The Effect of Emergency Liquidity Assistance (ELA) on Bank Lending during the Euro Area Crisis

Heather D. Gibson
Bank of Greece

Stephen G. Hall
University of Leicester, Bank of Greece and University of Pretoria

Pavlos Petroulas
Bank of Greece

Vassilis Spiliotopoulos
Bank of Greece

George S. Tavlas*
Bank of Greece and University of Leicester

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ABSTRACT

We examine the impact of emergency liquidity assistance (ELA) on bank lending in eleven euro area countries during the financial crisis. With the intensification of the crisis, ELA took on a pivotal role in some countries. However, assessments of the quantitative impact of ELA in the literature are non-existent. We estimate a structural panel model for the determination of bank lending, which includes the amount of ELA received by each bank, allowing us to investigate the direct effect of ELA on lending. Our model corrects a mis-specification found in the prototype model used in the literature. We then undertake a VAR analysis, which allows us to address the effect of ELA on GDP. Finally, we examine spillover effects among banks, indicating that ELA generated positive spillovers to other banks.

Keywords: euro area financial crisis, emergency liquidity assistance (ELA), European banks, spatial panel model
JEL Classification: E3, G01, G14, G21

* Corresponding author: Bank of Greece, 21 E Venizelos Ave, Athens, 10250, Greece, Tel. no. +30 210 320 2370; Fax. no. +30 210 320 2432; Email address: gtavlas@bankofgreece.gr

1. *Introduction*

With the failure of Lehman Brothers in September 2008, and the outbreak of the Greek sovereign debt crisis in late 2009, including its subsequent contagious effects on other euro area countries, interbank markets in the single-currency area seized-up and some euro area banks were forced to turn to the European Central Bank (ECB) for liquidity. Effectively, the ECB took over the role that the interbank market had played pre-crisis.[1] In responding to the crisis, the ECB faced two major challenges. First, it had to address a system-wide liquidity shock of unprecedented magnitude. The ECB dealt with this formidable stress by implementing a series of unorthodox monetary-policy measures, including quantitative easing, forward guidance, full-allotment of funds at a fixed rate, expansion of the universe of banks' eligible collateral, and negative interest rates on funds deposited with the ECB.[2] Second, and often in parallel with the above-mentioned measures, acute idiosyncratic liquidity strains faced by individual solvent banks, or groups of banks in national jurisdictions, were addressed through the provision of emergency liquidity assistance, or ELA.

During the early stages of the crisis -- that is, prior to 2011 -- ELA support was limited to individual banks in line with the principle under which the Eurosystem is permitted to lend to banks that are solvent and have sufficient collateral.[3] As the crisis intensified and banks and sovereigns of a number of euro area countries became targets of runs, the sovereigns having exhausted their fiscal capacities, entire national banking systems resorted to ELA.[4] The most extreme case was that of Greece, where the crisis originated

[1] Other major central banks also increased the amount of liquidity provided to their banks. However, in contrast to other jurisdictions, including the United States and the United Kingdom, in the euro area the vast majority of firms and households meet their financing needs via direct bank intermediation, reflecting the fact that market financing and securitization are less developed in the euro area than in other major jurisdictions.

[2] See ECB (2015) for a discussion of the ECB's unorthodox monetary measures.

[3] ELA is provided by euro area national central banks in their capacity as lenders of last resort (LOLR). The notion of LOLR was formulated by Thornton (1802) and expanded by Bagehot (1873). The latter author formulated rules for a lender of last resort as follows: in the face of an internal drain (banking panic), lend freely; in the face of an external drain (a currency crisis), lend at a high rate; and in the face of both, lend freely at a high rate (Bordo, 2019, p. 6). A formal theory of ELA was presented by Rochet and Vives (2004).

[4] Gibson, Hall, and Tavlas (2017) investigated the interactions among euro area sovereigns, sovereign credit ratings and bank credit ratings. Those authors found evidence of strong self-generating feedback loops during the euro area crisis.

and hit the hardest. For Greece, ELA borrowing by Greek banks peaked at 65 percent of the country's nominal GDP in 2012; it then, declined strongly before rising again in 2015, peaking at close to 50 percent. ELA provision to Greek banks was needed to keep the Greek banking system afloat, especially in 2012, which saw the restructuring of the country's sovereign debt, and, in 2015, in light of heightened redenomination risk in order to prevent an exit of Greece from the euro area.[5] As the then-ECB President Draghi (2015, p. 4) put it, "the ending of ELA would most likely have started a process that would have resulted in Greece exiting the euro area."

Despite the crucial role of ELA provision in some euro-area jurisdictions during the crisis, assessments of the quantitative impact of that role in the literature have been non-existent. This circumstance reflects the fact that data on the amounts of ELA provided to both individual banks and to national banking systems are kept confidential.[6] The aim of ELA is to provide central-bank money outside of normal monetary-policy operations to solvent financial institutions that are facing temporary liquidity problems. In the absence of the provision of ELA during the euro area crisis, some solvent financial institutions would have likely collapsed, leading, through contagious effects, to a collapse of bank lending in national jurisdictions. Such an occurrence would likely have had implications for banks outside the national jurisdiction concerned. Consequently, ELA provision would be expected to have helped sustain solvent financial institutions, reducing systemic risk, improving confidence, and, in this way, exerting a positive effect on bank lending.

As mentioned, data on ELA are kept confidential. However, were such data publicly available they would undoubtedly show a negative correlation with bank lending in a national jurisdiction that relied on emergency funding during the crisis since, typically, a bank requiring ELA is also likely to be deleveraging. Yet, for the reasons noted above, it would be simplistic to assume that such a negative correlation implies a negative *causal* link between ELA and bank lending. The important issue is what would have been the

[5] For a discussion of the evolution of the Greek financial crisis from late-2009 to 2017, see Tavlas (2019).

[6] In some cases, it is possible to make rough approximations of the annual amounts of ELA provided by national central banks from the accounts published in the annual reports of those banks. In addition, in 2015 the Bank of Greece began publishing ELA ceilings -- as opposed to the actual amounts of ELA -- provided to Greek banks. The ceilings could be used to make broad assessments of changes in the amount of ELA requests by Greek banks.

consequences for bank lending had ELA not been provided. Looked at from this perspective, we might well expect a positive effect from ELA on bank lending. An analogous situation is likely to pertain with regard to the relationship between ELA and real GDP; national jurisdictions in which banks have received ELA during the crisis are likely to have seen reductions in real growth, or even negative growth during the periods for which ELA was provided. Yet, we would have expected an increase in ELA to have had a beneficial impact on economic activity.

In this paper, we aim to fill the gap in the literature concerning the role of ELA. We use confidential data on ELA to shed light on three key questions: (1) what was the impact of Eurosystem ELA operations on banks' lending during the euro-area crisis? (2) What was the effect of ELA on countries' real GDP? (3) How do spillover effects -- working through confidence channels among banks -- impact on the effectiveness of ELA?

In order to shed light on these questions, we have assembled a panel data set of 105 banks from eleven euro-area countries; in our sample, some of the banks -- but not all -- have received ELA. We begin by constructing a structural panel model for the determination of bank lending. Our empirical specification extends the prototype model typically used in the literature in three main ways. First, and most obviously, we include an ELA variable in the standard model. Second, our model corrects a key mis-specification found in the prototype model on bank lending; specifically, under the prototype model there can be no long-run equilibrium. Third, the correction of mis-specification allows us to test for cointegration. We employ this model to investigate the direct effects of ELA on bank lending. We then undertake a VAR analysis, which allows us to address our second question concerning the effect of ELA on real GDP. Finally, we introduce a novel approach that examines spillover effects among banks using a spatial panel model.

The remainder of the paper is structured as follows. Section 2 presents a prototype bank-lending model, and our correction of that model's specification. Section 3 presents our data and the cointegration analysis. Section 4 provides the panel VAR for the system. Section 5 presents the spatial panel analysis. Section 6 concludes.

2. The determination of bank lending and ELA

The prototype model employed in the literature used to study the determinants of bank lending typically takes the following form:[7]

$$\begin{aligned}\Delta \ln(loans)_{it} &= \alpha_0 + \alpha_1 \Delta \ln(loans_{i,t-1}) + \delta_1 \Delta \ln(GDP_{i,t}) + \delta_2 \Delta(GDP_{i,t-1}) + \beta_1 \Delta i_{i,t} + \beta_2 \Delta i_{i,t-1} \\ &+ \rho_1 SIZE_{i,t-1} + \rho_2 LIQ_{i,t-1} + \rho_3 CAP_{i,t-1} + \rho_4 LLP_{i,t-1} + \tau_1 SIZE_{i,t-1} * \Delta i_{i,t} \\ &+ \tau_2 LIQ_{i,t-1} * \Delta i_{i,t} + \tau_3 CAP_{i,t-1} * \Delta i_{i.t-1} + \tau_4 LLP * \Delta i_{i,t-1} + \pi_t YEAR_t \\ &+ \varpi_i COUNTRY_i + \varepsilon_t \end{aligned} \qquad (1)$$

where the rate of growth of loans of bank i in time t ($\Delta\ln(loans)_{i,t}$) is modelled as a function of macroeconomic variables (growth of GDP in the country where bank i is located or operates ($\Delta\ln(GDP_{i,t})$) and the change in the policy interest rate ($\Delta i_{i,t}$). A second set of variables relates to bank-specific variables: *SIZE* is represented by a bank's total assets; *LIQ* is liquid assets as a ratio of total assets; *CAP* is a measure of capital to asset ratio; and *LLP* is loan-loss provisions and $\varepsilon_t \sim N(0,\sigma^2)$ is the error term.[8] The monetary-policy variable (the policy interest rate) is often interacted with the bank characteristics in order to determine whether the impact of the bank characteristics on loan growth differs during periods of monetary tightening and loosening; the interaction term suggests that smaller, less liquid, poorly capitalized and higher-credit-risk banks are expected to be more negatively affected by a tightening of monetary policy. Also typically included in the prototype specification are a lagged dependent variable, fixed effects (either country or bank), and time dummies.

Apart from using this basic specification to study the factors that determine bank lending, the literature has focused on specific issues. For example, Altunbas, *et al.* (2009) focused on securitization and found that banks which securitize have a higher rate of growth of loans since securitization provides banks with additional funding compared with

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[7] We use the formulation found in Cantero-Saiz, *et al.* (2014). That formulation is closely related to those of Kashyap and Stein (1995), Ehrmann, *et al.* (2003), Ashcraft (2006), Altunbas, *et al.* (2009), Brei, *et al.* (2013) and Gambacorta and Marques-Ibanez (2011).

[8] The idea that the level of liquid assets held by banks can have a considerable impact on the transmission mechanism of monetary policy was made by Angeloni, Kashyap and Mojon (2003). This argument was expanded by Ehrmann and Gambacorta (2005), Martinez-Pages, Sevestre, and Worms (2003) and Ehrmann and Worms (2004); collectively, these studies suggest that bank networks, state guarantees and public ownership affect the bank transmission mechanism. Similar work on the US economy found that institutional structures can significantly affect the workings of the bank lending channel (see Ashcraft, 2006; Ivashina and Sharfstein, 2008; and Cohen-Cole, *et al.*, 2008).

other banks. However, those banks that were tapping markets for funds suffered more than other banks during crises because market sources of finance dried up (Gambacorta and Marques-Ibanez, 2011). Brei, *et al.* (2013) examined whether bank rescues in the form of recapitalization improved loan supply; those authors found evidence that banks that underwent capital injections experienced stronger loan growth. Kaufman and Scharler (2013) investigated the role of lending standards on loan growth and found that, for the US, a tightening of loan standards was associated with falling loans; in the euro area the impact was less strong than in the U.S. but more persistent. Cantero-Saiz, *et al.* (2014) showed that, when monetary policy was tight, higher sovereign risk caused banks to reduce lending more strongly because higher sovereign risk increases the cost of funds for banks and also reduces the availability of funds.

In addition to studying the effects on bank lending of the standard variables included in equation (1), our purpose here is to examine the role of ELA funds in influencing loan supply during the euro area crisis.[9] As mentioned, ELA funds are provided at a penalty rate of interest, and collateral has to be posted which is subject to haircuts (that is, the bank does not receive the face value of the collateral posted).[10]

As also mentioned, ELA in the euro area is provided by individual national central banks to the domestic banks within the national banks' jurisdiction. ELA provision is outside normal monetary policy operations and it is subject to certain rules[11]. Most importantly, national central banks may have to seek a non-objection from the Governing Council of the ECB before ELA can be granted. A key condition for a non-objection to be forthcoming is that the ELA granted should not interfere with the single monetary policy

[9] Gibson, Hall, and Tavlas (2018) constructed a measure of vulnerability in selected European Union countries during the period of January 2000 to April 2016. The authors provided evidence of (i) rising vulnerability prior to the outbreak of the international financial crisis in 2007/08 in countries with banks exposed to toxic assets; (ii) vulnerability associated with the euro area sovereign debt crisis from late 2009; and (iii) continued concerns from 2013 onwards in light of the need for euro area banks to improve their balance sheets and raise new capital at a time of sluggish profitability.

[10] While the traditional view has been that ELA should only be used where a bank is solvent but short of liquidity, as Goodhart (1985) argued the distinction between being illiquid and insolvent is often hard to establish.

[11] For the Agreement on emergency liquidity assistance, published in May 2017, see https://www.ecb.europa.eu/pub/pdf/other/Agreement_on_emergency_liquidity_assistance_20170517.en.pdf

of the Eurosystem. ELA also comes with a higher interest rate compared to the ECB's funding. Thus, banks only have recourse to ELA as a last resort.

Apart from our investigation of the significance of ELA, as mentioned, our specification corrects a misspecification contained in the prototype loan supply model. Specifically, we argue that much of the literature has erred in specifying the estimation of a relationship between the change in loan supply and bank characteristics without a lagged level of the loans variable.[12] Consider the implication of that specification. For the variable measuring bank size, for example, this specification implies that, if a bank maintained a given size in the long run, a positive coefficient would correspond to a *permanent* growth in loans so that the level of loans would rise to infinity. Alternatively, a negative coefficient would imply that the level of loans collapses to zero. As a result, there would be no long-run equilibrium and cointegration between loans and the other variables is impossible.

The model we estimate corrects this misspecification. In particular, we estimate a model in a standard error-correction form (ECM), allowing us to obtain a sensible long-run equilibrium. A further important difference between the prototype model and the one we employ is that we do *not* use log transformations for most of the variables. The main reason for this circumstance is that our focus is on the role played by ELA; therefore, we split the size variable (in our case total liabilities) into non-ELA liabilities and ELA. Since most of the observations on ELA are zero, a log transformation of this variable is not possible.

3. The data and cointegration analysis

3.1 Data description

We focus on 105 banks from the following euro area countries – Austria, Belgium, Cyprus, France, Germany, Greece, Ireland, Italy, the Netherlands, Portugal and Spain. The data are either annual or semi-annual from 2007 to 2016. If the data were annual, they

[12] See, for example, Gambacorta and Marques-Ibanez (2011, p. 50) and De Santis and Surico (2013, pp. 16-17).

were interpolated to correspond to the semi-annual frequency available for the majority of banks in the sample.

On balance, our bank level dataset covers around 66 percent of all ELA disbursed between 2008 and 2016 in the euro area. The banks in our sample had more than €10 trillion in gross loans prior to the crisis. During the global financial crisis loans were reduced by around 10 percent, before increasing again to more than €9.6 trillion by 2016.

Splitting our sample into banks that received ELA (which comprised about 10 percent of total gross loans pre-crisis) and banks that did not receive ELA, we can note some stark differences (see Table 1). In particular, over the sample period banks that received ELA reduced their gross loans by 26.7 percent while their total assets and liabilities (excluding ELA) were reduced by 38.2 and 44.2 percent, respectively. Moreover, their NPLs increased by 21.1 percentage points. By contrast, banks that did not receive ELA increased their gross loans over the period by 3.9 percent, while their total assets and liabilities were reduced by only 2.7 and 4.5 percent, respectively, and their NPL ratio increased by only 4.2 percentage points.[13]

As mentioned, ELA funding was provided to banks which already had encountered problems and for which market based funding was not readily available. In this respect, the stark differences in lending developments by the two groups -- those banks that received ELA and those that did not do so -- may not be surprising. Even so, given the decrease in gross loans for the banks receiving ELA, the decrease in total assets and in total liabilities (excluding ELA) seem disproportionally large. Specifically, the decrease in total assets was 11.5 percentage points more than the decrease in gross loans; the decrease in total liabilities was 17.5 percentage points more than the decrease in gross loans. This implies that for the banks receiving ELA total gross loans as a share of total assets increased from 51.6 percent in 2008 to 61.2 percent in 2016, an increase of around 10 percentage points; correspondingly, gross loans as a share of total liabilities rose from 53.4 percent in 2008 to 70.2 percent on 2016 (see Table 2), an increase of around 17 percentage points. By contrast, for the group of banks that did not receive ELA the share of gross loans to total assets increased by only 3 percentage points; the share of growth

[13] Appendix A provides a complete description of the data and data sources.

loans to total liabilities increased from 46.1 percent to 50.2 percent, an increase of only 4 percentage points.[14] Consequently, the foregoing data suggest that in the absence of ELA the reduction in gross loans would have been significantly larger. In what follows, we investigate this possibility.

In this respect, our general empirical specification is a panel error correction model of the following form, where for simplicity we suppress the cross-section index for banks (i):[15]

$$\begin{aligned}\Delta GL_t &= \alpha_0 + \Sigma\alpha_{1j}\Delta GL_{t-j} + \beta_{1j}\Delta ELA_{t-j} + \Sigma\beta_{2j}\Delta(LIB_{t-1} - ELA_{t-1}) + \Sigma\beta_{3j}\Delta(LIQ_{t-j} / A_{t-j}) \\ &+ \Sigma\beta_{4j}\Delta(NPL_{t-j} / GL_{t-j}) + \Sigma\beta_{5j}\Delta GDP_{t-j} + \Sigma\beta_{6j}\Delta RL_{t-j} + \gamma(GL_{t-1} + \rho_1 ELA_{t-1} \\ &+ \rho_2(LIAB_{t-1} - ELA_{t-1}) + \rho_3(LIQ_{t-1} / A_{t-1}) + \rho_4(NPL_{t-1} / GL_{t-1}) + \rho_5 GDP_{t-1} \\ &+ \rho_6 RL_{t-1}) + \varepsilon_t\end{aligned} \quad (2)$$

The variables are as follows. The dependent variable is the change in gross loans (*GL*). The explanatory variables are:

- total liabilities (*LIB*);
- ELA (*ELA)*;
- total non-ELA liabilities (*LIB-ELA*);
- the ratio of liquid assets to total assets (*LIQ/A*);
- the ratio of non-performing loans to gross loans (*NPL/GL*);
- gross domestic product (*GDP*) for the home country in which bank i is situated;
- the interest rate on loans for the home country (*RL*).[16]

In contrast to equation (1), cointegration of the error correction component of (2) implies a well-defined equilibrium because it includes an error-correction term. The adjustment coefficient multiplying the error-correction term is γ. Given that the sample period is predominantly characterized by monetary loosening, we do not interact the interest term on loans with bank characteristics as in (1) (since there is no need to

[14] The average NPL ratio for the banks receiving ELA increased also by much more over the period of investigation which should impact further on gross loans developments.
[15] j = 0………. J with the exception of coefficient on ΔGL where j = 1………. J.
[16] Note that we do not use the policy rate but a banking lending rate – the average of rates on loans to corporates and households for each country m. The rationale for this choice stems from the divergence of lending rates across the euro area following the crisis.

distinguish between monetary loosening and monetary tightening episodes). ELA and non-ELA liabilities, which are sources of funding for banks, are expected to positively affect gross loans. If a bank invests more in liquid assets, it is less likely to invest in gross loans and hence we expect the coefficient on the ratio of liquid assets to total assets to be negative. A high ratio of non-performing loans to gross loans could have either a positive or negative effect on gross loans; it may prevent banks from making loans (*i.e.,* negative effect) or it may capture the effects of banks that follow a banking model that involves an aggressive loan strategy (*i.e.,* positive effect). GDP could reflect either demand or supply-side effects. The higher is GDP, the greater the demand for loans is likely to be; at the same time higher GDP implies higher deposits thus allowing banks to supply loans. Finally the interest rate is expected to exert a negative influence on gross loans.

3.2 ECM results

We begin by testing for the presence of unit roots in the variables. We do not test ELA and total non-ELA liabilities separately due to the prevalence of entries with zeros in the ELA data. Such a variable does not fit neatly into the I(1) or I(0) paradigm and so there is little point in subjecting it to the usual battery of tests. Nevertheless, to confirm the general presence of non-stationarity in our data, we test most of the variables (including total liabilities) for stationarity.

The results of the stationarity tests are shown in Table 3. In general, we cannot reject the null that the variables are non-stationary based on the Levin, Lin and Chu (LLC) test and Im, Pesaran and Shin (IPS) test, although the variable LIQ/A is stationary under both tests; non-stationarity of the variable LIB is rejected under one test -- the IPS test. These two tests do not, however, allow for cross-sectional dependence. Thus, Table 2 also reports the Hadri heteroscedastic consistent Z statistic, which allows for dependence under the null hypothesis of stationarity. This test rejects the hypothesis of stationarity for all series.

Here, we do not test all the variables together as the panel cointegration tests are not able to handle all the variables in our final model in one go. The reason for this circumstance is that most of the panel cointegration tests perform individual cointegrating regressions for each bank and then construct an aggregate test statistic from each of the individual regressions. Given the small number of observations for each individual bank it was not possible to perform these procedures using all the variables. However, in order to proceed with a dynamic two stage estimation process following the Granger representation theorem, what we need is the presence of cointegration amongst at least two of the variables; we test for cointegration between gross loans (GL) and total Liabilities (LIB). Taking these two variables, we can reject the null of no cointegration in light of the following results; the Kao residual cointegration test p=0.01 and the Pedroni residual cointegration test panel ADF-statistic p=0.000. Consequently, we can assert that there is cointegration between our series.

We now adopt a standard general-to-specific estimation strategy in the panel context starting with a two-way fixed-effects specification as the most general starting point as in equation (2). Following a suitable nesting down procedure, we estimate the parsimonious ECM specification below.

$$\begin{aligned}\Delta GL = & \underset{(0.6)}{7153} + \underset{(1.9)}{0.08}\, \Delta GL_{t-2} + \underset{(3.1)}{0.18}\, \Delta(LIAB - ELA) - \underset{(6.4)}{0.29}\, GL_{-1} + \underset{(2.5)}{0.08}(LIAB - ELA)_{t-1} \\ & + \underset{(2.8)}{0.32} ELA_{t-1} - \underset{(1.4)}{10968}(LIQ / A)_{t-1} - \underset{(1.0)}{1174} RL_{t-1} + \underset{(2.1)}{0.04} GDP_{t-1} + \vartheta_t \qquad (3)\end{aligned}$$

Where ϑ_t is the residual. Our primary interest is in the long-run equilibrium associated with equation (3). The derived long-run solution for gross loans is:

$$GL = 0.28(LIAB - ELA) + 1.1ELA - 37820(LIQ / A) - 4048\, RL + 0.14GDP + \vartheta_t / 0.29 \quad (4)$$

The adjustment coefficient, -0.29, in equation (3) suggests a (reasonably) rapid adjustment towards the long-run equilibrium; and the derived long-run coefficient on ELA -- at 1.1 in equation (4)-- suggests that ELA acts to support gross loans on a slightly more than a one-to-one basis. In other words, an increase in ELA of €1 billion raises gross loans by €1.1 billion. The effect from total non-ELA liabilities -- at 0.28 -- might appear to be small. However, non-ELA liabilities are one of two scale variables in the long-run equilibrium. Its effect works jointly with GDP, the other scale variable. That is, since the variables LIQ/A and RL do not trend, the total amount of gross loans over time is determined by the combination of GDP and total non-ELA liabilities.

4. A panel VAR model

To examine the role of ELA on GDP, we estimate a panel VAR model which includes gross loans, liquidity to total assets, non-performing loans to gross loans, GDP, non-ELA liabilities and the interest rate. The VAR is of the third order; the number of lags was chosen on the basis of both the Schwartz Bayesian information criterion and the AIC. Figure 1 shows the impulse response functions following a one standard deviation shock to ELA. Although the shock itself is for only one period the actual change in ELA persists for some time reflecting the fact that once ELA is granted, it remains in place for 4 or 5 periods. (This is broadly consistent with the ECM model above (3)).[17] Gross loans increase sharply before falling off, but remain positive. This is an interesting result when we recall that the shock here is for only one period; yet the effect on total loans is quite long-lasting, indicating that injecting ELA for only a short period can have quite long-lasting effects. Liquid assets to total assets fall by a small amount. This could reflect the fact that, since ELA is more expensive than normal refinancing operations, banks reduce their investment in liquid assets which generally carry lower rates of interest. GDP also rises and this result is more persistent than the change to ELA itself; as shown in Figure 1, an increase of € 1 billion euros of ELA to a bank in a particular country would increase GDP in that country by around €0.75 billion. Thus, the results suggest that ELA has played a role in ameliorating the size of the fall in GDP in countries where ELA was granted and that it has a long-run effect which is quite significant. Lending rates also rise reflecting the higher cost of ELA. The impact on NPLs appears very small.

Figure 2 shows the response of the system to a positive shock to GDP. GDP itself is highly persistent and, despite the temporary nature of the shock, rises throughout the whole period. This leads to an increase in both gross loans and total liabilities as the banking sector as a whole responds to the expansion in the economy. There is a small rise in interest rates which gradually returns to base values despite the permanently higher level of economic activity. Non-performing loans initially decline quite quickly and then gradually begin to return to their normal level.

[17] The full VAR specification is given in Appendix B1.

There is always an issue of the parameter stability of a VAR, especially in a case such as this where the time dimension is quite small, and so conventional parameter stability tests are hard to implement. In order to address this issue, however, we have performed a set of recursive estimates over the last 7 observations. These are reported in Appendix B2.

These results suggest that the use of ELA has been very effective. It has allowed the banking sector to continue to support a larger loan book than would otherwise have been the case and it has had a positive effect on general economic activity, thereby ameliorating the fall in output which would otherwise have taken place.

5. A spatial investigation of the impact of ELA

The previous sections have provided significant evidence for the effectiveness of ELA in supporting a bank's loan book. We did not, however, account for the effects of ELA that may work through the interrelationships among banks; that is, providing ELA to one bank may well have spillover effects on other banks. Interconnections could work through several channels. For example, there might be positive -- or negative -- confidence effects; economic agents might gain confidence that the entire banking sector will be protected when they observe that a single bank or a few banks are supported with ELA. Alternatively, it may be the case that, on realizing that a particular bank needs ELA, confidence in other banks might fall. ELA provision could also affect liquidity in the interbank market; the provision of ELA somewhere in the banking system might help to improve confidence amongst the other banks and encourage them to return to more normal lending behavior. These spillover effects are not easily captured within a conventional economic model. What is needed is a framework in which the ELA provided to one bank can influence the behavior of other banks. However, with 105 banks in our sample, estimation of banks' interconnections would involve a huge number of parameters since conditions of each bank in the sample could influence every other bank's loan behavior. That is, we would have to put each of our variables -- exogenous and endogenous -- for each bank in the sample in the equation determining lending for each individual bank.

A spatial econometric model can capture such spillover effects. A spatial model may be thought of as a generalization of a standard regression model to explicitly include spillover effects. What the spatial model does is to impose restrictions on a general model to make its estimation feasible. Specifically, the spatial model uses a weighing matrix to impose a set of restrictions on the spillover effects so that these effects can be estimated. Spatial models may be based on either cross section or panel data sets. Consider the standard panel regression:

$$y_t = \beta_0 + \beta_1 x_t + \varepsilon_t \tag{5}$$

where y_t is a vector of n endogenous variables at time t, x_t is a matrix of k exogenous variables with n cross-section observations at time t, and ε_t is a vector of n error terms at time t. A spatial model adds additional terms to this basic framework, thereby explicitly allowing for spillovers among the individual cross-sectional units. There are three basic forms that the spillover can take: (i) the so-called (below we explain the qualifier "so-called") spatial lag dependent variable model; (ii) a spatial lagged exogenous variable model; and (iii) a spatial autoregressive error model. The three forms are given in equation (4) as additions to the standard model.[18]

$$y_t = \beta_0 + \beta_1 x_t + \gamma_1 W y_t + \gamma_2 W x_t + (1 - \gamma_3 W)^{-1} \varepsilon_t \tag{6}$$

The term $\gamma_1 W y_t$ is the spatial lagged dependent variable. Although this term is called a lagged dependent variable, in fact, it represents the contemporaneous effect on a single bank of developments in all other banks. The term $\gamma_2 W x_t$ is the spatial lagged exogenous variable term. The final term, $(1 - \gamma_3 W)^{-1} \varepsilon_t$, is the spatial error term. This variable captures the effect of the error in the equations of all other banks on a particular bank. W is the nxn spatial weighting matrix, which is specified exogenously. The effect of each of these spatial terms is to put all other units into each individual equation -- either in terms of the dependent variable, the exogenous variables or the error terms.

The key choice here is how to determine the W matrix. The two most common ways are to use actual physical distance between each unit in the sample or to use the presence of a joint border. Neither of these possibilities would seem to be appropriate since we are

[18] See e.g. Kelejian (2017), Elhorst (2014), and Baltagi (2013).

dealing with liquidity, which can easily be moved between banks even in different countries.

Our weighting matrix is based on some stylized facts. The euro area crisis had a regional aspect, with countries in the southern part of the area being more affected by contagion than countries in the northern part. Moreover, there is also evidence of partial spillovers in the sovereign bond market in the euro area during both the global financial crisis as well as the European sovereign debt crisis.[19] Lastly we have to take into account a significant home bias which seems to permeate many aspects of economic activity.[20]

We, therefore, investigate the following weighing scheme. We placed banks into two categories -- North and South. The North consists of banks in Austria, Belgium, France, Germany and the Netherlands. The South consists of banks in Greece, Ireland, Italy, Portugal and Spain.[21] Banks within the same country have a spillover weight of 1 and we allow Southern and Northern banks to have limited spillovers of 0.5 amongst themselves, but we do not allow spillovers between Northern and Southern banks. Thus, our weighting matrix reflects aforementioned stylized facts in this circumstance – the regional aspect of the crisis (a North and South split of the weighting matrix), the home bias (stronger spillover across banks within a country) and the spillovers across countries.[22] Lastly, we can note that in order to facilitate interpretation of the coefficients, it is usual to normalize the rows of the weighting matrix so that they sum to unity.

The panel data set used above is an unbalanced one, but for spatial estimation we need a balanced panel. This circumstance reflects the fact that, if every member of the panel is entered into every equation, we need to have data on every member at every point in time. To obtain a balanced panel, we had to reduce the size of the panel by dropping some banks. In the estimation for the previous two sections, we used a total of

[19] See e.g. De Santis and Zimic (2017) and Antonakakis and Vergos (2013).
[20] See e.g. Lewis(1999), Obstfeld and Rogoff (2000), Portes and Rey (2005), Sørensen, *et al.* (2007), and Andreeva and Vlassopoulos (2016).
[21] Cyprus drops out because of the lack of a balanced data set.
[22] The results using the other weighting schemes are available on request. We focus here on results that have more economic meaning and reflect better the nature of the euro area crisis.

1,277 observations; after dropping banks with missing observations, we are left with 912 observations.[23]

Table 4 reports the results for four different versions of the spatial model for restrictions based on the weighting matrix[24]: the North-South distinction. The four forms of the model are: (1) the addition of a simple spatial lagged dependent variable; (2) a spatial lag with a spatial error term; (3) a spatial lag with a set of spatial exogenous variables; and (4) a spatial lag with a spatial error term and a spatial set of exogenous variables. Spatial dependence is estimated using a generalized spatial two-stage least squares procedure with heteroscedastic errors.[25] The results in Table 4 shed light on whether there is any evidence of spatial effects in the two regions that we examine.

Panel A of Table 4 shows the direct effect of a change in ELA. Panel B shows the total effect of a change in ELA -- that is, the effect that takes account of a change in ELA for one particular bank on other banks in its region (North or South) and the feedback effects from those other banks on the first bank. We first discuss the direct effects of ELA in Panel A. Columns (1) and (2) include a spatial lag term but not spatial exogenous variables -- thus, these columns present results of changing ELA in one particular bank on lending by that bank. The coefficients in columns (1) and (2) are 0.74 and 0.46, respectively. What these coefficients mean is that an increase in ELA of, say €1 billion, for a particular bank is associated with an increase in that bank's lending of €0.74 billion (column (1)) and €0.46 billion (column (2)). However, the point estimate of ELA in column 2 is not significant. Columns (3) and (4) show the corresponding results, which are marginally significant, of an increase in ELA on all banks in a particular region, taking into account spatial exogenous variables. The impact effects of an increase of ELA by all banks of, say, €1 billion, in a particular region on a bank in that region are €0.84 billion (column (3)) and €0.62 billion (column (4)), fairly close to the corresponding results reported in the first two columns.

[23] It should be noted that the dropping of these banks does not qualitatively impact on the results reported in previous sections.

[24] The results for the first two versions of the weighting matrix are available on request. To choose between the three specifications of the weighting matrix we appeal to an entropy based information criteria proposed by Gomez, Lacambra and Marin (2012).

[25] See Kelejian and Prucha (1998, 1999, 2010) and Kapoor, *et al.* (2007).

The total effects of ELA after taking account of spatial interactions are shown in Panel B of Table 4. The first two columns of Panel B do not contain spatial exogenous variables, so that the spillover effects are only captured through the spatial lag. In this case, the total effects are quite similar to the impact effect shown in Panel A of the table; for example, the direct effect of ELA in column (2) is 0.46 while the total effect after spillovers is 0.39; the other coefficients are also reduced only somewhat once the total effect is calculated -- and none of the coefficients changes sign. Once we introduce spatial exogenous variables, however, things change substantially since we are now addressing the following question: what would happen to a bank if each of the exogenous variables were changed in all banks? In this case, the effect of ELA rises to 2.5 and 2.2 in columns (3) and (4), respectively. In other words, an increase in ELA provision of € 1 billion to all banks in a region leads to increases in lending by every bank in that region of between € 2.2 billion and € 2.5 billion, suggesting that ELA provision reduced systemic risk and thus positively affected confidence more generally.

Of the four models presented in Table 4, column 4 represents the most general model; and, the effect of all the spatial terms are all highly significant. In the context of a general to specific approach, it would, therefore, be wrong to exclude any of these terms in column 4 from the model; thus, our preferred model is that in column 4. In this case, the direct contribution of an increase in ELA to a single representative bank is 0.62 to the lending behavior of that bank. However, because of the spatial effect other banks will also change their behavior in the light of the increase to the first bank. Consequently, the total effect across the banking sector would be larger. When we allow for the full interaction of all the spatial terms and a shock to ELA across the banking sector the total effect is given in Panel B as 2.2. It implies that If ELA is increased to all banks by € 1 billion then total lending would increase by € 2.2 billion in every bank. This results from the interaction of all the spatial terms and likely reflects a confidence effect.

6. Conclusions

Our results provide evidence that the provision of ELA by euro area national central banks helped in preventing loan growth from becoming even more negative than it already was.

1. The ECM results suggest that an increase in ELA of € 1 billion to a *single bank* raised gross loans of that bank by € 1.1 billion.
2. The results of the panel VAR suggest that ELA played a role in ameliorating the size of the fall in GDP in countries where ELA was granted and that ELA had a long-run effect that is quite significant. An increase of € 1 billion euros of ELA to a bank in a particular country would increase GDP in that country by around €0.75 billion.
3. Finally, we investigated whether spatial spillovers were present within the banking sector. We find strong evidence of such spillovers – the interrelationships between banks are important for final outcomes. The spatial estimations suggest that if € 1 billion ELA was provided to every bank in a region, gross loans in each bank would rise by around € 2.5 billion.

To conclude, ELA made a considerable contribution in stabilising the euro area during the crises. In the absence of ELA, contractions in bank lending and real growth rates that occurred would have been considerably worse.

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Appendix A: Data

The 105 banks are spread over the countries as follows:
Austria 10 bank; Belgium 10 banks; Cyprus 4 banks; France 11 banks; Germany 9 banks; Greece 5 banks; Ireland 9 banks; Italy 12 banks; The Netherlands 9 banks ;Portugal 12 banks; Spain 14 banks.

The bank-level data, non-performing loans (NPLs) to gross loans, total liabilities and liquid assets to total assets, is from Fitch Connect.

The bank-level ELA data is from Bank of Greece/ECB.

The lending rate is the average of rates on loans to corporates and households in each country. Source: ECB Statistical Data Warehouse

GDP is nominal GDP. Source: Thomson Reuters Datastream.

Appendix B1: The full VAR specification

Vector Autoregression Estimates, Sample (adjusted): 2008S2 2016S2

Included observations: 1005 after adjustments; T-statistics in [ ]

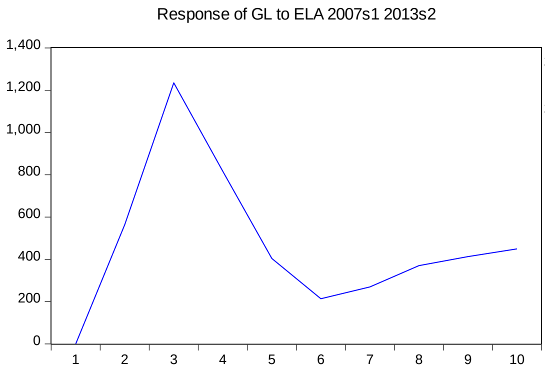
	GL	LIQ/A	NPL/GL	GDP	RL	$(NPL/GL)^2$	LIAB-ELA	ELA
GL(-1)	0.825	-8.8E-08	2.7E-08	-0.0441	-5.8E-07	1.1E-08	0.077	-0.008
	[22.87]	[-0.77]	[0.80]	[-1.66]	[-1.04]	[0.77]	[0.86]	[-1.91]
GL(-2)	0.282	-6.3E-08	-4.3E-08	0.02611	7.20E-07	-1.20E-08	0.552	0.004
	[5.94]	[-0.42]	[-0.95]	[0.74]	[0.97]	[-0.65]	[4.66]	[0.68]
GL(-3)	-0.127	1.3E-07	1.2E-08	0.00814	-2.5E-07	-1.6E-10	-0.574	0.004
	[-3.49]	[1.14]	[0.35]	[0.30]	[-0.44]	[-0.01]	[-6.36]	[0.95]
LIQ/A(-1)	-9202	0.214	0.002	23854.1	0.370	-0.002	33842.2	-1093.45
	[-0.93]	[6.86]	[0.18]	[3.27]	[2.41]	[-0.42]	[1.37]	[-1.00]
LIQ/A(-2)	8923.42	0.713	-0.006	-3093.27	0.09444	0.00262	13269.4	-141.778
	[1.30]	[32.98]	[-0.99]	[-0.61]	[0.89]	[0.96]	[0.78]	[-0.19]
LIQ/A(-3)	4336.29	-0.161	-0.013	-11367.9	-0.42889	-0.00257	-39066.3	138.858
	[0.46]	[-5.38]	[-1.43]	[-1.62]	[-2.91]	[-0.68]	[-1.66]	[0.13]
NPL/GL(-1)	-24271.8	0.269	1.091	-47282.5	1.59631	-0.04341	-68001.1	6900.09
	[-0.40]	[1.40]	[18.78]	[-1.05]	[1.68]	[-1.78]	[-0.45]	[1.02]
NPL/GL(-2)	-4169.11	0.147	0.037	-35963.6	-0.93013	0.10851	88533.3	23156.5
	[-0.04]	[0.49]	[0.41]	[-0.51]	[-0.62]	[2.84]	[0.37]	[2.18]
NPL/GL(-3)	32508.3	-0.529	-0.083	96620.7	-0.11451	-0.03772	26989.7	-30123.6
	[0.48]	[-2.49]	[-1.30]	[1.94]	[-0.11]	[-1.40]	[0.16]	[-4.04]
GDP(-1)	-0.01373	2.2E-07	-4.3E-08	1.13928	1.4E-06	-7.2E-09	-0.08852	0.006
	[-0.31]	[1.59]	[-1.02]	[34.94]	[2.02]	[-0.41]	[-0.81]	[1.18]
GDP(-2)	0.0425	-2.40E-07	-3.7E-08	-0.19501	-1.4E-06	-1.9E-09	0.16946	-0.007
	[0.65]	[-1.15]	[-0.60]	[-4.03]	[-1.41]	[-0.07]	[1.04]	[-0.90]
GDP(-3)	-0.02903	2.4E-08	8.1E-08	0.0627	1.9E-08	9.0E-09	-0.07574	0.001
	[-0.67]	[0.18]	[1.95]	[1.95]	[0.03]	[0.52]	[-0.70]	[0.12]
RL(-1)	2311.5	-0.010	0.008	-8266.71	1.379	0.002	5837.54	345.575
	[1.24]	[-1.78]	[4.59]	[-6.03]	[47.75]	[2.43]	[1.26]	[1.68]
RL(-2)	-3617.61	0.014	-0.002	5841.22	-0.767	0.000	-11144.1	182.558
	[-1.25]	[1.53]	[-0.84]	[2.73]	[-17.00]	[-0.23]	[-1.55]	[0.57]
RL(-3)	2305.78	-0.007	-0.001	116.885	0.277	0.000	5720.33	-296.619
	[1.33]	[-1.36]	[-0.50]	[0.09]	[10.25]	[-0.33]	[1.33]	[-1.55]
(NPL/GL)2(-1)	-13798.4	-0.485	0.516	103769	0.115	1.632	27843.4	9246.27
	[-0.10]	[-1.12]	[3.94]	[1.02]	[0.05]	[29.70]	[0.08]	[0.61]
(NPL/GL)2(-2)	66072	0.277	-0.832	19738.3	-1.400	-0.803	-52852.6	-63643.2
	[0.27]	[0.36]	[-3.62]	[0.11]	[-0.37]	[-8.34]	[-0.09]	[-2.38]
(NPL/GL)2(-3)	-71969.7	0.584	0.204	-161507	0.019	0.13046	-78995.4	69072.7
	[-0.44]	[1.12]	[1.30]	[-1.32]	[0.01]	[1.98]	[-0.19]	[3.78]
LIAB-ELA(-1)	0.074	-6.6E-08	-5.7E-09	-0.033	-3.0E-07	-2.3E-09	0.810	0.001
	[5.25]	[-1.49]	[-0.43]	[-3.15]	[-1.35]	[-0.40]	[23.13]	[0.80]
LIAB-ELA(-2)	-0.090	4.4E-08	1.2E-08	0.028	2.1E-07	3.1E-10	-0.146	0.000
	[-4.83]	[0.75]	[0.67]	[2.03]	[0.73]	[0.04]	[-3.16]	[-0.16]
LIAB-ELA(-3)	0.027	3.7E-08	-5.8E-09	0.009	1.5E-07	2.1E-09	0.305	-0.001

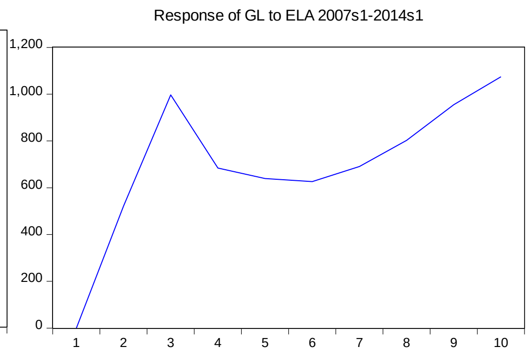
	[1.90]	[0.81]	[-0.42]	[0.88]	[0.68]	[0.37]	[8.54]	[-0.41]
ELA(-1)	0.116	-4.6E-07	1.3E-08	0.024	7.7E-06	8.1E-09	0.250	0.906
	[0.40]	[-0.50]	[0.05]	[0.11]	[1.72]	[0.07]	[0.35]	[28.42]
ELA(-2)	0.054	8.6E-08	3.4E-07	0.550	-8.9E-07	1.9E-07	-0.426	-0.335
	[0.14]	[0.07]	[0.93]	[1.97]	[-0.15]	[1.27]	[-0.45]	[-8.03]
ELA(-3)	-0.121	3.5E-07	-5.4E-07	-0.249	3.7E-06	-2.4E-07	0.062	0.003
	[-0.38]	[0.36]	[-1.82]	[-1.07]	[0.75]	[-1.89]	[0.08]	[0.09]
C	-4262.13	0.03	-0.02	6456.06	0.280	-0.005	-8218.64	-770.58
	[-1.35]	[2.51]	[-5.13]	[2.78]	[5.71]	[-4.21]	[-1.05]	[-2.21]

Adj. R-squared	0.993	0.651	0.976	0.999	0.924	0.980	0.992	0.638
S.E. equation	16565.5	0.052	0.016	12221.1	0.257	0.007	41203.8	1828.95
F-statistic	5723.46	79.2013	1679.77	49687.8	507.461	2062.21	4906	74.723
Log likelihood	-11177	1554.3	2759.52	-10871.3	-49.8156	3633.76	-12092.8	-8962.43
Akaike AIC	22.293	-3.043	-5.442	21.684	0.149	-7.182	24.115	17.885
Schwarz SC	22.415	-2.921	-5.320	21.807	0.271	-7.059	24.237	18.008

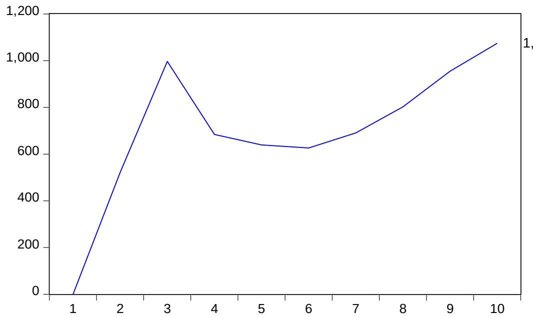
Appendix B2: Assessing the Stability of the VAR.

Assessing parameter constancy in a VAR context is not entirely straight forward. Some key references here are Hansen and Johansen (1999), Ploeberger, *et al.* (1989), Nyblom (1989) and Hansen (1992a, b) which all essentially build on the standard approach to parameter stability testing through recursive estimation. In particular, Hansen and Johansen (1999) consider the use of recursive eignevalues as a way of assessing the structural stability of the long run cointegrating vectors of the VAR. However, the data with which we are dealing have a relatively short time span, 2007-20016 on a semi-annual basis, giving 20 time series observations. Assessing the stability of the VAR is, therefore, difficult in this context. In order to address this issue, we have performed recursive estimation of the VAR over the last 7 observations. As our primary interest in estimating this VAR is the effect of ELA on gross loans, we have decided to focus on the stability of this relationship; hence, we show the impulse response of Gross Loans to ELA over the last 7 observations below.

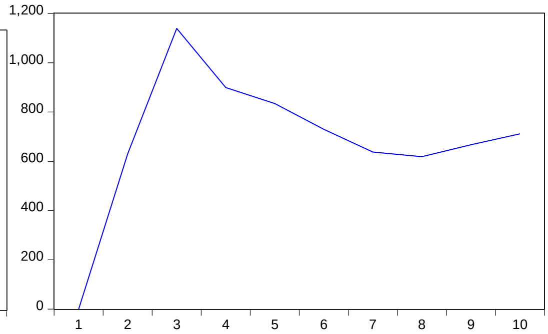




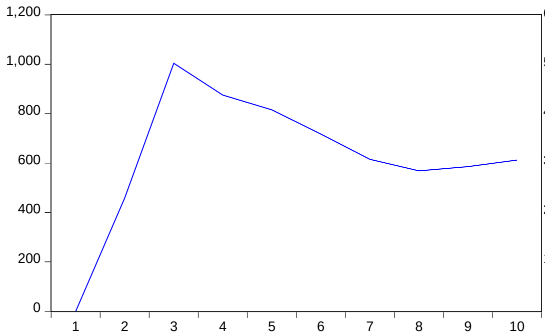
Response of GL to ELA 2007s1-2014s1



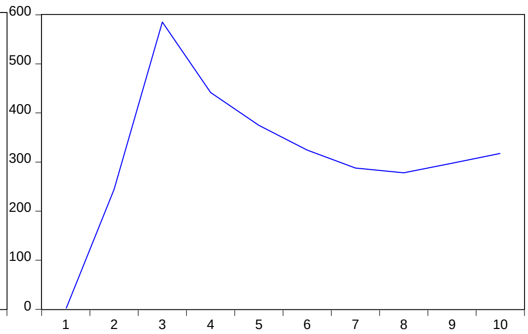
Response of GL to ELA 2007s1 2015s1



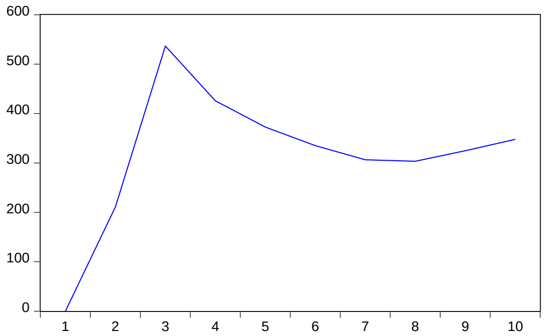
Response of GL to ELA 2007s1 2015s2



Response of GL to ELA 2007s1 to 20016s1



Response of GL to ELA 2007s1 to 2016s2



These recursive impulse responses all show a similar pattern of adjustment, although the total size of the effect varies somewhat over the last seven observations. Thus, the broad story of ELA having an initial positive response which dies away but remains positive for some time appears to be stable over this period.

Table 1: Cumulative increase/decrease from 2008 to 2016: unweighted averages.

Gross Loans	Total Assets	Total Liabilities (excluding ELA)	NPLs to Total Assets (percentage points)
Banks receiving ELA			
-26.7%	-38.2%	-44.2%	21.1
Banks not receiving ELA			
3.9%	-2.7%	-4.5%	4.2

Table 2: Loans to Assets and Loans to Liabilities

	Loans to Assets		Loans to Liabilities	
	ELA group	Non ELA group	ELA group	Non ELA group
2008	51.59%	44.35%	53.44%	46.13%
2016	61.23%	47.33%	70.19%	50.17%

Table 3: Stationarity tests

	Level			First Difference	
	LLC	IPS	Hadri	LLC	IPS
GL	0.24	0.45	0.0	0.0	0.0
LIB-ELA	0.0	0.32	0.0	0.0	0.0
LIQ/A	0.0	0.0	0.0	0.0	0.0
NPL/GL	0.34	0.024	0.0	0.0	0.0
GDP	1.0	1.0	0.0	0.0	0.0
RL	1.0	0.99	0.0	0.0	0.0

LLC is the Levin, Lin and Chu test; IPS is the Im, Pesaran and Shin W-statistic. Both have the null of non-stationarity. Hadri is the heterocedastic consistent Hadri Z-statistic, which has the null of stationarity. All numbers in the table are p values.

Table 4 : Spatial Model with North-North and South-South weighting matrix

	Column 1	Column 2	Column 3	Column 4
Panel A: Direct Effects				
LIAB-ELA	0.4 (0.0)	0.4 (0.0)	0.4 (0.0)	0.4 (0.0)
ELA	0.74 (0.04)	0.46 (0.24)	0.84 (0.11)	0.62 (0.1)
LIQ/TA	-1.76 (0.0)	-1.93 (0.0)	-1.31 (0.0)	-1.5 (0.0)
NPL/GL	1.72 (0.04)	1.98 (0.01	0.9 (0.35)	1.16 (0.1)
$(NPL/GL)^2$	-3.1 (0.05)	-3.97 (0.01)	-2.7 (0.14	-3.0 (0.06)
RL	-19.5 (0.0)	-16.65 (0.0)	1.65 (0.75)	-1.15 (0.8)
Spatial Lag	-0.15 (0.12)	-0.18 (0.05)	5.17 (0.0)	3.92 (0.0)
Spatial Error		-0.36 (0.09)		-2.25 (0.0)
Spatial LIAB-ELA			-1.73 (0.0)	-1.29 (0.0)
Spatial ELA			-11.45 (0.1)	-7.04 (0.0)
Spatial NPL/GL			-10.6 (0.1)	-7.05 (0.04)
Spatial (NPL/GL)2			45.96 (0.02)	31.16 (0.0)
Spatial RL			-100.4 (0.0)	-62.9 (0.0)
Panel B:Total effects				
LIAB-ELA	0.35	0.34	0.32	0.3
ELA	0.68	0.39	2.5	2,2
LIQ/TA	-1.5	-1.6	0.3	0.5
NPL/GL	1.5	1.7	2.3	2.0
$(NPL/GL)^2$	-2.7	-3.3	-10.3	-9.6
RL	-17.1	-14.2	23.5	22.1
Test statistics				
Wald test of spatial term –p-value	0.11	0.02	0.0	0.0
Pseudo R^2	0.8320	0.8318	0.6303	0.8312

P-values in parenthesis. All models have time fixed effects and a constant which are not reported

Figure 1: Impulse response functions following a shock to ELA

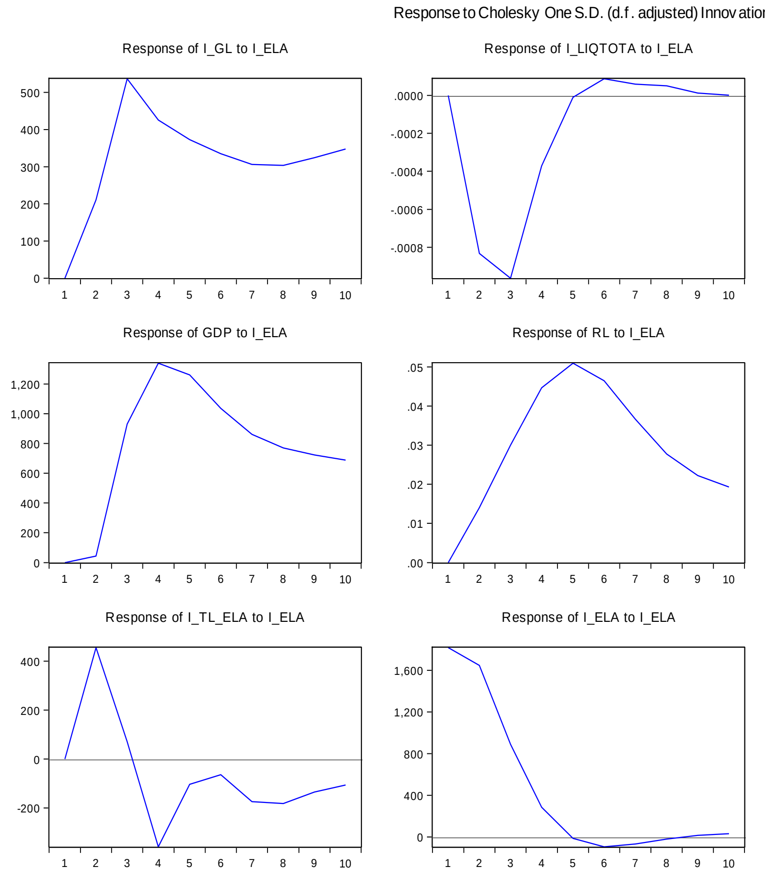


Figure 2. Impulse response Function following a Shock to GDP