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ECB Euro Liquidity Lines

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ABSTRACT: Central bank liquidity lines have gained momentum since the global financial crisis as a cross-currency liquidity management tool. We provide a complete timeline of the ECB liquidity line announcements and study their signalling and spillback effects. The announcement of an ECB euro liquidity line decreases the premium paid by foreign agents to borrow euros in FX markets relative to currencies not covered by these facilities by 51 basis points. Consistent with a stylized model, bank equity prices increase by around 1.75% in euro area countries highly exposed via banking linkages to countries whose currencies are targeted by liquidity lines.

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WORKING PAPERS

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Prepared by Silvia Albrizio, Iván Kataryniuk, Luis Molina and Jan Schäfer[1]

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Introduction

Central bank swap and repo lines have been used extensively in the last two decades to provide foreign currency liquidity across jurisdictions. These liquidity lines have two components, called legs. The first consists of the agreement between a source central bank and a recipient one. When a swap line is active, the recipient central bank can access the source central bank's currency in exchange for its domestic currency at the spot exchange rate, up to a maximum amount, and at a fixed interest rate, which is below the market rate. At maturity, the same amount of money is exchanged among the two counterparties at the same fixed spot exchange rate.[1] In this way, the recipient central bank can inject liquidity into the domestic market via repo lines with the domestic financial institutions - which is the second leg of the line. Ultimately, these liquidity injections prevent market pressure on the domestic currency, if currency needs were to be met by private agents, or avoid exhausting domestic reserves, if needs were to be met by reserves' sell-off (Aizenman et al. 2011). In the case of central bank repo lines, the recipient central bank has to pledge assets denominated in the source-country currency as collateral to have access to the currency.[2]

In this *do ut des* agreement, on the one hand, the recipient central bank can support the liquidity needs of its domestic banking system. On the other hand, by reducing foreign liquidity shortage, the source central bank prevents negative spillovers in the form of financial instability. Note that the latter is exempted from bearing credit risk, since the recipient central bank, based on its comparative advantage, takes care of monitoring the institutions accessing the credit. Finally, the transaction does not involve exchange rate risk for any of the two counterparts, since the forward exchange rate is fixed.

The objective of this paper is to analyze the effect of ECB euro liquidity lines. The euro represents the second most important currency in the international monetary system.[3] Just during the first month of the Covid-19 pandemic, the ECB has established eight new euro liquidity facilities and most of them have been extended twice, as of September 2022. In spite of this, the ECB liquidity line network and the effectiveness of these tools are, to the best of our knowledge, mostly unknown. We provide a description of the deployment of this tool by the ECB, creating a timeline of swap and repo line announcements based on ECB press releases. We test for the signalling effect of the ECB euro liquidity lines in reducing

[1] Although these arrangements are referred to as central bank swap lines, they have different features with respect to FX swap in private markets. De facto, the former provides a collateralized loan of the source central bank's currency.

[2] Bahaj and Reis (2022b) provide an in-depth discussion of the institutional framework and mechanisms of the central bank liquidity lines.

[3] According to the ECB, the euro represents around 36% of the share of global payments at the end of 2022 and around 20% of the share in global holdings of foreign reserves.

liquidity tensions and generating positive spillbacks to euro area (EA) countries. We use announcement dates instead of the actual activation of the line for two reasons: first, the announcement is publicly available, and therefore any signalling effect will appear on that date. Second, if these lines serve as a prevention tool, the announcement should be sufficient to provide confidence in the functioning of the foreign exchange swap market and increase liquidity. Schnabel and Panetta (2020) underline that these liquidity arrangements do not need to be actually used to be effective.

As shown in Bahaj and Reis (2022a), by providing an outside option to the FX market, central bank liquidity lines put a ceiling on deviations from covered interest parity, lowering recipient-country agents' borrowing costs. Moreover, by the expectations theory of the term structure, this argument also holds in the case of the mere announcement of a liquidity line, which ultimately caps the price of forward agreements. To test empirically the effectiveness of ECB euro liquidity lines we follow Cetorelli et al. (2020) and Bahaj and Reis (2022a). We measure the euro borrowing costs in FX markets using the daily deviations of the covered interest parity (CIP) before and after the announcement of a euro liquidity line on currencies targeted by the line versus a control, non-targeted group. Similar to Bahaj and Reis (2022a), our identification relies on a difference-in-differences (DID) strategy. Considering the lines the ECB established with small European countries, we find that the mere announcement of euro swap and repo lines reduces the euro funding cost in foreign exchange swap markets by 51 basis points.

Turning to the spillback effects, we rationalize the mechanism of transmission in a stylized model. The announcement of a central bank liquidity line decreases the bankruptcy probability of recipient-country financial intermediaries by reducing their refinancing cost. This increases the expected payoff of the source-country credit to the recipient bank, increasing the source-country bank's value and eventually its stock market price. We test the prediction of the model leveraging on the heterogeneity across euro area countries. Banks in different EA jurisdictions can be affected heterogeneously depending on their exposures to foreign markets via the domestic banking sector, proxied by the share of cross-border claims of EA banks towards countries that receive liquidity lines. By introducing the exposure of the banking sector in EA countries in a DID framework, we estimate the differential effect of these announcements on the change in Euro Area banks' stock prices. Consistent with our model, we find that EA countries with the most exposed banking sectors benefit the most from the announcement of the lines since they experience a relative increase in their equity prices of about 1.75% in a four-day window around the announcement. In other words, more exposed banks see their market valuation increase, and their profitability expectations improved after the announcement. Overall, the analysis suggests that the signalling effect

of central bank liquidity facilities is effective in generating a positive direct effect on foreign FX markets as well as spillovers on the source-country. Finally, in the current conjunction, liquidity arrangements in the EA may contribute to reducing the risk of fragmentation.

This paper is connected to the economic literature looking at the beneficial effects of swap lines. Several papers have studied how central bank liquidity lines have lubricated both money markets and foreign exchange swap markets in the global financial crisis (GFC) (Carré and Le Maux, 2020; Obstfeld et al., 2009) as well as in the more recent COVID-19 crisis (Aldasoro et al., 2020). Consistent with the central role of the USD in the global financial markets, most of these arrangements have provided liquidity in this currency. Indeed, Fed USD swap lines played an effective lender of last resort function in FX markets by putting a ceiling on deviations from the CIP (Baba and Packer (2009); Bahaj and Reis (2022a); Moessner and Allen (2013), among others). This mechanism also worked during the COVID-19 crisis (Bahaj and Reis, 2020a; Cetorelli et al., 2020). Aizenman et al. (2022) show that trade and banking linkages with the US are positively associated with access to Fed swap and repo lines during the COVID-19 crisis. Fed liquidity facilities announcements during 2020 have led to an appreciation of the recipient countries' currency with respect to the USD; while dollar auctions by major central banks have expansionary effects on other economies. Using micro-level data on FX forward and swap transactions, Ferrara et al. (2022) find that dealers that draw on swap lines reduce their demand for dollars at the forward leg in the FX market and increase their supply of dollars to non-financial institutions, improving market liquidity. Moreover, Bahaj and Reis (2022a) find that Fed liquidity lines have a positive spillback effect on the source-country by encouraging capital inflows into USD-denominated assets. In this way, while swap and repo lines can be thought of as a byproduct of globalisation in financial markets since they responded to the liquidity needs of an integrated global financial system, they also proved to be useful to reinforce the international role of the source currency in the international monetary system as well as in international trade. People's Bank of China's 38 swap lines in less than a decade are a clear example of alternative use of such tools (Bahaj and Reis, 2020b).

The paper is structured as follows: Section 1 provides an overview of the ECB repo and swap lines network across time; Section 4.1 explains the mechanism behind the signalling effect and introduces the theoretical framework illustrating the spillback channel; Section 2 presents the data used in the analysis; Section 3 presents the empirical analysis of the direct effect of ECB liquidity line on the euro funding costs in FX markets; Section 4 introduce our stylized model explaining one of the mechanisms behind the positive spillback effect of these facilities and test it empirically. Section 5 concludes with some considerations on the

desirability of a more stable and permanent central bank liquidity network and proposes some lines of future research.

1 ECB liquidity lines

Historically central banks' liquidity lines have been used for three main objectives: (i) defend a peg system (Bordo et al., 2015) or, more broadly, fund FX interventions (Bahaj and Reis, 2022b), (ii) offer a financial stability tool, which in the case of the Fed becomes a global liquidity backstop (Bahaj and Reis, 2022a among others), (iii) enhance the international use of the domestic currency (Bahaj and Reis, 2020b).

The first objective led to the establishment in 1962 of the Fed Reciprocal Currency Agreements, i.e. swap lines, first with the Bank of France and by the end of the same year with nine other key central banks. Under the Bretton-Woods system, the Fed intervened in forward foreign-exchange markets to reestablish confidence in the USD and to defend its gold peg. At the end of the 90s, this tool was discontinued. The global swap network regained importance as a cooperation tool across central banks only following the September 11th terrorist attack and more extensively in 2007 and 2008 with the Global Financial Crisis (GFC).[4] In this context, central banks' liquidity agreements transformed the Fed into the global lender of last resort, limiting fire sales and helping contain the risk of market contagion.

The G10 central banks contributed to this coordinated effort to expand the USD liquidity provision capacity.[5] In 2011, the network agreed on extending the scope of these swap lines to provide liquidity in each jurisdiction in any of their currencies. By 2013 these temporary bilateral liquidity swap arrangements were converted into a standing agreement with an unlimited withdrawal amount.

Not only did the ECB participate in such a network[6] and established swap lines with the People's Bank of China, Bank of England, and the Swiss National Bank to provide foreign-denominated liquidity, but between October 2008 and August 2022 it established fourteen new swap and repo lines to provide euro liquidity. The ECB has continued to renew and expand its euro facilities particularly during the COVID crisis. Euro lines have been extended both in terms of the time frame and the volume, and their pricing conditions

[4]The evolution of the USD swap lines have been described in McCauley and Schenk (2020), Allen et al. (2010) and Goldberg et al. (2010), among others.

[5]Participating central banks were the Fed, the Bank of Canada, the Bank of England, the Bank of Japan, the European Central Bank, and the Swiss National Bank.

[6]Since 2011 the agreement also enabled central banks of the network of temporary bilateral liquidity swap arrangements to provide liquidity operations, should they be needed, in Japanese yen, British pound sterling, Swiss francs, Canadian dollars, and Euro, in addition to US dollars.

changed. Counterparts were mostly EU countries outside the EA (Bulgaria, Croatia, Czech Republic, Denmark, Hungary, Latvia, Poland, Romania, and Sweden), however, since 20 March 2020, liquidity lines agreements were signed also with non-EU countries (Serbia, San Marino, Albania and Republic of North Macedonia).[7] In addition, on 25th June 2020, as part of the pandemic-related crisis response, the ECB announced the establishment of the EUREP, a new and temporary Eurosystem repo facility to provide euro liquidity to a broader set of non-European central banks.

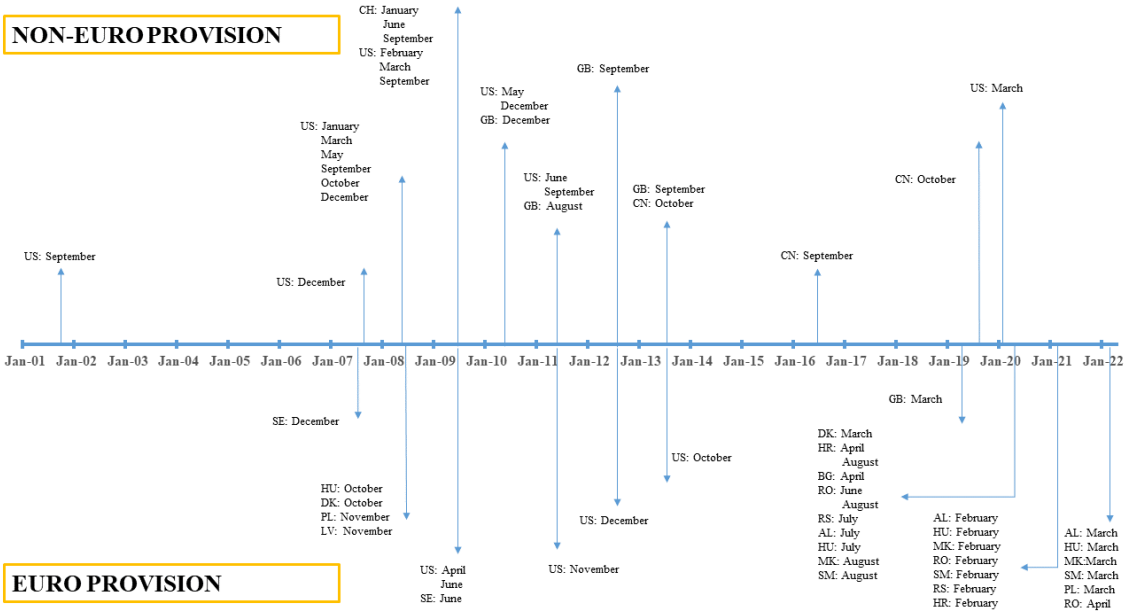
Figure 1 provides a complete picture of all ECB liquidity lines announcements until August 2022.[8] The timeline comprises announcements related to new agreements, time and volume extensions, and changes in the conditions. The latter may regard changes within the first leg of the line, i.e. on the agreement between the two central banks. An example is the 15th March 2020 announcement, which decreased the rate on the standing US dollar liquidity swap arrangements by 25 basis points. However, they may also refer to changes in the second leg of the line, which refers to the open market operations that the recipient-central bank put in place to provide liquidity to the domestic financial system. For example, it may entail a change in the frequency or the maturity of the liquidity-providing operations.[9] Although most of the lines within the network of the bilateral agreements among the G10 countries' central banks are reciprocal in nature, often these lines have been explicitly motivated by the need of providing USD liquidity. To capture the actual intention of the ECB in providing liquidity in euros versus other currencies, Figure 1 distinguishes between euro and non-euro lines based on the information reported in the ECB press releases. Announcements related to the former are reported below the timeline, while announcements related to the latter are above the timeline. As the chart shows, euro liquidity lines are mainly clustered around crisis episodes, suggesting the ECB liquidity lines have been mainly used as a liquidity backstop. However, some of these have also been used in the context of the exchange rate mechanism (ERM II), a peg system to the euro, which is a prerequisite for any EU Member State to join the euro area – as in the case of Bulgaria on 22nd April 2020. Differently from the PBoC, the ECB has not leveraged on euro liquidity facilities to provide incentives for the internationalization of its currency. Appendix A.3 reports the full timeline of ECB liquidity facilities, specifying additional characteristics of each line announcement.

[7]Previous to October 2008, in 2007, the ECB established its first euro swap line with the central bank of Sweden. However, this event is not included in the analysis since the goal of this paper is to estimate the signalling effect of these lines and the latter has been announced in the ECB press releases much later than the actual decision.

[8]The timeline does not include the EUREP facility since the respective country-specific announcements are not public.

[9]The timeline does not include discontinuations of central bank lines or maturities of liquidity-providing operations with the domestic financial system.

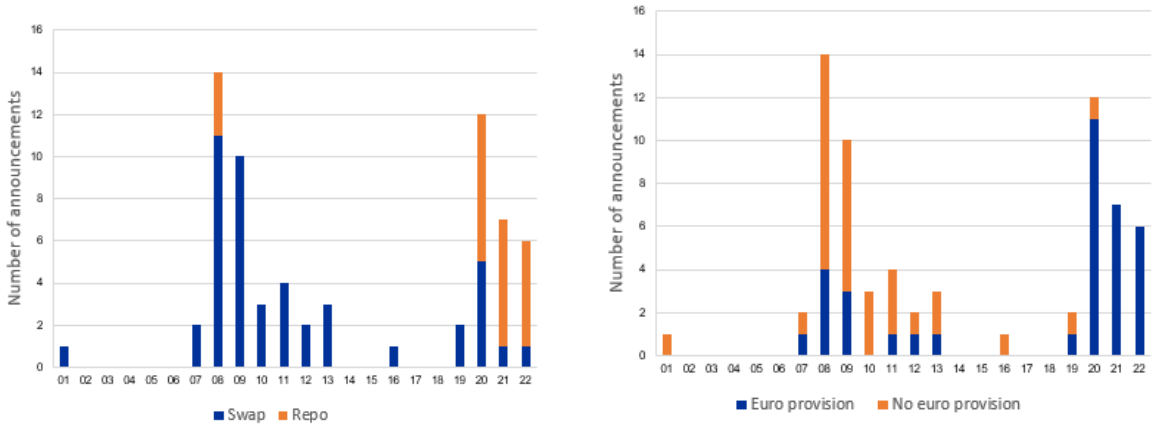
Figure 1: ECB liquidity facility announcements



Note: The figure reports the announcements of ECB liquidity facilities. Above the timeline, announcements related to lines between the ECB and other central banks for the provision of foreign currencies (such as USD, GBP, CHF, CNY) are reported. Below the timeline, ECB euro liquidity facilities are recorded.

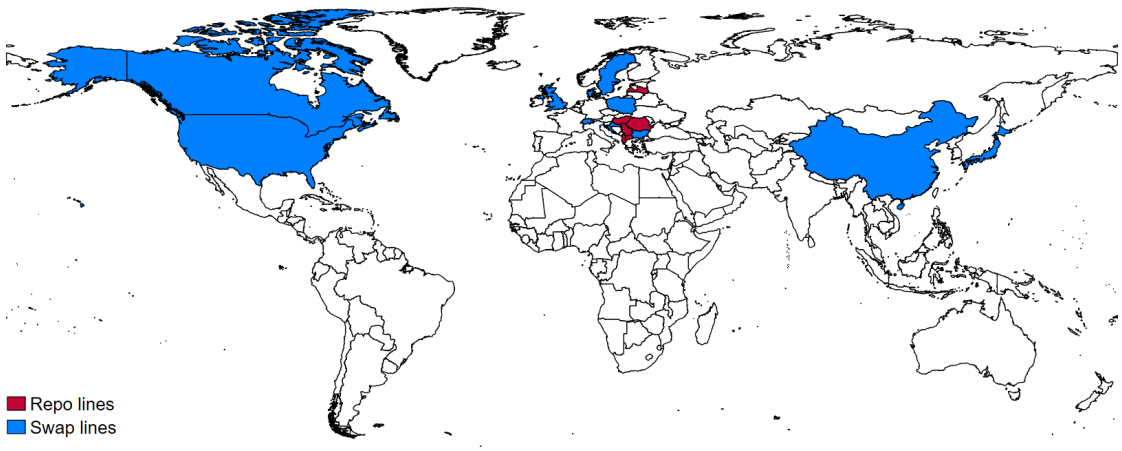
Figure 2, Panel A, shows the total number of announcements by year conditional on the type of facility, swap or repo. Repo facilities require adequate collateral in euro-denominated assets and feature a higher lending rate compared to swap lines. Figure 2, Panel B, reports the yearly number of announcements of lines explicitly motivated by the need of providing euro liquidity versus other currencies, such as the US dollar or Swiss Franc. Taken together, these two panels underline a shift in the role of the ECB. Initially, the lines serve mainly as facilities to enhance USD liquidity in the EA via swap lines. During the global financial crisis, both ECB euro and non-euro lines increased predominantly due to the increasing number of swap line extensions with G10 countries. However, the pandemic triggered increasing ECB interventions as regional LOLR providing euro-denominated loans to the European region outside the Euro Area, mainly via repos.

Figure 2: ECB liquidity facility announcements



Note: The left-hand panel shows the breakdown of the total number of announcements with respect to the type of facilities. Blue bars denote swap lines, while orange ones refer to repos. The right-hand side panel distinguishes between euro, in blue, and non-euro provisions, in orange, according to the explicit motivation provided in the ECB press releases.

Figure 3: Geographical distribution ECB euro liquidity facilities: repo and swap lines



Note: Countries whose central bank has established euro swap lines with the ECB are highlighted in blue while countries with euro repo lines are highlighted in red.

With respect to the conditions, except for the swap lines within the G10 network, most of the facilities are temporary and with a maximum amount of allotment at a fixed rate, which is defined as a spread over the OIS reference date with a minimum floor.

Finally, with respect to the activation of the lines, the available information is scarce. Based on recipient countries' sources of information, at least the liquidity lines with the Magyar Nemzeti Bank, the Sveriges Riksbank and the Bank of England have already been used, although in small amounts.

2 Data

For the purpose of this analysis, we consider the euro liquidity lines from 6 October 2008 through 18 August 2022 as reported in the ECB press releases.[10] The sample comprises seven countries whose currencies have been targeted by the lines: Bulgaria, Denmark, Croatia, Hungary, Poland, Serbia, and Sweden. We exclude (i) countries that are targeted by the lines but use the euro as the main currency, such as San Marino; (ii) the G10 network, due to the de iure reciprocal nature of the swap lines, to avoid confounding the effect of a euro liquidity line with the impact of USD or other currencies provisions; (iii) the agreements with the National Bank of the Republic of North Macedonia, the National Bank of Romania and the Bank of Albania, due to data limitation for the construction of the dependent variable; (iv) the agreement with the Bank of Latvia, since it was not included in the ECB press releases and therefore its signalling effect might be diluted.
The included events are the following:

- October 16, 2008: Repo agreement with the Magyar Nemzeti Bank (HU) to support the bank's instruments of euro liquidity provision.
- October 27, 2008: Swap agreement with the Danmarks Nationalbank (DK) to improve liquidity in euro short-term markets.
- November 21, 2008: Repo agreement with the National Bank of Poland (PL) to support the NBP's instruments of euro liquidity provision.
- June 10, 2009: Activation of the swap agreement signed with the Sveriges Riksbank (SE) on 20 December 2007 with the aim of facilitating the functioning of financial markets and providing euro liquidity to the latter if needed.
- March 20, 2020: Reactivation of the swap line with Danmarks Nationalbank (DK) to provide euro liquidity to Danish financial institutions.
- April 15, 2020: Precautionary swap agreement with the Central Bank of Croatia (HR) to provide euro liquidity to Croatian financial institutions in order to address possible market dysfunction.
- April 22, 2020: Precautionary swap agreement with the Bulgarian National Bank (BG) to provide euro liquidity.

[10] The timeline is available at: ECB liquidity lines - Timeline.

- July 17, 2020: Repo agreement with the National Bank of Serbia (RS) to provide euro liquidity to Serbian financial institutions to address possible euro liquidity needs in the presence of market dysfunctions due to the COVID-19 shock.

- July 23, 2020: Repo agreement with the Magyar Nemzeti Bank (HU) to provide euro liquidity to Hungarian financial institutions to address possible euro liquidity needs in the presence of market dysfunctions due to the COVID-19 shock.

- August 28, 2020: Extension of the repo facility with the Central Bank of Croatia (HR) to provide euro liquidity to financial institutions in the two countries via their respective national central banks to address possible euro liquidity needs in the presence of market dysfunctions due to the COVID-19 shock.

- February 04, 2021: Extension of its temporary swap and repo lines with non-euro area central banks (HR, RS, HU) to address possible euro liquidity needs in non-euro area countries in presence of market dysfunctions due to COVID-16

- March 28, 2021: Swap agreement with Narodowy Bank Polski (PL), and extension of temporary repo lines with central banks of Hungary (HU) to prevent spillover effects in euro area financial markets and economies that might adversely affect the smooth transmission of the ECB's monetary policy in the context of heightened geopolitical tensions triggered by the Russian invasion of Ukraine.

Finally, as a robustness check, we add two countries whose currencies have never been targeted by ECB liquidity lines: Norway and Iceland. They represent an interesting robustness check because, although both are small countries, close EU partners, and have experienced financial distress, they have not been targeted by the lines.

To test the effectiveness of the ECB euro liquidity line, we consider the change in the euro funding cost in FX markets. In a frictionless FX market, the covered interest parity (CIP) holds and the implied euro interest rate in the FX market equals the euro money market interest rate. If the CIP does not hold, the FX swap basis spread provides a measure of the premium paid by foreign agents to borrow euros for a specified time period in the FX market compared to the euro money market. In other words, a positive basis represents relatively high costs for euro funding in the FX market. Following Bahaj and Reis (2022a), the euro basis is defined as:

$$B_t = ln(F_t) - ln(S_t) - (r_t - r_t^*) \tag{1}$$

where F_t is the market forward rate of the euro against the rest of the currencies, S_t is the equivalent spot rate, r_t stands for the interest rate of the euro deposits and r_t^* is the interest rate for deposits in each of the foreign currencies considered.[11] We use one-week euro currency deposits when it is possible, and build back some series for some countries using the equivalent interbank interest rate. All data are obtained from Refinitiv databases on a daily frequency. We prefer to use OIS rates, but due to data availability constraints in some cases, we use Euribor rates instead. Table 8, in Appendix A.1, shows the main descriptive statistics for CIP deviations. Furthermore, since recipient-country idiosyncratic factors may drive the FX basis in times of financial turbulence, we purge the basis from country-specific factors closely related to the occurrence of financial crises, such as sovereign defaults, and banking runs, or currency crashes.

In other words, in the econometric specification, our main dependent variable is defined as the residuals res_{jt} of country-by-country regressions of the basis on country-specific characteristics collected in the vector $\boldsymbol{\Omega_{j,t}}$:

$$basis_{jt} = \alpha_j + \boldsymbol{\beta\Omega_{jt}} + res_{jt} \tag{2}$$

Following Alonso and Molina (2019), $\boldsymbol{\Omega_{jt}}$ includes the following battery of controls at different frequencies, sourced from Refinitiv. In terms of high-frequency data, we construct a volatility measure for the country-specific equity index as the forty-day standard deviation of the daily change of the domestic equity index. We also include the long-term yield of sovereign bonds, in local currency when it is possible, or using the EMBI instead. In terms of lower-frequency variables, we include the quarterly change in gross public debt as a percentage of GDP, the annual moving average of the current account balance as a percentage of GDP, countries' short-term external debt in percentage of international reserves, the inflation rate (year on year change of the Consumer Price Index), and the level of Central Bank's International Reserves in billions of USD. Finally, to proxy for the general economic performance and solvency of a country, we include the sovereign credit rating, as defined by Standard and Poor's, transforming its alphanumeric scale linearly, from 21 (AAA ratings) to 12 (BBB-, that is, the investment grade level) and 0 (restricted defaults or selective defaults, RD and SD). Note that this approach is preferable to just control for country characteristics in the DID analysis on the basis since it relies on longer time series, while the DID is just

[11] Under covered interest parity, the no-arbitrage condition $\frac{F_t}{S_t} = \frac{1+r_t}{1+r_t^*}$ holds. Equation (1) follows from taking logs and using the approximation $ln(1+r) \approx r$, valid for small r.

over a 4-day window.[12] Figures 10 to 13 report the time series of the basis and the residuals.

In the last part of the paper, to assess the potential spillback effect on the EA, we consider EA banks' stock prices as a relevant metric, since they capture market valuations and expectations about bank-specific profitability. Low stock prices are usually associated with banks in financial stress: their stock prices decrease to compensate for higher risk, inducing investors to hold their stocks. In the context of our analysis, the working hypothesis would be that the announcement of an ECB swap line with a third country outside the euro area reduces the risk of financial turbulence and/or the probability of default of banks or firms in that concrete market. This, in turn, improves the valuation of the highly exposed EA banks, and the stock price should increase. Equity prices are obtained on a daily frequency from Refinitiv, and we use the Datastream aggregate bank equity indices for each country. As in the case of the FX basis, we purge the equity indices from country-specific factors. Since in this last exercise the dependent variable is at the EA country level, we purge for variables that may affect the health of the banking sector of a given EA country. These are the short-term interest rate, defined as the 3-month Treasury Bill interest rate, or the closest maturity when the former is not available; the nominal effective exchange rate deviation, calculated as the difference between the observed nominal effective exchange rate and the exchange rate that would prevail if the real effective exchange rate were consistent with its long term mean, using the IMF nominal and real effective exchange rates; net foreign assets of domestic banks, defined as the difference between domestic banks' claims and liabilities with non-residents over GDP (as defined by the IMF's International Financial Statistics database); the loan-to-deposit ratio, defined as domestic banks' claims on the private sector over the sum of deposits (transferable deposits included in Broad Money definition, other deposits included in Broad Money, and deposits excluded from Broad Money), as posted by the IMF's International Financial Statistics database. In Appendix A.1 we summarize the descriptive statistics for the stock market data as well as the banks included in the respective aggregates.

Finally, to construct a measure of EA countries' banking sector exposure to foreign countries we use the BIS Consolidated Banking Statistics on a quarterly basis. In particular, we consider total claims of each EA domestic bank on foreign banking sectors, all maturities, and all instruments and currencies, measured on a guarantor basis. The exposure of the banking sector of EA country j to non-EA country i is calculated as the share of claims on country i over total claims of domestic banks of country j on all countries. For example,

[12] Since the inclusion of low-frequency variable may create concerns about jumps in the data, as robustness check we exclude them from the specification, and the results hold.

Italy's exposure to Bulgaria is proxied by the share of Italian banks' total claims on Bulgarian banks over the total of cross-border claims of Italian banks. When missing, data are imputed using linear interpolations. The EA country exposure is then calculated as the average exposure towards the countries targeted by a liquidity facility. Based on this measure, we construct a dummy that allows us to classify EA countries' banking sectors as highly exposed to non-EA countries if the average exposure of EA country j in the quarter prior to the announcement t is higher than the 75th percentile of the cross-country and event distribution. On the contrary, we defined a EA country banking sector as lightly exposed if its exposure is lower than 75th percentile threshold. Table 11, Appendix A.1, tabulates the exposure dummy across countries and announcements. As a robustness check, we also use (i) the 65th percentile as the relevant threshold, (ii) the continuous exposure measure without any threshold.

3 Direct effect: Euro funding in FX markets

3.1 Mechanism

Bahaj and Reis (2022a) show how an active liquidity line caps the forward price in FX swaps. Intuitively, central bank liquidity lines provide recipient-country banks with a cheaper outside option to the FX market which improves the bargaining terms that the recipient-country banks obtain from the traders. Through the term structure, this argument holds also in the case of the mere announcement of a liquidity line, which ultimately caps the price of forward agreements.[13] To see this, assume there is a trader who has access to 1-week swap agreements and 3-month swap agreements at time t. The liquidity announcement lowers the expected price of the future one-week agreements since there is a probability that the line will be activated, capping the swap price. Consequently, the announcement decreases also the price of 3-month swaps at t.[14]

This section, first, presents the methodology used to estimate the signalling effect of ECB euro liquidity facilities on the euro funding cost in FX market, as measured by CIP deviations; second, it reports the results and, finally, it provides evidence of the robustness.

3.2 Empirical strategy

As in Bahaj and Reis (2022a), our empirical strategy is based on a high-frequency DID approach. The high-frequency dimension of the approach consists of considering changes in

[13] We thank an anonymous referee for pointing this out.
[14] Proof in Appendix

financial variables in a short window around the announcement. It contributes to identifying the causal effect of central banks' actions since (i) markets react only to unexpected announcements and (ii) the short-time window helps to exclude other confounding factors. Specifically, we consider a window spanning two days before and one day after the announcement. In addition, the DID aspect is required for two reasons. First, since these events are sporadic, it is more informative to focus on specific episodes of financial stress when the volume of trading in swap contracts increases and the equilibrium is constrained by the FX swap supply curve. Second, as underlined in Section 1 as well as in the list of events considered, the ECB euro lines have been motivated by existing FX market dysfunction. This indicates a potential intrinsic correlation with confounding global factors, such as the contemporaneous worsening of global financial conditions. To avoid biased estimates, we compare the effect in the treatment group with an adequate control group.

In our context, the selection of the comparison group for the DID analysis merits some attention. The ECB euro liquidity lines have targeted most of the currencies of central banks in the geographical vicinity of the euro. This is a standard case of multiple periods and groups, where the treatment is staggered over time (Athey and Imbens, 2018; Callaway and Sant'Anna, 2020 among others). However, the treatment is not an absorbing state since we consider announcements and not implementations. Therefore, our identification strategy is as follows. For each announcement date, we compare treated countries, i.e.countries whose currency is targeted by the announcement of an ECB line, with a counterfactual that includes currencies that are targeted at previous or future dates.[15] This strategy is similar to Fadlon and Nielsen (2020), where the authors identify the effect of health shocks in labor supply using as control group households targeted on a future date. In other words, we define a currency as treated if it is targeted by the ECB line at time t, but this same currency is considered non-treated in other periods $\tilde{t} \neq t$. The idea behind this is that these countries have been targeted at least once, so they share similar characteristics under the eligibility lens of the ECB. Nevertheless, this approach could raise concerns that non-targeted countries in episode t might be affected by past liquidity line announcements. However, since we consider a short window around the announcement, we also prevent that subsequent announcements could contaminate the current one. Once defined the window and the control group, the identification ultimately relies on the timing of the announcement. In other words, the date announcement has to be random within the short-term window considered.[16]

Since we have a reduced amount of events, we collapse the panel around these announcements following previous contributions (see Bertrand et al., 2004), and we compute

[15] In the robustness we add two currencies never targeted by ECB lines.

[16] In the robustness subsection we test for anticipation and we find no such evidence.

the treatment effect using the two-way fixed effects DID estimator. More formally, we consider the following set-up, in which y_t^T denotes the mean outcome of the targeted countries at time t, y_t^{NT} is the mean outcome of non-targeted countries, and t is the date of the announcement of a liquidity line. We can retrieve the treatment effect β_t by comparing the outcome in t with the outcome in the previous period $(t-1)$, using the DID estimator:

$$\beta_t = (y_t^T - y_t^{NT}) - (y_{t-1}^T - y_{t-1}^{NT}) \tag{3}$$

First, as in Bahaj and Reis (2022a), we inspect the distribution of the FX swap basis spread around the facilities' announcements graphically. In Figure 4, we pool the observations to show the frequency distribution of the basis in this four-day window around the events for treated currencies (left panel) and for non-treated currencies (right panel). A country is considered treated in the window around event t if its currency is targeted by the ECB liquidity line announced in t, and it will be considered non-treated in the other events $\tilde{t} \neq t$. As shown in Figure 4, the histogram for treated countries suggests a shift to the left. On the contrary, we do not observe such a shift in the non-treated group. This graphical inspection suggests that announcements of ECB liquidity lines are associated with a reduction of the cost of euro funding in the FX market.

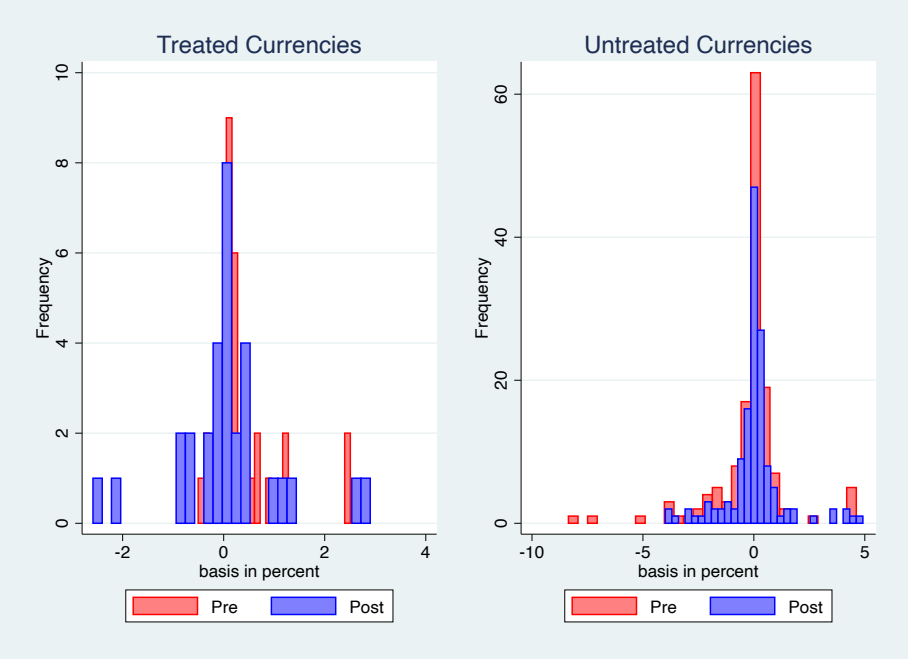


Figure 4: Basis Density Before and After Announcement

Frequency distribution in a 4-day window around the announcement. Country sample: Bulgaria, Denmark, Croatia, Hungary, Poland, Serbia, Sweden. For any announcement considered (see 2 for the list of events considered), the treated currency/ies is/are going to be the one/s targeted by the announcement, while the non-targeted currencies in the sample are untreated. Post-treatment is defined as the day of treatment and the day after, while pre-treatment is the two days prior to treatment.

To further reassert our grouping strategy and mimic our econometric specification, we purge the basis from country-specific relevant factors, as explained in Section 2, to control for country-specific factors that might contribute to diverging trends between control and treated currencies. Figure 5 shows the evolution of the residuals of the FX basis in the four-day window around the announcements of the treated versus the control group. The figure suggests a marked divergence at the time of the announcement ($t = 0$). Additionally, Figure 8 in the Appendix shows the evolution of the basis, which yields a similar picture.

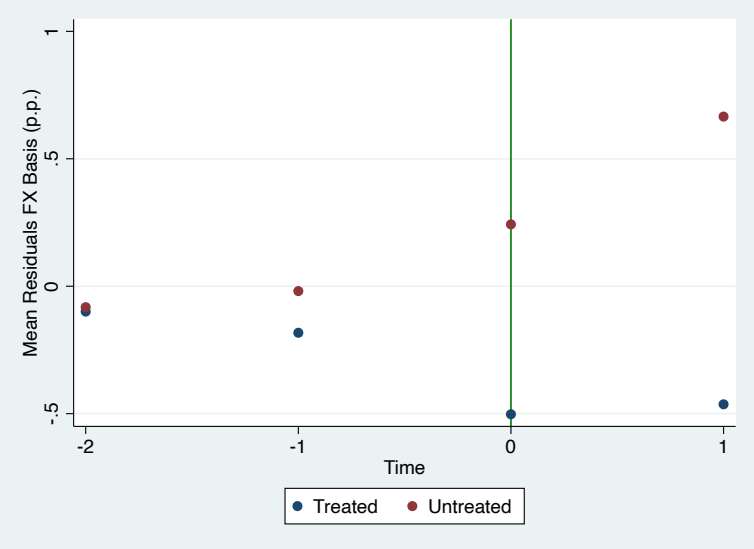


Figure 5: Residuals Before and After Announcement

The figure shows the average evolution of the variable of interest in the four-day window around each announcement of an ECB liquidity line for the treated currencies versus non-treated. The variable is defined as the residual obtained from the regression of the FX basis on the recipient-country stock market volatility, change in public debt, current account balance, sovereign rating, sovereign yield, short-term debt, reserves and inflation. For any announcement, the treated currency/ies is/are going to be the one/s corresponding to the announcement, while the rest of the currencies in the sample are used as controls. The events are pooled and the green vertical line indicates the day of the announcement.

Turning to the econometric specification, we exploit variation over two dimensions, as we do in the graphical inspection in Figure 4. First, the time of the announcement, namely we consider daily changes in the FX basis in the two days before the announcement versus the changes on the day of the announcement as well as the following day. Second, the variation between treatment versus the control group, i.e. currencies directly targeted by the swap line announcement relative to the rest. Equation (4) specifies this difference-in-differences (DID) framework via a two-way fixed effect approach, where the daily change of the euro basis is regressed over a group variable for treated currencies at event e ($T_{i,e}$), which takes the value of 1 in the four-day interval around the announcement when the economies of concern are targeted by the ECB liquidity line, and zero for the non-targeted currencies; a period dummy ($Post_t$) that equals one on each of the days of the announcements and the following day (in t and $t+1$), while it is zero in the two days before the announcement ((in $t-1$ and $t-2$); as well as the interaction of the two ($T'_{i,e}Post_t$) which captures the differential effect of the line on the treated group at event e.

If the difference-in-differences estimation is implemented properly there should be no need to control for global events that affect the treatment and control group similarly. To check for this, we include the following controls. Other ECB monetary policy decisions are captured by

a dummy corresponding to the date of the ECB monetary policy meetings (mp_t). Moreover, we add a set of global controls included in a vector (Z_t), i.e. the Global Citi Economic Surprise Index and the EU high-yield spread.[17]

Finally, since we consider a collapsed panel, we include currency-event fixed effects $\mu_{i,e}$ to fully control for all currency-specific factors at the time of the announcement. Under this fixed effect structure, $T_{i,e}$ is dropped because it is absorbed by the fixed effects. Standard errors are clustered at currency-event level. Finally, we include event-specific post dummies $Post_{t,e}$ to allow for a heterogeneous effect across events. The equation to be estimated is then given by Eq. (4):

$$res_{i,t,e} = \beta_1 T_{i,e} \times Post_t + \beta_2 T_{i,e} + \sum_e \beta_{3e} Post_{t,e} + \beta_4 mp_t + \varphi' Z_t + \mu_{i,e} + u_{i,t,e} \quad (4)$$

The effect of the ECB liquidity line is identified by β_1 which is the group-time average treatment effect defined as the difference of the average treatment effect on the treated and control groups. The inclusion of the aforementioned global covariates controls for other events that could systematically occur in that short time window.

3.3 Results

Table 1 shows the results for the basis residuals. The euro funding cost decreases in a short window around the announcement by an average of 51 basis points in a sample of small EU countries (note that since the residuals are in percent the effect in the tables is in pp and we need to multiply it by 100 to interpret the effect in basis points). This effect corresponds to about 40% of one standard deviation of the residuals (see Table 8 in the Appendix). Since the coefficient is invariant in the second column, we can be sure that the DID strategy is implemented properly. This result underlines the regional importance of the ECB euro liquidity network.

Results are robust to a battery of robustness checks. First, we add Norway and Iceland to the sample. These countries can be considered comparable to some of the countries in our sample and have experienced financial distress although they have not been targeted by any ECB liquidity line. As in the baseline sample case, there is a marked divergence of the basis residuals at the time of the announcement and the following day. Empirical results

[17] No further global volatility measures are included since the basis is already regressed on a country-specific measure of stock market volatility.

Table 1: Effect of ECB liquidity swap line announcement

Dependent Variable: FX Basis Residuals		
	Baseline Sample	
	(1)	(2)
Treated_Post	-0.512**	-0.511**
	(0.030)	(0.031)
MP meetings		-0.209*
		(0.052)
EU high yield		-0.956**
		(0.022)
Surprise index		-0.00132
		(0.203)
Observations	324	324
R^2	0.115	0.167
CurrencyxEvent FE	yes	yes
PostMat	yes	yes

p-values in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: The table reports the output of the two-way fixed effects DID estimation on a collapsed panel which is composed by the four-day window around each ECB euro swap line announcement. Treated is defined as the currency targeted by the line in t, while the control group comprises the countries not targeted by the line announced in t. Sample composition is described in Section 3.

are robust and reported in Table 4, in the Appendix, although the magnitude of the effect reduces to 37 basis points.

Second, although our results are robust to the inclusion and exclusion of a battery of global controls, we further test for anticipation and potential pre-trends. We investigate whether the DID results are robust to a placebo test, in which we artificially move the announcement date three days before the actual event to detect anticipation (in case of a negative and significant effect) as well as to detect non-parallel pre-trends. By doing this, we ensure that the window in the placebo test does not include the day of the announcement. The results for the two samples can be found in Table 6 Appendix A.2. Since the effect is always very far from being statistically significant and sometimes even has a positive sign, the results indicate no sign of anticipation and it confirms the parallel pre-trends assumption.

Third, we restimate the equation by considering the basis as dependent variable instead of the residuals. In addition to global controls, we include two country-specific covariates that change daily: stock market volatility and sovereign yield. Results are confirmed again under this set-up as shown in Table 5 in Appendix A.2.

Fourth, we estimate the treatment effect for each event separately using three different estimators: the standard two-way fixed effects estimator we have employed so far, the Arkhangelsky et al. (2021) Synthetic Differences-in-Differences estimator, and the Abadie et al. (2015) Synthetic Control estimator. The latter two estimators first estimate regularized weights that optimally combine the control group observations to fit the trend of the treated units in the sample, before calculating the differencing estimator. Consistent with our previously employed strategy, treatment is defined as the day of the announcement and the day after. For each event, we keep 15 days previous to each announcement and drop any country from the control group that was treated during this time window. Fig. 15 depicts the estimated pre-trends from the Arkhangelsky et al. (2021) estimator. The average treatment effects and standard errors (in parentheses) are -0.679 (0.606) for the DID estimator, -0.259 (0.471) for the SDID estimator and -0.484 (0.473) for the SC estimator. While the standard errors are relatively high (which is not surprising, since estimating the effect for each event separately leads to quite a low number of observations), the overall negative effect of the liquidity line announcement on the FX basis is confirmed.[18]

Lastly, Appendix B presents alternative evidence from an event study using time-series regressions of the FX basis residuals on the post-treatment dummy and a vector of controls.

[18]Inference is problematic with one treated unit: We use bootstrap, since the jackknife is not defined and placebo methods outlined in Arkhangelsky et al. (2021) rely on homoskedasticity across units, which is clearly violated. We note however that bootstrap with just one treated unit might be less reliable. See Arkhangelsky et al. (2021) for further discussion.

The estimated effect is statistically significant and slightly higher, but of similar magnitude as in the DID approach. The results are thus re-confirmed.

4 Spillbacks

In this section, we turn to the euro domestic market and test for spillbacks. First, we provide a theoretical argument on how the announcement of a liquidity line can increase source-country equity prices by decreasing the bankruptcy probabilities of the recipient-country's financial sector. Second, we test the prediction of the model empirically.

4.1 Mechanism

To illustrate how a liquidity line announcement can affect euro area banks we propose a stylized two-country three-period model. Each country has a representative bank. In the source-country there is a euro area bank and in the recipient-country there is a local bank. The model features cross-border lending between the euro area bank and local bank, with currency and maturity mismatches. In this context, an exogenous exchange rate shock generates a refinancing risk. The liquidity line announcement reduces the probability of default of the local bank facing the shock. Therefore, it increases the expected profits of the euro area bank that hold claims in the recipient-country. In turn, this increases its stock prices, generating positive spillbacks.

Figure 6 illustrates the timeline of the model.

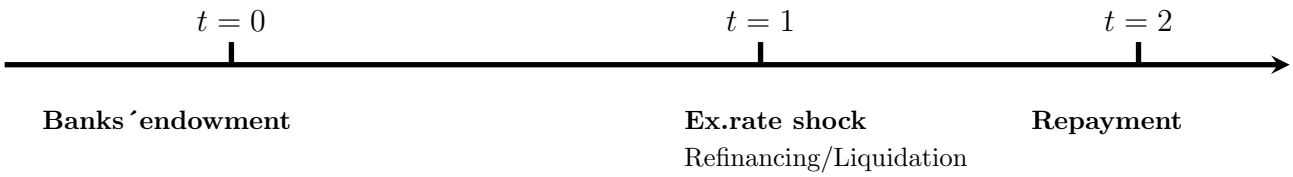


Figure 6: Model Time Line

Endowment: cross-country lending

Local Bank	
Assets	Liabilities
$L^* = 1$ (€, Matur. $t = 2$)	1 (€, Matur. $t = 1$)
I^* (LC)	D^* (LC)

EA Bank	
Assets	Liabilities
A_0 (€)	D_0 (€)
1 (€)	E_0 (€)

Table 2: Balance Sheets $t = 0$

At time $t = 0$, the euro area bank is funded by E_0 equity and D_0 insured deposits. It holds 1 unit of one-period euro-denominated debt of the local banks and invested A_0 in a safe asset. The bank's balance sheet at time 0 is:

$$A_0 + 1 = D_0 + E_0 \tag{5}$$

We assume that both deposits and safe assets are remunerated at the central bank policy rate r. The gross interest rate that the local bank has to pay to borrow from the euro area bank is $1 + r_C$. These quantities are taken as exogenous from the model's perspective, as the exact quantities are irrelevant for the mechanism we wish to emphasize.[19] The bank is managed in the interest of equity owners, who are risk-neutral, enjoy limited liability and have a discount factor of β. We further assume for simplicity that $D_1 = (1 + r)D_0$, i.e. the bank only has to pay out deposits at $t = 2$.

Meanwhile, the local bank has invested the 1 unit of the borrowed euro-denominated debt in a euro-denominated loan maturing at time $t = 2$ with a safe net rate of return $r_L > r_C$.[20] It also has insured local currency deposits D^* remunerated at the net rate r^* which it has invested in a short term investment I^*, yielding a safe net return of r_I paying off a safe amount $X = (r_I - r^*)D^*$ in local currency at $t = 1$. From the euro area bank perspective, the $t = 0$ balance sheet and interest rates that the local bank faces are taken as exogenous.

[19] Ex-post it can be verified that there exist loan rates r_C such that it is optimal for both banks to enter the loan agreement.

[20] Local banks might extend credits in source-currency denomination for various reasons, among them: lower interest rates combined with underestimation of exchange rate risk (documented for e.g. Hungarian households by Pellényi and Bilek (2009) and Indian firms Acharya and Vij (2020)), credits used to purchase or invest in foreign commodities (Caruana, 2016) or portfolio allocation (Yeyati, 2006).

Exchange Rate Shock

At $t = 1$, the exchange rate S (Euro per unit of local currency) is low with probability q, such that $S_L(X+D^*) < 1+r_C$ or high with probability $1-q$, such that $S_H(X+D^*) > 1+r_C$. Note that r_C is taken as exogenous. The exchange rate shock introduces exogenous liquidity risk for the local bank since it has to pay back the unit borrowed. If the realization of the exchange rate is low, it is unable to repay the loan to the euro area bank using internal funds. The local bank could rollover the loan, however, to mimic the situation in which central bank liquidity lines are normally established, we assume that the market is dysfunctional and rollover is not possible.

Thus, in absence of central bank liquidity lines, the local bank only has the option to refinance the remaining debt at $t = 1$ through an FX swap. It is common knowledge that the effective cost b of refinancing 1 unit of debt using FX swaps is distributed according to $b \sim F_b^h$, $h \in \{nl, l\}$.[21] The realization of b is learned at $t = 1$. The total cost C_s of refinancing via FX swaps is then:

$$C_s(b) = (1 + b)[1 + r_c - \lambda_S] \tag{6}$$

Where $\lambda_S = S_L(X + D^*)$ denotes the availability of internal funds, to shorten the notation. Define $\bar{b}$ as the maximum rate that the local bank would ever accept:

$$C_s(\bar{b}) = 1 + r_L \tag{7}$$

Should the local bank be unable to refinance the outstanding obligation with an FX swap, the euro area bank has the right to liquidate the local bank. In this case, it receives $\lambda_{L,1}$, where $\lambda_{L,1}$ is the liquidation value of the long-term loan at $t = 1$. We assume that $\lambda_{L,1}+\lambda_S < 1+r_C$, such that euro area banks face loan default risk.

Effect on Euro Area Bank Stock Prices without Liquidity Lines

To disentangle the effect of central bank liquidity lines on stock prices we analyze first the counterfactual scenario without the announcement of the facility. Since equity owners

[21] A distribution of b obtains if as in Bahaj and Reis (2022a) the local bank is randomly matched with a source-country trader and traders differ in their bargaining power. This is further explained below. While the distribution of δ_a remains fixed, a liquidity line provides an outside option to local banks,leading to the state dependence in the distribution F_b^h.

are risk-neutral, stock prices are given by the expected value of equity at time $t = 2$. For simplicity, any funds at $t = 1$ are invested at the safe policy rate $1 + r$:

$$A_1 = \begin{cases} \lambda_S + \lambda_{L,1} + (1+r)A_0 \text{ if loan liquidated at } t = 1 \\ (1 + r_C) + (1+r)A_0 \text{ if loan repays at } t = 1 \end{cases} \tag{8}$$

The value of equity at time $t = 2$ is then given by:

$$V_2 = \max\{(1+r)A_1 - (1+r)D_1, 0\} \tag{9}$$

Using $D_1 = (1+r)D_0$ and substituting the balance sheet constraint, Eq. (5):

$$V_2 = \max\{(1+r)A_1 - (1+r)^2 + (1+r)^2 E_0 - (1+r)^2 A_0, 0\} \tag{10}$$

The $t = 0$ stock price $V_0(x)$, where x is the loan repayment at $t = 1$, is then given by:

$$V_0(x) = \beta^2 \mathbb{E}_0 V_2 \tag{11}$$

It follows that:

$$V_0(\lambda_S + \lambda_{L,1}) = \beta^2 \max\{(1+r)(\lambda_S + \lambda_{L,1}) - (1+r)^2 + (1+r)^2 E_0, 0\} \tag{12}$$

$$V_0(1 + r_C) = \beta^2 \max\{(1+r)(1+r_C) - (1+r)^2 + (1+r)^2 E_0, 0\} \tag{13}$$

While we take r_c as exogenous, the bank would never set a loan rate that would lead the bank to default in case of full repayment, therefore $(1 + r_C) - (1 + r) + (1 + r)E_0 \geq 0$. And due to the possibility of default, we must have $(1+r_C)-(1+r)+(1+r)E_0 > 0$. Hence:

$$V_0(1 + r_C) = \beta^2((1+r)(1+r_C) - (1+r)^2 + (1+r)^2 E_0) \tag{14}$$

Two cases may be distinguished: In Case 1, the euro area bank is perfectly safe:

$$(1+r)(\lambda_S + \lambda_{L,1}) - (1+r)^2 + (1+r)^2 E_0 \geq 0 \tag{15}$$

Refinancing at $t = 1$ is only possible via FX swaps. Therefore, the $t = 1$ default probability of the local bank is given by:

$$p_1 = q(1 - F_b^h(\bar{b})) \tag{16}$$

And Euro-Area bank stock prices are given by:

$$V_0 = \beta^2(1+r)[q(1-F_b^h(\bar{b}))(\lambda_S+\lambda_{L,1})+[(1-q)+qF_b^h(\bar{b})](1+r_c)-(1+r)+(1+r)E_0] \quad (17)$$

In Case 2, the euro area bank defaults if the local bank defaults at $t = 1$:

$$(1+r)(\lambda_S+\lambda_{L,1})-(1+r)^2+(1+r)^2E_0<0 \quad (18)$$

In this case, Euro-Area bank stock prices are given by:

$$V_0 = \beta^2(1+r)[[(1-q)+qF_b^h(\bar{b})](1+r_c)-(1+r)+(1+r)E_0] \quad (19)$$

The Euro-Area bank's stock prices depend on the default probability of the local bank and, therefore, on the distribution of the CIP deviations through F_b^h.

Effect on Euro Area Bank Stock Prices with Liquidity Lines

Now consider the announcement of a liquidity line at time $t = 0$.
Figure 7 illustrates the timeline of the model.

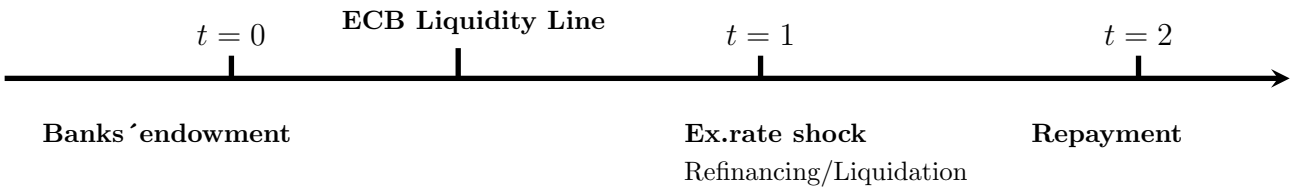


Figure 7: Model Time Line

Note that the refinancing cost via FX swaps is $b = r^* + f - s$, where f and s are the log forward rate and the log spot rate (Euro per unit of local currency), respectively. Hence, b is equivalent to the FX swap basis, net of the foreign interest rate on deposits. The basis, as explained in detail in the following section, captures the premium that foreign agents have to pay to borrow euros in the FX markets. Bahaj and Reis (2022a) show how an active liquidity line caps the forward price in FX swaps. Intuitively, central bank liquidity lines provide local banks with a cheaper outside option to the FX market which improves the bargaining terms that the local banks obtain from the traders. In Bahaj and Reis (2022a), differences in bargaining power $\delta_a \in [0,1]$ between source-country traders leads to a distribution of $b(\delta_a)$, with $b(0) < b(1)$. They show an active liquidity line reduces $b(\delta_a)$ for every bargaining power $\delta_a > 0$, i.e. unless local banks have all bargaining power. The FX basis is therefore state-dependent: $b = b^h(\delta_a)$ and $b(0) = b^l(0) = b^{nl}(0)$. It follows that the swap price distribution

without liquidity line has first order stochastic dominance over the distribution with liquidity line:

$$F_b^l(x) \geq F_b^{nl}(x) \tag{20}$$

The inequality is strict for all $x \in (b(0), b^{nl}(1)]$.
As shown in Appendix C, by the theory of the term structure, this argument holds also in the case of the mere announcement of a liquidity line, which ultimately caps the price of forward agreements.

Based on the above, we can distinguish three regimes: In Regime 1, $\bar{b} < b(0)$ and the local bank defaults with probability $p_1^l = p_1^{nl} = q$, i.e. always when it receives the low exchange rate shock. Next, in Regime 2 the local bank defaults if it is matched with a trader with sufficiently high market power: $\bar{b} \in [b(0), b^{nl}(1))$ and $p_1^l, p_1^{nl} \in (0, q)$ witht $p_1^l \leq p_1^{nl}$. Lastly, in Regime 3, the local bank never defaults: $\bar{b} \geq b^{nl}(1)$ and $p_1^l = p_1^{nl} = 0$.
The liquidity line announcement is therefore neutral in Regimes 1 and 3. In Regime 2, it decreases the default probability p_1 of the local bank unless it has all bargaining power.
This implies the following proposition:

Proposition 1 *A liquidity line announcement in times of a freeze of the international interbank lending market leads to an increase in euro area stock prices unless local banks exposed to a low exchange rate realization (a) never default, (b) always default, (c) have all bargaining power in negotiating FX swap prices.*

Proposition 2 *In Case 1 (safe euro area bank), the effect is decreasing in the liquidation value λ_{L1} of the local bank.*

4.2 Empirical strategy

Since central bank liquidity lines are often announced in times of financial distress, the positive effect of announcements may merely cushion the negative effect of rising bankruptcy probabilities due to financial distress in the recipient economy on euro funding costs and euro area banks' balance sheets. Therefore, we might not expect to see a positive net effect of announcements in the data, but rather a positive counterfactual effect – calling for a Differences-in-Differences strategy. In the following exercise, we test for positive differential effects by exploiting the heterogeneous banking exposure of EA countries towards the countries considered in the treated versus control groups, in a similar fashion to Aizenman et al. (2022). While Aizenman et al. (2022) look at the impact of Fed lines on key financial variables of recipient economies, such as long-term interest rates and sovereign credit default spreads, we focus on source-country equity prices. We take advantage of the fact that some

EA countries have stronger trade and banking ties with some of the countries whose currencies are targeted by ECB lines due to historical or geographical reasons. For instance, Italy has strong trade and therefore banking connections with Romania, Austria with Hungary, etc. Therefore, we expect that an ECB announcement of a repo line with Romania will benefit Italy more than Spain, which does not have strong linkages with Romania.

While this beneficial effect may affect euro area banks in various ways, we consider the stock price consistent with our model. We expect that, following an ECB liquidity line announcement, the equity price of EA banks most exposed to the countries targeted by the line will increase relatively more than the less exposed banks. To account for this heterogeneous effect we consider the following two dimensions: time (pre vs. post announcement) and the exposure in terms of cross-border banking flows between EA source countries and non-EA counter-parties. Therefore, our main explanatory variable of interest is the interaction between the dummy capturing the announcement and the following day ($Post_t$) and the exposure dummy ($Exp_{j,e}$). Furthermore, as in the case of the basis, we first purge the dependent variable for country-specific controls as explained in Section 2. Finally, we use changes and not the levels of the stock price residuals as the dependent variable, due to stationarity concerns.[22] We adjust the specification accordingly:

$$\Delta PriceRes_{j,t,e} = \beta_1 Post_t \times EXP_{j,e} + \sum_e \beta_{2e} Post_{t,e} + \beta_3 EXP_{j,e} + \beta_4 mp_t + \boldsymbol{\varphi}' \boldsymbol{Z_t} + \mu_{j,e} + u_{j,t,e} \tag{21}$$

where $\Delta PriceRes_{j,t,e}$ is the change in the purged average log stock price of the banks in EA country j at time t in the event e, $EXP_{j,e}$ is a dummy equal to one if the average exposure of the EA country j to non-EA countries targeted by the line at event e is higher than the 75th percentile of the cross-country exposure distribution, and 0 otherwise.[23]. As in the analysis of the basis, the specification includes country-event fixed effects and a Post dummy per event. $\boldsymbol{Z_t}$ is a vector of global controls. Standard errors are clustered at country-event level.

The sample focuses on the same events of the previous exercise in order to ensure that the effect is not contaminated by liquidity lines in USD or other currencies that may happen at the same time.

[22]Unit root tests for the individual time series as well as panel unit root tests suggest that stock prices contain a unit root. This is not surprising, as it is a common feature of financial data.

[23]In order to simplify the notation, the exposure dummy is indexed by country and event. Precisely, it is constructed based on the country j average share in portfolio holdings by the banking sector of EA countries, in the quarter prior to the announcement t, as explained in Section 2

Table 3: Spillbacks of Announcement to EA banks

	(1) Banking Exposure p75	(2) Banking Exposure p65	(3) Continuous
Post × Exp	0.0175**	0.0148*	0.0299**
	(0.04)	(0.08)	(0.01)
VIX	-0.00301	-0.00300	-0.00306
	(0.14)	(0.15)	(0.13)
EU high yield	0.0525	0.0525	0.0524
	(0.11)	(0.11)	(0.11)
MP meetings	-0.0150	-0.0150	-0.0149
	(0.19)	(0.18)	(0.19)
Observations	284	284	284
R^2	0.275	0.272	0.303
Controls	full	full	full
CurrencyxEvent FE	yes	yes	yes
PostMat	yes	yes	yes

p-values in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: The table reports the output of the two-way fixed effects DID estimation on a collapsed panel which is composed by the four-day window around each ECB euro liquidity line announcement. The exercise focuses on ECB lines towards EU countries to reduce potential overlapping concerns with USD liquidity lines. In column 1 and 2 Exposure (*Exp*) is a dummy that equals one if the share of claims of the banking sector of EA-country j towards the recipient country banking sector of the country targeted by the line in t, is higher than the 75th percentile (first column) or 65th percentile (second column) of the distribution across EA countries at the moment of announcement in t. In column 3, Exposure is continuous. The EA sample comprises AT, BE, DE, ES, FI, FR, IR, PT, IT.

Figure 9, Appendix A.4, shows the evolution of the change in the stock price in the ten-day window around each announcement. The highly exposed and less exposed countries follow a very close pattern. Table 11, Appendix A.4 gives an overview of the EA countries classified as exposed at each announcement. As expected, Italy and Austria are on average more exposed than any other EA countries to ECB liquidity line recipients.

4.3 Results

According to the results in column 1 of Table 3 the announcement of a ECB euro liquidity line increases EA stock prices by 1.75% for EA countries with a banking sector more exposed to countries whose currencies are targeted by the line.[24] As a robustness check, instead of constructing the exposure dummy based on the 75th percentile of the distribution, we (i) reduce the threshold to the 65th percentile - Table 3, Column 2, (ii) use a continuous exposure variable - Table 3, Column 3. Estimates confirm an increase in banks' equity prices. Future research at bank level may further exploit the heterogeneity in the treatment effect that ECB liquidity lines might have.

5 Conclusion

Central bank liquidity lines in times of distress function as a backstop facility, preventing episodes of liquidity shortage to turn into global financial stability problems. In line with the stated policy goal to use such swap lines as a backstop, the ECB has expanded considerably its network of swap lines during episodes of global financial stress (the global financial crisis and the current COVID-19 crisis).

While previous contributions have focused on the effects of USD liquidity lines, this paper presents original descriptive and empirical evidence for the case of the ECB. Concretely, we show that ECB euro liquidity lines have been effective in decreasing the premium paid by foreign agents to borrow euros in FX markets in a narrow window around the announcement. Furthermore, this paper provides evidence of positive spillbacks to the euro area generated by these facilities in the form of relatively higher bank equity prices, which are associated with better market valuations of future profitability, in euro area countries highly exposed via banking linkages to countries whose currencies are targeted by liquidity lines. We show how such a spillback effect on profits can arise in theory, and provide empirical evidence consistent with our theoretical predictions.

[24] This effect corresponds to approximately half a standard deviation of stock price variations.

From our descriptive analysis, we notice that the ECB has provided FX insurance to central banks in its vicinity, mainly non-EA EU countries. Therefore, in contrast with the Fed, its role has been more of a regional lender of last resort than a global one. This difference seems to be driven by the different trade ties of the US and the EU with the rest of the world, as supported by the evidence found in Aizenman et al. (2022) for the US. An unanswered question is then whether these arrangements can also boost the usage of the euro as an international currency, as has been stated in some official speeches (see Schnabel and Panetta, 2020). In general, if these swap lines become a well-established tool (either through permanent arrangements or through temporary but predictable ones), market participants may anticipate that liquidity in euro FX markets will be sufficient and CIP deviations will be small even in times of crisis. These considerations are particularly relevant in the current conjuncture characterized by the uncertainty and financial volatility generated by the war in Ukraine and the high risk of fragmentation in the Euro Area.

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Appendix

A.1. Data Sources

Stock Prices are sourced from Datastream (Refinitiv) and are country aggregates from the following banks:

- Germany: Deutsche Bank, Commerzbank, Aareal, Deutsche Pfandbriefbank, Procredit and Umweltbank
- France: BNP, Crédit Agricole, Société Generale, Natixis, Nord CCI, Ille de France, Brie Picardie, and Crédit Foncier
- Italy: Intesa, Unicredit, Generali, BPM, BPER, Finecobank, Monte dei Paschi, Credito Emiliano, Illimity, Sondrio, Profilo, Sistema, Piccolo credito
- Spain: Santander, BBVA, Caixabank, Bankinter, Sabadell, Liberbank and Unicaja
- Belgium: KBC, Banque Nationale de Belgique and KBC Ancora
- Austria: Erste, Raiffeisen, BAWAG Group, Oberbank, BKS, Addiko Bank, and Bank für Tirol und Vorarlberg
- Finland: Nordea and Aktia
- Ireland: Bank of Ireland and Permanent THB
- Portugal: Banco Comercial Portugues

A.2. Regression Tables

Table 4: Effect of ECB liquidity swap line announcement

Dependent Variable: FX Basis Residuals				
	Baseline Sample		Extended Sample	
	(1)	(2)	(3)	(4)
Treated_Post	-0.512**	-0.511**	-0.373*	-0.373*
	(0.030)	(0.031)	(0.051)	(0.052)
MP meetings		-0.209*		-0.0405
		(0.052)		(0.760)
EU high yield		-0.956**		-0.544
		(0.022)		(0.268)
Surprise index		-0.00132		-0.00196**
		(0.203)		(0.022)
Observations	324	324	428	428
R^2	0.115	0.167	0.059	0.076
CurrencyxEvent FE	yes	yes	yes	yes
PostMat	yes	yes	yes	yes

p-values in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: The table reports the output of the two-way fixed effects DID estimation on a collapsed panel which is composed by the four-day window around each ECB euro swap line announcement. Treated is defined as the currency targeted by the line in t, while the control group comprises the countries not targeted by the line announced in t. Sample composition is described in Section 3.

Table 5: Effect of ECB liquidity line announcement (Baseline Sample)

Dependent Variable: FX Basis	
	(1)
Treated_Post	-0.410**
	(0.026)
EU high yield	-1.087**
	(0.024)
MP meetings	-0.233**
	(0.027)
Surprise index	-0.00117
	(0.324)
Stock exchange volatility	2.365
	(0.385)
Sovereign yield	-0.824
	(0.176)
Observations	332
R^2	0.197
CurrencyxEvent FE	yes
PostMat	yes

p-values in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: The table reports the output of the two-way fixed effects DID estimation on a collapsed panel which is composed by the four-day window around each ECB euro swap line announcement. Treated is defined as the currency targeted by the line in t, while the control group comprises the countries not targeted by the line announced in t. Sample composition is described in Section 3.

Table 6: Effect of ECB liquidity line announcement (Placebo)

Dependent Variable: FX Basis Residuals

	Baseline Sample		Extended Sample	
	(1)	(2)	(3)	(4)
Treated_Post	-0.0984	-0.0987	-0.0124	-0.0127
	(0.744)	(0.745)	(0.969)	(0.969)
MP meetings		0.0639		0.266
		(0.841)		(0.447)
EU high yield		-0.349		-0.130
		(0.462)		(0.753)
Surprise index		0.00824		0.0104
		(0.276)		(0.197)
Observations	324	324	428	428
R^2	0.043	0.056	0.036	0.043
CurrencyxEvent FE	yes	yes	yes	yes
PostMat	yes	yes	yes	yes

p-values in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: The table reports the output of the two-way fixed effects DID estimation on a collapsed panel which is composed by the four-day window around each ECB euro swap line announcement. For the purpose of the placebo exercise, the date of the announcement has been anticipated by 3 days, consequently moving the window ahead of the actual announcement, preventing any overlap with true window. Treated is defined as the currency targeted by the line in t, while the control group comprises the countries not targeted by the line announced in t. Sample composition is described in Section 3. The extended sample adds Iceland and Norway to the control group.

A.3. Timeline and main features of ECB lines (announcements)

The timeline reported below is based on ECB press releases. Due to space constraints the table omits some information and link, but can be found here: ECB liquidity lines - Timeline

- The timeline does not include information on the Term Auction Facility nor the EUREP.
- Swap time extensions refer to central bank swap lines and domestic CB repo operations against ECB-eligible collateral with domestic financial institutions to redistribute the liquidity.
- The timeline does not include discontinuations of lines or maturities.
- The column "Reciprocal" means that, in at least one of the counterparts' press releases, there is an explicit reference to the fact that the agreement is reciprocal.
- The column "Euro provision" indicate whether in the press release there is a clear intention of providing euro liquidity. Note that, although some agreements might be reciprocal, their actual intention is to provide liquidity in only one currency denomination.
- Publicly announced: "p" indicates lines or changes announced in ECB press releases on the same date the decision was taken, "np" lines or changes announced ex-post.
- Federal Reserve(*) indicates operations and agreements in the context of the multi-central bank agreements between Federal Reserve, European Central Bank, Bank of England, Bank of Japan, Swiss National Bank.
- Federal Reserve(**) indicates episodes when swap lines also enable central banks of the network of temporary bilateral liquidity swap arrangements to provide liquidity operations, should they be needed, in Japanese yen, British pound sterling sterling, Swiss francs, Canadian dollars, and Euro, in addition to US dollars.
- Sveriges Riksbank (§) indicates that the arrangement was not publicly announced in 2007. The activation of the line was announced in 2009, and the link refers to the activation announcement.
- (§§) Sourced from other ECB documents different from press releases. This announcement is not included in the analysis since we assume that the main channel of communication for the signalling effect consists of press releases.
- LEG 1 reports the maximum length of drawing in the context of the first leg of the agreement, i.e. between two central banks.
- LEG 2 reports the maturities of operations with domestic counterparts, i.e. the repo facilities between recipient-country central bank to the domestic banking sector.

DATE	*COUNTRY*	*COUNTERPART*	*EURO PROVISION*	*RECIPROCAL*	*ANNOUNCEMENT*	*EXPIRATION*	*LEG1*	*LEG2*	*MAXIMUM AMOUNT*
13-Sep-2001	USA	Federal Reserve	No	No	swap	13-Oct-2001	—	—	USD 50 bn
12-Dec-2007	USA	Federal Reserve (*)	No	Yes	swap	—	—	28 and 35 days	USD 20 bn
20-Dec-2007	SWE	Sveriges Riksbank (§)	Yes	Yes	swap	—	3 months	—	EUR 10 bn
10-Jan-2008	USA	Federal Reserve (*)	No	Yes	swap time extension	—	—	28 days	USD 20 bn
11-Mar-2008	USA	Federal Reserve (*)	No	Yes	swap time extension	—	—	28 days	USD 15 bn
2-May-2008	USA	Federal Reserve (*)	No	Yes	swap volume expansion	—	—	28 days	USD 25 bn
18-Sep-2008	USA	Federal Reserve (*)	No	Yes	swap volume expansion	—	—	1, 28 and 84 days	USD 40 bn
26-Sep-2008	USA	Federal Reserve (*)	No	Yes	swap volume expansion	Over the quarter end	—	1-7 days	USD 35 bn
29-Sep-2008	USA	Federal Reserve (*)	No	Yes	swap volume expansion	30-Apr-2009	—	—	USD 120 to 240 bn
13-Oct-2008	USA	Federal Reserve (*)	No	Yes	swap time extension	31-Jan-2009	—	7, 28 and 84 days	—
15-Oct-2008	CHE	Swiss National Bank	No	No	swap	31-Jan-2009	—	7 days	—
	USA	Federal Reserve (*)	No	Yes	foreign exchange swaps expansion of collateral pool	31-Jan-2009	—	—	—
16-Oct-2008	HUN	Magyar Nemzeti Bank	Yes	Yes	repo	—	—	—	EUR 5 bn
27-Oct-2008	DNK	Danmarks Nationalbank	Yes	Yes	swap	—	—	—	EUR 12 bn
11-Nov-2008	LVA	Latvijas Banka (§§)	Yes	No	repo	—	—	—	EUR 1 bn
21-Nov-2008	POL	Narodowy Bank Polski	Yes	No	repo	—	—	—	EUR 10 bn
19-Dec-2008	USA	Federal Reserve (*)	No	Yes	swap time extension	31-Mar-2009	—	7, 28 and 84 days	—
16-Jan-2009	CHE	Swiss National Bank	No	No	swap time extension	30-Apr-2009	—	7 days	—
3-Feb-2009	USA	Federal Reserve (*)	No	Yes	swap time extension	30-Oct-2009	—	—	—
19-Mar-2009	USA	Federal Reserve (*)	No	Yes	swap time extension	30-Jun-2009	—	7, 28 and 84 days	—
6-Apr-2009	USA	Federal Reserve (*)	Yes	Yes	swap volume expansion	30-Oct-2009	—	—	EUR 80 bn
10-Jun-2009	SWE	Sveriges Riksbank	Yes	Yes	swap activation of 2007 line	—	3 months	—	EUR 3 bn (EUR 10 bn max)
25-Jun-2009	USA	Federal Reserve (*)	No	Yes	swap time extension	30-Sep-2009	—	7 and 84 days	—
			Yes	Yes	swap time extension	1-Feb-2010	—	—	—
24-Sep-2009	CHE	Swiss National Bank	No	No	swap time extension	31-Oct-2009	—	7 days	—
	CHE	Swiss National Bank	No	No	swap time extension	31-Jan-2010	—	7 days	—
	USA	Federal Reserve (*)	No	Yes	swap time extension	31-Jan-2010	—	7 days	—

10-May-2010	USA	Federal Reserve (*)	No	Yes	swap reactivation	—	—	7 and 84 days	—
17-Dec-2010	GBR	Bank of England	No	Yes	swap	30-Sep-2011	—	—	GBP 10 bn
21-Dec-2010	USA	Federal Reserve (*)	No	Yes	swap time extension	1-Aug-2011	—	7 days	—
29-Jun-2011	USA	Federal Reserve (*)	No	Yes	swap time extension	1-Aug-2012	—	7 days	—
25-Aug-2011	GBR	Bank of England	No	Yes	swap time extension	28-Sep-2012	—	—	GBP 10 bn
15-Sep-2011	USA	Federal Reserve (*)	No	Yes	swap time extension	1-Mar-2012	—	7 days and 3 months	—
30-Nov-2011	USA	Federal Reserve (**)	Yes	Yes	swap time extension and rate change (leg 2)	1-Feb-2013	—	7 days and 3 months	—
12-Sep-2012	GBR	Bank of England	No	Yes	swap time extension	30-Sep-2013	—	—	—
13-Dec-2012	USA	Federal Reserve (**)	Yes	Yes	swap time extension	1-Feb-2014	—	7 days and 3 months	—
16-Sep-2013	GBR	Bank of England	No	Yes	swap time extension	30-Sep-2014	—	—	—
10-Oct-2013	CHN	People's Bank of China	No	Yes	swap	8-Oct-2016	—	—	CNY 350bn EUR 45bn
31-Oct-2013	USA	Federal Reserve (**)	Yes	Yes	swap time extension (***)	Until further notice	—	7 days and 3 months	—
27-Sep-2016	CHN	People's Bank of China	No	Yes	swap time extension	25-Oct-2019	—	—	CNY 350bn EUR 45bn
5-Mar-2019	GBR	Bank of England	Yes	Yes	swap activation of 2010 line	—	—	7 days	—
25-Oct-2019	CHN	People's Bank of China	No	Yes	swap time extension	8-Oct-2022	—	—	CNY 350bn EUR 45bn
15-Mar-2020	USA	Federal Reserve (*)	No	Yes	swap rate change	—	—	7 days and 84 days	—
20-Mar-2020	DNK	Danmarks Nationalbank	Yes	Yes	swap reactivation swap volume expansion	As long as needed	—	—	EUR 24 bn
15-Apr-2020	HRV	Hrvatska Narodna Banka	Yes	No	swap	31-Dec-2020	3 months	—	EUR 2 bn
22-Apr-2020	BGR	Bulgarian National Bank	Yes	No	swap	31-Dec-2020	3 months	—	EUR 2 bn
5-Jun-2020	ROU	Banca Nationala a României	Yes	No	repo	31-Dec-2020	3 months	—	EUR 4.5 bn
17-Jul-2020	SRB	Narodna Banka Srbije	Yes	No	repo	30-Jun-2021	3 months	—	EUR 1 bn
	ALB	Bank of Albania	Yes	No	repo	30-Jun-2021	3 months	—	EUR 0.4 bn
23-Jul-2020	HUN	Magyar Nemzeti Bank	Yes	No	repo	30-Jun-2021	3 months	—	EUR 4 bn
18-Aug-2020	MKD	Narodna Banka na Republika Severna Makedonija	Yes	No	repo	30-Jun-2021	3 months	—	EUR 0.4 bn
	SMR	Banca Centrale della Repubblica di San Marino	Yes	No	repo	30-Jun-2021	3 months	—	EUR 0.1 bn
28-Aug-2020	ROU	Banca Nationala a României	Yes	No	repo time extension	30-Jun-2021	3 months	—	EUR 4.5 bn
	HRV	Hrvatska Narodna Banka	Yes	No	swap time extension	30-Jun-2021	3 months	—	EUR 2 bn
	ALB	Bank of Albania	Yes	No	repo time extension	31-Mar-2022	3 months	—	EUR 0.4 bn
	HRV	Hrvatska Narodna Banka	Yes	No	swap time extension	31-Mar-2022	3 months	—	EUR 2 bn

	HUN	Magyar Nemzeti Bank	Yes	No	repo time extension	31-Mar-2022	3 months	—	EUR 4 bn
4-Feb-2021	MKD	Narodna Banka na Republika Severna Makedonija	Yes	No	repo time extension	31-Mar-2022	3 months	—	EUR 0.4 bn
	ROU	Banca Nationala a României	Yes	No	repo time extension	31-Mar-2022	3 months	—	EUR 4.5 bn
	SMR	Banca Centrale della Repubblica di San Marino	Yes	No	repo time extension	31-Mar-2022	3 months	—	EUR 0.1 bn
	SRB	Narodna Banka Srbije	Yes	No	repo time extension	31-Mar-2022	3 months	—	EUR 1 bn
	ALB	Bank of Albania	Yes	No	repo time extension	15-Jan-2023	3 months	—	EUR 0.4 bn
	HUN	Magyar Nemzeti Bank	Yes	No	repo time extension	15-Jan-2023	3 months	—	EUR 4 bn
28-Mar-2022	MKD	Narodna Banka na Republika Severna Makedonija	Yes	No	repo time extension	15-Jan-2023	3 months	—	EUR 0.4 bn
	SMR	Banca Centrale della Repubblica di San Marino	Yes	No	repo time extension	15-Jan-2023	3 months	—	EUR 0.1 bn
	POL	Narodowy Bank Polski	Yes	No	swap	15-Jan-2023	3 months	—	EUR 10 bn
27-Apr-2022	ROU	Banca Nationala a României	Yes	No	repo time extension	15-Jan-2023	3 months	—	EUR 1 bn

Table 8: Summary Statistics

	Mean		SD		*N*	
Country	Basis	Residuals	Basis	Residuals	Basis	Residuals
BG	-.006	-.005	.748	.698	3638	3587
DK	.11	.003	.443	.436	3638	3522
HR	-.195	0	1.521	1.194	3638	3284
HU	.658	.018	1.292	1.195	3638	3458
IS	.267	-.086	3.601	2.571	3638	3522
NO	-.173	.009	.755	.76	3638	3522
PL	-.013	.034	1.346	1.332	3638	3587
RS	-.022	0	2.059	1.767	2915	2735
SE	-.11	-.003	1.379	1.398	3638	3522
ALL	-.044	-.003	1.5	1.218	64761	61784

Unbalanced panel from 1st October 2008 to 10th September 2022.

A.4. Additional Tables and Figures

Table 9: Summary Statistics

Variable	mean	sd	min	max	N
MP meetings	.038	.191	0	1	32019
Δ Public debt ratio	.16	2.48	-10.52	18.66	31608
CAB	1.541	5.852	-22.09	23.38	32019
External debt ratio	247.5	332.8	1.083	1839	31235
Rating	A-	4	BB-	AAA	32019
Int. reserves	43.59	32.45	2.947	156	31749
Inflation	2.599	2.844	-2.614	18.58	31933
VIX	19.99	9.519	9.14	82.69	32019
EU high yield	5.023	3.433	2.341	23.61	32019
Surprise index	3.685	65.59	-304.6	212.4	32019
Sovereign yield	3.129	2.018	-.792	15.01	31716
Stock exchange volatility	1.042	.732	.243	11.37	32019

Unbalanced panel from 1st October 2008 to 10th September 2022. CAB is the current account balance. International reserves is the level of Central Bank's international reserves in billions of USD. The external debt ratio is measured as a percentage of international reserves.

Table 10: Summary Statistics

	Mean			SD			*N*		
Country	log Stock Price	Δ(%) Stock Price	Δ(%) Resid.	log Stock Price	Δ(%) Stock Price	Δ(%) Resid.	log Stock Price	Δlog Stock Price	Δ(%) Resid.
AT	5.849	-.01	.009	.224	2.143	2.4	3641	3641	3296
BE	5.813	-.013	.015	.407	2.624	3.455	3641	3641	3296
DE	4.779	-.043	.015	.533	2.294	2.744	3641	3641	3296
ES	5.32	-.025	-.002	.341	2.211	3.152	3641	3641	2764
FI	4.52	.007	-.003	.235	1.503	1.52	3382	3381	3036
FR	6.022	-.007	.005	.254	2.361	2.55	3641	3641	3296
IR	4.835	-.084	.078	.767	4.198	4.324	3641	3641	3185
IT	6.509	-.031	.015	.343	2.371	3.941	3641	3641	3097
PT	2.89	-.084	.051	.986	2.525	5.437	3641	3641	2289
ALL	5.176	-.033	.02	1.144	2.569	3.377	32510	32509	27555

Unbalanced panel from 1st October 2008 to 15th September 2022. Columns 3, 4, 6 and 7 are expressed in percent.

Table 11: Banking exposure dummy by EA country and announcement, 75th percentile threshold

Announcement	AT	BE	DE	ES	FI	FR	IR	IT	PT
16oct2008	1	1	1	1	1	0	0	1	0
27oct2008	1	0	1	1	1	0	1	0	1
21nov2008	1	0	1	1	1	1	0	1	0
10jun2009	1	0	1	1	1	0	1	0	1
20mar2020	1	0	0	0	0	0	1	0	1
15apr2020	1	0	0	0	0	1	0	1	0
22apr2020	1	1	0	0	0	1	0	0	0
17jul2020	1	0	0	0	0	1	0	1	0
23jul2020	1	1	0	0	0	0	0	1	0
28aug2020	1	1	0	0	0	0	0	1	0
04feb2021	1	1	0	0	0	0	0	1	0
28mar2022	1	1	1	0	0	0	0	0	0

Exposure is defined as the percentage of the banking sector claims of EA country j on non-EA country i over total claims of domestic banks of EA country j globally. If the EA country exposure is higher or equal to the 75th percentile of the cross-country distribution at the announcement date, the exposure dummy takes a value equal to one and zero otherwise

Table 12: Banking exposure dummy by EA country and announcement, 65th percentile threshold

Announcement	AT	BE	DE	ES	FI	FR	IR	IT	PT
16oct2008	1	1	1	1	1	0	0	1	0
27oct2008	1	0	1	1	1	0	1	0	1
21nov2008	1	0	1	1	1	1	0	1	0
10jun2009	1	0	1	1	1	0	1	0	1
20mar2020	1	0	1	0	0	0	1	0	1
15apr2020	1	0	0	0	0	1	1	1	0
22apr2020	1	1	1	0	0	1	0	0	0
17jul2020	1	1	1	1	1	1	1	1	1
23jul2020	1	1	1	0	0	0	0	1	0
28aug2020	1	1	0	0	0	1	0	1	0
04feb2021	1	1	0	0	0	1	0	1	0
28mar2022	1	1	1	0	0	0	0	1	0

Exposure is defined as the percentage of the banking sector claims of EA country j on non-EA country i over total claims of domestic banks of EA country j globally. If the EA country exposure is higher or equal to the 65th percentile of the cross-country distribution at the announcement date, the exposure dummy takes a value equal to one and zero otherwise

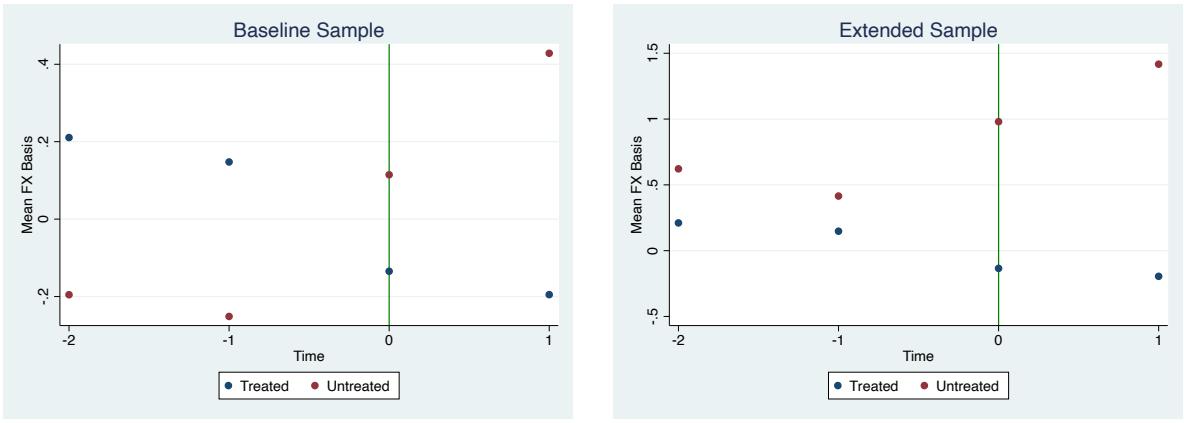


Figure 8: Basis in Levels: Averaged over Events 2008-2020

The figure shows the average evolution of the FX basis in the four-day window around each announcement of an ECB liquidity line for the treated currencies versus non-treated. Each panel of the figure corresponds to a sample, as defined in Section 3. For any announcement, the treated currency/ies is/are going to be the one/s corresponding to the announcement, while the rest of the currencies in the sample are used as controls.

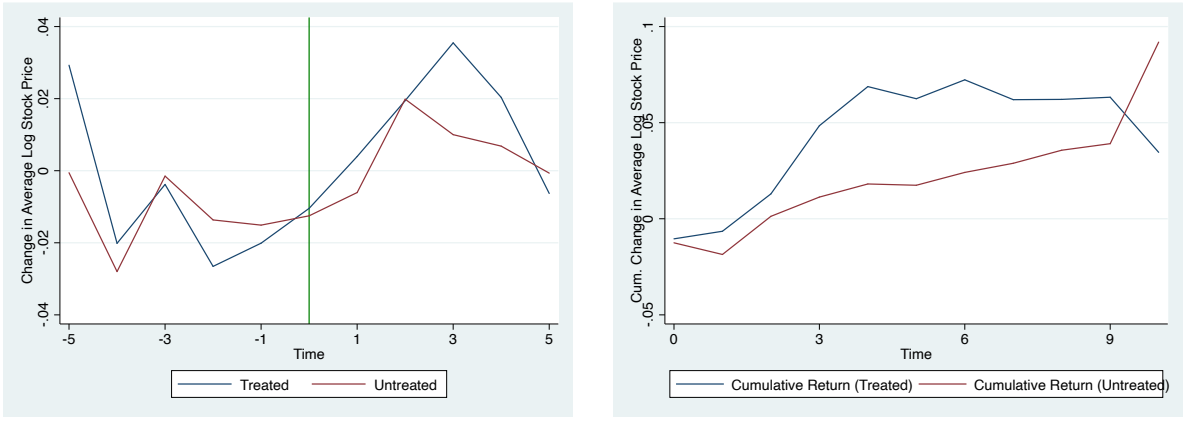
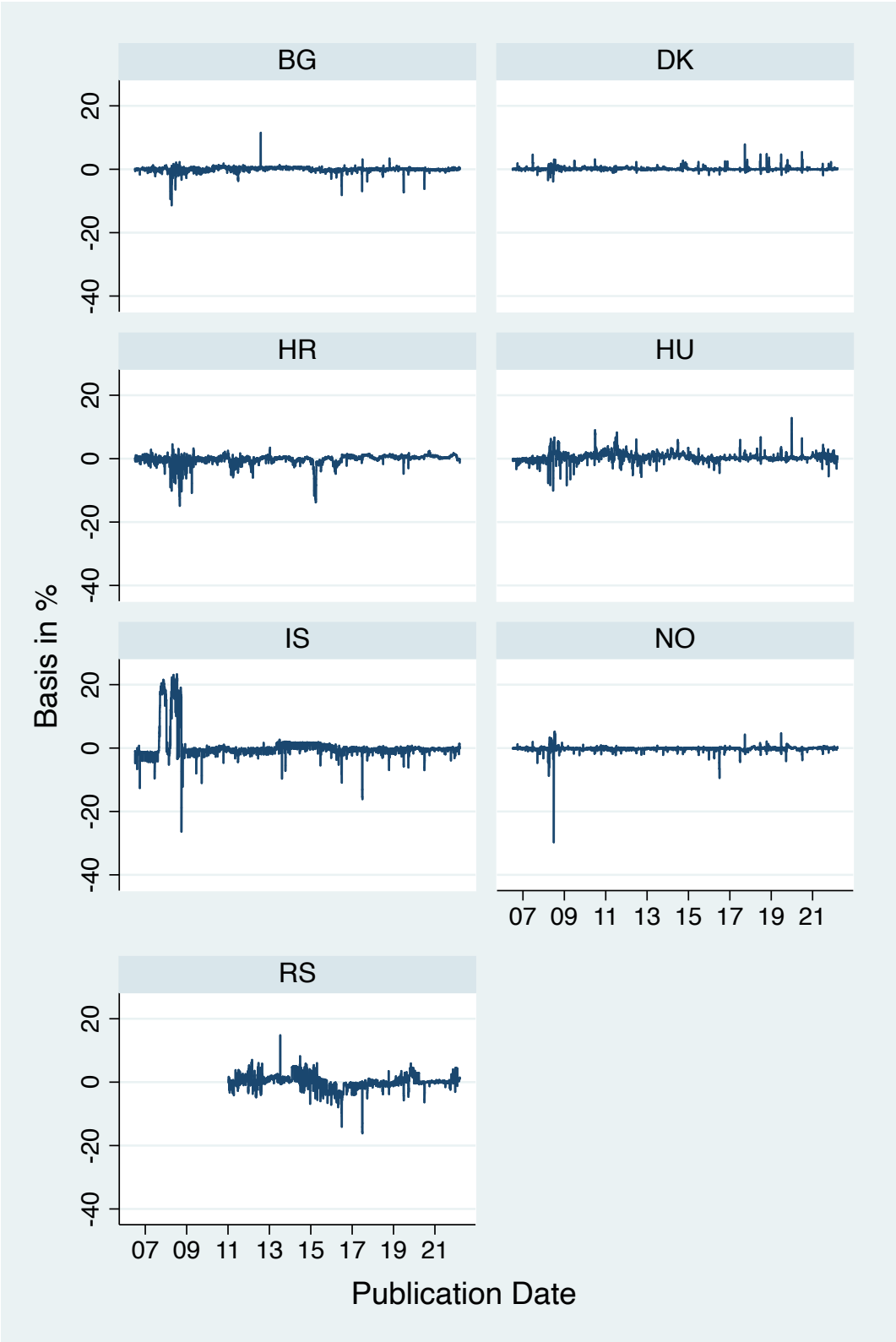


Figure 9: Stock Price Changes

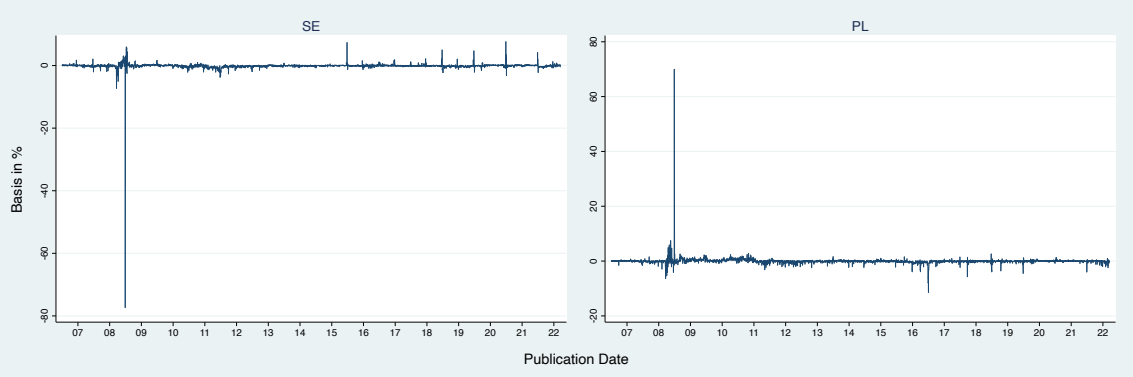
The left panel shows the average evolution of the residuals of average bank stock prices in the 10-day window around each announcement of an ECB liquidity line for the treated currencies versus non-treated. The right panel show the cumulative residuals since the announcement for the two groups. The residuals are obtained from regressing the average stock prices on the short term rate, net foreign assets, loan-to-deposit ratio and NEER deviations. Tables 11 indicates the treated and non-treated countries at each announcement considered.

Figure 10: Time Series of CIP Deviations by Country



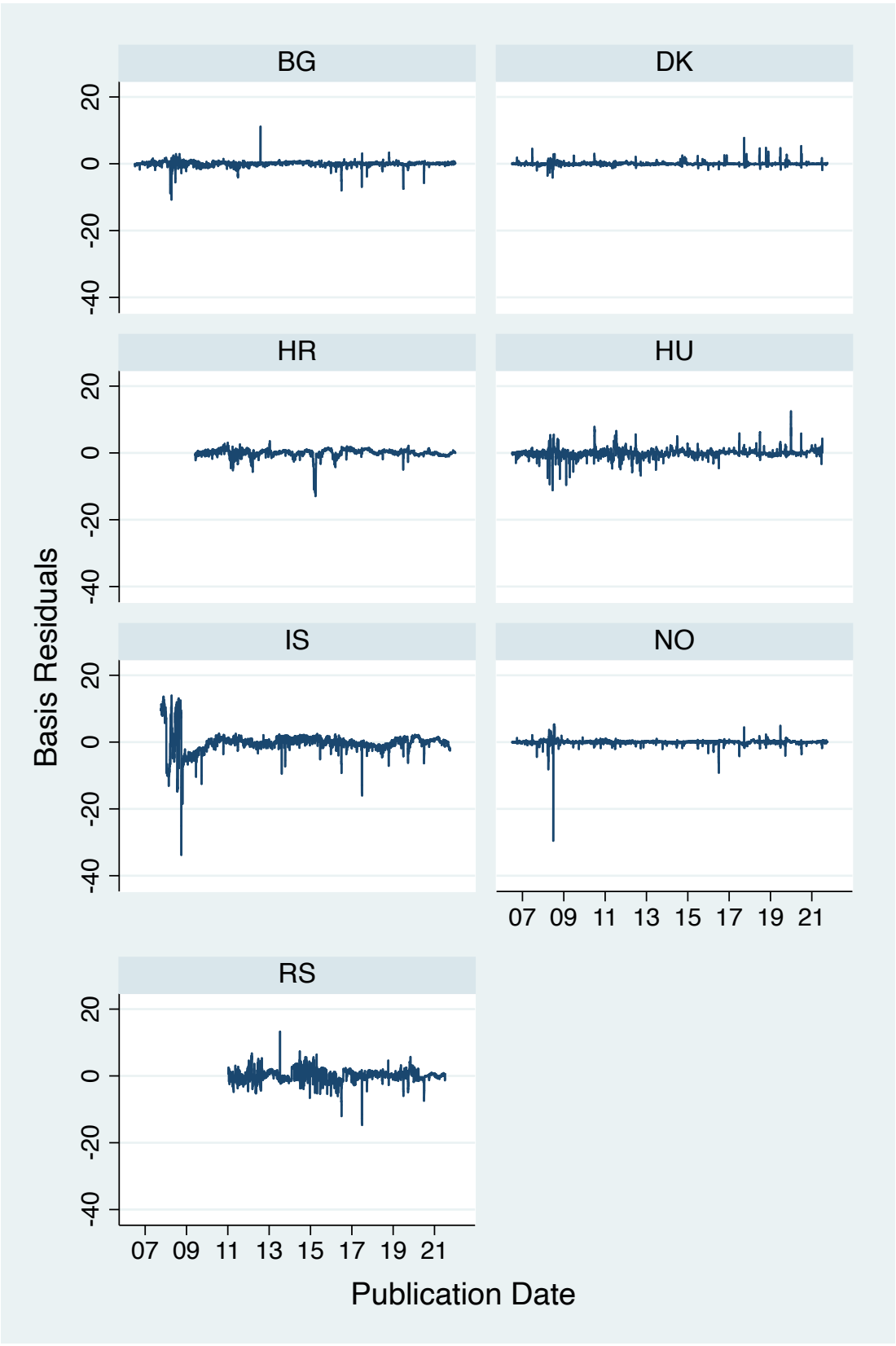
Evolution of the FX Basis over the sample period by country (Part I).

Figure 11: Time Series of CIP Deviations by Country



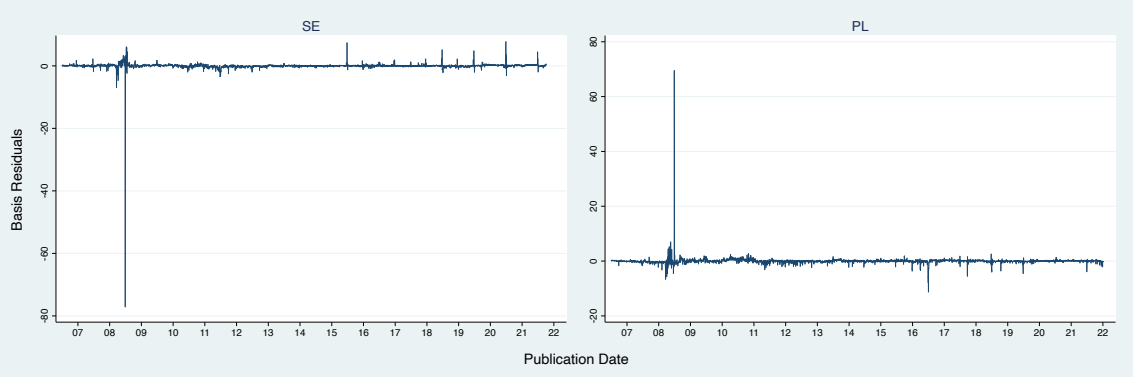
Evolution of the FX Basis over the sample period by country (Part II).

Figure 12: Time Series of Residuals of CIP Deviations by Country

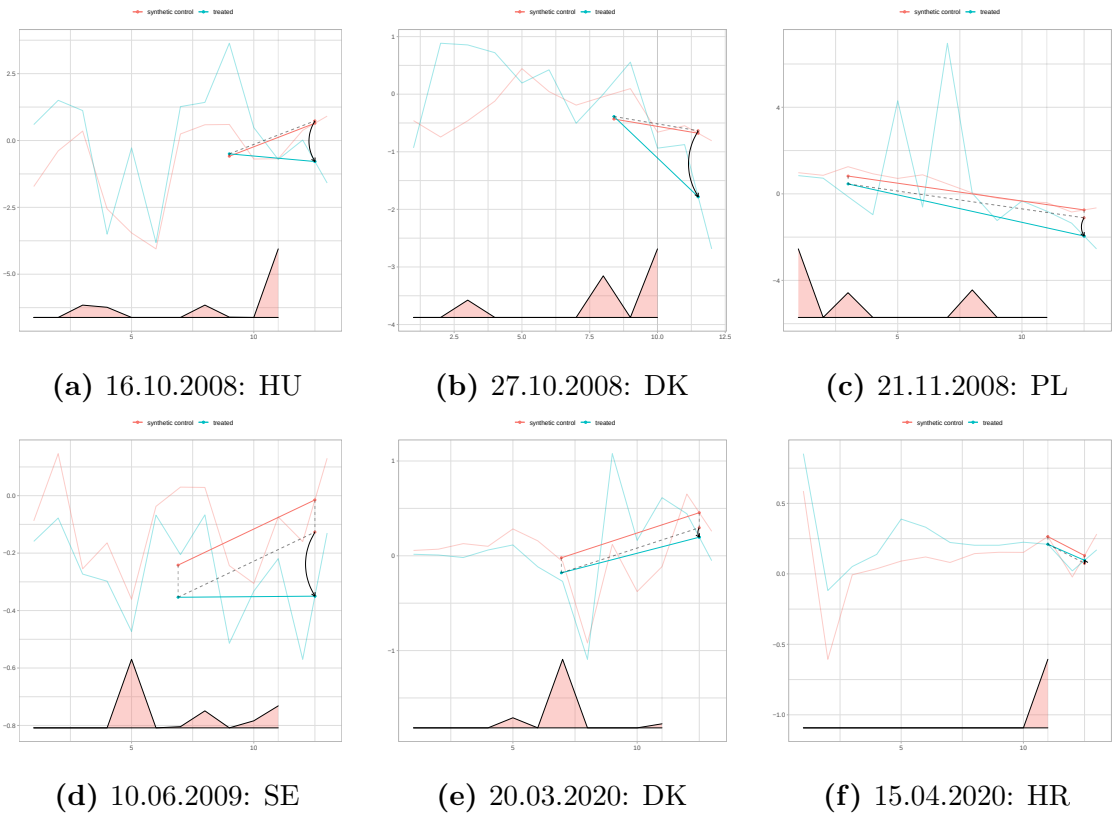


Evolution of the residuals from country-by-country regressions of the FX basis on country-specific characteristics as explained in Section 3 (Part I).

Figure 13: Time Series of Residuals of CIP Deviations by Country



Evolution of the residuals from country-by-country regressions of the FX basis on country-specific characteristics as explained in Section 3 (Part II).

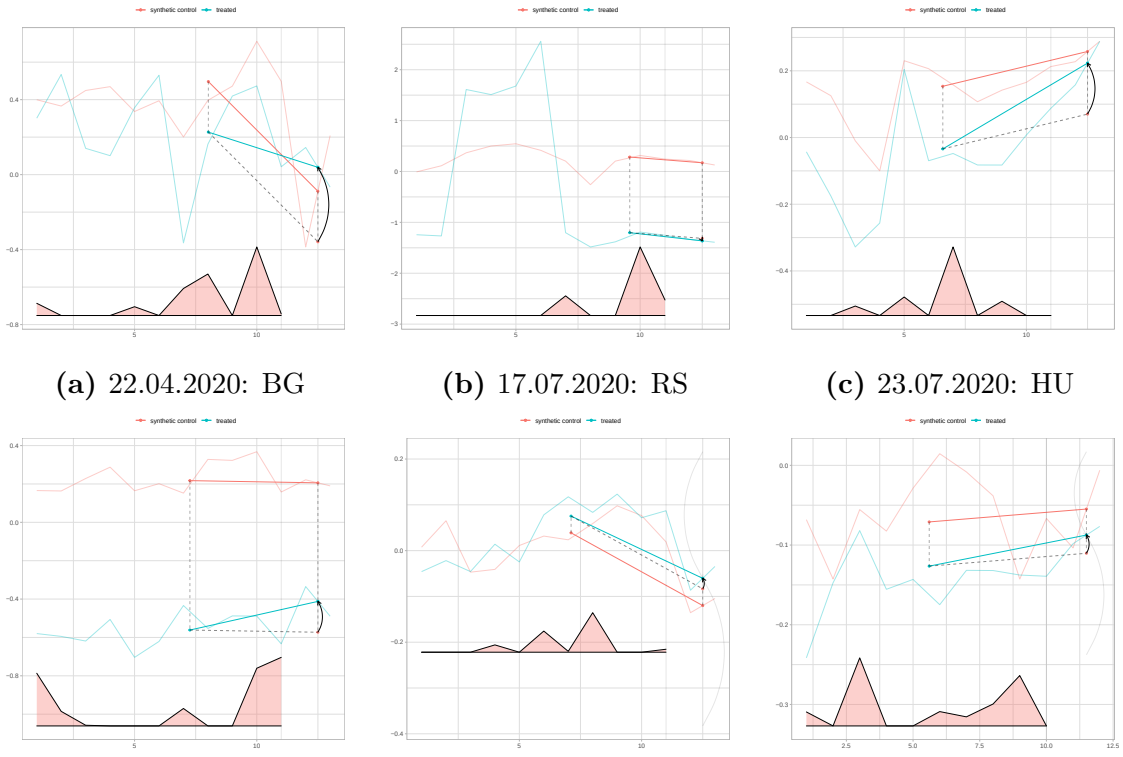


(a) 16.10.2008: HU **(b)** 27.10.2008: DK **(c)** 21.11.2008: PL

(d) 10.06.2009: SE **(e)** 20.03.2020: DK **(f)** 15.04.2020: HR

Figure 14: Pretrends SDID (I)

The figure shows estimates of the Arkhangelsky et al. (2021) SDID estimator for all events. The dependent variable is FX Basis residuals. Treated currencies and treatment date are indicated below each figure. Treated is defined as the currency targeted by the line at t, while the control group comprises the countries not targeted by the line announced at t, and not targeted in the previous 15 days. The specification does not include further control variables.



(a) 22.04.2020: BG **(b)** 17.07.2020: RS **(c)** 23.07.2020: HU

(d) 28.08.2020: HR **(e)** 04.02.2021: HR, RS, HU **(f)** 28.03.2021: HU, PL

Figure 15: Pretrends SDID (II)

The figure shows estimates of the Arkhangelsky et al. (2021) SDID estimator for all events. The dependent variable is FX Basis residuals. Treated currencies and treatment date are indicated below each figure. Treated is defined as the currency targeted by the line at t, while the control group comprises the countries not targeted by the line announced at t, and not targeted in the previous 15 days. The specification does not include further control variables.

Table 13: Summary Statistics

	Mean				SD				*N*			
Country	Δ Public debt ratio	Int. reserves	External debt ratio	Rating	Δ Public debt ratio	Int. reserves	External debt ratio	Rating (notches)	Δ Public debt ratio	Int. reserves	External debt ratio	Rating
BG	.2	21.94	59.52	BBB-	1.73	6.11	28.507	1	3638	3608	3587	3638
DK	.12	72.98	303.196	AAA	1.35	12.03	87.22	0	3638	3608	3522	3638
HR	.68	17.61	33.081	BB+	2.42	4.21	14.136	1	3638	3608	3587	3638
HU	.27	37.32	58.542	BBB-	2.89	8.28	9.626	1	3458	3608	3587	3638
IS	.12	5.62	616.201	BBB+	4.71	1.45	639.21	2	3587	3608	3522	3638
NO	-.27	62.44	405.401	AAA	2.78	10.32	71.452	0	3638	3608	3522	3638
PL	.03	104.67	48.372	A-	1.55	20.65	10.936	0	3638	3608	3587	3638
RS	.37	12.66	7.24	BB	1.51	1.76	4.776	1	2735	2885	2799	2915
SE	-.02	50.85	661.435	AAA	.81	8.21	137.678	0	3638	3608	3522	3638
ALL	.48	177.87	859.395	AA-	2.58	298.37	1669.279	4	64350	64200	62280	64761

Unbalanced panel from 1st October 2008 to 10th September 2022. International reserves is the level of Central Bank's international reserves in billions of USD. The external debt ratio is measured as a percentage of international reserves.

Table 14: Summary Statistics

	Mean				SD				*N*			
Country	CAB	Inflation	Sovereign yield	Stock exchange volatility	CAB	Inflation	Sovereign yield	Stock exchange volatility	CAB	Inflation	Sovereign yield	Stock exchange volatility
BG	-1.08	2.57	2.37	.86	5.324	3.55	1.42	.56	3638	3631	3638	3638
DK	7.26	1.52	1.24	.89	1.726	1.53	1.27	.46	3638	3631	3638	3638
HR	-.23	1.6	3.98	.78	3.429	2.3	1.74	.69	3638	3608	3335	3638
HU	.32	3.29	4.4	1.33	2.613	2.65	1.48	.73	3638	3631	3638	3638
IS	.2	4.33	5.84	1.02	6.747	3.44	1.64	1.16	3638	3631	3638	3638
NO	9.22	2.34	2.2	1.27	4.568	1.2	.95	.8	3638	3631	3638	3638
PL	-2.16	2.76	2.9	1.09	2.503	3.02	1.16	.54	3638	3631	3638	3638
RS	-5.85	3.93	4.15	1	2.374	3.53	1.58	.57	2915	2908	2915	2915
SE	4.72	1.33	1.35	1.13	1.344	1.69	1.12	.61	3638	3631	3638	3638
ALL	1.8	2.12	2.61	1.01	6.45	2.4	1.81	.68	64761	64455	64458	64761

Unbalanced panel from 1st October 2008 to 10th September 2022. CAB is the current account balance.

B Time Series Regression

This section presents the results of an event study using fixed effects estimates for the baseline and the extended country-sample of the following regression:

$$Res_{jt} = \alpha_j + \beta_1 post_{jt} + \boldsymbol{\beta X_{jt}} + \boldsymbol{\gamma W} + u_{jt} \tag{22}$$

where $post_{jt}$ is the main explanatory variable. It takes the value equal to one in the day of the announcement and in the following day for the treated country and zero otherwise, j indexes country, t time, $\boldsymbol{W}$ are monthly dummies and $\boldsymbol{X_{jt}}$ is a vector of controls. This equation is estimated using fixed effects and heterogeneous robust s.e., however results are robust to using Driscoll-Kraay standard errors.

For the reasons outlined in Section 3, DID is a more demanding method and thus it is not surprising that the effect in the estimates in the event study is slightly higher throughout the samples. Moreover, the results are robust and the estimates are slightly higher when we include week × year dummies instead of monthly fixed effects.

Table 15: Event Study

	Baseline Sample		Extended Sample	
	(1) Residuals	(2) Residuals	(3) Residuals	(4) Residuals
post	-0.447*	-0.432*	-0.484**	-0.458**
	(0.064)	(0.066)	(0.023)	(0.020)
MP meetings	-0.0373	-0.0387	0.00842	0.00538
	(0.437)	(0.425)	(0.871)	(0.916)
EU high yield		-0.0279		-0.0358
		(0.507)		(0.297)
Surprise index		0.00000882		-0.000350
		(0.987)		(0.470)
Observations	13720	13720	17961	17961
R^2	0.045	0.046	0.074	0.074
MonthFE	yes	yes	yes	yes
CurrencyFE	yes	yes	yes	yes

p-values in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: The table reports the output of the time series regressions. Post takes the value of 1 on the of the announcement and the day after for the currency targeted by the line in t, and zero otherwise. The extended sample adds Iceland and Norway to the control group. The model includes a fixed effect for every month in the sample, as well as currency fixed effects.

C Proof Announcement Effect

The following proof shows that by the term structure, the mere announcement of ECB liquidity lines reduces the euro funding cost on the FX market.

Let $S^l(n, n+1)$ and $S^{nl}(n, n+1)$ denote the price of a swap agreement at time n maturing at time $n+1$ in the presence of a liquidity line and in absence of a liquidity line, respectively. As shown in Bahaj and Reis (2022a), the price of swap agreements in presence of an active liquidity line is lower: $S^l(n, n+1) < S^{nl}(n, n+1)$. Consider now a trader choosing between entering an agreement at time 0 and maturing at time N at price $S(0, N)$, or rolling over short-term agreements. At time 0 there is no liquidity line in place, but there is a probability $\alpha_h, h \in \{a, na\}$ that a liquidity line will be activated at any time between 0 and N, which depends on whether a line was announced $(h = a)$ or not $(h = na)$. Naturally, $\alpha_a > \alpha_{na}$.

The expected cost of rolling over agreements or purchasing a long-term agreement should be identical by no arbitrage, therefore:

$$S^{nl,na}(0, N) = \mathbb{E}_0 \sum_{n=1}^{N} (1 - \alpha_{na}) S^{nl}(n-1, n) + \alpha_{na} S^l(n-1, n) \tag{23}$$

$$S^{nl,a}(0, N) = \mathbb{E}_0 \sum_{n=1}^{N} (1 - \alpha_a) S^{nl}(n-1, n) + \alpha_a S^l(n-1, n) \tag{24}$$

Hence, we have $S^{nl,a}(0, N) < S^{nl,na}(0, N)$.

5.1 Proof of Propositions 1 and 2

Proposition 1 Denote Euro Area bank stock prices by V_0^{nl} if no liquidity line is announced, and V_0^l if a line is announced.
For Case 1, note that from Eq. (17) we have:

$$V_0^l - V_0^{nl} = \beta^2 (1 + r) q \left[F_b^l(\bar{b}) - F_b^{nl}(\bar{b}) \right] [1 + r_c - \lambda_S - \lambda_{L,1}] \geq 0 \tag{25}$$

While for Case 2, from Eq. (19) we have:

$$V_0^l - V_0^{nl} = \beta^2 (1 + r) q \left[F_b^l(\bar{b}) - F_b^{nl}(\bar{b}) \right] [1 + r_c] \geq 0 \tag{26}$$

As discussed in the main text $1 + r_c - \lambda_S - \lambda_{L,1} > 0$ by assumption, to ensure that Euro Area banks face loan default risk. From Eq. (20) we have $(F_b^l(\bar{b}) - F_b^{nl}(\bar{b})) \geq 0$. It follows that:

$$F_b^l(\bar{b}) > F_b^{nl}(\bar{b}) \implies V_0^l - V_0^{nl} > 0$$

We have explained in the main text that the minimum of $b(\delta_a)$ is attained at 0, and the maximum at 1. Further, $b(0) = b^l(0) = b^{nl}(0)$ and $b^l(1) < b^{nl}(1)$. The latter result is shown in Bahaj and Reis (2022a).

By the properties of a CDF, we then have $F_b^l(b(0)) = F_b^{nl}(b(0)) = 0$ and $F_b^l(b^l(1)) = 1$, $F_b^{nl}(b^{nl}(1)) = 1$. Therefore $F_b^l(b^{nl}(1)) = F_b^{nl}(b^{nl}(1)) = 1$. The difference between the two CDFs can then be summarized as follows:

$$F_b^l(\bar{b}) - F_b^{nl}(\bar{b}) = \begin{cases} 0 \text{ if } \bar{b} \leq b(0) \\ > 0 \text{ if } \bar{b} \in (b(0), b^{nl}(1)) \\ 0 \text{ if } \bar{b} \geq b^{nl}(1) \end{cases} \tag{27}$$

Proposition 1 follows directly.

Proposition 2 In Case 1 we have from Eq. (25):

$$\frac{\partial(V_0^l - V_0^{nl})}{\partial \lambda_{L,1}} = -\beta^2(1+r)q\left[F_b^l(\bar{b}) - F_b^{nl}(\bar{b})\right] \leq 0 \tag{28}$$

Where the inequality is strict under the conditions stated in Proposition 1.

PUBLICATIONS

ECB Euro Liquidity Lines

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