

EFFECTS OF LONG-TERM LIQUIDITY PROVISIONS ON BANK LOAN SUPPLY

A Euro Area Review

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Abstract

Following the financial and sovereign debt crises, the European Central Bank has implemented a variety of unconventional monetary policy measures to maintain financial stability, among other mandated aims. One such measure are the long-term refinancing operations, both non-targeted and targeted. These operations have been undertaken with the aim of stimulating the credit supply from commercial banks.

This literature review seeks to evaluate the effect these operations have had on loan supply in the euro area. A variant of the Monti-Klein model of banking is introduced from the literature, and a hypothesis is formed. The findings of the empirical literature are then evaluated against this hypothesis before forming the answer to the research question of this review.

It is found that these long-term refinancing measures undertaken by the European Central Bank have broadly succeeded in their main aims: loan supply has increased as measured across the euro area, as well as in individual countries within. The positive shift in loan supply is observed as increased probabilities of favorable lending conditions, and as increased volumes of credit. These increases in lending have been heterogeneous by country, bank, and bank customer characteristics.

Keywords Bank lending channel, central banking, financial crisis, loan supply, LTRO, monetary policy, TLTRO

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1 Introduction

This literature review studies the effects of the European Central Bank's (ECB) long-term liquidity provisions on bank loan supply, specifically following the financial and sovereign debt crises in the euro area. It seeks to answer the research question "*how have LTROs and TLTROs affected loan supply in the Euro area?*"

Long-term refinancing operations (LTRO) beginning in 2011, and targeted long-term refinancing operations (TLTRO) beginning during 2014-2019 are studied. The theoretical underpinnings of bank lending are explored along with the empirical TLTRO and LTRO literature. The theoretical model utilized is a Monti-Klein model of banking with Cournot competition. The empirical works that are reviewed study either the loan supply effects in the larger euro area, or in specific countries within the area.

This review is related to three strands of economic literature. Firstly, it considers a method of unconventional monetary policy, being thus related to literature concerning unconventional monetary tools. This topic is also related to the literature on the transmission mechanisms of monetary policy, most importantly the bank lending channel literature. Thirdly, and most directly, this review is related to empirical long-term refinancing operations literature, as it forms a central part of this review.

1.1 Rationale for study

The ECB has, among others, the following objectives agreed upon in the Treaty on the Functioning of the European Union: price stability, support of general economic policies toward the achievement of the objectives of the union, full employment, and balanced economic growth. (European Central Bank, 2015).

This review is economically relevant, because the answer to its research question gives implications for implementation and effectiveness of monetary policy in the euro area. In order to achieve any given goal, it is important to understand what the effects of available policy tools are. In seeking to achieve the objectives laid out above, the ECB needs to understand in what ways the monetary policy tools and actions at their disposal affect the economy and its components. The effectiveness of the LTROs and TLTROs and the mechanisms by which they operate are therefore an important area of study within economics.

The importance this topic and research question in terms of general welfare are closely related to their economic importance. Understanding of the bank lending channel of monetary transmission and the effects of liquidity provisions are important in times of financial crises. This is because financial and banking crises have adverse effects on general welfare due to economic instability and unemployment that can be caused by them. When monetary authorities have a clearer understanding of the monetary transmission mechanism, they may target their policy more effectively towards the banking sector or other sectors.

Banks are the predominant financial intermediary for firms and households in the euro area (Bondt, Mojon, and Valla, 2005). Hence, the understanding of policies related to banks is essential in crisis alleviation, both in the economic sense and in terms of general welfare, especially in the euro area context.

1.2 Overview

A theoretical model is used to formulate a hypothesis of the effects of long-term liquidity provisions on bank loan supply in the euro area. This framework is a variant of the model of bank competition first introduced in Monti, 1971 and in Klein, 1971. The formulation of the Monti-Klein model introduced in Andreeva and García-Posada, 2021 shows, theoretically, how banks decrease loan supply following a funding impairment, and how a liquidity provision will affect this supply. The hypothesis formed is, in short, that long-term liquidity provided by the ECB shifts the loan supply curve outward.

The empirical LTRO literature provides nearly unanimous evidence in support of the above hypothesis, in that LTROs are observed to increase loan supply. This is the case across the euro area (Darracq-Paries and De Santis, 2015), in Spain (García-Posada and Marchetti, 2016), in Italy (Carpinelli and Crosignani, 2021, and Casiraghi et al., 2013), and in France (Andrade et al., 2019). The effects of LTROs are found to be heterogeneous: credit supply has increased most to small and medium-sized enterprises (SMEs) (García-Posada and Marchetti, 2016), and from financially constrained banks (Andrade et al., 2019).

The findings from the TLTRO literature are somewhat similar to those of the LTRO literature. Across the euro area, participation in TLTRO-I is found to correspond with an increase in the probability of easing credit standards and lowering lending spreads (Andreeva and García-Posada, 2021). Direct effects (for participating banks) are found for household loans, in the form of an increased probability of lower lending spreads. Indirect positive effects (for banks that do not participate) on credit standards are found for both household loans and loans to non-financial corporations (NFCs) (ibid.). Participation in TLTRO-II is found to increase lending to NFCs, but not to households (Laine, 2021). TLTRO-II uptake amounts are found to have a positive impact on corporate credit but a negative impact on household loans (ibid.).

1.3 Main challenges

Targeted monetary policy is a very recent development in the euro area. Only a handful of empirical studies have been conducted, as the operations themselves and bank data following them are so new. Theoretical models for these specific purpose are also sparse. These difficulties have to be considered in answering the research question.

Another challenge is that, as the research question addresses a problem of supply and demand, empirical work used to answer it will necessarily be faced with the identification prob-

lem of disentangling supply and demand effects. These are important to consider, in order to avoid false conclusions. Hence, the internal validity of empirical studies reviewed in this study need to be evaluated.

1.4 Scope and structure

Geographically, this review focuses mainly on the euro area as a whole and specific countries within. Content-wise, this review is focused on LTRO (beginning in 2011) and TLTRO I-II (beginning in 2014 and 2016 respectively), and the effects these operations have had on loan supply both to firms and to households.

In the next section, LTROs and TLTROs undertaken by the ECB are introduced. The concept of monetary transmission – specifically the bank lending channel of transmission – is elaborated on, along with context about the crises preceding these policies. In section 3, important theoretical frameworks for the understanding of this topic are introduced. Sections 4 and 5 discuss findings and problems of the empirical LTRO and TLTRO literature, respectively. Section 6 proceeds to discussion and section 7 concludes.

2 Institutional and conceptual background

Distinct from main refinancing operations (MRO), long-term refinancing operations and targeted long-term refinancing operations are significantly longer-term in their scope. While MRO's are short term liquidity provisions (typically up to a week in length), the ECB's LTRO loans were up to three years and TLTROs up to four years in maturity. LTROs and TLTROs are methods of unconventional monetary policy used primarily to provide liquidity in order to prevent credit crunches. As a crisis alleviation method, the study of their effectiveness is economically pertinent.

2.1 Financial and European debt crises

The global economy experienced a financial crisis originating from the United States in 2007-2008. In the Euro area, the resulting decrease in the availability of foreign financing contributed towards a sovereign debt crisis (Lane, 2012). This crisis begun in 2009 with initial signs of distress from Greece (ibid.). The European debt crisis (and therefore the preceding global financial crisis) – among other effects – decreased bank loan supply in European countries (García-Posada and Marchetti, 2016). The long-term refinancing operations studied in this review were initially a response to these tightening credit conditions in the euro area (ibid.). This review will not consider the reasons for these crises, nor their effects on credit supply explicitly, as they are beyond its scope. However, it is important to acknowledge the conditions to which the policies under review were a response to.

2.2 LTRO

The term LTRO refers, in the euro area context, to two operations conducted in December 2011. The operations were fixed rate tenders with full allotment, i.e. ones with a fixed interest rate specified by the ECB and in which all bids submitted are accepted in full (Bank of Slovenia, 2019). The LTROs were a measure to "support bank lending and liquidity in the euro area money market" (European Central Bank, 2011). In addition to the set maturities of these operations, banks were allowed to repay any amount of their allotted amounts on MRO settlement days, after one year (ibid.). Settlement was thus flexible.

The first of the two operations amounted to EUR 489 billion lent to 523 counterparties, and the second operation amounted to EUR 530 billion lent to 800 counterparties (Darracq-Paries and De Santis, 2015). These liquidity provisions were provided with a fixed rate of 1% (ibid.). The maturities of these operations were 1134 and 1092 days respectively (European Central Bank, 2011).

2.3 TLTRO

TLTROs refer to three separate *series* of targeted long-term refinancing operations, with each series consisting of multiple separate operations. What differentiates these operations from the ones conducted in 2011 is that they are *targeted* – the amount of liquidity available to banks depends on the amounts lent to firms and households. Further, in TLTRO-II, the interest rate of settlement depends on the lending behavior of counterparty banks, rather than being a fixed rate from the beginning: banks that lend more face lower rates on the TLTRO-II. (European Central Bank, 2021).

TLTRO-I, the first series of operations, constituted to a total of EUR 432 billion in borrowing by banks, between December 2014 and June 2016 (Andreeva and García-Posada, 2021). In TLTRO-I, there were a total of eight separate operations. TLTRO-II, the second series of operations which was announced in March 2016 and begun in June 2016, totaled to EUR 739 billion in borrowing by banks (Laine, 2019). TLTRO-III operations are as of yet ongoing, and as such are not considered in this review.

2.4 Bank lending channel of monetary transmission

Monetary transmission refers to the mechanisms by which monetary policy actions affect the economy. Four commonly identified main channels are the interest rate channel, asset price channel, exchange rate channel, and the credit channel (see for example Mishkin, 1996). These main channels themselves are typically divided by functions into narrower subchannels. The bank lending channel, which is the channel by which monetary policy affecting banks affects the economy, is a subchannel of the credit channel. Specifically, it considers how changes in

policy affect bank lending conditions such as credit supply (Mishkin, 1996), and how these changes in lending conditions affect the economy in turn.

3 Theoretical background

3.1 Monti-Klein model with Cournot competition

This section presents the theoretical framework utilised in this review, which is a Monti-Klein model of banking with duopoly Cournot competition – henceforth referred to as the Monti-Klein model. This model provides a microeconomic foundation for the effects of liquidity impairment and liquidity provisions on bank lending. At the end of this section, a hypothesis is formed, and the limitations of this model in this research context are discussed.

The use of Cournot competition in the model is justified in that it allows the analysis specifically of supply effects of loans, as opposed to loan demand. It allows us to determine how banks set their loan supply strategically, that is, given what they assume to be the choices of other firms. The use of the simplified case - a duopoly - is reasonable because the results generalize (to an extent) to a larger oligopoly. This is because the model has two limiting cases: monopoly and perfect competition (Freixas and Rochet, 2008). Furthermore, limiting the theoretical framework to a duopoly allows it to be presented in a more concise manner. The banking sector is not a monopoly, as there are an abundance of banks in the euro area and countries within. Further, as the number of firms grows larger, the results begin to resemble to perfect competition, which is problematic as the banking sector is not necessarily perfectly competitive (ibid.). Thus, the limiting cases are not considered in this model.

The variant of the Monti-Klein model discussed here is introduced in Andreeva and García-Posada, 2021. Their formulation is the following. There are assumed to be two banks - a safe bank (lower index S) and a risky bank (lower index R). The inverse demand for loans and the inverse supply of deposits are represented as the following generic linear functions:

$$\begin{aligned} r_L(L_S + L_R) &= a - (L_S + L_R) \\ r_D(D_S + D_L) &= c + (D_S + D_R) \end{aligned}$$

The balance sheet identity of banks, $L_i = D_i$ for bank i , is assumed to hold. The market clearing conditions are:

$$\begin{aligned} L^* &= L_S + L_R \\ D^* &= D_S + D_R \\ L^* &= D^*, \end{aligned}$$

where L^* , D^* are the aggregate loan supply and aggregate deposit funding, respectively.

The authors consider the three following cases of Cournot competition to show how loan supply is affected by liquidity impairment and targeted liquidity provisions in this model:

1. The banks are identical
2. The banks are asymmetric (one bank is liquidity impaired)
3. One bank is liquidity impaired and a TLTRO is available

Case 1: symmetric duopoly

The profit function of the safe bank is:

$$\pi_S = (a - (L_S + L_R))L_S - (c + (D_S + D_R))D_S,$$

which leads to the following profit maximization problem:

$$\max_{L_S, D_S} \pi_S = (a - (L_S + L_R))L_S - (c + (D_S + D_R))D_S$$

s.t.

$$L_S = D_S$$

$$L_R = D_R.$$

Solving the maximization problem:

$$\begin{aligned} \pi_S &= (a - (L_S + L_R))L_S - (c + (L_S + L_R))L_S \\ &= aL_S - L_S^2 - L_R L_S - cL_S - L_S^2 - L_R L_S \\ \frac{\partial \pi_S}{\partial L_S} &= a - c - 4L_S - 2L_R = 0 \\ &\iff L_S = \frac{a - c - 2L_R}{4}. \end{aligned}$$

The reaction function of the safe bank is therefore:

$$L_S(L_R) = \frac{a - \frac{a+c}{2}}{2} - \frac{1}{2}L_R. \quad (1)$$

Due to symmetry, the reaction function of the risky bank is essentially the same:

$$L_R(L_S) = \frac{a - \frac{a+c}{2}}{2} - \frac{1}{2}L_S. \quad (2)$$

The two above reaction functions represent the Nash equilibrium in case 1, as identified by Andreeva and García-Posada, 2021. This equilibrium indicates that if the two banks are identical in all aspects, their strategic choices of loan supply are the same.

Case 2: funding impairment

In this case, the risky bank is impaired and depositors require a risk premium ρ to fund it. The safe bank remains safe as in case 1, with no premium required. The profit function of the risky bank:

$$\pi_R = (a - (L_S + L_R))L_R - (1 + \rho)(c + (D_S + D_R))D_R,$$

which leads to the following profit maximization problem:

$$\max_{L_R, D_R} \pi_R = (a - (L_S + L_R))L_R - (1 + \rho)(c + (D_S + D_R))D_R$$

subject to:

$$L_S = D_S$$

$$L_R = D_R.$$

Solving the maximization problem:

$$\begin{aligned} \pi_R &= (a - (L_S + L_R))L_R - (1 + \rho)(c + (D_S + D_R))D_R \\ &= (a - L_S - L_R)L_R - ((1 + \rho)(c + L_S + L_R)L_R) \\ \frac{\partial \pi_R}{\partial L_R} &= a - c - 2L_S - 4L_R - \rho c - \rho L_S - 2\rho L_R = 0 \\ \iff L_R &= \frac{a - c(\rho + 1) - (\rho + 2)L_S}{2(\rho + 2)}. \end{aligned}$$

The reaction function of the risky bank is therefore:

$$L_R(L_S) = \frac{a - \frac{a+c}{1+\frac{1}{1+\rho}}}{2} - \frac{1}{2}L_S, \quad (3)$$

and the reaction function of the safe bank remains as in case 1:

$$L_S(L_R) = \frac{a - \frac{a+c}{2}}{2} - \frac{1}{2}L_R. \quad (4)$$

The above two reaction functions represent the Nash equilibrium in case 2, as shown in Andreeva and García-Posada, 2021. As can be seen, the risk premium required of the risky bank leads to a funding impairment, decreasing loan supply. As ρ increases, the loan supply of the risky bank decreases.

Case 3: funding impairment and TLTRO

The TLTRO brings additional constraints to the problem. Firstly, it is assumed that the safe bank does not partake in the TLTRO bid, since it brings administrative costs, and the safe bank does not need funding cost reduction at the new cost. Further, the risky bank will borrow up to its borrowing limit, which is a fraction β of total lending by the bank. Lastly, as the risky bank now funds a portion of their loan portfolio via the TLTRO, the balance sheet constraint is altered to include the TLTRO. These additional constraints are represented in the following way:

- $TLTRO = \beta L_R$
- $L_R = D_R + TLTRO$

- $D_R = (1 - \beta)L_R$.

The new profit function of the risky bank:

$$\pi_R = (a - (L_S + L_R))L_R - (1 + \rho)(c + (D_S + D_R))D_R - i * TLTRO,$$

which leads to the following profit maximization problem:

$$\max_{L_R, D_R} \pi_R = (a - (L_S + L_R))L_R - (1 + \rho)(c + (D_S + D_R))D_R - i * TLTRO$$

subject to:

$$L_S = D_S$$

$$(1 - \beta)L_R = D_R$$

$$TLTRO = \beta L_R.$$

Solving the maximization problem:

$$\begin{aligned} \pi_R &= (a - (L_S + L_R))L_R - (1 + \rho)(c + (D_S + D_R))D_R - i * TLTRO \\ &= (a - (L_S + L_R))L_R - (1 + \rho)(c + (L_S + (1 - \beta)L_R))(1 - \beta)L_R - i\beta L_R \\ \frac{\partial \pi_R}{\partial L_R} &= a - 2\beta^2 \rho L_R - 2\beta^2 L_R + \beta c \rho + \beta c - \beta i + 4\beta \rho L_R + \beta \rho L_S + 4\beta L_R + \beta L_S \\ &\quad - c\rho - c - 2\rho L_R - \rho L_S - 4L_R - 2L_S = 0 \\ \Leftrightarrow L_R &= \frac{a + \beta(c(\rho + 1) - i + (\rho + 1)L_S) - c(\rho + 1) - (\rho + 2)L_S}{2(\beta^2(\rho + 1) - 2\beta(\rho + 1) + \rho + 2)}. \end{aligned}$$

The above solution of the maximisation problem is equivalent to the formulation of the authors, by which the reaction function of the risky bank is:

$$L_R(L_S) = \frac{\xi}{2} - \left(\frac{1}{2} + \frac{1}{2} \frac{\beta(1 - \beta)}{\frac{1}{1 + \rho} + (1 - \beta)^2} \right) L_S, \quad (5)$$

$$\text{where } \xi = a - i\beta - \frac{1 - \beta}{\frac{1}{1 + \rho} + (1 - \beta)^2} (a + c) + \frac{1 - \beta}{\frac{1}{1 + \rho} + (1 - \beta)^2} (a + i(1 - \beta)).$$

This is a rather involved reaction function, but showcases that the cost of funding decreases for the risky bank, thus increasing its loan supply for any given choice by the safe bank (Andreeva and García-Posada, 2021). In other words, regardless of the parameters and the choice of the safe bank in the reaction function, $L_R(L_S)$ will be greater than in case 2. This means that the TLTRO, in theory, increases loan supply of the risky bank.

The introduction of the balance sheet constraint, $(1 - \beta)L_R = D_R$, also affects the reaction function of the safe bank. This is shown below. The profit function of the safe bank remains as before. However, the new balance sheet constraint is included in its maximisation

problem:

$$\max_{L_S, D_S} \pi_S = (a - (L_S + L_R))L_S - (c + (D_S + D_R))D_S$$

subject to:

$$L_S = D_S$$

$$(1 - \beta)L_R = D_R.$$

Solving the maximisation problem:

$$\begin{aligned} \pi_S &= (a - (L_S + L_R))L_S - (c + (L_S + (1 - \beta)L_R))L_S \\ \frac{\partial \pi_S}{\partial L_S} &= a - c - 4L_S + \beta L_R - 2L_R = 0 \\ \Leftrightarrow L_S &= \frac{a - c + \beta L_R - 2L_R}{4}. \end{aligned}$$

The reaction function of the safe bank is therefore:

$$L_S(L_R) = \frac{a - \frac{a+c}{2}}{2} - \left(\frac{1}{2} - \frac{1}{4}\beta \right) L_R. \quad (6)$$

Eq. (5) and (6) represent the Nash equilibrium in the case of a funding impairment of bank R, which is alleviated by a TLTRO, as shown in Andreeva and García-Posada, 2021.

The interpretation of the safe bank's new reaction function is that its loan supply is also affected by the TLTRO. Depending on the parameter values a, c, β and i , the safe bank may increase or decrease its loan supply as an indirect effect of the TLTRO, even though it does not partake. This is due to the tightening of competition in the loan market by the loan supply increase of bank R, along with the loosening of competition in the deposit market. The deposit market competition decreases because bank R no longer fully finances its lending by deposits. (ibid.).

3.2 Limitations and hypothesis

This model, though useful in answering the research question of this study, comes with several limitations. These are, however, taken into consideration and will prove not to undermine the purpose of using the model.

Firstly, the model is specifically constructed to consider the effects of targeted operations. Nonetheless, it can, with some consideration, be applied to LTROs as well. It is the provision of liquidity that is at the core of the model, and liquidity is what is provided in LTROs as in TLTROs, albeit at different terms. Targeting was used to disincentivize the use of funds for non-targeted sectors, and to incentivize constrained banks specifically to bid. Thus, the model allows the analysis of how liquidity provision affects constrained banks, but not how it affects banks that bid for other reasons in non-targeted operations.

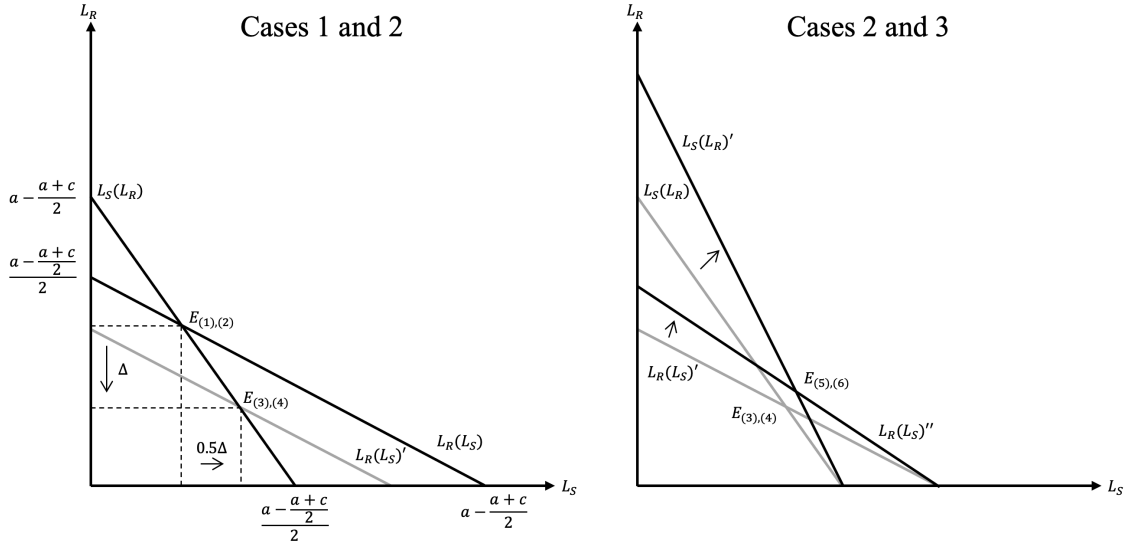


Fig. 1. Loan supply reaction functions in the three scenarios of the Monti-Klein model. E 's denote the Cournot equilibria, and the subindices identify the specific numbered reaction function pairs. Recreated and modified from Andreeva and García-Posada, 2021.

Secondly, there are notable simplifying assumptions in the model. It considers only the lending and deposit functions of banks, and costs are only implicitly considered. Regarding the banking functions included, they were the only ones considered for the sake of conciseness, as they are the most pertinent for the study of loan supply. Similarly, costs are implicit (such as the administrative costs associated with TLTRO uptake), again, for the sake of simplicity. Banking costs could, for example, be assumed to be linear as the rest of the model, but in that case they would not necessarily change the implications of the model.

These limitations in mind, the following hypothesis is formed: TLTROs will be found to have both direct and indirect positive effects on loan supply, shifting the loan supply curve outward, as indicated by the model. The positive effects will likely be pronounced for financially stressed areas, in which banks may be more severely impaired, or in which more banks may be impaired. Non-targeted LTROs will have a positive impact, depending on the extent to which funding is used as intended.

4 Empirical studies on non-targeted operations

4.1 Euro area-wide studies

The impact of LTROs at the euro area level is analyzed in Darracq-Paries and De Santis, 2015. The authors, as Andreeva and García-Posada in the case of TLTROs, utilize data from the euro area Bank Lending Survey (BLS). In the survey, respondents answered questions about their lending conditions, including loan supply following the LTRO. The authors seek to evaluate

the impact of the liquidity provisions on the macroeconomy. They identify the LTROs as credit supply shocks. The authors find an increase in bank loans extended to non-financial corporations, along with a narrowing of lending spreads. The increase in bank loans to NFC's is 2.7 – 2.9 percentage points (pp) at its maximum, and the decrease of lending spreads was found to be 19 – 20 pp. These findings support the hypothesis of a positive shift in credit supply as a consequence of long-term liquidity provisions.

4.2 Country-specific studies

García-Posada and Marchetti, 2016 explore the effects of LTROs on the Spanish banking sector, which is considered financially strained in this context (see e.g. Laine, 2021). Their findings suggest that LTROs had a positive moderate effect of 0.8% on annual credit growth to firms. Also heterogenous effects are found: the positive effects observed for annual credit growth to firms was higher for liquidity constringer banks, with liquidity being measured by the amount of sovereign debt in the banks' balance sheets. The authors do not find the capital of banks to be an important determinant in the heterogeneity of transmission. A further aspect of heterogenous transmission is found at the firms' end: credit supply to SMEs is increased by LTROs, while the coefficient on loans to large firms is insignificant. The length of lending relationships is found to bear on the strength of the observed effects, as longer lending relationships were affected less. The authors propose that this is indicative of relationship lending being more stable than transaction lending.

Carpinelli and Crosignani, 2021 analyze the effects on the Italian banks. They show how banks, during a run, cut down on their credit supply (as suggested by the Monti-Klein model). The authors determine banks that cut their credit supply as being the sole transmitters of LTRO effects on the economy. They find support for the hypothesis: long-term liquidity had a positive effect on bank loan supply to firms, in the order of 2%.

Casiraghi et al., 2013, as Carpinelli and Crosignani, and Benetton and Fantino in the case of TLTROs, also analyze the impacts on the Italian banking sector. BLS data is used in this study. The authors construct the following index of credit supply conditions, which they then use as the dependent variable in their regressions:

Value	Effect on credit conditions
1	Tightened considerably
0.5	Tightened somewhat
0	Unchanged
-0.5	Eased somewhat
-1	Eased considerably

A direct impact of -0.2 on the BLS index is found. This indicates an easing of credit conditions, between “unchanged” and “eased somewhat” at Italian banks. These findings, as many

of the other articles, support the hypothesis of a positive loan supply shift.

Andrade et al., 2019, explore the impact of long-term liquidity provisions in the French banking sector. France is considered a less vulnerable country in this context (see e.g. Laine, 2021 or Andreeva and García-Posada, 2021). Their findings suggest that LTROs had a positive and significant effect on bank lending supply: in their baseline estimates, a EUR 1 billion provision corresponded to an increase of EUR 186 million in loans to firms during the year after the operations. Their findings corroborate the findings of other papers thus far reviewed regarding the heterogeneity of effects, as they also find that LTROs had a larger impact on more financially constrained firms. The authors, moreover, provide evidence that the longer maturity of liquidity provided contributed to the positive impact on lending. The impact of the first and second rounds of the LTRO are compared. The first round is found to have a larger impact. Additionally, the second round was larger in the number of participants and quantities borrowed. A reason for the larger impact of the first operation that the authors identify is the stigma associated with the first operation: liquidity constrained banks were more likely to bid in the first round, since they were under higher pressure. In contrast, the ECB sought to dismantle this stigma by official statements encouraging banks to bid. This supports the notion that the LTRO had a higher impact for liquidity constrained banks.

The LTRO literature findings are strikingly similar: all found evidence of a positive and significant effect on the supply of credit to firms. These support broadly the hypothesis formed in the theoretical section of this review. The LTRO literature, however, does not delve deeper into analyzing the potential indirect loan supply effects postulated by the Monti-Klein model, as they are focused on how total loan supply was affected as a consequence of LTROs.

4.3 Empirical problems

There are three common identification problems in the reviewed LTRO literature. The first is disentangling credit supply effects from credit demand effects (García-Posada and Marchetti, 2016, Andrade et al., 2019). The second identification problem is that the banks' customers are not randomly assigned. This is a problem in essence because of the observed heterogeneity in pass-through to different firms. The third challenge is that LTRO amounts may be endogenous, as constrained banks were more likely to bid larger amounts.

García-Posada and Marchetti deal with the first issue by conducting their analyses on only those firms with multiple banking relationships. Andrade et al. utilize this same approach, which is essentially to include only the sample of the aforementioned firms, and to include time-varying firm fixed effects in their regressions. Thus the authors will have dummies for firm-time combinations, and can control for credit demand, allowing the comparison in credit supplied to said firms by different banks, that in turn have bid different amounts.

Non-random assignment of bank-firm relationships is addressed in García-Posada and Marchetti, 2016 by further restricting the sample to those relationships that both were in place

prior to the operations, and continued after it. This allows the authors the comparison of credit amounts for a given firm from different banks, both before and after the operations. The third problem is dealt in García-Posada and Marchetti, 2016 by controlling for bank funding conditions in regressions. The correlation between the error term and the LTRO is sought to be brought to zero by including time-varying characteristics of banks in the regressions. These include, for example, bank fixed effects, liquidity, capital and others. Andrade et al. suggest two potential ways of addressing this issue: the first is the same approach of controlling for the variables of bank lending conditions, and the second is using an instrument for LTROs. However, they utilize the same approach as García-Posada and Marchetti, as they state that an instrument would be difficult to find.

These approaches to the common main empirical problems faced by the literature show that they are effectively dealt with, supporting the papers' internal validity.

5 Empirical studies on targeted operations

5.1 Euro area-wide studies

Andreeva and García-Posada (2021), as well as Laine (2021), analyze the impacts of TLTROs on credit supply at the euro area level. Andreeva and García-Posada focus on TLTRO-I operations, while Laine considers the second series, TLTRO-II. Their methodologies differ somewhat, as Laine utilizes a 2SLS differences-in-differences approach with monthly, bank-level data from the ECB's Individual Balance Sheet Items database, while Andreeva and García-Posada employ a standard 2SLS regression analysis. The latter authors use data from the Individual Bank Lending Survey, Individual Balance Sheet Items, and Individual MFI Interest Rate databases.

Andreeva and García-Posada analyze the effects of TLTROs on the probabilities of different effects on bank loan supply. Specifically, the effects that are analyzed are changes in credit standards and lending margins. The authors identify an easing of credit standards as a positive effect on loan supply and a tightening or narrowing of lending margins as a positive effect as well. Credit standards refer to the criteria by which the banks loan to customers. Lending margins refer to the spreads on reference rates, that is, the differences between their lending rates and policy rates, for example.

Andreeva and García-Posada find that a standard deviation increase in bank-level TLTRO resulted in a direct effect of a 15.8 pp higher probability of narrower average lending margins for loans to households. No evidence is found of lending margin effects for NFCs, or of credit standard effects either for households or for NFCs. These findings are somewhat surprising and partly differ from the assumptions of the Monti-Klein model. The model suggests that a TLTRO would increase loan supply for bidding banks (a direct effect), but the only evidence of this at the bank-level is found for household loan margins.

For indirect effects, that is effects for non-bidding banks, Andreeva and García-Posada find that a standard deviation increase in bank-level TLTRO resulted in a 5.2 pp higher probability of lower credit standards on all NFC loans, with a smaller effect on small and medium sized firms, and a higher effect on large firms. They also found evidence of an 8.8pp higher probability of credit standard decrease for households. No evidence is found for indirect effects on lending margins. These findings are in line with the Monti-Klein model in that loan supply, via credit standards, is significantly affected by competing banks bidding in the TLTRO.

When analyzing the participation effects at the extensive margin, the authors find that participating banks have a 61.7 pp higher probability of narrower lending margins for household loans, compared to non-bidding banks. No other effects are found at the extensive margin. This brings additional support for the findings at the bank-level for direct effects. This also suggests that participating in the TLTRO transmits direct effects mainly through household loans.

At the intensive margin, the authors find that a standard deviation increase in TLTRO for participating banks have 12.4 pp higher probability of eased credit standards for large corporations, and a 20 pp higher probability of narrower average margins. Further, participating banks exhibited a 28.6 pp higher probability of narrower average margins to households, from the same standard deviation increase in TLTRO. These findings bring broader support for the theoretical model, as participation increases probabilities of narrower margins both for firms and for households, and the probability of lower credit standards for firms.

The authors also observe empirical support for the theoretical propositions of changes in competition in the funding markets as an effect of the TLTRO. The authors use a competition dummy with a value 1 if competition has contributed to decreased credit standards or to narrower margins. This dummy, along with country-level TLTRO, is used to determine the effects of competing banks' TLTRO uptake on the credit variables of non-bidding banks. They find that competition along with competitor TLTRO uptake have contributed to decreases on credit standards at all firm sizes, and to tighter margins on loans to firms. For household loans, the findings are similar. This provides support for the existence of positive funding externalities, which are also implied by the Monti-Klein model. This supports the notion that an easing of competition in the funding market can have a positive effect on the credit supply of non-bidding banks.

The authors also find heterogeneity in the indirect impacts of TLTRO's on loan supply. Vulnerable countries (Ireland, Italy, Portugal, Spain) are found to be more exposed to TLTRO effects, as the impact on bank lending is found to be stronger than for countries considered less vulnerable.

Laine, in his 2021 paper, analyzes the effects of TLTRO-II participation on the stocks of credit at banks. He finds that participating in TLTRO-II increased credit stocks to non-financial corporations, as the estimate of the cumulative effect of participation exceeds 20%. However, for household loans (loans for consumption), the cumulative effect is estimated to be negative

but not significant. This indicates that TLTRO-II participation increased corporate lending but had no effects on household lending.

In addition to participation effects, Laine also analyzes the effects of TLTRO-II uptake amounts. He finds that in contrast to expectations, TLTRO-II borrowing did not correlate with growth of credit to NFC's. He then proceeds to a different approach. He uses the logarithm of the amount of eligible outstanding loans as an instrument for the logarithm of TLTRO borrowing, and observes an impact on lending amounts: lending was estimated to be higher to NFCs and lower for households. When he uses the logarithm of central bank credit amounts as an instrument, he finds that credit remained unchanged for NFCs, and increased slightly for households. These results are somewhat ambiguous and contradictory; however, Laine identifies eligible loans as a stronger instrument, and places emphasis on the findings with it as an instrument. Thus, Laine's findings indicate that TLTRO-II amounts had a positive impact on corporate credit, and a negative impact on loans to households.

In line with Andreeva and García-Posada, Laine finds that TLTROs are associated with heterogenous effects on lending. His results suggest that crisis countries have experienced a stronger impact on bank lending by TLTROs than others. The crisis countries he identifies are Spain, Italy, Greece and Portugal.

In contrast with the approach of Andreeva and García-Posada, Laine does not distinguish between direct and indirect effects. Thus, his results do not provide additional insight into the indirect effects postulated by the Monti-Klein model, but his findings can be compared to the direct effects suggested by the model. His findings cannot be concluded to support or contradict the model in terms of lending as a whole, as he finds support in terms of lending to NFCs, but not for households. However, his findings in terms of loans to NFCs do support the hypothesis based on the Monti-Klein model.

The euro area wide-studies, similar to the LTRO literature, mostly provide support for the hypothesis. The TLTRO papers, especially Andreeva's and García-Posada's, are more suited to be used alongside the Monti-Klein mode, but this was expected, as the model does consider specifically the effects of TLTROs.

5.2 Country-specific studies

Benetton and Fantino, 2021 investigate the first series of TLTROs and their effects on the supply curve of bank credit to firms in the Italian banking sector. They utilize data mainly from the Italian Credit Register. Their approach is similar to that of Andreeva and García-Posada: a 2SLS regression analysis with the same allocation rule as an instrument.

The authors observe a loan supply increase of 10%, on average, for treated banks compared to non-treated banks. After two quarters, this increase is 17%. Further, the authors find that interest rates on loans to firms are decreased significantly. For example, in the two first quarters of 2015, a log increase of 18.83 amounted to a 6 pp decrease in rates for banks that bor-

rowed a net positive amount from the ECB. These findings imply that the TLTRO has shifted the loan supply curve outward, increasing loan supply. These findings can be interpreted as causal, as the results from 2SLS estimations show an even larger outward shift of the supply curve.

Benetton and Fantino also analyze whether the effects on loan supply have been homogenous or heterogenous. What they find is that pass-through was stronger for banks in more competitive markets, with banks increasing supply most for smaller and safer firms, suggesting a “flight to quality”, as they put it. This finding differs from Laine’s and Andreeva and García-Posada’s findings: their results suggested financially stressed regions as being most affected. This paper is, however, a country-specific study, whereas the other two are regional.

Thus, findings from Italy are broadly in support of the hypothesis formed in the theoretical section: banks that participated in the first operation did increase their credit supply to firms significantly. Furthermore, the model suggests that financially stressed participants would be most affected by TLTRO uptake, and Italy was identified as a financially stressed country in Andreeva and García-Posada, 2021 and Laine, 2021. A further consideration is that as in the above papers, the authors find that financially stressed countries were more affected, and Italy was in fact significantly affected. This thus lends further support towards the hypothesis.

5.3 Empirical problems

Similar empirical problems faced in the LTRO literature are also encountered in the TLTRO literature, that is, the issue of disentangling supply and demand effects in the credit context. This is also the case in Andreeva and García-Posada, 2021, and in Laine, 2021. To counter this problem, Andreeva and García-Posada utilize a vector of control variables which enables them to measure changes in credit demand across different credit market segments, similar to some of the LTRO literature. Laine, on the other hand, uses country-time fixed effects to address the same issue. In contrast to the LTRO literature, Laine does not have available data on firms with multiple banking relationships, and thus cannot use them to control for demand. Laine, however identifies further problems with using the country-time fixed effects: using them, it is possible of capturing supply side effects. Further issues from using country-time fixed effects is that it relies somewhat on an assumption of identical credit demand faced by countries, and that it may capture the indirect effects of lending increases by all banks. This is problematic, as Laine only studies direct lending effects. He however does account for these problems via robustness tests by replacing the country-time fixed effects by time fixed effects, and adds the logarithm of loans for house purchases into his vector of bank-level control variables (as loans for house purchases were not eligible outstanding loans). He determines that household loans allow for control of mainly credit demand.

Another empirical problem which is present in most of the literature considered in this review is the endogeneity of TLTRO uptake. The selection into TLTRO treatment is non-

random, as participation is completely voluntary from the bank standpoint. To deal with this issue, both Andreeva and García-Posada, and Andrade use the same instrumental variable approach: they utilize the allocation rule by which banks were allowed to borrow up to a set percentage of their eligible outstanding loans, and the allocation was calculated with values prior to the announcement. This effectively makes the allocation amounts themselves exogenous. This allocation is used as an instrument, and it is found to be strong (Andreeva and García-Posada, 2021). Laine, as he analyzes TLTRO-II, uses a different instrument: the banks' ratio of prior ECB credit to balance sheet size.

These show, as in the case of nontargeted operations, that the main empirical problems faced by the literature are effectively dealt with, supporting the papers' internal validity. Further, the use of strong instruments allows the results to be interpreted as causal, which is important in this research question context.

6 Discussion

The research question of this review is "how have LTROs and TLTROs affected loan supply in the euro area?" The answer to this question has to be formulated both in terms of the Monti-Klein model and the empirical model. The findings of the empirical papers are to be compared to the theoretical propositions of the model. Firstly, in regards to the effects on bank loan supply, and further, the implications to the funding markets and loan markets, ideally, would be answered. These implications include the tightening of the loan market by the increased loan supply as an effect of the liquidity provisions, and the easing of the funding market by the decrease in the utilization of deposits by constrained banks.

The majority of empirical studies reviewed support the Monti-Klein model in that they indicate an expansion of loan supply as a result of the long-term liquidity provisions. However, the papers differ in their methodologies and in some cases, in the assumptions of the channels through which the provisions affect loan supply. This needs to be considered in formulating an answer.

LTROs shifted the loan supply curve outward the most in stressed countries, according to the euro area-wide studies, and the country-specific studies in the financially stressed countries. Further, the findings from France indicate that the shift occurred in non-stressed countries as well. These are in line with the most straightforward implication of the Monti-Klein model, which is the increase in loan supply for partaking banks between cases 2 and 3. Case 2 was when a bank is liquidity constrained, and decreases its loan supply as a result. Case 3 then shows how the partaking bank can increase its loan supply due to a funding relief. This brings an important limitation to the empirical papers' findings: they do indicate that there was a positive shift in supply, but they do not explicitly indicate that the shift is specifically due to the provision being a funding relief.

The LTRO literature also comes to differing conclusions on the types of shifts in loan supply due to the differences in dependent variables used. Most of the papers that use BLS data deal with quantified changes in qualitative indexes describing lending conditions, such as how did credit standards change. Conversely, papers that use bank-level quantitative data provide quantitative changes in loan supply amounts. Qualitative findings indicate simply that credit conditions eased between "unchanged" and "somewhat". Quantitative findings indicate that annual credit growth in Spain was 0.8%, bank loan supply increased 2% in Italy, and a EUR 1 billion increase in LTROs in France amounted to a loan supply increase of EUR 186 million. Taken together, these findings indicate that LTROs had a positive effect on bank loan supply, but fail to collectively quantify the effect.

The TLTRO literature also indicate that broadly considered, loan supply expanded following TLTRO-I and TLTRO-II. However, these findings face the same issues as the LTRO literature, namely, that the results differ in terms of what they measure. Andreeva and García-Posada, 2021 present quantified findings from qualitative observations, indicating increased probabilities of eased lending conditions. Benetton and Fantino, 2021 provide quantitative results that suggest a significant increase in loan supply and a decrease in interest rates. Laine, 2021 provides cumulative findings from TLTRO-II that indicate similar results for NFCs, and contrasting results for households. The literature presents notable participation effects as well. Participating in either of the two operations shifted the respective banks' loan supply curve outward. In terms of loans to firms, these results together indicate that loan supply has increased. In terms of loans to households, TLTRO-I seems to have increased loan supply, while TLTRO-II seems to have decreased it.

One of the most interesting implications across both the LTRO and TLTRO literature is the heterogeneous effects of the operations on loan supply. Firstly, loans to smaller firms were affected more, which was identified as potentially stemming from relationship banking. Further, financially constrained banks were seen to be affected the most – exactly as indicated by the Monti-Klein model. What is indirectly indicated by the model is the geographical heterogeneity also seen: financially stressed countries were more exposed to the effects of these operations. This could be due to the degree of financial strain to banks in those countries, or the number of strained banks in those countries.

This observed heterogeneity is interestingly in line with the broader literature on monetary transmission in the euro area. Other unconventional methods of monetary policy have been found to transmit heterogeneously as well. For example, interest rate pass-through was heterogeneous following the financial and sovereign debt crises (see for example Altavilla, Canova, and Ciccarelli, 2020).

7 Conclusion

This literature review studied the effects of long-term liquidity provisions on the credit supply of banks in the euro area. A theoretical model was introduced, and was used to discuss findings from the empirical literature. The answer to the research question of this review is the following.

Both non-targeted and targeted long-term liquidity provisions alike resulted in a positive shift of loan supply to firms in the euro area. The positive shifts are observable both as increased stocks of credit available to non-financial corporations and increased probabilities of eased lending conditions. For households, the first targeted operation increased loan supply, while the second targeted operation slightly decreased it. These positive shifts in credit supply to firms were heterogeneous by the size of borrowing firms and by the financial conditions of both banks and countries.

Tying back to the rationale of this study, the above answer provides some policy implications as well. Firstly, targeted long-term liquidity can be particularly of use when crises cause segments of the economy liquidity impairments, as they increase credit availability in those segments the most. Moreover, the operations studied may also affect segments that are not constrained, as shown by Andreeva and García-Posada, 2021. Lastly, the findings discussed in this review show that (targeted) long-term refinancing operations have been an effective tool in achieving their set aims, and this can help in policy decisions in potential similar situations in the future.

This topic also lends itself to a variety of rather interesting avenues of potential future research. A natural one would be the loan supply effects of the ongoing TLTRO-III, after it ends. The unconventional monetary measures conducted during the COVID-19 crisis and their effects on bank lending could be another. Another possibility would also be a more in-depth study of direct versus indirect effects of liquidity provisions, and whether the loan market and funding market effects of the Monti-Klein model are corroborated.

Literary references

- Altavilla, Carlo, Fabio Canova, and Matteo Ciccarelli (2020). “Mending the broken link: Heterogeneous bank lending rates and monetary policy pass-through”. In: *Journal of Monetary Economics* 110, pp. 81–98.
- Andrade, Philippe et al. (2019). “Can the Provision of Long-Term Liquidity Help to Avoid a Credit Crunch? Evidence from the Eurosystem’s LTRO”. In: *Journal of the European Economic Association* 17.4, pp. 1070–1106.
- Andreeva, Desislava C. and Miguel García-Posada (2021). “The impact of the ECB’s targeted long-term refinancing operations on banks’ lending policies: The role of competition”. In: *Journal of Banking & Finance* 122.
- Benetton, Matteo and Davide Fantino (2021). “Targeted monetary policy and bank lending behavior”. In: *Journal of Financial Economics* [In press].
- Bondt, Gabe de, Benoît Mojon, and Natacha Valla (2005). “Term structure and the sluggishness of retail bank interest rates in euro area countries”. In: *ECB Working Paper Series* 518.
- Carpinelli, Luisa and Matteo Crosignani (2021). “The design and transmission of central bank liquidity provisions”. In: *Journal of Financial Economics* 141.1, pp. 27–47.
- Casiraghi, Marco et al. (2013). “The Impact of Unconventional Monetary Policy on the Italian Economy During the Sovereign Debt Crisis”. In: *Bank of Italy Occasional Papers* 203.
- Darracq-Paries, Matthieu and Roberto A. De Santis (2015). “A non-standard monetary policy shock: The ECB’s 3-year LTROs and the shift in credit supply”. In: *Journal of International Money and Finance* 54, pp. 1–34.
- García-Posada, Miguel and Marcos Marchetti (2016). “The bank lending channel of unconventional monetary policy: The impact of the VLTROs on credit supply in Spain”. In: *Economic Modelling* 58, pp. 427–441.
- Klein, Michael A. (1971). “A Theory of the Banking Firm”. In: *Journal of Money, Credit and Banking* 3.2, pp. 205–218.
- Laine, Olli-Matti (2019). “The Effect of TITRO-II on Bank Lending”. In: *Bank of Finland Research Discussion Papers* 2019.7.
- (2021). “The Effect of Targeted Monetary Policy on Bank Lending”. In: *Journal of Banking and Financial Economics* 1(15), pp. 25–43.
- Lane, Philip R (2012). “The European Sovereign Debt Crisis”. In: *Journal of Economic Perspectives* 26.3, pp. 49–68.

Mishkin, Frederic S. (1996). “The Channels of Monetary Transmission: Lessons for Monetary Policy”. In: *NBER Working Paper Series 5464*.

Monti, Mario (1971). “A theoretical model of bank behavior and its implications for monetary policy”. In: *Review of Industrial Economics and Policy 2*, pp. 165–191.

Other references

Bank of Slovenia (2019). *ECB interest rates*. en. URL: <https://www.bsi.si/en/statistics/interest-rates/ecb-interest-rates> (visited on 08/01/2021).

European Central Bank (Dec. 2011). *ECB announces measures to support bank lending and money market activity*. en. URL: https://www.ecb.europa.eu/press/pr/date/2011/html/pr111208_1.en.html (visited on 07/27/2021).

— (June 2015). *Objective of monetary policy*. en. URL: <https://www.ecb.europa.eu/mopo/intro/objective/html/index.en.html> (visited on 07/13/2021).

— (July 2021). *TLTROs*. en. URL: <https://www.ecb.europa.eu/mopo/implement/omo/tltro/html/index.en.html> (visited on 07/27/2021).

Freixas, Xavier and Jean-Charles Rochet (2008). *Microeconomics of Banking, Second Edition*. Cambridge, USA: MIT Press. ISBN: 978-0-262-27317-6.

A List of symbols used

In order of appearance:

- r_L : Inverse demand of loans
- r_D : Inverse supply of deposits
- L^* : Market clearing aggregate loan supply
- D^* : Market clearing aggregate deposit demand
- π_i : Profit of bank i
- a, c : Constants
- L_i : Loan supply of bank i
- D_i : Deposit demand of bank i
- ρ : Risk premium
- i : Interest rate on TLTRO
- β : Fraction of loans funded by TLTRO

B List of abbreviations used

Alphabetical by abbreviation:

- 2SLS : Two-stage least squares
- BLS : Bank lending survey
- ECB : European Central Bank
- EUR : Euro
- LTRO : Long-term refinancing operation
- MFI : Monetary financial institution
- MRO : Main refinancing operation
- NFC : Non-financial corporation
- PP : Percentage point
- TLTRO : Targeted long-term refinancing operation