, the variable of the share of wholesale funding, which is related to bond holdings and redemptions, turns out to be less relevant and is tested only as part of the auxiliary regressions.

Chart 10: Average partial effect of the cost advantage as a function of interaction variables



Note: APEs are calculated at different levels of the cost advantage (x-axis) and of the interaction variables (excess liquidity over assets, non-performing loans to assets and the unemployment rate). The box plots indicate 95% confidence intervals.

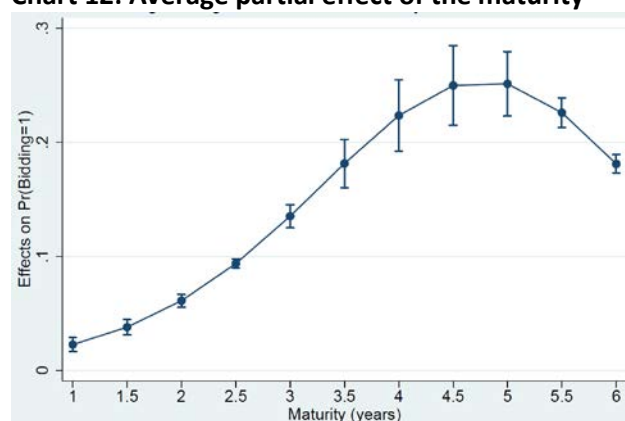
Chart 11: Average partial effect of over-collateralisation as a function of interaction variables



Note: APEs are calculated at different levels of over-collateralisation (x-axis) and of the interaction variables (outstanding TLTROs, outstanding other Eurosystem credit and non-HQLA holdings over assets). The box plots indicate 95% confidence intervals.

Economically, the cost advantage is again among the strongest drivers. The APE of the cost advantage suggests that a one percentage point cost advantage raises the probability of participation by 38 pp on average (Table 2(c)), and a one standard deviation of the cost advantage accounts for 88% of the standard deviation of the participation likelihood. Equivalently, a 10 bps cut in the TLTRO rate would all else equal raise participation by 3.8 pp. The complex interaction effects on the APE overall suggest that banks in dire conditions may simply be keen on the access to funding offered by the operations and pay less attention to the conditions of the operations. Chart 10 presents the APE for the cost advantage at specific values for the interaction variables, namely excess liquidity and unemployment using the base regression (1). Unemployment has the largest dampening impact with very high levels reducing the effect of the cost advantage to low levels that may not be significantly different from zero and vary little with the level of the cost advantage. Thus, while the APE of unemployment is sizeable and positive (Table 2(c)), suggesting that banks in countries with low loan demand overall participate more, the cost advantage is less effective for those banks. The result suggests that participation can be boosted by lowering the rate on the operation but that this is little effective if the loan demand is very low.

Chart 12: Average partial effect of the maturity



Note: APEs are calculated at different levels of the maturity. The box plots indicate 95% confidence intervals.

In the presence of excess liquidity, the cost advantage needs to be raised to achieve equal effects on participation. Chart 10 suggests that excess liquidity has a dampening effect on the marginal effect in most cases, in particular by flattening and stretching the hump-shaped curves that hold if unemployment is low. Overall, the APE of excess liquidity suggests one percentage point of excess liquidity over assets lowers the probability of participation by one percentage point.

Only the effect of the switch opportunity is economically stronger than the cost advantage, but that effect was of course concentrated in time. One standard deviation more of switchable amounts accounts for 121% of the standard deviation in the participation likelihood. TLTROs with a maturity of four-and-a-half to five years boost participation the most (Chart 12). This is longer than the four-year maturity that most TLTROs had and longer than the three-year maturity that was found to be optimal to boost take-up amounts.

On the asset side, the collateral availability and liquidity transformation are found to have strong economic effects on participation. Having 10% more collateral and 10% more non-HQLA on the balance sheet are found to boost the probability of participation by 36% and 21%, respectively. And, one standard deviation increase in these variables accounts for 44% and 26% of the standard deviation of the participation likelihood. As suggested by Table 2(b), the effect is also non-linear for these variables and turns out to be relatively complex. Chart 11 shows how the effect of over-collateralisation rises on average and becomes more hump-shaped as a function of the over-

collateral level if the bank has high outstanding amounts of TLTRO funds. This suggests that those banks that already participated are likely to participate more if they have a collateral buffer that is neither small nor very large. However, non-HQLA holdings have mainly a dampening effect on the APE of over-collateralisation, suggesting those banks that can rely most on liquidity transformation pay less attention to their over-collateral level in the participation decision.

On the funding side, if the bank expects bond redemptions in the near term, then the probability of participation is estimated to be only marginally higher. Namely, for one percentage point more of redemptions over assets the probability of participation rises by 0.9 pp (Table 2(c)). The small impact may appear surprising because the launch of longer-term refinancing operations have traditionally been seen as means of addressing imminent funding pressure at banks when market access may be impaired. The small role found for redemptions contrasts with the euro area bank lending survey where about 40% of banks indicated that they used the funds for “substituting maturing debt”. One reason could be that this is driven by the focus on large banks in the survey. It could also be that the substitution was spread over time and that funding pressures were low during the TLTRO period as it took place during a period of low funding stress. In addition, for banks that do have market access, business considerations may support a continued presence in the market, making a switch to TLTRO funds less likely.

Economically, credit risk conditions do not have a significant impact on participation. In particular, tier-1 capital, equity and non-performing loans receive small APEs that are not statistically significant (Table 2(c)). On the contrary, the APE of unemployment suggests that banks that face weak demand are more likely to participate and hence that country risk and lack of market access may still support more participation through this channel. In that sense, the results differ somewhat from the Tobit result where credit risk indicators are found to play a tentative role while the impact of unemployment is ambiguous.

Finally, note that the coefficient on the lagged dependent variable is larger than in the Tobit models, suggesting the (non)-participation is more persistent than the take-up amounts.

5.2 Alternative drivers

As a robustness check we consider alternative variables for certain potential drivers. As the information considered here only exists for a small number of banks, the new specifications can in any case not be seen as true alternatives to the main specifications discussed above. Table 3 presents the Tobit estimates for the alternative explanatory variables when they are included in the base regression (1) as presented in Table 1.

Short-term loans. Banks that provide more short-term loans do not take up more TLTRO funds. Regression (1) tests if the share of short-term loans could be a driver of TLTRO take-up as an alternative to the share of total loans on the bank balance sheet that turned out to be insignificant in Section 4. As total loans may comprise loans with maturities that are much higher than the maturity of TLTROs, the link with TLTRO take-up may be blurred. As a variable we include short-term loans that mature in the next year. The APE of the alternative explanatory variable is small, carries the

wrong sign and is not statistically significant suggesting that economically the share of short-term loans does not make a difference.²⁹

CDS spread and credit rating. Neither the credit rating, nor the credit default swap price of banks suggests there is a larger role for bank credit risk. The rating variable is defined as the corporate long-term rating of banks which is quantified by taking its rank within the rating tables of Fitch, Moody's and S&P, and withholding the best rating among those three providers. For instance, a rating value of 1 corresponds to the highest possible rating, e.g. AAA-rating according to the S&P rating scheme. The CDS spread variable consists of the mid-quote for 5-year CDS on the banks. Table 3 presents regression results when either the CDS spread or the rating is included in the base specification, either individually or in combination with the equity ratio and/or tier-1 capital ratio. Neither of the two variables appears to bring in new information. This differs from what the findings of Cassola et al. (2013) may suggest. They found a link between CDS rates and bids in MROs under the variable rate tender procedure. Namely, they demonstrate that banks' willingness-to-pay for ECB liquidity during financial turmoil is linked to deterioration in CDS rates. Therefore, one may also expect more aggressive take-up in TLTROs, but in our sample higher CDS spreads do not predict more take-up, possibly because the period saw relatively calm financial conditions.

Country fixed effects. The model captures differences across countries adequately. Chart 3 presents the outstanding amount per country in all LTROs, i.e. also including 3-month LTROs, directly after the allotment of the last TLTRO. As 3-month LTROs were small in size, the chart provides a good idea of the distribution of TLTRO funds across euro area countries. The asymmetric distribution of take-up may suggest that country effects are important, but country dummies are not found to add information to the regressions presented below. This shows that the control variables included as part of the estimation strategy account well for unobserved heterogeneity and that the explanatory variables adequately capture country differences without the need for country dummies.

5.3 Linear probability model

Correlated random effects (CRE) estimation appears to control well for heterogeneity. As a robustness test, the linear probability model can be estimated with fixed effects and compared with the Probit model estimated with CRE. The coefficients are very close across the methods with the Probit CRE coefficients only deviating by -0.001 on average from those of the linear probability model with fixed effects, and with a root mean squared error of only 0.012. Although this test only holds for a base specification of the static Probit model with linear regressors, it suggests that CRE works well in our context.

6. Conclusion

This paper studied the drivers of individual banks' participation and take-up in the targeted longer-term refinancing operations (TLTROs) that the ECB conducted between September 2014 and March

²⁹ The insignificance may reflect that the definition of the variable is not ideal variable because the maturity of the selected loans is now significantly shorter than most of the TLTROs, but unfortunately no other loan maturity breakdowns are available to set up a better test.

2017 to stimulate bank lending to the real economy. Panel regressions allow us to determine the relevance of a series of potential drivers reflecting characteristics of the operations, bank balance sheet items, business model characteristics, and macroeconomic conditions.

We find that the drivers of take-up with the largest impact refer to the pricing of the operations, the collateral availability of banks and the composition of that collateral. The cost advantage of the operations has varied over time and in economic terms was the most important driver determining participation and take-up. A one standard deviation rise in the cost advantage leads to 37 percentage point (pp) increase in the likelihood of participation and 0.80 pp of take-up over assets per operation, and these effects account for 88% and 42% of the standard deviation of the outcome variables. The strong role for TLTRO pricing must be comforting to the ECB that thought to have launched an attractive programme.

Economically, the amount of available collateral is the second most important driver. One standard deviation more available collateral on the balance sheet predicts 19 pp higher probability of participation and 0.43 pp higher take-up over assets per operation, which account for 44% and 23% of the standard deviation of the outcome variables. The result does not reflect collateral constraints, as few banks are constrained even at the end of the programme. Instead, banks that have collateral available appear to be incentivised to use it partly for TLTRO take-up. However, that effect on participation is smaller if they hold really large amounts of available collateral which may signal their liquidity position and market access is comfortable.

We find that liquidity transformation is the third most important driver for taking up funds in TLTROs. In other words, banks find the operations attractive because they offer an opportunity to pledge non high quality liquid assets as collateral with the Eurosystem in return for (high quality liquid) bank reserves. In particular, one standard deviation more of such non high quality liquid assets on the bank balance sheet predicts 11 pp more participation in TLTROs and 0.42 pp more take-up over assets per operation, which account for 26% and 22% of the standard deviation of the outcome variables.

As the liquidity transformation can support banks' liquidity ratios, the result quantifies an important link between regulatory motives and take-up in Eurosystem refinancing operations where empirical evidence is still scarce. The result also shows that by accepting a broad set of collateral, the Eurosystem collateral framework has been vital for monetary easing via TLTROs. More indirectly, the positive effect on banks' liquidity ratios reduces financial stability risk which may in turn be supportive to the monetary easing the TLTROs were launched for in the first place. On a critical note, the TLTROs can be seen as blurring the real underlying liquidity situation at banks.

Take-up was particularly high in the first and last TLTRO-II operation owing to their special conditions and opportunistic behaviour of banks. The first operation came with the opportunity to switch any outstanding TLTRO-I take-up into TLTRO-II at more attractive conditions which importantly determined participation. Furthermore, the probability of participation in the last operation is estimated to be 25% higher than what other drivers can explain suggesting there was opportunistic behaviour to lock in the attractive conditions at the last opportunity. The fact that higher levels of

available collateral and non-performing loans are associated with take-up in the last operation contributes to the hypothesis of opportunistic motives.

The TLTRO funds do not end up dominantly with financially weak banks. On the contrary, if anything, those with a higher tier-1 capital ratio take-up relatively more, possibly reflecting that they have more balance sheet capacity for new lending. Controlling for other credit risk indicators such as CDS spreads or credit ratings does not alter the conclusion. Holdings of non-performing loans which signal a riskier asset side of banks tend to predict higher take-up but economically the effect is small. Banks with higher equity are found to take-up less in TLTROs, but after controlling for capital and non-performing loans this appears more of a funding model indicator than a credit risk indicator, suggesting those with more debt funding more easily participate in TLTROs. In addition, country fixed effects are not statistically significant suggesting there is no country risk effect left unaccounted for and the other explanatory and auxiliary variables do well in capturing cross-country variation. Furthermore, aggregate funding stress did not play a role as that had reached low levels by the time of the operations and the profit of banks is found to be statistically insignificant in explaining take-up. Overall, the finding that financial weakness is not an important driver is probably the strongest difference to that of other studies on the use of 3-year LTROs during the height of the sovereign debt crisis. One take-away is that while standard LTROs support the lender of last resort function of the central bank, targeted LTROs offer an alternative tool when bank runs are less of a concern to channel funds to entities that are considered more central to the transmission of monetary policy.

Several lessons on the design of TLTROs can be drawn. From the top-3 of drivers of take-up we conclude that the central bank should pay particular attention to those three parameters if it aims to create an accommodative programme. We notice that these are exactly the parameters which the ECB has changed when it made its third TLTRO programme more attractive during the Covid-19 crisis in March-April 2020, namely by reducing the TLTRO interest rate and expanding the amount and types of eligible collateral. Furthermore, the ECB's choice to set the maturity of most operations of TLTRO-I and TLTRO-II to four years appears appropriate as it roughly balances two aspects: the four-year maturity is found to be just too long to maximise take-up and just too short to maximise participation. Furthermore, as the second and third strongest driver relate to collateral, the results confirm that a broad collateral framework, both in terms of the amount and composition of eligible assets, is important to incentivise take-up in funding for lending schemes. In addition, applying different lending benchmark requirements to banks depending on their deleveraging pressure appears to have been important to have take-up also by deleveraging banks. Overall, the conditions attached to participation and take-up in TLTROs appear to promote broad-based participation across banks of different financial strength and size.

From the interaction effects among the drivers, we learn that setting a lower TLTRO interest rate can help offsetting the dampening effects on take-up from weak loan demand. However, as regards the participation rate, the TLTRO cost is found to be irrelevant if loan demand is very weak, suggesting there are limits to how stimulating the price setting can be in very dire economic settings. Furthermore, excess liquidity holdings are found to dampen take-up and participation, but

economically the impact is limited. The result suggests that the reserves injected in the banking system through the ECB's asset purchases that took place in parallel to the TLTROs as of March 2015 have led only to limited competition to TLTRO participation. However, if banks underestimated the future rise in excess liquidity and holdings at the time of the operations were a bad predictor of the future holding distribution, then we may be underestimating this effect. In any case, interaction effects show that if banks already hold excess reserves, a more attractive TLTRO rate can help to maintain the participation likelihood.

The fact that banks' forthcoming bond redemptions only have a weak role in boosting participation leaves some unanswered questions. Does it mean that the timing of the bond redemptions was not that important because banks did not face funding stress or does it reflect pressure to keep issuance presence in the market? Or, would one see more take-up if TLTROs were accessible at a higher frequency than quarterly such that roll-over from maturing bonds into TLTROs is facilitated?

The results on the drivers of take-up contain promising signals about the transmission of the TLTRO conditions to the real economy. As the price and maturity of the operations are important drivers of take-up they suggest that the attractive conditions are passed on to banks. Moreover, the large switch from TLTRO-I into TLTRO-II, which was considered more attractive, would add to that effect. Also, the signs that the funds reached a large and broad set of banks reflects positively on transmission. Namely, the set of participants was fairly balanced as regards their deleveraging mode, bank size and financial strength. Finally, the fact that carry trade incentives were low during that period raises the likelihood that funds were directed towards new lending. However, a full assessment of TLTROs needs to rely on a study of the use of the funds and in particular how much lending it promoted. Future research should ideally shed light on that aspect.

Table 1: Panel Tobit model for TLTRO take-up**(a) estimates for linear explanatory variables**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Cost advantage	5.161*** (7.83)	5.176*** (7.80)	5.161*** (7.84)	5.137*** (7.82)	5.007*** (7.61)	4.916*** (6.03)	
Switch Opportunity	1.125*** (3.74)	1.126*** (3.74)	1.125*** (3.74)	1.120*** (3.71)	1.106*** (3.66)	0.652** (2.21)	0.951*** (3.25)
Last Opportunity	0.936*** (2.64)	0.947*** (2.67)	0.936*** (2.63)	0.917*** (2.59)	0.952*** (2.67)	0.794** (2.15)	1.365*** (4.21)
Tier-1 capital ratio	0.051 (0.80)	0.051 (0.80)	0.051 (0.80)	0.056 (0.97)	0.050 (0.77)	0.051 (0.49)	0.055 (0.87)
Equity	-0.145 (-1.19)	-0.149 (-1.23)	-0.145 (-1.19)	-0.180 (-1.45)	-0.140 (-1.15)	-0.169 (-1.27)	-0.120 (-1.01)
Non performing loans	-0.167*** (-2.01)	-0.166** (-1.99)	-0.167*** (-2.01)	-0.174** (-2.07)	-0.165** (-1.98)	-0.146 (-1.59)	-0.112 (-1.51)
Non-HQLA	0.531*** (9.78)	0.531*** (9.75)	0.531*** (9.74)	0.527*** (9.69)	0.528*** (9.69)	0.498*** (8.81)	0.511*** (9.75)
Other Eurosystem credit	-0.329*** (-6.81)	-0.328*** (-6.79)	-0.329*** (-6.81)	-0.323*** (-6.65)	-0.326*** (-6.77)	-0.305*** (-6.35)	-0.314*** (-6.64)
Excess liquidity	-0.209*** (-4.64)	-0.210*** (-4.67)	-0.209*** (-4.64)	-0.205*** (-4.53)	-0.212*** (-4.70)	-0.224*** (-4.70)	-0.198*** (-4.34)
Wholesale funding	-0.030 (-1.59)	-0.030 (-1.61)	-0.030 (-1.58)	-0.029 (-1.56)	-0.029 (-1.57)	-0.010 (-0.52)	-0.031* (-1.70)
Over-collateralisation	0.264*** (4.17)	0.264*** (4.16)	0.264*** (4.16)	0.269*** (4.24)	0.264*** (4.21)	0.268*** (4.31)	0.239*** (4.13)
Outstanding TLTRO	-0.717*** (-12.01)	-0.717*** (-11.99)	-0.717*** (-12.04)	-0.714*** (-11.91)	-0.713*** (-11.96)	-0.715*** (-12.49)	-0.587*** (-11.26)
Unemployment	-0.042 (-0.16)	-0.041 (-0.15)	-0.042 (-0.16)	-0.026 (-0.10)	-0.169 (-0.62)	1.867*** (5.04)	-0.351 (-1.38)
Profit		0.035 (0.19)					
Redemptions			0.004 (0.06)				
Loan share				0.034 (1.54)			
Subsidiary				-0.087 (-0.47)			
Total Assets				0.000 (0.81)			
Expected loan demand					-0.009*** (-3.02)		
Funding stress spread						-22.650*** (-7.40)	
Interest rate uncertainty						1.910 (1.23)	
Rate cut expectations						0.028*** (8.96)	
Maturity							10.525*** (4.57)
Maturity # Maturity							-1.241*** (-3.67)
Take-up (t-1)	0.211*** (5.70)	0.211*** (5.70)	0.211*** (5.69)	0.212*** (5.69)	0.204*** (5.54)	0.121*** (3.40)	0.014 (0.42)
Take-up (t=1)	0.446 (1.24)	0.446 (1.24)	0.447 (1.24)	0.426 (1.19)	0.444 (1.24)	0.459 (1.25)	0.478 (1.28)
Constant	3.339 (0.11)	3.379 (0.11)	3.330 (0.11)	3.185 (0.10)	2.064 (0.07)	-2.856 (-0.09)	-21.326 (-0.67)
Chamberlain-Mundlak	Y	Y	Y	Y	Y	Y	Y
Observations	6869	6867	6869	6867	6869	6869	6869
Nr of groups	630	630	630	630	630	630	630
Pseudo R-squared	0.57	0.57	0.57	0.57	0.57	0.58	0.58

Note: Shown are the estimates of the coefficients on the linear explanatory variables in seven regression specifications.. # indicates an interaction term; t-statistics are in parentheses based on robust standard errors obtained through jackknife resampling; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Chamberlain-Mundlak indicates whether the history and time series mean of the explanatory variables were included. Take-up (t=1) is the initial condition in line with Wooldridge (2005).

(b) estimates for interaction variables

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Last Opportunity # Cost advantage	-0.585** (-2.29)	-0.588** (-2.29)	-0.583** (-2.30)	-0.571** (-2.22)	-0.572** (-2.25)	-0.610** (-2.52)	
Cost advantage # Non performing loans	-0.019* (-1.87)	-0.019* (-1.87)	-0.019* (-1.85)	-0.018* (-1.81)	-0.019* (-1.84)	-0.024** (-2.12)	
Cost advantage # Unemployment	-0.197*** (-7.06)	-0.198*** (-7.03)	-0.197*** (-7.05)	-0.197*** (-7.05)	-0.192*** (-6.84)	-0.188*** (-5.43)	
Switch Opportunity # Switch Opportunity	-0.043*** (-6.59)	-0.043*** (-6.58)	-0.043*** (-6.59)	-0.043*** (-6.75)	-0.043*** (-6.55)	-0.026*** (-3.05)	-0.035*** (-5.15)
Switch Opportunity # Non performing loans	0.014* (1.95)	0.014* (1.94)	0.015* (1.95)	0.015** (1.98)	0.018** (2.33)	0.018** (2.51)	0.013* (1.81)
Switch Opportunity # Non-HQLA	-0.025*** (-2.76)	-0.025*** (-2.76)	-0.025*** (-2.75)	-0.025*** (-2.76)	-0.025*** (-2.77)	-0.021*** (-2.63)	-0.023*** (-2.74)
Switch Opportunity # Over-collateralisation	0.020 (1.52)	0.020 (1.52)	0.020 (1.51)	0.020 (1.56)	0.020 (1.49)	0.016 (1.62)	0.018 (1.38)
Last Opportunity # Non performing loans	0.123*** (3.60)	0.123*** (3.59)	0.123*** (3.59)	0.124*** (3.63)	0.118*** (3.49)	0.119*** (3.68)	0.107*** (3.31)
Last Opportunity # Non-HQLA	-0.052 (-1.42)	-0.052 (-1.43)	-0.052 (-1.41)	-0.052 (-1.44)	-0.051 (-1.40)	-0.060* (-1.67)	-0.081** (-2.29)
Last Opportunity # Over-collateralisation	0.234*** (3.86)	0.234*** (3.86)	0.234*** (3.86)	0.234*** (3.90)	0.234*** (3.78)	0.244*** (3.93)	0.253*** (4.19)
Last Opportunity # Unemployment	0.128** (2.50)	0.128** (2.48)	0.128** (2.49)	0.128** (2.52)	0.109** (2.14)	0.115** (2.28)	0.006 (0.15)
Tier-1 capital ratio # Switch Opportunity	-0.041** (-2.22)	-0.041** (-2.22)	-0.041** (-2.22)	-0.041** (-2.23)	-0.039** (-2.10)	-0.038** (-2.18)	-0.041** (-2.28)
Tier-1 capital ratio # Non performing loans	0.007** (2.48)	0.007** (2.48)	0.007** (2.48)	0.008*** (2.61)	0.007** (2.48)	0.007** (2.37)	0.008*** (2.82)
Equity # Switch Opportunity	0.043** (2.35)	0.043** (2.34)	0.043** (2.35)	0.044** (2.43)	0.042** (2.28)	0.045*** (2.68)	0.047*** (2.64)
Equity # Unemployment	-0.014* (-1.89)	-0.014* (-1.90)	-0.014* (-1.89)	-0.014** (-2.00)	-0.013* (-1.84)	-0.012* (-1.66)	-0.016** (-2.15)
Non performing loans # Non-HQLA	-0.010*** (-2.96)	-0.010*** (-2.96)	-0.010*** (-2.95)	-0.009*** (-2.89)	-0.010*** (-2.93)	-0.010*** (-3.02)	-0.009*** (-2.93)
Non performing loans # Over-collateralisation	0.017*** (3.47)	0.017*** (3.43)	0.017*** (3.47)	0.017*** (3.37)	0.017*** (3.50)	0.016*** (3.30)	0.018*** (3.78)
Non performing loans # Unemployment	0.008 (1.62)	0.008 (1.62)	0.008 (1.62)	0.008 (1.57)	0.008 (1.56)	0.008 (1.35)	0.002 (0.46)
Non-HQLA # Excess liquidity	0.015** (2.18)	0.015** (2.18)	0.015** (2.18)	0.016** (2.35)	0.015** (2.19)	0.014* (1.90)	0.014** (1.98)
Non-HQLA # Over-collateralisation	-0.018*** (-5.57)	-0.018*** (-5.57)	-0.018*** (-5.55)	-0.018*** (-5.66)	-0.018*** (-5.55)	-0.018*** (-5.50)	-0.017*** (-5.44)
Non-HQLA # Unemployment	-0.007** (-2.01)	-0.007** (-2.01)	-0.007** (-2.00)	-0.007** (-2.07)	-0.007** (-1.99)	-0.006* (-1.74)	-0.009** (-2.51)
Other Eurosystem credit # Over-collateralisation	0.011 (1.57)	0.011 (1.57)	0.011 (1.57)	0.011 (1.54)	0.010 (1.51)	0.009 (1.32)	0.011 (1.63)
Other Eurosystem credit # Outstanding TLTRO	0.016*** (2.84)	0.016*** (2.84)	0.016*** (2.84)	0.016*** (2.88)	0.017*** (2.93)	0.018*** (3.03)	0.017** (2.36)
Unemployment # Unemployment	0.018** (2.21)	0.018** (2.20)	0.018** (2.20)	0.018** (2.18)	0.021*** (2.63)	-0.021** (-2.15)	0.021*** (2.89)

*Note: Shown are the estimates of the coefficients on the interaction and quadratic explanatory variables that were included in the regressions and that were significant at the 10% significance level. # indicates an interaction term; t-statistics are in parentheses based on robust standard errors obtained through jackknife resampling; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.*

(c) average partial effects							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Cost advantage	0.831*** (8.31)	0.833*** (8.27)	0.831*** (8.32)	0.828*** (8.28)	0.803*** (8.11)	0.784*** (6.34)	
Switch Opportunity	0.217*** (10.76)	0.217*** (10.73)	0.217*** (10.76)	0.218*** (10.80)	0.221*** (11.02)	0.123*** (4.71)	0.182*** (9.31)
Last Opportunity	1.163*** (10.21)	1.164*** (10.20)	1.162*** (10.29)	1.160*** (10.21)	1.084*** (9.67)	1.030*** (8.51)	0.952*** (10.23)
Non performing loans	0.015 (1.60)	0.015 (1.60)	0.015 (1.60)	0.014 (1.52)	0.015* (1.67)	0.016* (1.72)	0.022** (2.49)
Unemployment	0.013 (0.33)	0.013 (0.32)	0.012 (0.32)	0.014 (0.35)	-0.004 (-0.11)	0.334*** (6.39)	-0.043 (-1.12)
Non-HQLA	0.082*** (7.89)	0.082*** (7.87)	0.082*** (7.82)	0.081*** (7.75)	0.081*** (7.78)	0.075*** (7.21)	0.073*** (7.49)
Excess liquidity	-0.032*** (-2.84)	-0.032*** (-2.87)	-0.032*** (-2.84)	-0.030*** (-2.65)	-0.033*** (-2.94)	-0.037*** (-3.02)	-0.031*** (-2.87)
Over-collateralisation	0.083*** (5.90)	0.083*** (5.88)	0.083*** (5.89)	0.084*** (5.96)	0.083*** (5.94)	0.082*** (5.92)	0.080*** (6.09)
Other Eurosystem credit	-0.061*** (-6.51)	-0.061*** (-6.49)	-0.061*** (-6.51)	-0.060*** (-6.40)	-0.061*** (-6.50)	-0.057*** (-6.08)	-0.057*** (-6.35)
Outstanding TLTRO	-0.171*** (-11.90)	-0.171*** (-11.88)	-0.171*** (-11.95)	-0.170*** (-11.83)	-0.170*** (-11.83)	-0.170*** (-12.18)	-0.138*** (-10.42)
Tier-1 capital ratio	0.014 (0.87)	0.014 (0.86)	0.014 (0.87)	0.015 (1.06)	0.014 (0.87)	0.014 (0.56)	0.016 (0.99)
Equity	-0.057** (-2.08)	-0.059** (-2.11)	-0.057** (-2.08)	-0.068** (-2.37)	-0.056** (-2.01)	-0.060** (-1.98)	-0.054** (-2.02)
Wholesale funding	-0.007 (-1.59)	-0.008 (-1.61)	-0.008 (-1.58)	-0.007 (-1.56)	-0.007 (-1.58)	-0.003 (-0.52)	-0.008* (-1.71)
Profit		0.009 (0.19)					
Redemptions			0.001 (0.06)				
Loan share				0.009 (1.55)			
Subsidiary				-0.022 (-0.47)			
Total Assets				0.000 (0.81)			
Expected loan demand					-0.002*** (-3.02)		
Funding stress spread						-5.717*** (-7.49)	
Interest rate uncertainty						0.482 (1.23)	
Rate cut expectations						0.007*** (9.21)	
Maturity							0.274*** (3.44)

Note: estimates based on the seven regression specifications shown in Table 1(a-b). t-statistics are in parentheses based on robust standard errors obtained through jackknife resampling; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 2: Panel Probit model for TLTRO participation
(a) estimates for linear explanatory variables

	(1)	(2)	(3)	(4)	(5)	(6)
Cost advantage	3.118*** (9.59)	3.125*** (9.61)	3.102*** (9.44)	3.082*** (9.26)	2.969*** (7.80)	
Switch Opportunity	2.155*** (5.92)	2.155*** (5.92)	2.102*** (5.81)	2.154*** (5.96)	1.811*** (4.97)	1.932*** (5.34)
Last Opportunity	0.899*** (2.97)	0.899*** (2.98)	0.856*** (2.81)	0.909*** (3.01)	0.887*** (2.75)	1.305*** (4.58)
Tier-1 capital ratio	0.002 (0.20)	0.002 (0.20)	0.003 (0.29)	0.002 (0.17)	0.003 (0.26)	0.004 (0.36)
Equity	-0.048 (-1.30)	-0.051 (-1.35)	-0.069* (-1.76)	-0.047 (-1.28)	-0.057 (-1.52)	-0.061* (-1.72)
Non performing loans	-0.103*** (-3.51)	-0.102*** (-3.50)	-0.101*** (-3.48)	-0.103*** (-3.52)	-0.099*** (-3.15)	-0.045* (-1.83)
Non-HQLA	0.158*** (5.70)	0.158*** (5.69)	0.157*** (5.61)	0.158*** (5.70)	0.149*** (5.16)	0.150*** (5.35)
Other Eurosystem credit	-0.076*** (-3.63)	-0.076*** (-3.63)	-0.079*** (-3.72)	-0.077*** (-3.64)	-0.068*** (-3.17)	-0.078*** (-3.67)
Excess liquidity	-0.073*** (-2.71)	-0.074*** (-2.72)	-0.070*** (-2.62)	-0.074*** (-2.72)	-0.089*** (-3.08)	-0.099*** (-4.45)
Redemptions	0.019 (0.47)	0.019 (0.47)	0.028 (0.67)	0.017 (0.42)	0.032 (0.72)	0.025 (0.56)
Over-collateralisation	0.145*** (4.97)	0.146*** (4.99)	0.141*** (4.90)	0.144*** (4.93)	0.142*** (4.68)	0.132*** (4.47)
Outstanding TLTRO	-0.252*** (-9.22)	-0.251*** (-9.23)	-0.260*** (-9.33)	-0.249*** (-9.12)	-0.248*** (-8.65)	-0.181*** (-6.73)
Unemployment	0.171 (1.64)	0.171 (1.64)	0.166 (1.61)	0.139 (1.31)	0.671*** (4.82)	0.032 (0.31)
Profit		0.021 (0.39)				
Loan share			0.010 (1.15)			
Subsidiary			-0.048 (-0.59)			
Total Assets			-0.000 (-0.31)			
Wholesale funding			0.011 (1.23)			
Wholesale funding # Wholesale funding			-0.000*** (-3.27)			
Expected loan demand				-0.003** (-2.37)		
Funding stress spread					-5.654*** (-4.69)	
Interest rate uncertainty					-1.441** (-2.42)	
Rate cut expectations					0.008*** (6.08)	
Maturity						0.849*** (16.00)
Bidding (t-1)	0.594*** (10.23)	0.594*** (10.23)	0.595*** (10.21)	0.577*** (9.75)	0.481*** (7.81)	0.296*** (5.23)
Bidding (t=1)	0.421*** (6.94)	0.420*** (6.93)	0.413*** (6.87)	0.422*** (6.93)	0.468*** (7.12)	0.447*** (6.97)
Constant	-2.834*** (-6.88)	-2.840*** (-6.87)	-2.965*** (-6.61)	-2.815*** (-6.94)	-2.453*** (-7.56)	-2.473*** (-7.99)
Chamberlain-Mundlak	Y	Y	Y	Y	Y	Y
Observations	6869	6867	6867	6869	6869	6869
Nr of groups	630	630	630	630	630	630
Pseudo R-squared	0.30	0.30	0.30	0.30	0.31	0.32

*Note: Shown are the estimates of the coefficients on the linear explanatory variables in six regression specifications. # indicates a quadratic variable; t-statistics are in parentheses based on Hubert-White robust standard errors; * p<0.10, ** p<0.05, *** p<0.01. Chamberlain-Mundlak indicates whether the history and time series mean of the explanatory variables were included. Bidding (t=1) is the initial condition in line with Wooldridge (2005).*

(b) estimates for interaction variables

	(1)	(2)	(3)	(4)	(5)	(6)
Cost advantage # Cost advantage	0.021** (2.22)	0.021** (2.24)	0.019** (2.01)	0.022** (2.29)	0.023** (2.41)	
Cost advantage # Equity	-0.036* (-1.87)	-0.036* (-1.86)	-0.039** (-2.04)	-0.034* (-1.78)	-0.037* (-1.87)	
Cost advantage # Non performing loans	-0.013*** (-4.22)	-0.013*** (-4.24)	-0.012*** (-3.83)	-0.014*** (-4.29)	-0.014*** (-4.25)	
Cost advantage # Excess liquidity	-0.042* (-1.80)	-0.042* (-1.81)	-0.043* (-1.83)	-0.042* (-1.81)	-0.030 (-1.22)	
Cost advantage # Unemployment	-0.126*** (-7.19)	-0.126*** (-7.23)	-0.123*** (-6.94)	-0.127*** (-6.93)	-0.122*** (-6.11)	
Switch Opportunity # Tier-1 capital ratio	-0.049** (-2.02)	-0.049** (-2.02)	-0.047* (-1.93)	-0.048** (-2.00)	-0.047* (-1.94)	-0.048** (-1.99)
Last Opportunity # Other Eurosystem credit	-0.054* (-1.74)	-0.054* (-1.74)	-0.056* (-1.77)	-0.058* (-1.85)	-0.067** (-2.18)	-0.054* (-1.86)
Last Opportunity # Over-collateralisation	0.054** (2.06)	0.054** (2.04)	0.053** (2.01)	0.054** (2.05)	0.056** (2.01)	0.053** (2.05)
Last Opportunity # Outstanding TLTRO	0.003 (0.19)	0.003 (0.17)	0.003 (0.15)	0.001 (0.04)	-0.001 (-0.04)	-0.019 (-1.05)
Last Opportunity # Unemployment	0.055*** (2.81)	0.055*** (2.80)	0.053*** (2.70)	0.051*** (2.58)	0.055*** (2.79)	0.028 (1.47)
Tier-1 capital ratio # Non performing loans	0.003*** (2.82)	0.003*** (2.81)	0.003*** (2.61)	0.003*** (2.86)	0.003*** (2.65)	0.002** (2.28)
Tier-1 capital ratio # Redemptions	0.005** (2.38)	0.005** (2.36)	0.005** (2.27)	0.006** (2.40)	0.005** (2.10)	0.005** (2.07)
Last Opportunity # Equity	-0.052** (-2.09)	-0.052** (-2.08)	-0.045* (-1.79)	-0.053** (-2.13)	-0.047* (-1.79)	-0.061** (-2.52)
Equity # Over-collateralisation	0.005** (2.22)	0.005** (2.22)	0.005** (2.46)	0.005** (2.19)	0.005** (2.28)	0.005** (2.38)
Non performing loans # Non-HQLA	-0.003* (-1.93)	-0.003* (-1.93)	-0.003** (-2.06)	-0.003* (-1.95)	-0.003** (-1.98)	-0.002* (-1.79)
Non performing loans # Other Eurosystem credit	-0.003** (-2.35)	-0.003** (-2.35)	-0.002* (-1.92)	-0.002** (-2.25)	-0.002** (-2.15)	-0.002* (-1.69)
Non performing loans # Over-collateralisation	0.003* (1.71)	0.003* (1.69)	0.003* (1.80)	0.003* (1.73)	0.003 (1.60)	0.003** (2.06)
Non performing loans # Unemployment	0.007*** (3.80)	0.007*** (3.81)	0.007*** (3.70)	0.007*** (3.74)	0.007*** (3.31)	0.001 (0.94)
Non-HQLA # Non-HQLA	-0.001 (-1.17)	-0.001 (-1.15)	-0.001 (-1.00)	-0.001 (-1.12)	-0.001 (-0.96)	-0.001 (-0.79)
Non-HQLA # Excess liquidity	0.010*** (4.11)	0.010*** (4.11)	0.010*** (3.93)	0.010*** (4.11)	0.010*** (4.01)	0.010*** (4.24)
Non-HQLA # Redemptions	0.006** (2.28)	0.006** (2.27)	0.006** (2.33)	0.006** (2.29)	0.006* (1.83)	0.006* (1.95)
Non-HQLA # Over-collateralisation	-0.007*** (-5.00)	-0.007*** (-4.99)	-0.007*** (-4.94)	-0.007*** (-5.07)	-0.008*** (-5.23)	-0.007*** (-5.44)
Non-HQLA # Outstanding TLTRO	-0.003* (-1.92)	-0.003* (-1.92)	-0.002* (-1.80)	-0.003* (-1.86)	-0.003* (-1.86)	-0.003* (-1.94)
Non-HQLA # Unemployment	-0.002* (-1.86)	-0.002* (-1.86)	-0.002* (-1.81)	-0.002* (-1.89)	-0.002* (-1.72)	-0.003** (-2.42)
Other Eurosystem credit # Other Eurosystem credit	0.001** (2.28)	0.001** (2.28)	0.001** (2.57)	0.001** (2.26)	0.001* (1.94)	0.001** (2.10)
Other Eurosystem credit # Over-collateralisation	0.003* (1.82)	0.003* (1.82)	0.003* (1.87)	0.003* (1.80)	0.003 (1.59)	0.002 (1.50)
Other Eurosystem credit # Outstanding TLTRO	0.006*** (4.22)	0.006*** (4.22)	0.006*** (4.55)	0.006*** (4.31)	0.007*** (4.61)	0.007*** (4.50)
Redemptions # Over-collateralisation	-0.007* (-1.72)	-0.007* (-1.72)	-0.007* (-1.80)	-0.007* (-1.73)	-0.006 (-1.52)	-0.006 (-1.55)
Redemptions # Outstanding TLTRO	-0.008** (-2.09)	-0.008** (-2.09)	-0.007** (-2.05)	-0.008** (-2.09)	-0.007* (-1.83)	-0.006 (-1.48)
Redemptions # Unemployment	-0.006** (-2.05)	-0.006** (-2.03)	-0.006** (-2.19)	-0.006** (-2.05)	-0.006** (-1.97)	-0.006** (-2.04)
Over-collateralisation # Over-collateralisation	-0.002*** (-4.87)	-0.002*** (-4.89)	-0.002*** (-4.94)	-0.002*** (-4.67)	-0.002*** (-4.58)	-0.002*** (-4.17)
Over-collateralisation # Outstanding TLTRO	0.010*** (3.89)	0.010*** (3.89)	0.010*** (3.95)	0.010*** (3.83)	0.011*** (3.91)	0.010*** (3.55)
Outstanding TLTRO # Outstanding TLTRO	0.005*** (4.40)	0.005*** (4.40)	0.005*** (4.30)	0.005*** (4.27)	0.004*** (3.70)	0.002** (2.06)
Unemployment # Unemployment	0.005 (1.48)	0.005 (1.49)	0.005 (1.46)	0.006* (1.77)	-0.005 (-1.35)	0.008*** (2.69)

*Note: Shown are the estimates of the coefficients on the interaction and quadratic explanatory variables that were included in the regressions and that were significant at the 10% significance level. # indicates an interaction term; t-statistics are in parentheses based on Hubert-White robust standard errors; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.*

(c) average partial effects

	(1)	(2)	(3)	(4)	(5)	(6)
Cost advantage	0.383*** (11.50)	0.384*** (11.55)	0.378*** (11.30)	0.376*** (11.22)	0.349*** (8.47)	
Switch Opportunity	0.393*** (13.50)	0.393*** (13.54)	0.388*** (13.36)	0.396*** (13.55)	0.295*** (8.12)	0.318*** (11.14)
Last Opportunity	0.248*** (9.81)	0.249*** (9.81)	0.247*** (9.72)	0.239*** (9.38)	0.246*** (8.88)	0.263*** (12.01)
Tier-1 capital ratio	0.003 (1.22)	0.003 (1.21)	0.003 (1.22)	0.003 (1.21)	0.003 (1.21)	0.003 (1.16)
Equity	-0.011 (-1.46)	-0.011 (-1.51)	-0.015* (-1.93)	-0.010 (-1.43)	-0.012* (-1.66)	-0.010 (-1.34)
Non performing loans	-0.004 (-1.34)	-0.004 (-1.32)	-0.004 (-1.57)	-0.004 (-1.31)	-0.004 (-1.27)	-0.000 (-0.06)
Excess liquidity	-0.010*** (-2.63)	-0.010*** (-2.65)	-0.010** (-2.57)	-0.010*** (-2.68)	-0.012*** (-2.96)	-0.011*** (-3.07)
Other Eurosystem credit	-0.014*** (-4.56)	-0.014*** (-4.56)	-0.014*** (-4.54)	-0.014*** (-4.58)	-0.013*** (-4.04)	-0.014*** (-4.52)
Over-collateralisation	0.036*** (8.34)	0.036*** (8.34)	0.036*** (8.37)	0.036*** (8.27)	0.035*** (8.00)	0.033*** (7.92)
Outstanding TLTRO	-0.042*** (-9.91)	-0.042*** (-9.92)	-0.043*** (-10.06)	-0.041*** (-9.81)	-0.039*** (-9.11)	-0.028*** (-6.79)
Redemptions	0.009* (1.87)	0.009* (1.86)	0.010** (1.97)	0.009* (1.80)	0.010* (1.89)	0.009* (1.85)
Non-HQLA	0.021*** (5.50)	0.021*** (5.48)	0.021*** (5.50)	0.021*** (5.50)	0.018*** (4.76)	0.018*** (4.80)
Unemployment	0.043*** (3.16)	0.043*** (3.15)	0.041*** (3.08)	0.039*** (2.84)	0.115*** (6.37)	0.030** (2.32)
Profit		0.004 (0.39)				
Loan share			0.002 (1.15)			
Subsidiary			-0.010 (-0.59)			
Total Assets			-0.000 (-0.20)			
Wholesale funding			-0.001 (-0.52)			
Expected loan demand				-0.001** (-2.37)		
Funding stress spread					-1.168*** (-4.79)	
Interest rate uncertainty					-0.298** (-2.41)	
Rate cut expectations					0.002*** (6.31)	
Maturity						0.174*** (16.96)

Note: estimates based on the specifications shown in Table 2(a-b). t-statistics are in parentheses based on Hubert-White robust standard errors; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 3 : Panel Tobit model for TLTRO take-up – APEs of alternative regressors

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Short-term Loans	-0.007 (-0.23)						
CDS spread		0.000 (1.26)	0.000 (0.96)	0.000 (0.68)			
Equity	-0.125 (-0.21)		-0.223* (-1.89)	-0.261* (-1.81)		-0.103 (-1.16)	-0.128 (-1.05)
Tier-1 capital ratio	0.020 (0.15)			0.027 (0.36)			0.010 (0.25)
Rating					-0.071 (-1.09)	-0.052 (-0.75)	-0.055 (-0.78)
Chamberlain-Mundlak	Y	Y	Y	Y	Y	Y	Y
Observations	1373	537	537	536	1011	1011	1002
Nr of groups	126	50	50	50	99	99	98

*Note: Shown are the average partial effects of the alternative explanatory variables when they are included in the base specification (1) that is presented in Table 1. t-statistics are in parentheses based on robust standard errors obtained through jackknife resampling; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.*

Table 4: Number of bidders in 3-year LTROs and TLTROs

Bid in 3-year LTRO?	Bid in TLTRO?	
	No	Yes
No	104	407
Yes	57	442

Source: ECB.

Note: based on the set of banks active in ECB refinancing operations.

Annex 1: Details of the TLTRO programme

The first TLTRO programme (TLTRO-I)

Allowance: In the first two operations allotted in September and December 2014, counterparties were entitled to an initial borrowing allowance equal to 7% of the total amount of their loans to the euro area non-financial private sector, excluding loans to households for house purchase, outstanding on 30 April 2014. In the next six quarterly operations from March 2015 to June 2016, counterparties were able to borrow additional amounts. These additional amounts could cumulatively reach up to three times each counterparty's net lending to the euro area non-financial private sector, excluding loans to households for house purchase, provided between 30 April 2014 and the respective allotment reference date in excess of a specified benchmark.

Benchmark: Two benchmarks were distinguished: 1) for banks that exhibited positive eligible net lending in the twelve-month period to 30 April 2014, the benchmark was set at zero; 2) for banks that exhibited negative eligible net lending in the year to 30 April 2014, different benchmarks applied. These were set as follows: the average monthly net lending of each bank in the year to 30 April 2014 was extrapolated for 12 months until 30 April 2015. For the year from 30 April 2015 to 30 April 2016, the benchmark monthly net lending was set at zero.

Interest rate: The interest rate on the first two operations was the rate on the Eurosystem's main refinancing operations (MRO), prevailing at the time of take-up, plus a 10 basis points spread. In January 2015, the Governing Council decided that for the subsequent six operations the 10 basis points spread would be dropped.

Maturity: all operations matured in September 2018.

Voluntary repayment: Starting 24 months after each TLTRO, counterparties had the option to repay any part of the amounts they were allotted in that TLTRO at a six-monthly frequency.

Mandatory repayment: Counterparties whose net lending to the euro area non-financial private sector, excluding loans to households for house purchase, in the period from 1 May 2014 to 30 April 2016 was below the benchmark were required to pay back their borrowings in full in September 2016.

For calculations and illustrations of the allowance, benchmark and repayment see ECB (2014).

The second TLTRO programme (TLTRO-II)

Allowance: In the four additional operations conducted between June 2016 and March 2017, counterparties were able to borrow in the operations a total amount of up to 30% of the eligible loans as at 31 January 2016, less any amount which was previously borrowed and was still outstanding under the first two TLTRO operations conducted in 2014. As in TLTRO-I the eligible loans were defined as those to euro area non-financial corporations and households excluding loans to households for house purchase.

Benchmark: Two benchmarks were distinguished: 1) For counterparties that exhibited positive eligible net lending in the 12-month period to 31 January 2016, the benchmark net lending was set

at zero; 2) For counterparties that exhibited negative eligible net lending in the 12-month period to 31 January 2016, the benchmark net lending was equal to the eligible net lending in that period.

Interest rate: The interest rate was fixed for each operation at the rate applied in the MROs prevailing at the time of allotment. In addition, counterparties whose eligible net lending in the period between 1 February 2016 and 31 January 2018 exceeded their benchmark were charged a lower rate for the entire term of the operation. This lower rate was linked to the interest rate on the deposit facility prevailing at the time of the allotment of each operation. Counterparties received the maximum rate reduction equal to the difference between the MRO rate and the rate on the deposit facility applicable at the time of take-up if they exceeded their benchmark stock of eligible loans by 2.5% in total as at 31 January 2018. Up to this limit, the size of the decrease in the interest rate was graduated linearly depending on the percentage by which a counterparty exceeded its benchmark stock of eligible loans. For illustrations of the borrowing rate and the benchmark see ECB (2016).

Maturity: each operation had a four-year maturity.

Voluntary repayment: after two years, the possibility to repay at quarterly frequency started. There were no mandatory repayments foreseen.

Additional voluntary repayment: An additional voluntary repayment possibility was introduced for all outstanding TLTRO-I amounts in June 2016, coinciding with the settlement of the first TLTRO-II operation. This allowed counterparties to roll over amounts borrowed under the TLTRO-I into TLTRO-II.

The details are specified in the legal acts; see decisions ECB/2014/34, ECB/2015/5, ECB/2016/10, ECB/2016/11, and ECB/2016/30.

Annex 2: Descriptive Statistics

	N	mean	median	st.dev.	min.	max.	unit	source	level
Dependent									
Bidding	10,999	0.22	0.00	0.42	0.00	1.00	dummy	2	bank & time
Take-up/Assets	10,976	0.58	0.00	1.90	0.00	56.55	percent	2, 6	bank & time
Explanatory variables									
Bid limit/Assets	10,976	3.43	0.00	8.11	0.00	265.49	percent	2, 6	bank & time
Loan demand	11,088	13.23	11.08	17.74	-100.00	100.00	percent	2	country & time
Loan demand exp.	11,088	18.17	12.50	21.78	-28.57	100.00	percent	2	country & time
Bond redemption/Assets	10,918	0.69	0.00	3.04	0.00	62.23	percent	2, 6	bank & time
Tier-1 capital ratio	9,863	14.87	13.78	6.45	-1.17	145.55	percent	6	bank & time
CDS spread	584	248	137	414	24	3917	basis points	6	bank & time
ECB credit/Assets	10,926	1.39	0.00	4.41	0.00	75.96	percent	2, 6	bank & time
Outstanding TLTRO/Assets	10,287	1.56	0.00	3.33	0.00	50.36	percent	2, 6	bank & time
Excess liquidity/Assets	10,969	0.88	0.00	3.93	-0.07	98.66	percent	2, 6	bank & time
Equity/Assets	10,287	8.76	8.47	3.56	0.53	54.94	percent	6	bank & time
Income/Assets	10,283	0.18	0.20	0.62	-12.07	7.15	percent	6	bank & time
Short-term loans/Assets	1,711	12.02	11.65	6.85	0.08	41.34	percent	6	bank & time
Loans/Assets	10,281	58.75	60.96	16.43	0.00	97.42	percent	6	bank & time
NPL/Assets	10,952	3.24	1.33	5.61	0.00	69.41	percent	6	bank & time
Non-HQLA/Assets	8,668	4.31	2.81	5.16	0.00	97.98	percent	2, 6	bank & time
Overcollateral/Assets	8,594	4.08	2.50	5.17	0.00	89.33	percent	2, 6	bank & time
Cost advantage	11,078	0.43	0.30	0.96	0.02	26.99	percent	1, 2, 5, 7	country & time
Rating	1,177	9.05	8.00	3.99	1.00	19.00	index	6	bank & time
Switch Option/Assets	10,287	0.19	0.00	1.30	0.00	34.63	percent	2, 6	bank & time
Unemployment	11,088	7.47	4.90	4.74	3.90	26.30	percent	3	country & time
Wholesale funding/Assets	10,985	22.74	17.31	18.52	0.00	97.00	percent	6	bank & time
Subsidiary	11,088	0.23	0.00	0.42	0.00	1.00	dummy	6	bank
Funding Stress	11,088	0.08	0.11	0.04	0.01	0.13	percent	1	time
Rate uncertainty	11,088	0.26	0.27	0.04	0.17	0.32	percent	4	time
Last Opportunity	11,088	0.09	0.00	0.29	0.00	1.00	dummy	2	time
Maturity	11,088	3.52	3.75	0.54	2.50	4.00	years	2	time
Rate expectations	11,088	16.82	0.00	22.19	0.00	69.00	percent	1	time

Variables in absolute values:

Dependent									
Take-up	10,999	107	0	836	0	34,210	EUR mn	2	bank & time
Explanatory variables									
Assets	10,287	29,522	1,715	143,054	21	2,392,177	EUR mn	6	bank & time
Bid limit	10,997	573	1	3,134	0	78,842	EUR mn	2	bank & time
Equity	10,287	1,752	145	7,494	2	107,282	EUR mn	6	bank & time
Bond redemption	10,919	664	0	3,112	0	54,945	EUR mn	2	bank & time
ECB credit	10,940	137	0	1,002	0	40,500	EUR mn	2	bank & time
Outstanding TLTROs	11,088	295	0	1,698	0	42,710	EUR mn	2	bank & time
Excess liquidity	10,979	351	0	2,488	-23	78,255	EUR mn	2	bank & time
Income	10,285	40	3	309	-13,438	4,302	EUR mn	6	bank & time
Short-term loans	1,711	15,759	2,764	36,464	8	294,122	EUR mn	6	bank & time
Loans	10,281	14,030	1,009	59,709	0	799,233	EUR mn	6	bank & time
Non-performing loans	10,952	767	16	4,279	0	84,359	EUR mn	6	bank & time
Non-HQLA	9,177	1,198	52	4,969	0	76,675	EUR mn	2	bank & time
Overcollateral	9,088	1,173	50	4,467	0	70,474	EUR mn	2	bank & time
Switch Option	11,088	42	0	642	0	26,710	EUR mn	2	bank & time
Wholesale funding	10,985	9,584	260	46,996	0	686,920	EUR mn	6	bank & time

Sources

- | | |
|---------------|----------------------------------|
| 1 Bloomberg | 5 Markit iBoxx |
| 2 ECB | 6 S&P Global Market Intelligence |
| 3 Eurostat | 7 Thomson Reuters |
| 4 ICE Futures | |

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