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Abstract

We estimate a panel VAR model for the euro area to quantitatively assess the contribution of the TARGET2 system to the propagation of different types of structural economic shocks as well as to the historical evolution of aggregate economic activity in euro area member countries. Our results suggest that TARGET2 has significantly affected the transmission of capital flow shocks while leaving the macroeconomic responses to other aggregate shocks virtually unaltered. Furthermore, on basis of counterfactual analyses, we find that TARGET2 has contributed substantially to avoid deeper recessions in distressed periphery member countries like Spain, Italy, Ireland and Portugal, while to a smaller degree depressing aggregate economic activity in core member states, such as Germany, the Netherlands and Finland.

JEL-Codes: E420, F320, F410, F450.

Keywords: euro area, TARGET2 balances, capital inflow shocks, panel vector autoregressive model.

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1 Introduction

During the first five years after the onset of the Global Financial Crisis, several member states of the euro area - Greece, Ireland, Portugal, Spain, Italy and Cyprus - suffered from repeated waves of significant, in some cases even drastic net outflows of foreign private capital. In particular, in a series of run-style sell-offs, international investors sharply reduced their holdings of debt issued by those countries' governments, banks and other public and private institutions. Like in many other episodes of "sudden stops", the distressed economies of the euro area had to cope with sharply rising borrowing costs and significant difficulties to tap international capital and money markets. The governments of Greece, Ireland, Portugal were even confronted with a complete exclusion from financial markets and had to rely on voluminous intergovernmental rescue programs.

However, unlike the typical situation, in which a country with a national currency finds itself during a sudden stop, the economies of the euro area had almost automatic access to additional resources to cushion the effects of private capital outflows. In particular, they enjoyed the almost unlimited provision of liquidity to commercial banks by the European Central Bank (ECB) as part of important unconventional monetary policy measures combined with access to the Trans-European payment system, known as TARGET2. Given these features of the European Monetary Union (EMU), the domestic banks of a distressed economy could obtain from their National Central Bank (NCB) the liquidity needed to finance the transactions associated with the net outflows of private capital. The domestic NCB in turn increases its liabilities vis-à-vis the rest of the Eurosystem. This sequence of transactions resulted in the accumulation of substantial TARGET2 liabilities by distressed countries' NCBs and an increase of TARGET2 claims of countries like Germany, the Netherlands and Finland.[1]

The accumulation of significant TARGET2 positions has been the subject of a very controversial discussion among economists regarding possible consequences for the cross-country distribution of resources and risks or moral hazard effects delaying structural adjustment in distressed countries. This is hardly surprising since on the one hand TARGET2 in combination with the almost unlimited provision of liquidity by the ECB largely acts as financing at substantially below-market interest rates for euro area economies in trouble. However, in contrast to other official credit programs (e.g. by the EU or the IMF), TARGET2 liabilities are of infinite maturity, not conditional on any commitments regarding future fiscal policy or structural reforms, not subject to monitoring by international institutions and largely independent of the solvency of the borrowing country.[2] In addition, the presence of the TARGET2

[1] The mechanics of TARGET2 balances are discussed in more detail in Section 2.

[2] Note, however that despite the ECB's full allotment policy the volume of central bank refi-

system enables national commercial banks to obtain emergency liquidity without any implementation lags, which might reduce the likelihood of liquidity crises. On the other hand opponents fear that TARGET2 might reduce the incentives for structural reforms and serve as an instrument for the mutualization of risks within the euro area. Furthermore they criticize that the emergence of TARGET2 is not subject to any democratic legitimation, which is in sharp contrast to the official rescue packages designed by the national governments and the EU.[3]

The literature on TARGET2 balances is mainly qualitative in nature and largely focuses on the risks associated with the accumulation of TARGET2 liabilities as well as on distributional aspects from a normative perspective. While delivering valuable insights and providing interesting impulses for researchers and policy makers, the literature is widely silent about the precise quantitative effects of TARGET2 liabilities on real output, inflation, interest rates or real exchange rates. This is where the current paper steps in. It looks at TARGET2 balances from a quantitative and purely positive perspective. To this end, a panel vector autoregressive (VAR) model for the euro area is estimated in order to explore how TARGET2, combined with the easy access to central bank liquidity, affects the propagation of capital inflow shocks as well as other types of aggregate disturbances in several crisis and non-crisis member countries of the euro area in the period between the onset of the Global Financial Crisis and 2015. In what follows, we refer to the combination of the TARGET2 system with the almost unlimited liquidity provision by the ECB as the "TARGET2 system" or simply "TARGET2".

Our main findings are twofold. First, the results of our structural VAR analysis indicate that since the onset of the Global Financial Crisis, the movements of national TARGET2 liabilities have been mainly driven by capital inflow shocks. In contrast, cyclical drivers like innovations to aggregate demand or aggregate supply do not seem to induce statistically significant changes in TARGET2 balances. Second, in counterfactual experiments we find that, in the period 2008-2015, the access to the TARGET2 system has contributed substantially to avoid deeper recessions in the distressed euro area member countries Spain, Italy, Ireland and Portugal.[4] In particular, TARGET2 has allowed for more favorable refinancing conditions as measured by national long-term government bond rates and higher GDP levels. Without TARGET2, aggregate output would have fallen short of its actual level by between 10% and 40% in Ireland and between 5% and 20% in Spain and Portugal. In Italy,

nancing is limited to the availability of adequate collateral. However, the latter was continuously downgraded.

[3]See e.g. Bindseil, Cour-Thimann, and König (2012), Sinn and Wollmershäuser (2012b) and Whelan (2014) for a broad discussion of these issues.

[4]Note that we neglect Greece in our analysis because it obtained external finance merely through financial aid programmes of the euro area member countries since May 2010. External financing through capital markets did not take place while at the same time government bond rates increased tremendously.

the contribution of TARGET2 turns out to have been smaller. Nevertheless, absent access to this payments system in combination with the ECB's full allotment policy, Italian GDP would have been by up to 5% lower than actually observed. In addition, TARGET2 has also provided an upward contribution to the price level and the real effective exchange rate of the distressed countries. In contrast, the presence of the TARGET2 system dampened the level of GDP in the core member countries Germany, the Netherlands and Finland. However, the contribution was more muted than in the distressed economies. In particular, absent TARGET2, aggregate output would have exceeded its actual level by about 6% in Germany and by around 7% in the Netherlands and Finland. On the other hand, France seems to have barely been affected by TARGET2.

The present paper is related to four strands of the literature. First, there is a large body of studies investigating the macroeconomic effects of sudden stops in emerging and advanced economies. Despite using different empirical methodologies and samples, those papers reach the conclusion that sudden stops lead to substantial and persistent drops in real GDP, an improvement in current accounts and a significant real depreciation.[5] Second, more closely related to our work are papers that also resort to structural VAR models with sign restrictions to identify capital inflow shocks. In particular, Tillmann (2013) investigates the effects of capital flow reversals on asset markets in emerging Asia while Sa, Towbin, and Wieladek (2014) and Sa and Wieladek (2015) look at the contribution of capital inflow shocks to the housing booms in OECD countries and the US respectively. Zwick (2015) explores the extent to which capital flow shocks were responsible for the protracted contraction of loan supply in the EMU after the outbreak of the Global Financial Crisis. However, the evidence provided by these studies is silent about the quantitative impact of TARGET2. Third, our paper contributes to a recent approach in the literature that was initiated by Fagan and McNelis (2014). They integrate a TARGET2-style financing system into the small open economy DSGE model of Mendoza (2010) and find that the availability of TARGET2 substantially mitigates the adverse effects of a sudden-stop episode on GDP, consumption and investment. Furthermore, the TARGET2 system implies only small welfare gains for the economy. In contrast to Fagan and McNelis (2014), our approach is more agnostic, purely empirical and based on a different methodology, relying on a smaller number of structural assumptions. We view our set-up and results as complementary to those of Fagan and McNelis (2014). Finally, our work is also related to studies by Corsetti and Pesenti (2001), Obstfeld and Rogoff (2002), Tille (2001) and Clarida, Gali, and Gertler (2002), among others, which explore the distributional effects of monetary policy across countries.

[5]See for example Mendoza (2010), Lane and Milesi-Ferretti (2011) and Barkbu, Eichengreen, and Mody (2012) for reviews of the empirical literature. In addition Schmidt and Zwick (2015) and Zwick (2015) provide recent evidence for the euro area during the financial crisis.

The findings of these studies show that welfare shifts between open economies can be sizable after a policy-induced currency depreciation depending on certain conditions that affect international price competitiveness such as nominal rigidities or the degree of substitutability of internationally traded goods. In our analysis, we find that TARGET2 has also caused distributional effects across countries, i.e. by moderating the recessions in distressed periphery euro area member countries while at the same time depressing aggregate economic activity in core member states of the currency union.

The reminder of the paper is organized as follows. Section 2 describes the mechanics behind the emergence of TARGET2 balances and their evolution over time. In Section 3, we outline the structural panel VAR model setup and discuss the identification of structural shocks. In Section 4, we present and discuss our results. Finally, Section 5 concludes.

2 The mechanics of TARGET2 balances

TARGET2 is an acronym that stands for the second generation of the Trans-European Automated Real-time Gross settlement Express Transfer system. It is the transaction settlement system in the euro area through which the commercial banks of one country make payments to the commercial banks of another country. Until 2007 TARGET2 balances of the euro area member countries were virtually zero, implying that the balance of payments was in equilibrium (see Figure 1). In each country incoming and outgoing payments that were related to the accumulation of persistently large current account and financial account balances, canceled out each other.

The situation changed significantly in the course of the Global Financial Crisis and the Euro Crisis. Until August 2012 Italy, Ireland, Portugal and Spain had accumulated TARGET2 liabilities totaling 875 billion euros. These liabilities built up because the crisis countries experienced sharp reversals in private capital inflows. In particular, interbank lending came to a standstill, and most of the capital flight materialized in a decline in cross-border lending of commercial banks (Sinn and Wollmershäuser, 2012a). The resulting funding gap in the commercial banks' balance sheets and the current account was closed by an unlimited supply of central bank money from these countries' NCBs which de facto "issued" liabilities against the Eurosystem (Bindseil, Cour-Thimann, and König, 2012; Sinn and Wollmershäuser, 2012b; Whelan, 2014).[6] Hence, unlike in the pre-crisis period, the

[6]To this end, the ECB decided to switch to a fixed-rate full allotment policy in September 2008 and provided liquidity to the banking sector at both, increasingly long durations and against a wider range of collateral with lower quality. As a number of commercial banks in particular in Ireland and Greece were not able to provide sufficient or adequate collateral, their NCBs provided

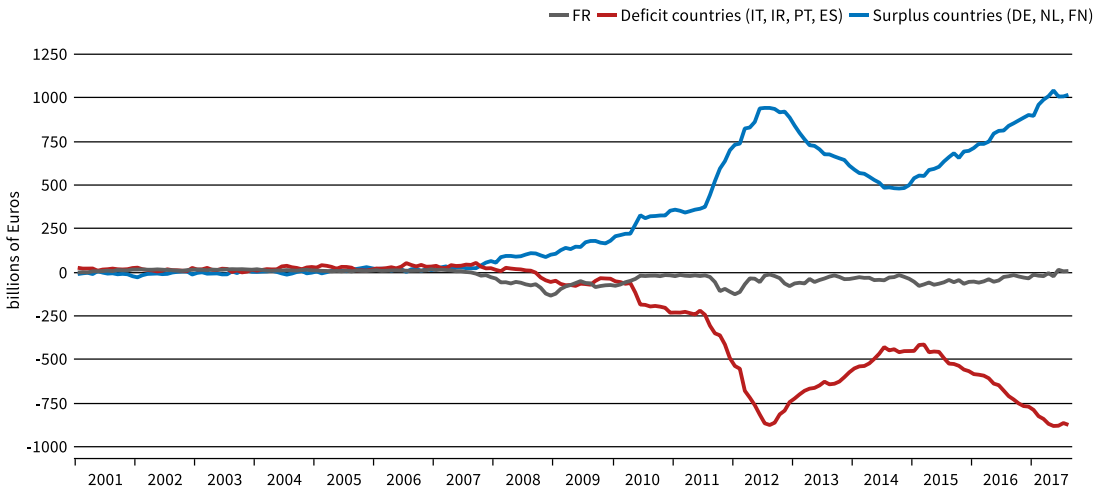
current account deficits of the crisis countries were no longer financed by private capital inflows, but by loans of the NCB to the banking system. The degree of this funding gap was measured by the build-up of the imbalances in the TARGET2 system. In the absence of such liquidity assistance, the capital flow reversal would have most likely required a sharp contraction of domestic demand and imports to improve the current account position of the crisis countries. On the other hand, the countries which were perceived as safe havens during the crisis, attracted the reversed capital flows. Until August 2012 Germany, the Netherlands and Finland built up TARGET2 claims totaling 940 billion euros.

After August 2012 TARGET2 balances started to decline towards their pre-crisis levels. The promise of the ECB to do whatever it takes to preserve the euro, marked a turning point of the Euro Crisis with a remarkable fall of risk premia for public and private securities. Capital outflows from crisis countries started to moderate gradually and commercial banks reduced their reliance on the ECB funding. At the same time the current account balance of the crisis countries was improving significantly and even turned positive from 2013 on, which reduced the countries' dependency on foreign capital. As a consequence TARGET2 balances decreased until the beginning of 2015.

The renewed surge in TARGET2 balances since 2015 coincides with the beginning of the ECB's outright purchase of euro area government bonds under the Public Sector Purchase Programme (PSPP) in March 2015. According to statements of ECB officials, instead of signaling another balance-of-payments crisis period in the euro area, movements in TARGET2 balances rather reflect the decentralized implementation of the bond purchases (see e.g. Eisenschmidt, Kedan, Schmitz, Adalid, and Papsdorf, 2017). As the majority of bonds is bought from counterparties that are located outside the country of the purchasing NCB, the PSPP involves cross-border payments via TARGET2 with central bank money that was created by the NCB. And since most of these counterparties have accounts at the Deutsche Bundesbank (either because they are located in Germany or, in the case of counterparties from outside the euro area, have historically accessed TARGET2 via the Deutsche Bundesbank), the German TARGET2 claims rise with the government bonds purchased by the NCBs in Italy, Spain and other countries. Meanwhile there are however doubts about this purely mechanical explanation. Dor (2016) and Minenna (2017) show that for Spain and Italy at least part of the increase in TARGET2 liabilities is related to capital outflows by domestic investors. Since the true nature of the current increase in TARGET2 balances is unclear and at least to some extent different from the capital flight episode of the years 2007 to 2012, we decided to exclude the period from 2016 on from our analysis.

short-term emergency loans to these banks (Emergency Liquidity Assistance, or ELA), where collateral requirements were further lowered (see e.g. Whelan, 2012, on the Irish case).

Figure 1: TARGET2 balances of major countries



Source: European Central Bank. Own calculations.

3 Panel-VAR model setup

3.1 Panel VAR

Consider a panel VAR model in reduced form:

$$X_{i,t} = \sum_{j=1}^{p} A_j X_{i,t-j} + c_i + \varepsilon_{i,t}, \tag{3.1}$$

where $X_{i,t}$ is a vector of endogenous variables for country i, A_j is a matrix of autoregressive coefficients for lag j, p is the number of lags, c_i is a vector of country–specific intercepts and $\varepsilon_{i,t}$ is a vector of reduced-form residuals. The vector $X_{i,t}$ consists of six variables

$$X_{i,t} = [y_{i,t} \;\; p_{i,t} \;\; lr_{i,t} \;\; reer_{i,t} \;\; nfl_{i,t} \;\; tgt_{i,t}]', \tag{3.2}$$

where $y_{i,t}$ denotes real GDP, $p_{i,t}$ is the overall price level, measured by the GDP deflator, $lr_{i,t}$ is the long-term nominal interest rate proxied by the yield on ten-year government bonds, $reer_{i,t}$ is the real effective exchange rate, $nfl_{i,t}$ is the net foreign liability position and $tgt_{i,t}$ is the net stock of TARGET2 liabilities. Real GDP, the price level and the real effective exchange rate are in logs, while the long-term interest rate is expressed in percent. Net foreign liabilities and TARGET2 are measured in percent of nominal GDP. For each variable, we use a pooled set of $M \cdot T$ observations, where M denotes the number of countries and T denotes the number of observations corrected for the number of lags p. The reduced-form residuals $\varepsilon_{i,t}$ are stacked into a vector $\varepsilon_t = [\varepsilon'_{1,t} \ldots \varepsilon'_{M,t}]'$, which is normally distributed with mean

zero and variance-covariance matrix Σ.

We use quarterly data that are taken from Eurostat, the ECB and the OECD covering the period from 2008Q1 to 2015Q4.[7] The beginning of the sample is determined by the availability of quarterly data on net foreign liability positions and TARGET2 balances which are available from the ECB's database since 2001. We abstain from using post-2015 data since, as discussed in Section 2, it is particularly unclear whether the behavior of the TARGET2 balances in this most recent episode is a mere technical reflection of the ECB's quantitative easing programme (PSPP) or the result of active capital flight as during and around the peak of the European debt crisis.

Since the sample is short, we follow Ciccarelli, Maddaloni, and Peydro (2015) and use a panel of eight euro area member countries, comprising Spain (ESP), Italy (ITA), Portugal (PRT), Ireland (IRL), Germany (DEU), France (FRA), the Netherlands (NLD) and Finland (FIN).[8] The main advantage of using a panel approach is that it increases the efficiency of the statistical inference, which would otherwise suffer from a small number of degrees of freedom when the VAR is estimated at the country or the euro area level. While this comes at the cost of disregarding cross-country differences by imposing the same underlying structure for each cross-sectional unit, Gavin and Theodorou (2005) emphasize that estimating a panel allows to uncover common dynamic relationships. In fact, the panel approach is prone to the same error as any empirical approach that uses aggregate euro area data and thereby treats the currency union as a homogenous entity.

The matrix of constant terms c comprises individual country dummies that account for possible heterogeneity across the units. The panel VAR model is estimated with Bayesian methods using a Normal-inverted Wishart prior, 500 draws and a lag order of $p = 2$.

3.2 Identification of structural shocks

Based on the VAR model (3.1) we generate impulse responses of the variables to structural shocks η_t. As in Canova and de Nicolo (2002), Peersman (2005) and Uhlig (2005) the shocks are identified by imposing sign restrictions. The reduced-form residuals ε_t are related to the structural shocks η_t according to $\eta_t = (U\Omega^{1/2}Q)^{-1}\varepsilon_t$, where $U\Omega^{1/2}$ is the Cholesky factor, $\Sigma = U\Omega U'$, of each draw and Q is an orthogonal matrix, $QQ' = I$, generated from a QR decomposition of some random matrix W, which is drawn from an $N(0, 1)$ density. For each of the 500 Colesky factors resulting

[7] See Appendix A for a detailed description of the data.

[8] Ciccarelli, Maddaloni, and Peydro (2015) estimate a panel VAR for the euro area over the period 2002Q4 to 2009Q4 and argue that this period covers at least one complete business cycle. Recall that we neglect Greece in our analysis because it obtained external finance merely through financial aid programmes of the euro area member countries since May 2010.

from the Bayesian estimation of the VAR model, the draws of the random matrix W are repeated until a matrix Q is found that generates impulse responses to η_t, which satisfy the sign restrictions.

Our identification of the shocks is set-up according to the following principles. First, in addition to a capital inflow shock we also impose restrictions on two further types of shocks: an aggregate demand and an aggregate supply shock. The reason is that it has been shown that increasing the number of identified innovations can help to uncover the correct sign of the impulse response functions (Paustian, 2007). The restrictions uniquely identify the three shocks, in the sense that the set of sign restrictions imposed is mutually exclusive *ex ante*. Furthermore, the simultaneous identification of the two additional disturbances, besides the capital-inflow shock, ensures that the latter indeed captures exogenous shifts in investors' attitude towards a particular country rather than any endogenous reaction of international capital flows to one of the other shocks. Moreover, the literature considers shocks to aggregate supply and aggregate demand to be the most important driving forces of the business cycle. Finally, the restrictions are consistent with what would be suggested by dynamic stochastic general equilibrium (DSGE) models.

3.2.1 Aggregate demand and aggregate supply shocks

For an aggregate demand shock we assume that output and prices move in the same direction. While these restrictions are sufficient to separate the aggregate demand shock from an aggregate supply shock, we need an additional restriction to distinguish it from unexpected capital inflow disturbances. Here we assume that the long-term interest rate falls following a negative aggregate demand shock as the central bank lowers the short-term rate in an attempt to mitigate the effects of the shock.[9] In addition, the decline in aggregate demand is typically associated with a weakening of credit demand which, everything else equal, also exerts downward pressure on long-term rates.[10] Finally, we also assume that the real (effective) exchange rate falls following a negative aggregate demand shock. This restriction can be motivated by acknowledging that a decline in domestic demand is typically associated with a deceleration in inflation and a depreciation of the nominal exchange rate as the central bank seeks to compensate the slack in demand by lowering the policy rate. Both, the reduced domestic price pressure and the reaction of the nominal exchange rate work towards depreciating the economy's real exchange rate

[9]Note that the restriction on the long-term rate, i.e. to move in the same direction as output and prices, makes the innovation to aggregate demand different from typical monetary policy shocks. The latter are usually associated with nominal interest rates moving in a direction opposite to that of output and prices.

[10]See e.g. Peersman (2005), Fratzscher, Saborowski, and Straub (2009), for similar restrictions in VARs, and Straub and Peersman (2006), and Canova and Paustian (2011), for evidence from standard DSGE models.

and thus improving its international competitiveness.[11] Restrictions on the stock of TARGET2 liabilities are not imposed, implying that the data will determine the sign of their response (see Table 1).

For an aggregate supply shock we assume that output and prices move in the opposite direction.[12] In addition, we assume that the real exchange rate appreciates following an adverse aggregate supply shock as, in the face of a more intense upward pressure on production costs, domestic inflation accelerates.[13] The reaction of TARGET2 liabilities is again left unrestricted (see Table 1).

3.2.2 Capital inflow shocks

A sudden surge in capital flows to a country might be associated with either "pull" or "push" factors. The former mainly reflect domestic demand and supply side shocks which alter a country's relative attractiveness from the perspective of international investors. In contrast, "push" factors are sources of unexpected changes in capital inflows entirely originating abroad. In the following, we define a capital inflow shock as one reflecting a disturbance to the "push" factors while the "pull" side of investment flows from abroad is captured by the endogenous response of the net foreign liability position to the main domestic drivers of the business cycle (disturbances to aggregate demand or aggregate supply).

Open economy general equilibrium models identify various "push"- sources of capital inflow shocks to an individual country. Such shocks might result from different supply, demand or monetary disturbances abroad, which, from the perspective of the country, act as sudden changes in foreign investors' demand for domestic assets. For example, if a country's assets are viewed as safer, a decline in foreigners' risk aversion might trigger a higher inflow of capital form the rest of the world (e.g. as in Sa and Viani, 2013). Likewise, a change in the structure of an important foreign financial markets or the bursting of a bubble there typically changes the amount of resources channeled towards the domestic economy (e.g. Caballero, Farhi, and Gourinchas, 2008). Moreover, any demand-side driven shift in aggregate investment or saving in the rest of the world typically alters the intensity of capital flows to the domestic economy, provided foreigners' portfolios are not subject to a complete home bias (e.g. Caballero and Krishnamurthy, 2009). Finally, fluctuations in capital flows might be triggered by foreign governments regulatory - e.g. macroprudential - interventions or changes in the desired currency and amount of foreign reserves

[11] See Tillmann (2013), Sa, Towbin, and Wieladek (2014), Sa and Wieladek (2015)for similar sign restrictions in VARs.

[12] See again Peersman (2005), Fratzscher, Saborowski, and Straub (2009), for similar restrictions in VARs, and Straub and Peersman (2006), and Canova and Paustian (2011), for evidence from standard DSGE models.

[13] See for example Bems, Dedola, and Smets (2007) for VAR evidence or Glick and Rogoff (1995) for a general equilibrium analysis.

held by monetary authorities abroad (e.g. Favilukis, Kohn, Ludvigson, and Nieuwerburgh, 2013). However, these theories suggest that irrespective of the precise source and/or mechanism leading to the capital inflow shock, its effects on the destination economy's net foreign liability position, nominal and real exchange rate, domestic interest rates and domestic price level are unambiguous.[14]

The theoretical considerations are supported by several empirical studies. In particular, Warnock and Warnock (2006) and Favilukis, Kohn, Ludvigson, and Nieuwerburgh (2013) and Reinhart and Reinhart (2009) provide results supporting a negative reaction of a country's long-term nominal yields to an unexpected increase in capital flowing from abroad. In addition, the evidence in Reinhart and Reinhart (2009) suggest that, during episodes of "capital flow bonanzas", a surge in capital inflows accelerates a country's GDP growth and leads to an appreciation of nominal and real exchange rates. In studies focusing on emerging and developing economies, Cardarelli, Elekdag, and Kose (2010), Kim and Yang (2011), Jongwanich and Kohpaiboon (2013) and Kim and Kim (2013) also find a positive relation between surges in capital inflows and domestic GDP, price level and real and/or nominal appreciation.

Based on the theoretical and empirical findings mentioned above, we impose the following sign restrictions to identify a capital inflow shock. The later is associated with an increase in the net foreign liability position (a decrease in the net foreign asset position), non-negative reactions of aggregate output and the price level, a decline in long-term interest rates and a real appreciation. The sudden surge in inflowing foreign capital relaxes credit conditions and thus puts downward pressure on long-term interest rates. The easier access to credit in turn fuels domestic demand and inflation. The reaction of TARGET2 balances is again left unrestricted. Related VAR studies identifying capital inflow shocks based on sign restrictions resort to similar assumptions. In particular, Tillmann (2013) imposes restrictions on the response of the net foreign asset/liability position, the long-term interest rate, the real effective exchange rate and GDP. Sa, Towbin, and Wieladek (2014) and Sa and Wieladek (2015) only impose restrictions on the net foreign asset/liability position, the real exchange rate and the *real* long-term interest rate to identify a capital inflow shock.

Note that the sign restrictions used to identify the adverse capital inflow shock also make it different from contractionary monetary policy disturbances. The latter typically lead to an unexpected rise of the long-term nominal interest rate while having a non-positive effect on output and prices.[15] In addition, adverse monetary

[14]See Caballero, Farhi, and Gourinchas (2008), Caballero and Krishnamurthy (2009), Sa and Viani (2013), Favilukis, Kohn, Ludvigson, and Nieuwerburgh (2013), among others, for a discussion.

[15]The reason why we abstain from identifying a monetary policy shock explicitly within our set of sign restrictions is that in our subsequent counterfactual experiments the monetary policy shock

shocks are usually associated with an *appreciation* of the real exchange rate.[16]

3.3 Summary of sign restrictions

Table 1 summarizes our sign restrictions to identify the capital inflow shock as well as the shocks to aggregate supply and aggregate demand. The remaining shocks are interpreted as a residual shocks, which capture the remaining variation in the data.

Table 1: Sign Restrictions

Shock	Real GDP	GDP deflator	Long term rate	Real exchange rate	Net foreign liabilities	Target liabilities
Capital inflow	↑	↑	↓	↑	↑	
Aggregate demand	↑	↑	↑	↑		
Aggregate supply	↑	↓		↓		

Notes: Sign restrictions are imposed for four quarters.

For all variables we set the time period over which the sign restrictions are binding equal to four quarters. This is in line with Peersman (2005), Uhlig (2005), Farrant and Peersman (2006) and Scholl and Uhlig (2008), who assume that the effects of shocks on economic activity can be quite persistent. Assuming that the sign restrictions only hold for two quarters leaves our results qualitatively unchanged. All sign restrictions are imposed as $\leq$ or $\geq$.[17]

would be country-specific, which, however, is never the case in a monetary union.

[16]The intuition why the real exchange rate appreciates following a contractionary monetary shock is that the increase in the policy rate typically comes along with an appreciation of the nominal exchange rate as foreign investors try to take advantage of the higher domestic short-term rates. The reaction of the nominal exchange rate translates into an appreciation of its real counterpart if the domestic economy and the rest of the world exhibit some degree of nominal price rigidity. For example, based on various types of approaches, Eichenbaum and Evans (1995), Faust and Rogers (2003), Zettelmeyer (2004), Lee and Chinn (2006), Bems, Dedola, and Smets (2007), Scholl and Uhlig (2008), Forni and Gambetti (2010) provide empirical evidence indicating an appreciation of a country's real effective exchange rate in the case of an adverse domestic monetary shock. Theoretical explanation for this empirical finding is provided by Lane (2001) and Tille (2001) among others.

[17]The estimation of the Bayesian VAR and the identification of the structural shocks is performed in MATLAB, using the codes `bvar.m`, `bvar_chol_impulse.m` and `bvar_sign_ident.m` provided by Fabio Canova (http://www.crei.cat/people/canova/).

4 Empirical results

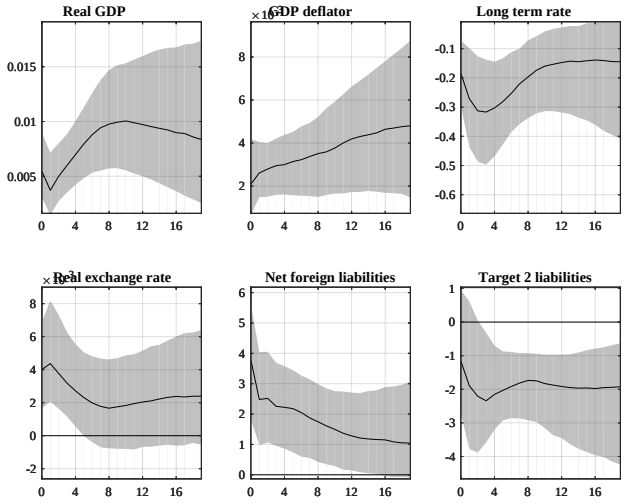
4.1 Impulse response functions

Figure 2 displays the impulse responses of the six macro variables to capital inflow, aggregate demand and aggregate supply shocks. The results indicate that sudden capital flow reversals are associated with substantially more persistent reactions of GDP, the GDP deflator and long-term interest rates than disturbances to aggregate demand or aggregate supply. Further, TARGET2 balances react significantly only in the case the economy is hit by a capital flow shock. In particular, an unexpected acceleration of the inflow of capital reduces the necessity to borrow from the Eurosystem which corresponds to a decline in TARGET2 liabilities (or an increase in TARGET2 claims). Interestingly, sudden shifts in aggregate demand or aggregate supply do not seem to affect the net foreign liability position or the TARGET2 balance significantly. This result suggests that so called domestic "pull" factors are unlikely to have been a driving force behind capital flows in and out of euro area member countries.[18]

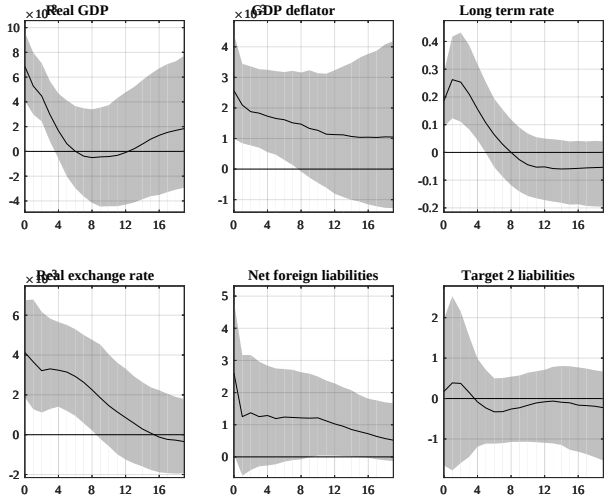
[18]Note that by construction, the capital inflow shock comes along with an increase of net foreign liabilities (see also Table 1).

Figure 2: Impulse responses to aggregate shocks. Sample: 2008Q1-2015Q4

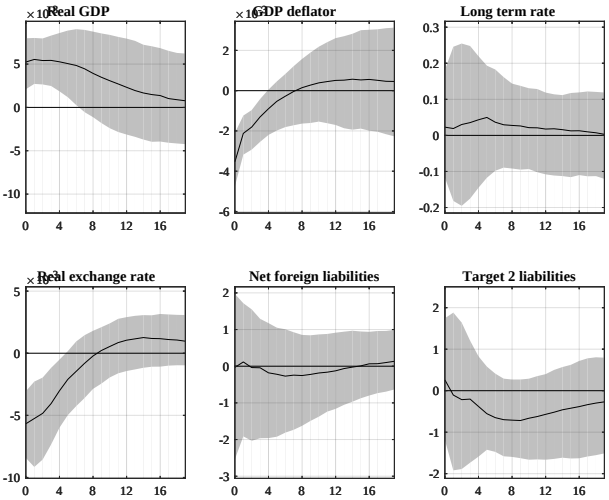
Capital inflow shock



Aggregate demand shock



Aggregate supply shock



Notes: Real GDP, the price level and the real effective exchange rate are in logs. The long-term nominal interest rate is in percent. The net foreign liability position and the TARGET2 liabilities are measured in percentages of nominal GDP. An increase of the NFL or TARGET2 is equivalent to a net accumulation of liabilities. Solid black lines and shaded areas reflect the median response and the 68% confidence interval.

4.2 Counterfactual historical evolution

4.2.1 Counterfactual I

To assess the quantitative importance of having access to TARGET2, we construct a counterfactual time series for the six macro variables under a "deactivated" TARGET2 system. Technically, we follow Sims (1998), Sims and Zha (2006a, 2006b) and Pesaran and Smith (2016) among others and choose the paths of the fifth and sixth shock in the model, such that TARGET2 balances are equal to zero and, at the same time, the counterfactual evolution of the net foreign liabilities corresponds to private capital flows only, i.e.

$$\widetilde{nfl}_{i,t} = nfl_{i,t} - tgt_{i,t}. \tag{4.1}$$

The paths of the remaining shocks are identical to their estimated actual historical values. The difference between the actual and counterfactual evolution of an endogenous variable is then an estimate of the *ex post* effect of shutting-off the TARGET2 channel.[19]

The results of our counterfactual analysis are shown in Figure 3, where red lines correspond to the actual series while the blue lines are the counterfactuals. For Spain, Ireland and Portugal, the inability to build up TARGET2 liabilities would have implied substantially lower GDP and price levels, higher long-term interest rates and thus more unfavorable financing conditions and a tendency for a faster and/or more pronounced depreciation of the real exchange rate. The effects were particularly strong in the periods characterized by substantial private capital outflows and corresponding sharp increases in national TARGET2 liabilities. Around the first peak of the European debt crisis, i.e. in the second half of 2011 and in 2012, the actual level of Spanish GDP would have been more than 5% lower than actually observed. At the end of our sample in 2015 Spain's economy was still benefiting from

[19] See Bernanke, Gertler, and Watson (1997) or Sims (1998), among others for a discussion on the use of counterfactuals. In our case, the *ex post* deviation between the actual and the counterfactual evolution of the endogenous variables $X_{i,t}$ in period t, $d^{ep}_{i,t}$, is given by $d^{ep}_{i,t} = E_{t-1}(X_{i,t}|\eta_{i,1t},...,\eta_{i,6t}) - E_{t-1}(X_{i,t}|\widetilde{tgt}_{i,t},\widetilde{nfl}_{i,t},\eta_{i,1t},...,\eta_{i,4t})$, where $\widetilde{tgt}_{i,t}$ and $\widetilde{nfl}_{i,t}$ are the values of TARGET2 balances and net foreign liabilities according to our counterfactual assumption, $[\eta_{i,1t},...,\eta_{i,6t}]$ is the vector of actual structural shocks, $[\eta_{i,1t},...,\eta_{i,4t}]$ is the vector of actual values of the subset of structural shocks that are not determined endogenously in accordance with our counterfactual. In contrast, if we abstain from conditioning on the actual values of the free shocks and rather construct the difference between the sequence of unconditional one-step-ahead forecasts and the corresponding sequence of forecasts conditional on the values of TARGET2 balances and net foreign liabilities, we would end up with the *ex ante* contribution $d^{i,ea}_t$ of the TARGET2 channel: $d^{i,ea}_t = E_{t-1}(X_{i,t}) - E_{t-1}(X_{i,t}|\widetilde{tgt}_{i,t},\widetilde{nfl}_{i,t})$ (see Pesaran and Smith (2016) for an application).

the presence of the TARGET2 channel as aggregate output exceeded by about 5% its hypothetical level that would have prevailed in the absence of TARGET2. Ireland would have experienced a persistently weaker aggregate economic activity, both in the early stages of the crisis (2008-2010) as well as more recently (2014/2015). In particular, in both phases, Irish GDP would have been more than 10% lower than actually observed. Absent the TARGET2 channel, Portugal would have been confronted with a similarly persistent, albeit less pronounced (around 4%) loss of GDP. In contrast, the effects of shutting-off the TARGET2 channel in Italy seem to be much more muted. In particular, the counterfactual level of GDP is slightly lower (by about 2%) than its actual level around 2011/2012 as Italian TARGET2 liabilities increased sharply; in 2013 and 2014 GDP would have even been slightly higher. These two phases almost offset each other out in terms of cumulative GDP losses. In addition, the GDP deflator, the effective real exchange rate and the long-term interest rate in Italy would have been barely different from those actually observed. The reason for the weak contribution of the TARGET2 channel to the Italian business cycle most likely results from the relatively limited magnitude of the increase of net foreign liabilities and TARGET2 liabilities, if measured as a percentage of GDP. In particular, Italian net foreign liabilities have never exceeded 25% of GDP while, even at the first peak of the European Debt Crisis (2011/2012), the corresponding TARGET2 liabilities barely reached 20% of aggregate output. In contrast, the ratio of net foreign liabilities to GDP amounted to more than 90% in Spain, around 120% in Portugal and more than 200% in Ireland. The corresponding ratios of TARGET2 liabilities to GDP reached 40% in Spain and Portugal and almost 100% in Ireland.

The analogous counterfactuals for the core countries in our sample, i.e. Germany, France, the Netherlands and Finland, are depicted in Figure 4. Unsurprisingly, the presence of the TARGET2 system tended to contribute negatively to the level of aggregate economic activity there, reflecting the redistribution of real resources towards the distressed euro area member states. However, the effect of TARGET2 on individual core countries' GDP was substantially weaker than in the case of their counterparts in the periphery of the euro area. In particular, the level of aggregate output was depressed by about 2.7% in Germany, 3.6% in the Netherlands and 4.3% in Finland. Like Italy, France remained almost unaffected by TARGET2. This most likely stems from the substantially smaller TARGET2-to-GDP ratio of the country relative to that of Germany, the Netherlands and Finland.

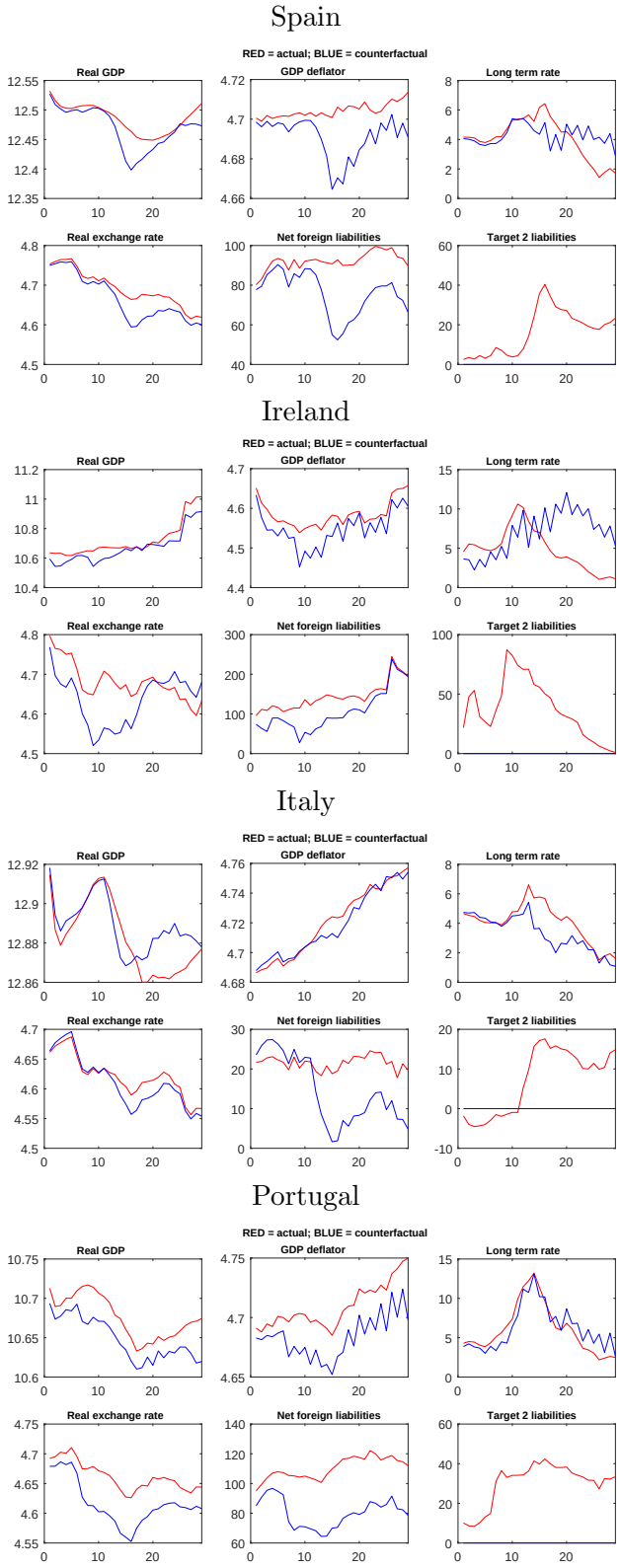
Clearly, as most counterfactuals carried out in the literature, our analysis could be challenged through the lens of the *Lucas critique*. However, as emphasized by Sims (1998), as long as the counterfactual scenario can be considered element of

agents (subjective) distributional beliefs regarding the relevant economic parameters, the scenario itself does not necessarily represent a structural change. It should be rather viewed as a draw from the *unchanged* parameter distributions underlying the structure of the economy. In such a case, a counterfactual analysis is substantially less prone to the *Lucas critique* (Sims, 1998; Leeper and Zha, 2003).[20] In fact, to construct our counterfactual, we need sequences of fairly unsystematic shocks that only rarely exceed their estimated two standard deviations.[21] Accordingly, we believe that the problems giving rise to the *Lucas critique* do not bias our results in a substantial way.

[20] As Sims (1998) points out, the *Lucas critique* of econometric policy evaluation (Lucas, 1976) can be summarized in terms of two relevant versions: First, according to the *Lucas critique* using a stochastic model that explicitly models the dynamics of expectations formation to evaluate changes in the policy rule as if they could be made permanent, while leaving expectations formation dynamics unchanged, is misleading (Sims, 1998, p. 153). Second, the *Lucas critique* states that conditioning on policy instruments or other stochastic variables exhibiting variations lying outside their relevant historical distributions, can be misleading as it is implausible that the public would view such variations as the realizations of a fixed probability law, e.g. for policy behavior (Sims, 1998, p. 154). Akin to Sims (1998) our counterfactual analysis is not subject to the first version of the *Lucas critique*, because our model contains no explicit dynamics of expectations formation. The second version of the Lucas critique applies but, given Sims' arguments, without a noteworthy severity. See also the discussion in Bernanke, Gertler, and Watson (1997), Leeper and Zha (2003) and Pesaran and Smith (2016).

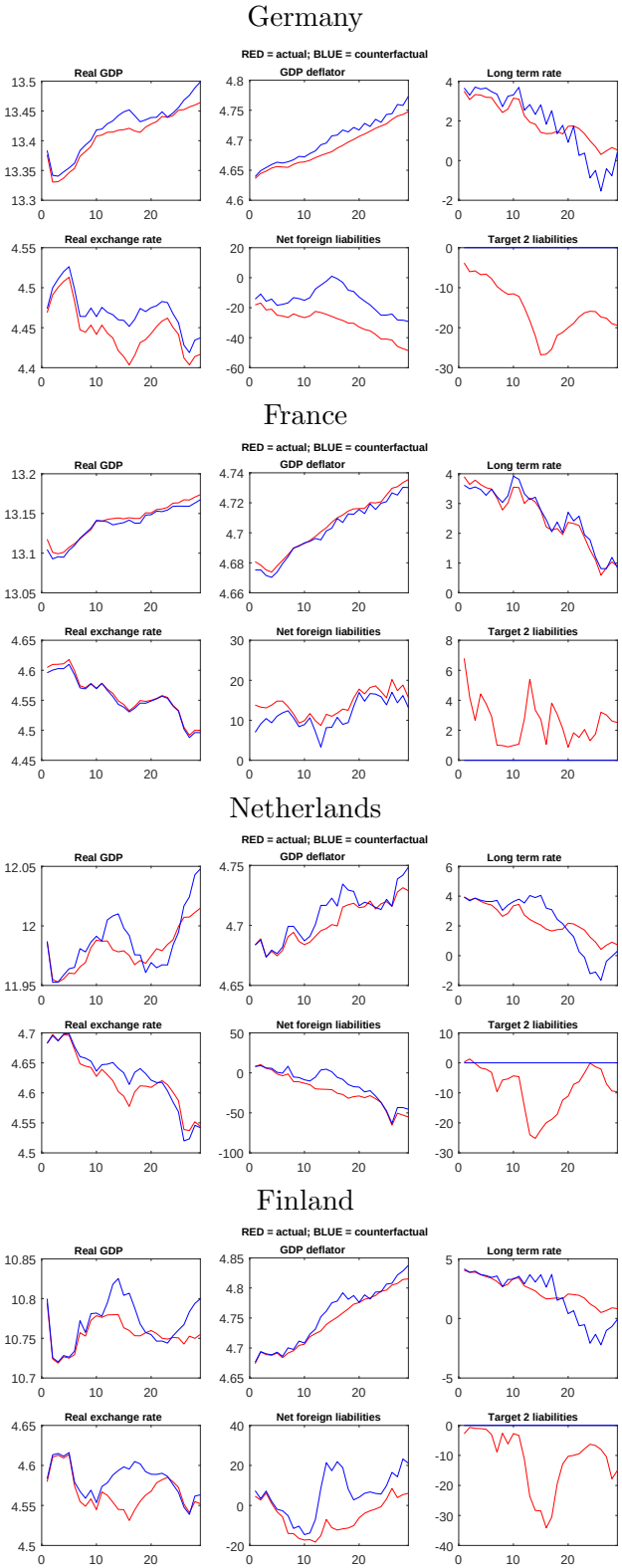
[21] The shock sequences are available upon request.

Figure 3: Actual (red) and counterfactual (blue) evolution of macro aggregates. Sample: 2008Q1-2015Q4. Distressed countries



Notes: The graphs plot the actual and counterfactual evolution of the macroeconomic aggregates. Actuals are represented by red color, counterfactuals in blue. The counterfactuals are constructed by setting the 4th and 5th shock in the VAR to the values implying TARGET2 balances equal to zero and an evolution of the NFL reflecting only private capital flows. Real GDP, the price level and the real effective exchange rate are in logs. The long-term rate is in percent. The net foreign liability position and the TARGET2 liabilities are measured as percentages of nominal GDP.

Figure 4: Actual (red) and counterfactual (blue) evolution of macro aggregates. Sample: 2008Q1-2015Q4. Core countries



Notes: The graphs plot the actual and counterfactual evolution of the macroeconomic aggregates. Actuals are represented by red color, counterfactuals in blue. The counterfactuals are constructed by setting the 4th and 5th shock in the VAR to the values implying TARGET2 balances equal to zero and an evolution of the NFL reflecting only private capital flows. Real GDP, the price level and the real effective exchange rate are in logs. The long-term rate is in percent. The net foreign liability position and the TARGET2 liabilities are measured as percentages of nominal GDP.

4.2.2 Counterfactual II: Alternative specification

For an alternative specification of the counterfactual we follow the approach described by Sims and Zha (2006b) and set the coefficients in the TARGET2 equation to their means estimated over the pre-crisis sample, i.e. 2001Q1-2007Q4. In addition, we choose one of the structural shocks such that the counterfactual evolution of net foreign liabilities corresponds to private capital flows only as in equation (4.1). The rationale for viewing this approach (at least partly) immune to the *Lucas critique* is similar to that underlying the counterfactual spelled out in Section 4.2.1. In particular, if a subset of the actual coefficients in a VAR are replaced by values which lie within certain bounds of the corresponding (posterior) distributions, the counterfactual coefficients and the associated scenario deviate from the baseline ones only *modestly* in the sense of Leeper and Zha (2003). In such a case, the counterfactual does not necessarily represent a structural change but rather one possible draw from the *unchanged* parameter distributions underlying the structure of the economy.[22] Indeed, the pre-crisis values of the coefficients in the TARGET2 equation of our VAR lie within the 95% credibility bounds of the post-crisis distributions of the same parameters. Accordingly, we view the coefficient restriction imposed as a *modest* change.

A necessary preliminary step is to estimate the model over the years preceding the outbreak of the Global Financial Crisis. The results are again summarized by impulse response functions to the three structural shocks discussed in Section 3.2 and identified as in Table 1. Figure 5 displays the impulse responses. As can be seen, in contrast to the period after 2008, the structural shocks do not induce statistically significant changes in the TARGET2 liabilities. This is barely surprising since the latter were almost time invariant over the period 2001-2007 (see also Figure 1).

For each distressed country, Figure 6 displays the evolution of the six endogenous model variables along their respective actual (red) as well as the counterfactual (blue) paths. The figure reveals a qualitatively similar picture as that presented in Section 4.2.1. Again, switching-off of the TARGET2 channel would have induced much stronger adverse effects in Spain, Ireland and Portugal while being associated with still unfavorable but relatively more muted contribution to the evolution of economic activity in Italy. However, in contrast to the counterfactual analysis presented in Section 4.2.1, now the contribution of the TARGET2 system is substantially larger. In particular, absent the access to TARGET2, GDP would have persistently fallen short of its actual level by about 40% in Ireland, 20% in Spain and Portugal and 5% in Italy. Correspondingly, in each country, the long-term in-

[22] See Sims and Zha (2006b) for a detailed discussion and several applications.

terest rates would have been way higher, while the price level and the real exchange rate would have been markedly lower than actually observed. Figure 7 displays the corresponding counterfactual simulations for the core countries. TARGET2 exerted a negative effect on the level of GDP in Germany, the Netherlands and Finland while leaving the French economy almost unaffected. Figure 7 also indicates that the quantitative contributions of the TARGET2 system might have been stronger than those resulting from the counterfactual discussed in section 4.2.1 and shown in Figure 4. Absent the TARGET2 system, GDP would have exceeded its actually observed level by about 9.4% in Germany, 9.6% in the Netherlands and 10% in Finland.

The quantitatively different importance assigned to the TARGET2 channel by the two types of counterfactual analyses (compare Figures 6 and 7 with Figures 3 and 4) is barely surprising. As discussed by Sims and Zha (2006b), counterfactuals based on sequences of structural white noise shocks, which are of modest magnitude in order not to exceed certain distributional bounds, *typically* generate relatively small and short-lived deviations between the counterfactual and the actual evolution of the endogenous variables in a VAR. In contrast, imposing counterfactuals constructed by restricting a subset of the VAR-coefficients tend to be associated with a larger contribution of the channel under consideration.

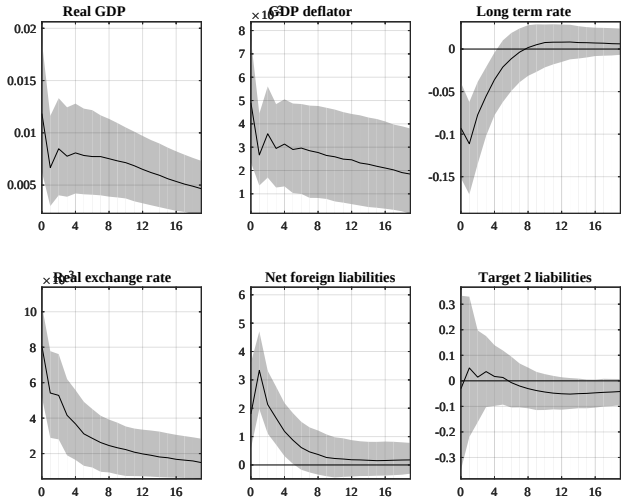
4.3 Robustness checks

We ran a number of robustness checks along several dimensions of the VAR.[23] In particular, our results are qualitatively unaffected and subject to only marginal quantitative changes if we vary the lag length p of the VAR between 2 and 6, if we impose the sign restrictions over a shorter horizon, i.e. only 2 or 3 quarters and if we reduce the number of identified structural shocks beyond the capital inflow shock. Finally, within both, the set-up of Section 4.2.1 and that of Section 4.2.2 we varied the subset of structural shocks that are determined endogenously to satisfy the counterfactual assumptions. The quantitative effects turned to be very small.

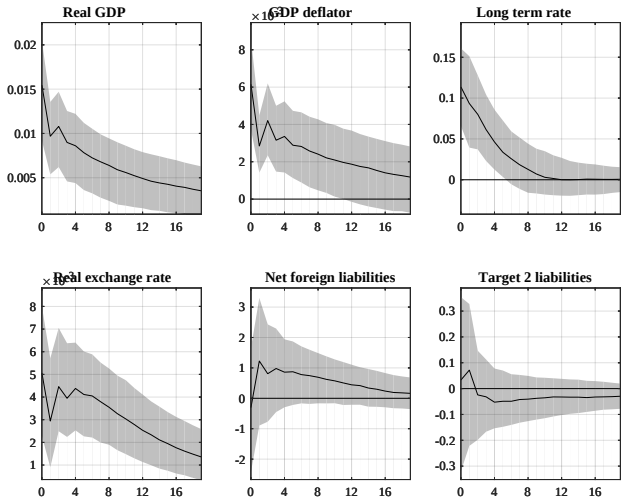
[23]The results are available upon request.

Figure 5: Impulse responses to aggregate shocks. Sample: 2001Q1-2007Q4

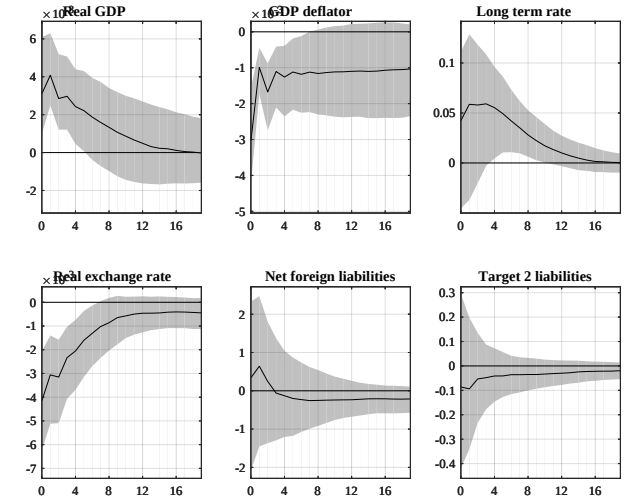
Capital inflow shock



Aggregate demand shock

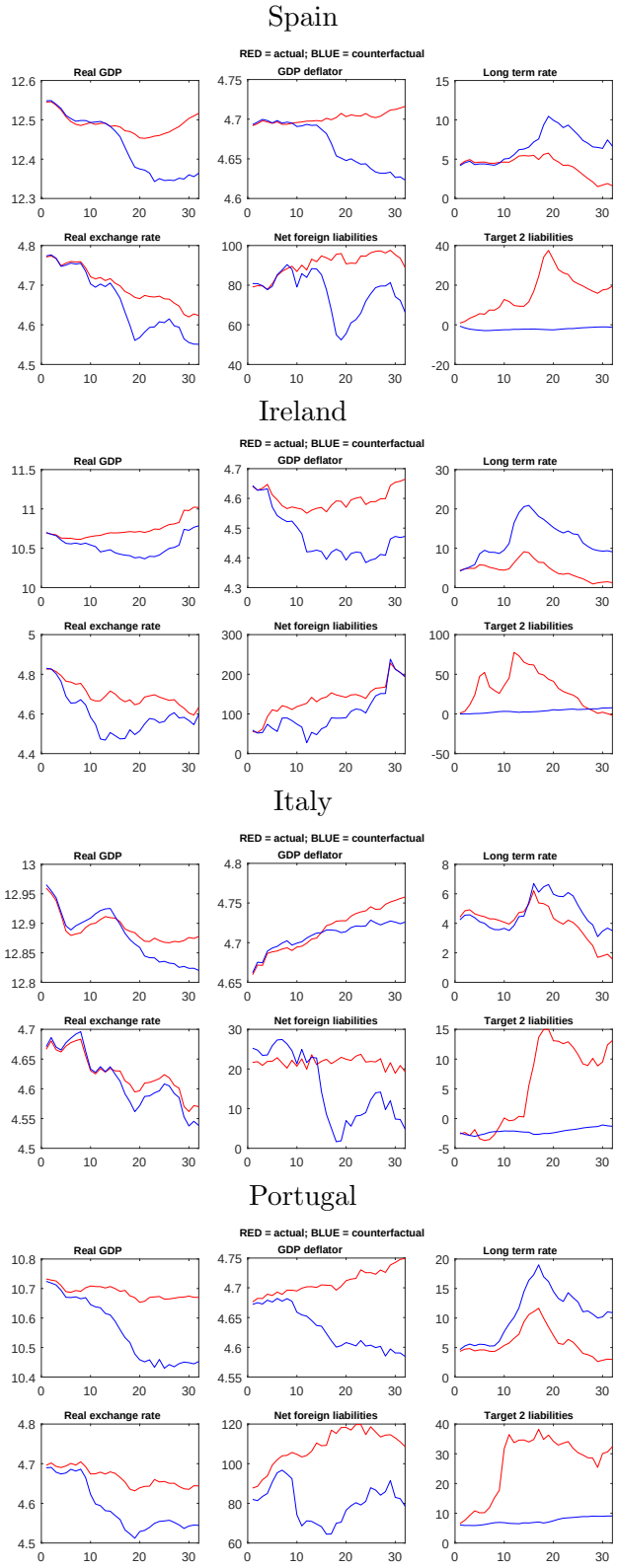


Aggregate supply shock



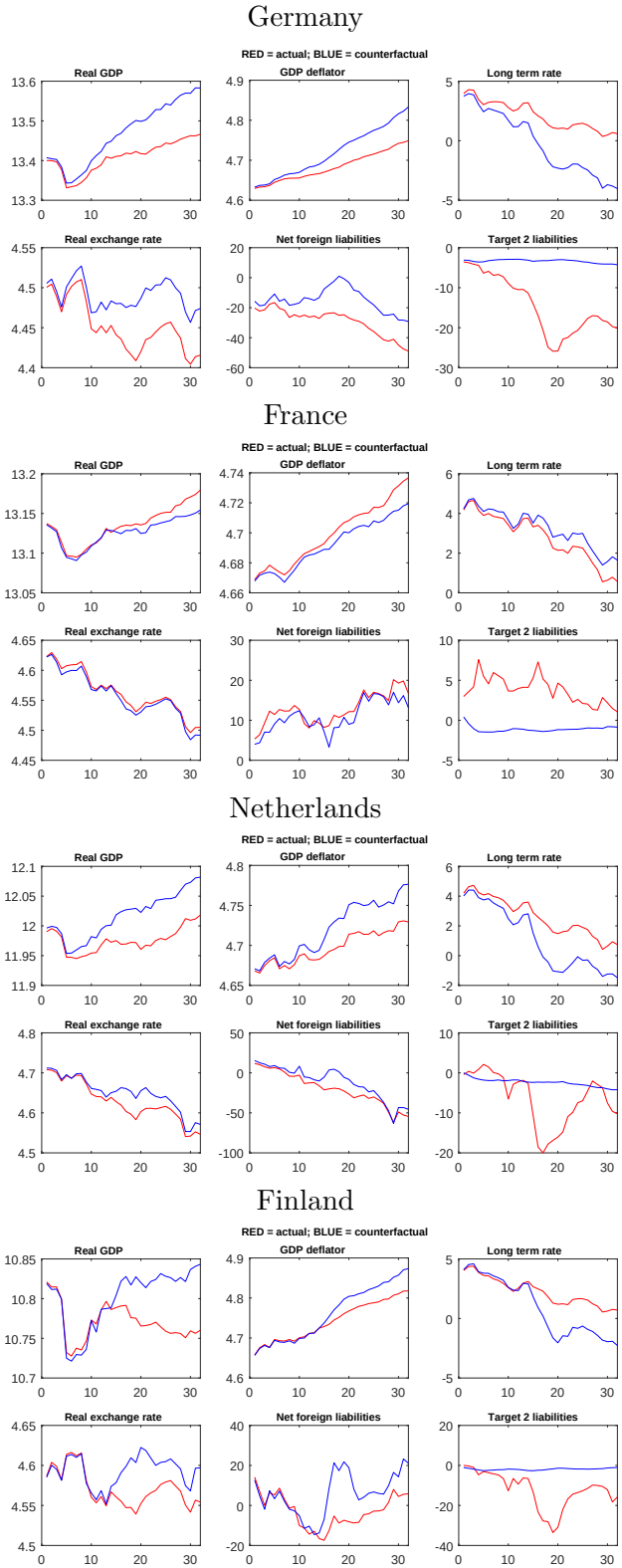
Notes: Real GDP, the price level and the real effective exchange rate are in logs. The long-term nominal interest rate is in percent. The net foreign liability position and the TARGET2 liabilities are measured as percentages of nominal GDP. An increase of the NFL or TARGET2 is equivalent to a net accumulation of liabilities. Solid black lines and shaded areas reflect the median response and the 68% confidence interval.

Figure 6: Actual (red) and counterfactual (blue) evolution of macro aggregates. Sample: 2008Q1-2015Q4. Distressed countries



Notes: The graphs plot the actual and counterfactual evolution of the macroeconomic aggregates. Actuals are represented by red color, counterfactuals in blue. The counterfactuals are constructed by setting the coefficients in the equations for TARGET2 and NFL to their estimated means based on the pre-crisis sample, i.e. 2001Q1-2007Q4. Real GDP, the price level and the real effective exchange rate are in logs. The long-term rate is in percent. The net foreign liability position and the TARGET2 liabilities are measured as percentages of nominal GDP.

Figure 7: Actual (red) and counterfactual (blue) evolution of macro aggregates. Sample: 2008Q1-2015Q4. Core countries



Notes: The graphs plot the actual and counterfactual evolution of the macroeconomic aggregates. Actuals are represented by red color, counterfactuals in blue. The counterfactuals are constructed by setting the coefficients in the equations for TARGET2 and NFL to their estimated means based on the pre-crisis sample, i.e. 2001Q1-2007Q4. Real GDP, the price level and the real effective exchange rate are in logs. The long-term rate is in percent. The net foreign liability position and the TARGET2 liabilities are measured as percentages of nominal GDP.

5 Conclusion

This paper explores how the access to the TARGET2 system in combination with the ECB's full allotment policy has contributed to the evolution of GDP, long-term interest rates, aggregate prices and international competitiveness in important member states of the euro area, in the period between the onset of the Global Financial Crisis and 2015. We estimate a structural panel VAR model for 8 euro area member countries and identify the structural shocks by means of sign restrictions.

Our main findings are as follows. First, the results of our structural VAR analysis indicate that since the onset of the Global Financial Crisis, the movements of national TARGET2 liabilities have been mainly driven by capital inflow shocks. In contrast, cyclical drivers like innovations to aggregate demand or aggregate supply do not seem to induce statistically significant changes in TARGET2. Second, our counterfactual experiments indicate that, in the period 2008-2015, access to the TARGET2 system has contributed substantially to avoid deeper recessions in the distressed euro area member countries Spain, Italy, Ireland and Portugal. In particular, TARGET2 has allowed for more favorable refinancing conditions as measured by national long-term government bond rates and higher GDP levels. Without TARGET2, aggregate output would have fallen short of its actual level by between 10% and 40% in Ireland and between 5% and 20% in Spain and Portugal. In Italy, the contribution of TARGET2 turns out to have been smaller. Nevertheless, absent access to this payment system in combination with the ECB's full allotment policy, Italian GDP would have been by up to 5% lower than actually observed. TARGET2 has also provided an upward contribution to the price level and the real effective exchange rate of the distressed countries. In the core countries, Germany, the Netherlands and Finland, the contribution of TARGET2 to aggregate economic activity has been unfavorable but substantially smaller at the individual country level than in the distressed member states of the euro zone. Aggregate output in France was barely affected by the presence of the TARGET2 system. Overall our results point towards a distributional effect of the TARGET2 system shifting real resources from Germany, the Netherlands and Finland towards Spain, Ireland, Portugal and to a more limited extent Italy.

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Appendix

A Data

The series for real GDP, the GDP deflator and the long-term nominal interest rate are taken from the database of the OECD. Real GDP refers to seasonally-adjusted quarterly gross domestic product in Euros and at constant prices. The GDP deflator is the related price index, which is set equal to 100 in 2010. The long-term nominal interest rate is measured in per cent and proxied by the quarterly average yield of ten-year government bonds.

The real effective exchange rate is the quarterly harmonised competitiveness indicator of the ECB. It is calculated as weighted average of the nominal exchange rate of the euro area member countries vis-à-vis the 19 most important trading partners of the Euro Area and the other euro area member countries and is deflated by GDP deflators. The weights are based on bilateral data on trade in manufactured goods. The real effective exchange rate is a seasonally-adjusted index, which is equal to 100 in 1999Q1.

The net foreign liabilities are calculated as balance between all financial liabilities and assets of an economys residents vis-à-vis the rest of the world, valued at market prices at the end of the quarter and divided by the annualised nominal GDP of this quarter. The series are taken from the Eurostat database (Tables on EU policy, Macroeconomic imbalance procedure indicators, International investment position). Missing data for Ireland (2001) and the Netherlands (2001 and 2002) was taken from a discontinued earlier version of Eurostat's balance of payments statistics (which was calculated according to the fifth edition of the IMF's Balance of Payments and International Investment Position Manual).

The TARGET2 (net) liabilities represent total TARGET2 liabilities netted against total TARGET2 claims. The quarterly value is calculated from the average value of the NCB's TARGET2 liability in the third month of each quarter, divided by the annualised nominal GDP of this quarter. The series are taken from the ECB database.