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Abstract

Using the shock persistence methodology of Lee, Pesaran and Pierse (1992), we examine whether monetary policy has persistent effects on bank lending behaviour, both directly through the credit channel and indirectly through the risk-taking and liquidity channels. The findings suggest that policy actions aimed at affecting credit risk and bank lending will not have any persistent effects if only the interest rate is employed. Macro-prudential policy should focus on other factors which affect lending decisions, notably the liquidity channel which appears to be an important determinant of the level of lending.

Keywords: bank lending, persistence, euro area, monetary policy, interest rate
JEL Classification: E52, E58, E44

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1. Introduction

Through the manipulation of interest rates, monetary policy functions have the ability to make investment opportunities appear less appealing when the economy is booming and more appealing when in a downturn (Bernanke and Gertler, 1995). This has been described in the literature as the "credit channel" or the "bank lending channel" (Mishkin, 1995). Even though the short-run properties of this pass-through of monetary policy have been extensively studied, this is not the only interest rate channel which matters for macro-prudential purposes. Apart from the direct influence of monetary policy on the economy there are also some indirect but important effects through the "risk taking channel of monetary policy transmission", i.e. the link between monetary policy and the perception and pricing of risk by economic agents. Borio and Zhu (2012), who introduced this term, suggest that changes in interest rates and the characteristics of the central bank's reaction function can influence risk-taking, both directly and indirectly, by imposing perceptions of risks and risk tolerance.

Since excess bank risk-taking has been pointed out as the culprit for the creation of the financial crisis, a recent line of debate has posed the question of whether the relatively low interest rates of the early- to mid-2000s increased the risk-taking appetite of banks. If this premise holds, then the formation of credit bubbles and the over-investment in risky products (ABS, MBS, etc), which have increased the overall fragility of both banks and the economy, can be attributed to policy effects. In addition, an examination of any persistent direct effects of monetary policy through the bank lending channel is also of importance in order to complement the findings of short-run studies. To assess these aspects of monetary policy transmission, this paper empirically examines whether monetary policy has any persistent effects on bank lending behaviour, both directly through the bank lending/credit channel and indirectly through the risk-taking and liquidity channel.

With the literature on the bank lending channel of monetary policy being vast (see Bernanke and Gertler, 1995 for an introduction and an early review), many studies have provided evidence on its existence but the results have been unclear about the size of the effect. For example, Kashyap and Stein (2000) show that such a channel exists but they are unable to make precise statements about its quantitative importance. Complementing these findings, Lown and Morgan (2002) report results which suggest that even though bank lending may have an important role in macroeconomic fluctuations, the bank lending channel for monetary policy changes may be quite small. In addition, Iacoviello and Minetti (2008) present results that suggest the presence of a bank-lending channel for households in countries where mortgage finance is more bank dependent. In a country-specific example, Frühwirth-Schnatter and Kaufmann (2006) find that in Austria, the evidence for a bank lending channel is quite weak since most of the banks fall into one single group that displays only a minor reaction to interest rate changes during the observation period.

Other authors find evidence that the bank lending channel has grown much smaller in recent years. For example, Perez (1998) finds that while a bank lending channel existed in the 1960s, it was no longer operative by the 1990s. Boivin *et al* (2010) support this result, as they also find that the bank lending channel has been more muted in recent years since credit appears to respond more slowly and by a smaller amount to policy shifts after 1982. An earlier example of this behaviour can be found in Miron *et al* (1994) who also suggest that model failure to find systematic changes to monetary contractions in the indicators they examine is an indicator that the bank lending channel is very weak.

Recent contributions to the field of monetary policy transmission, mostly stem from the literature on the effects of interest rate changes to bank risk aversion. Since this channel has not received as much attention as the bank lending/credit channel a short review of the literature is justified. Of the early contributors to the risk taking channel were Altunbas *et al* (2009) and De Nicolo *et al* (2010), who support the view that the easing of monetary policy has important effects on risk taking, suggesting that a reduction in policy rates can increase risk appetite.

Country-specific studies such as Ioannidou *et al* (2014) show that a decrease in the US Federal Funds rate increases bank risk taking in Bolivia. Jiménez *et al* (2014) examine how policy rates affect lending in Spain, with their findings indicating that lower overnight rates lead lower-capitalised banks to grant loans to *ex-ante* riskier firms, and commit large loan volumes with fewer collateral requirements to them. As such, the authors conclude that monetary policy drives risk appetite thus assigning more responsibility to the macroeconomic supervisor. Their results complement those of Diamond and Rajan (2012) who suggest that raising the policy rate in normal times can offset the regulator's propensity to lower them during downturns.

Euro area studies provide evidence which are supportive of the risk taking channel. For example, Maddaloni and Peydró (2011) study the responses of the Bank Lending Survey in the euro area and provide evidence that lower interest rates soften lending standards for both businesses and households. In addition, they suggest that rates which are too low for too long further soften these standards, a finding also presented by Altunbas *et al* (2014). Similarly, Ehrmann *et al* (2003), Dell'Ariccia *et al* (2008) and Delis and Kouretas (2011), support these conclusions and suggest that non-traditional bank activities such as securitization play a central role in the banks' risk appetite.

The only opposing view in the euro area literature is presented by Guerello (2014), who employs a panel of euro area countries and finds that monetary policy does not have an effect on bank credit risk. This result supports the Blanchard *et al* (2010) argument that the policy rate is probably a weak and costly tool to deal with excessive risk taking and regulatory policy may be more effective in dealing with excessive risk-taking.

Given that studies aiming to examine whether changes in monetary policy have any permanent effects, both through the bank lending as well as through the risk taking channel, are non-existent, this aspect of the transmission mechanism deserves further exploration. More specifically, this study uses macro data on 10 euro area countries to examine, for the first time in the literature, whether monetary policy has any persistent effects on bank lending and bank risk taking. Specifically, through the shock persistence methodology developed by Lee *et al* (1992), we provide evidence against the existence of persistent direct effects of euro area monetary policy on bank lending. Overall, the findings in this paper suggest that interest rates have no persistent impact on bank lending or bank credit risk-taking either directly or indirectly. Instead, it is the liquidity channel (i.e. deposits in the economy), which appears to be an important determinant of the level of lending.

The rest of the paper is structured as follows: the next section provides details on the empirical specification and the methodology employed. Section 3 presents the results while section 4 refers to policy implications and concludes.

2. Empirical Specification and Methodology

2.1. Data and Methodology

We propose the examination of the relationship between monetary policy and bank lending using the shock persistence method presented in Lee *et al* (1992) and further utilized by Pesaran *et al* (1993), Lee and Pesaran (1993) and Antonini *et al* (2013). The examination of the persistent effects in bank lending (L) will be undertaken by studying both the effects of its own lags as well as those of other macroeconomic variables. More specifically, as with the existing literature on the effects of monetary policy on bank behaviour, the other macro variables will be real GDP (Y), the policy rate (I), the level of bank deposits (D) and credit risk (R) as a proxy for bank risk-taking behaviour in the EA countries.

The existing literature on bank risk-taking and monetary policy (e.g. Delis and Kourateas, 2013) has usually employed two different measures of bank risk-taking behaviour: the ratio of risk weighted assets (RWA) to total assets (TA) and the ratio of non-performing loans (NPLs) to total loans. However, the second measure presents some obvious caveats: while non-performing loans do indicate banks' exposure to risk, they do not signify the current risk appetite as this is purely a backward-looking item, reflecting past decisions on loan granting. For example, while risk taking during recessions and banking crises is (usually) reduced, NPLs could rise due to, *inter alia*, the banks' past policies, macroeconomic developments and strategic defaults. As such, the ratio does not even depend solely on bank decisions: while a specific loan could have been a good choice at the time of granting, it may have moved it into the non-performing territory by changes in the macroeconomic environment, a consequence which is unrelated to banks' attitude towards risk. As such, we refrain from using such a ratio in our estimation.

In addition, even though the ratio of risk-weighted assets as a share of total assets is a far better proxy for risk appetite than the share of NPLs, unavailability of such data at the country level prior to 2014Q2 from the ECB database[1], provides an obstacle for its use. However, the availability of data on outstanding loans and assets allows us to construct a close alternative, namely a credit risk index, i.e. the ratio of outstanding loans to outstanding assets. According to the BIS[2], "credit risk is the risk of default on a debt that may arise from a borrower failing to make required payments". Thus, an increase in bank lending is expected to increase credit risk since these loans are assigned a specific risk weight. In the standardized (and also the IRB) approach to credit risk, this weight is by definition greater than zero for private sector loans. Obviously, the caveat that more loans do not necessarily mean riskier loans exists, both in the case of the RWA to TA ratio as well as the credit index. However, higher bank lending growth rates tend to be associated with riskier loans, or at least in our case, an increase in the credit risk of the bank.

While a bi-annual comparison of the two indices shows that the RWA to TA and the credit risk index are very close in values (the average difference is 4.7%), it can be argued that a credit risk index is an even better proxy for risk appetite. The rationale lies in the fact that total risk-weighted assets include other items such as government or corporate bonds, which, in most cases (at least in the majority of euro area countries) carry less risk than lending to the private sector. Consequently, given that credit risk is the dominant risk for banks (see Schuermann, 2004) and that the risk-taking behaviour this paper aims to examine is precisely lending to the private sector, there is no reason to obscure the relationship between monetary policy and bank lending by including other items.

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[1] Data from 2010H1 exist on a bi-annual basis, with a total of 7 observations until 2014Q2.

[2] http://www.bis.org/publ/bcbs75.htm (accessed: 20 November 2015)

Data on total banking assets and total loans to the private sector are obtained from the ECB SDW while macroeconomic data are obtained from Eurostat. For the policy rate, the main refinancing operations (MRO) rate is employed. Given that this measure of monetary policy is highly correlated with the other measures, namely the Eonia rate (correlation of 0.99) and the 3-month Euribor rate (correlation of 0.98), the use of any alternative is expected to have no significant effect on the results.[3] The data span from 1999Q1 to 2014Q4 and the sample includes Germany, Belgium, Ireland, Spain, France, Italy, Netherlands, Austria, Portugal and Finland (henceforth EA10). A detailed presentation of the data and their sources can be found in the Appendix.

2.2. Empirical Specification and Shock Identification

The dynamics of bank lending in a group of countries can be easily modeled through a simple vector autoregression (VAR), explaining the growth of each country's loan stock in terms of its recent path and the past values of growth in other countries. The stock of loans of countries' usually follows a unit root process and, in addition, these are likely to be related to each other, as Figure 1 and the unit root tests in sub-section 2.3 suggest. An economically important feature of the series is their long-run properties and thus the persistence of shocks (i.e. the infinite-horizon effect of a shock to the ratio) is a key statistic.

Denoting the (logarithm of) bank lending in country i at time t by l_{it} and assuming that l_{it} is integrated of order 1 (i.e. I(1)), we can characterize the time series of the countries' stock of loans through the Wold representation:

$$\Delta l_t = \mu + C(L)\varepsilon_t \tag{1}$$

[3] Indeed changing the policy rate only alters the second decimal point of the results presented in this paper.

where $l_t = (l_{1t}, l_{2t}, ..., l_{mt})'$ is the $m \times 1$ vector containing the loan stocks for the m countries of interest, μ is a vector of constants representing mean growth rates, $C(L) = I + C_1 L + ... + C_p L^p$ is a p-order polynomial in the lag operator L, $\boldsymbol{C}_j$ are $m \times m$ matrices of parameters and ε_t is the vector of $m \times 1$ one-step-ahead forecast errors in Δl_t given information on lagged values of Δl_t. The ε_t are serially uncorrelated with mean zero and covariance Ω.

As also suggested by Antonini *et al* (2013), equation (1) can capture complicate cross-country interdependencies, including the effect of innovations to countries' stock of loans that are correlated contemporaneously through the covariance matrix Ω. In addition, the specification can capture feedback effects across countries' stock of loans over time through $\boldsymbol{C}_i$. Therefore, it provides a useful tool to capture the dynamics of loan evolution.[4]

Following Lee and Pesaran (1993), important features of loan dynamics will be captured by the $m \times m$ matrix **P** whose (i, j)-th element is given by

$$\rho_{ij} = \frac{e_i^{'} C(1) \Omega C(1)' e_j}{\sqrt{(e_i^{'} C(0) \Omega C(0)' e_i)(e_j^{'} C(0) \Omega C(0)' e_j)}}, \quad i, j = 1, ..., m \qquad (2)$$

where e_i is the $m \times 1$ selection vector with unity in its i-th element and zeros elsewhere. P is the "persistence matrix" that provides a variance-based measure of the infinite-horizon effect of shocks to the system. It can be most easily interpreted by considering the measures of $P_i = \sqrt{\rho_{ii}}$ based on its diagonal elements. These measures show the size of the permanent effect on the loan stock in country *i* of a shock to the system that causes loans in that country to rise by 1% on impact.

[4] Nevertheless, despite of all its advantages, the specification is subject to the usual limitation of multivariate time series, i.e. that there exist an infinite number of MA representations of this type and a structural interpretation of the innovations or parameters requires, a usually large number of, identifying restrictions provided by economic theory.

This can be considered as an "impulse-based" measure of persistence in the univariate case, describing the effect of a 1% shock to the variable.

An advantage of this variance-based measure is that it does not require, and is in fact invariant to, the identifying assumptions necessary to provide structural meaning to the shocks in an impulse response analysis conducted in a multivariate setting (Lee and Pesaran, 1993). The moving average representation of (1) takes into account the possibility that the instantaneous effect of shocks is gradually eroded over time and thus persistence can be close or equal to zero (for example, in the case where the loan stock series is stationary).

The derivation of P_i suggests two extensions, described in detail in Lee and Pesaran (1993). First, the time-profile of the effect of the shocks can be readily traced over time, defining $P(n)$ as the matrix whose (i, j)-th element is given by

$$\rho_{ij}(n) = \frac{e_i^{'} H(n)' e_j}{\sqrt{(e_i^{'} C(0)\Omega C(0)' e_i)(e_j^{'} C(0)\Omega C(0)' e_j)}} \qquad (3)$$

where $H(n) = \left(\sum_{i=0}^{n} Ci\right)\Omega\left(\sum_{i=0}^{n} Ci\right)^{'}$ for $n = 0,1,...$

In this case, *H(n)* captures the size of the permanent effects of the shocks as they accumulate over time, up to period n.As $n \to \infty$ the $P(n)$ converges to the persistence matrix P. Similarly, the persistence profiles defined by the individual country-specific measures $P_i(n) = \sqrt{\rho_{ii}(n)}$ also converge to P_i. These profiles provide a useful characterisation of loan dynamics which again avoids the need for any structural assumptions.

The second extension, allows for a decomposition of the shocks to loans in the simple Wold representation in (1) in order to provide us with the ability to describe the way through which different system-wide shocks impact the loan stock and their effects are propagated through time. Suppose that X_t is a vector of EA-wide aggregates, which impact in distinct way and over different time-frames, loans in the EA economies. Specifically, in our case there are four types of shocks, i.e. output, credit risk, deposits and the policy rate. We assume that innovations in these aggregates are given by

$$v_t = x_t - \Gamma z_t \tag{4}$$

with mean zero and variance Ψ with Γ being fixed parameters and z_t being a set of predetermined variables. Then, equation (1) can be generalized to

$$\Delta l_t = \mu + D(L)v_t + C(L)\varepsilon_t \tag{5}$$

where $D(L) = I + D_1 L + ... + D_q L^q$ is a matrix of lag polynomials capturing the effects of the identified system-wide shocks and the ε_t are now interpreted as "other, unidentified" innovations to loans, which are assumed to be uncorrelated with the v_t. In this case, the *P(n)* matrix is defined by its *(i,j)-th* element in a way that can be decomposed as:

$$\rho_{ij}(n) = \rho_{Sj}(n) + \rho_{Oij}(n) \tag{6}$$

with $\rho_{Sij}(n) = \dfrac{e_i^{'} F(n)' e_j}{\sqrt{(e_i^{'} H(0)' e_i)(e_j^{'} H(0)' e_j)}}$, $\rho_{Oij}(n) = \dfrac{e_i^{'} G(n)' e_j}{\sqrt{(e_i^{'} H(0)' e_i)(e_j^{'} H(0)' e_j)}}$

and speficying $F(n) = \left(\sum_{i=0}^{n} Di\right)\Psi\left(\sum_{i=0}^{n} Di\right)^{'}$, $G(n) = \left(\sum_{i=0}^{n} Ci\right)\Omega\left(\sum_{i=0}^{n} Ci\right)^{'}$ and

$$H(n) = \left(\sum_{i=0}^{n} Di\right)\Psi\left(\sum_{i=0}^{n} Di\right)^{'} + \left(\sum_{i=0}^{n} Ci\right)\Omega\left(\sum_{i=0}^{n} Ci\right)^{'} \text{ for } n = 0,1,...$$

In this case, the profiles described by $P_{Si}(n)=\sqrt{\rho_{Sii}(n)}$ and $P_{Oi}(n)=\sqrt{\rho_{Oii}(n)}$ summarise the effects of the identified EA-wide shocks and the unidentified shocks on each country's loans while the scaling reflects the size of the identified and unidentified shocks on impact.

2.3. Model Specification

The characterisation of the EA-10 loan data and the analysis of the persistence of the shocks to these is provided by the following two simple regression models estimated for each country and stacked in each case to obtain a multi-country VAR.

$$M_1:\ \Delta l_{it}=a_i+\sum_{s=1}^{r}\beta_{s,ii}\Delta l_{i,t-s}+\sum_{s=1}^{r}\gamma_{s,i}\Delta l_{-i,t-s}+\varepsilon_{it},\quad i=1,\ldots,m \tag{7}$$

M_2: a restricted version of M_1 where variables with coefficients with a |t-ratio| <1 are excluded. (7b)

As already discussed, the models are estimated for the EA10 over the period after the introduction of the euro, (1999q1-2014q3), using Full Information Maximum Likelihood (FIML). Lag order is set by information criteria (BIC) which suggest that two lags are sufficient (i.e. r=2 while m=10).

In specifying the source of shocks, we use model M_2 where shock is decomposed according to equation (4) into p different types of identified shocks, $v_{j,t}$, $j=1,\ldots,p$ and unidentified shocks $\tilde{\varepsilon}_{it}$ as follows:

$$\tilde{M}_2:\ \ \Delta l_{it}=a_i+\sum_{s=1}^{r}\tilde{\beta}_{s,ii}\Delta l_{i,t-s}+\sum_{s=1}^{r}\tilde{\gamma}_{s,i}\Delta l_{-i,t-s}+\sum_{j=1}^{p}\ \sum_{j=1}^{p}\delta_{i,js}v_{j,t-s}+\tilde{\varepsilon}_{it},\quad i=1,\ldots,m \tag{8}$$

We employ four types of shocks which affect the evolution of bank lending, namely, shocks to EA10 output (Y), shocks to the credit risk (R), shocks to deposits (D) and shocks to the policy rate

(P). The shocks are to be inferred as system-wide ones and are identified from simple specifications regressing each variable on its own lag as follows:

$$\Delta x_{j,t} = \lambda_{0j} + \lambda_{1j}\Delta x_{j,t-1} + v_{j,t}, \quad j = 1,\ldots,4 \qquad (9)$$

In this case, the $x_{j,t}$ denotes Y, R, I and P respectively. As the sources of shocks do not rely on any short-run identifying assumptions (e.g. Cholesky decompositions), they are invariant to the ordering of the variables in the VAR. Similar to the above, to test the effects of policy on credit risk (deposits) in order to capture possible indirect effects of policy on the level of bank lending, we modify models M_1, M_2 and $\tilde{M}_2$ to treat the values of R (D) as the dependent variable and the shocks now becoming output, deposits (credit risk), lending in the economy and the policy rate.

2.3. Data Overview

Figure 1
Individual Country Total Lending levels

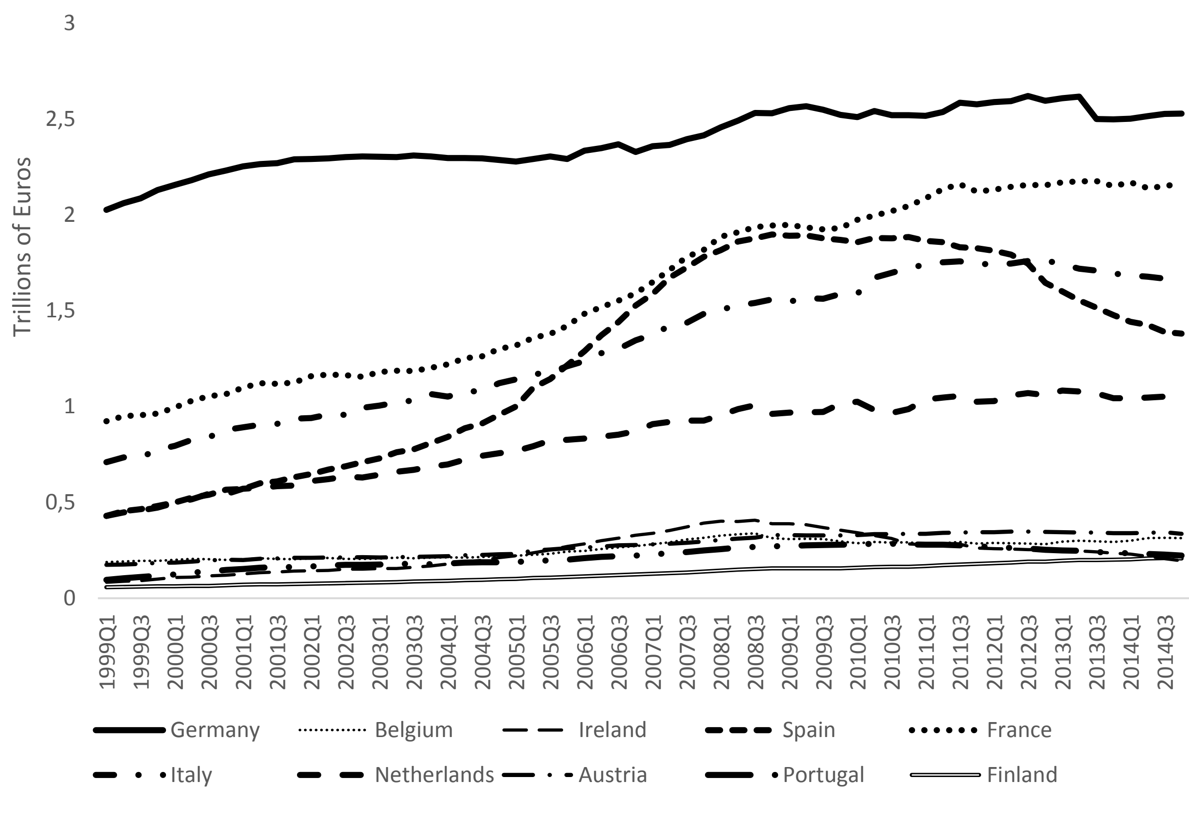

Figure 1 plots the loan stock evolution in the 10 EA countries since the euro adoption. The amount of lending in each individual country has increased over time, with a slowdown observed after the global financial crisis. The decrease in loans in most of the EA countries has only been observed after the European sovereign crisis.

Table 1
Augmented Dickey-Fuller Tests for Unit roots in bank lending levels

	ADF(1)	ADF(2)	ADF(3)	ADF(4)
Germany	-1.53	-1.85	-2.11	-1.96
Belgium	-1.23	-1.27	-1.62	-1.59
Ireland	0.02	-0.35	-0.54	-0.38
Spain	0.81	-1.22	-1.01	-1.05
France	-0.17	-0.58	-0.95	-0.95
Italy	1.88	0.26	0.69	0.58
Netherlands	-1.64	-1.46	-1.22	-0.73
Austria	0.41	0.12	-0.1	0.04
Portugal	0.97	0.8	0.62	0.41
Finland	-0.11	0.04	0.03	0
Mean	**-0.06**	**-0.55**	**-0.62**	**-0.56**
(IPS test stat)	**7.80**	**5.61**	**5.17**	**4.98**

Note: The variables are all in logarithms. ADF(p) statistics are computed using ADF regressions with an intercept a linear trend and p lagged differences of the dependent variable. The 10% critical value is -3.18 the 5% value is -3.50 and the 1% value is -4.15. The IPS test statistic is the normalized value of the mean of the ADF statistics and is compared to a normal standard distribution. ** denotes significance at the 5% level.

Tests for unit roots in the loan stock of each country can be found in Tables 1 and 2. More specifically, Table 1 suggests that the unit root hypothesis cannot be rejected for any country and for any order of the augmented Dickey-Fuller test. In addition, the IPS test (Im *et al*., 2003) shows the standardized value of the mean of the ADF statistics across countries. When compared to a standard normal distribution, the IPS statistic provides powerful test for the presence of unit root, based on all the countries taken together. In our case, the IPS blurs the picture as it contrasts the individual ADF results, i.e. the presence of a unit root is rejected. However, Table 2 results present a clearer image and indicate that a unit root process is absent in the growth of bank lending, as suggested by most individual country ADF tests as well as the overall IPS tests.

Table 2
Augmented Dickey-Fuller Tests for Unit roots in the growth of bank lending

	ADF(0)	ADF(1)	ADF(2)	ADF(3)
Germany	-7.05***	-4.55***	-3.67***	-3.77***
Belgium	-5.69***	-4.43***	-3.15**	-3.1**
Ireland	-2.38	-1.31	-0.84	-1.02
Spain	-2.49	-0.9	-0.98	-0.91
France	-4.53***	-3.28**	-2.47	-2.42
Italy	-6.32***	-2.4	-2.51	-2.32
Netherlands	-6.13***	-5.1***	-4.84***	-5.32***
Austria	-5.05***	-3.31**	-2.57	-2.81*
Portugal	-3.23**	-2.59	-2.35	-1.87
Finland	-4.22***	-3.54**	-2.79*	-2.71*
Mean	**-4.71*** **	**-3.14** **	**-2.62** *	**-2.62** *
(IPS test stat)	**-12.11**	**-5.99**	**-4.21**	**-4.12**

Note: The variables are all in logarithms. ADF(p) statistics are computed using ADF regressions with an intercept and p lagged differences of the dependent variable. The 10% critical value is -2.60 the 5% value is -2.93 and the 1% value is -3.58. The IPS test statistic is the normalized value of the mean of the ADF statistics and is compared to a normal standard distribution. ** denotes significance at the 5% level.

In Tables 3 and 4 the corresponding cross-sectional ADF (CADF) tests are presented.[5] These tests augment the ADF regressions with lagged differences of the cross-sectional average, taking into consideration the cross-sectional dependencies among countries' lending stocks. The findings of Tables 1 and 2 are confirmed. The unit root hypothesis cannot be rejected by either the individual ADF tests or the CIPS test in the levels, but is rejected by both in the growth rate at least at the 5% level. In addition, there is now no contradiction between the IPS and the individual ADF tests, as they both support the same view. Taken together, the results of the first 4 Tables provide evidence that the bank lending stock level is a difference-stationary variable in the EA-10 countries.

[5] see Pesaran (2007) for more details.

Table 3
Cross-Sectionally Augmented Dickey-Fuller Tests for Unit roots in bank lending levels

	CADF(1)	CADF(2)	CADF(3)	CADF(4)
Germany	-0.39	-1.7	-1.65	-1.74
Belgium	-1.23	-0.74	-0.33	-0.5
Ireland	-0.84	-1.4	-1.45	-1.68
Spain	-0.14	-1.38	-1.21	-1.1
France	-0.53	-0.11	-0.23	-0.8
Italy	-1.29	-2.16	-1.76	-2.82
Netherlands	-3.76*	-3.34	-2.69	-2.01
Austria	-1.37	-1.02	-0.93	-1.6
Portugal	-3.29	-4.12	-3.63	-3.87
Finland	-3.43	-3.15	-3.03	-2.81
Mean (CIPS test stat)	**-1.63**	**-1.91**	**-1.69**	**-1.89**

Note: The variables are all in logarithms. CADF(p) statistics are computed using ADF regressions with an intercept a linear trend and p lagged differences of the dependent variable. The 10% critical value is -3.44 the 5% value is -3.78 and the 1% value is -4.69. The CIPS test statistic is the cross-sectional mean compared to the distribution in Pesaran (2007) where the 1% 5% and 10% critical values are -3.06 -2.84 and -2.73 respectively. ** denotes significance at the 5% level.

Table 4
Cross-Sectionally Augmented Dickey-Fuller Tests for Unit roots in the growth of bank lending

	CADF(0)	CADF(1)	CADF(2)	CADF(3)
Germany	-6.95***	-3.08*	-2.66	-2.12
Belgium	-5.1***	-4.15***	-3.39**	-1.88
Ireland	-5.54***	-3.39**	-2.73	-2.17
Spain	-4.72***	-1.46	-1.83	-1.47
France	-6.52***	-4.62***	-3.17*	-2.04
Italy	-8.9***	-3.59**	-3.79**	-2.6
Netherlands	-6.59***	-5.6***	-5.98***	-4.7***
Austria	-6.7***	-5.57***	-3.82**	-2.7
Portugal	-5.45***	-3.6**	-3.68**	-3.18*
Finland	-6.11***	-5.85***	-4.84***	-4.71***
Mean (CIPS test stat)	**-6.26*****	**-4.09*****	**-3.59*****	**-2.76*****

Note: The variables are all in logarithms. CADF(p) statistics are computed using ADF regressions with an intercept a linear trend and p lagged differences of the dependent variable. . The 10% critical value is -2.94 the 5% value is -3.29 and the 1% value is -3.94. The CIPS test statistic is the cross-sectional mean compared to the distribution in Pesaran (2007) where the 1% 5% and 10% critical values are -2.55 -2.33 and -2.21 respectively. ** denotes significance at the 5% level.

3. Results

3.1. Baseline Specification

Table 5 presents the aggregate persistence of the total system-wide shocks in models M_2 and $\tilde{M}_2$. In both specifications, total persistence is strong and statistically significant. As the reader may observe, the extent of the EA persistence is similar in both specifications.

Table 5
Total Persistence Measures

	Model M_1	**Model M_2**
Germany	2.88 (2.26)	17.2 (12.94)
Belgium	5.85 (12.34)	1.61 (0.3)
Ireland	9.09 (6.28)	8.47 (5.31)
Spain	7.46 (2.71)	7.8 (2.51)
France	3.69 (1.76)	11.82 (6.00)
Italy	3.34 (1.42)	3.64 (1.88)
Netherlands	2.58 (1.45)	2.38 (0.67)
Austria	9.98 (23.53)	35.58 (15.41)
Portugal	9.64 (5.45)	11.98 (9.51)
Finland	2.7 (1.33)	2.49 (0.59)
EA-10	**7.19** **(3.16)**	**7.28** **(2.01)**

Note: Individual country persistence measures are estimated using equation (2) and the aggregate persistence measures is obtained using a vector of ones in the place of e_i and e_j. Figures in brackets represent asymptotic standard errors.

Specifically, the combination of all shocks in M_2 (i.e. policy, credit risk, GDP and deposits) would have a persistent effect of 7.19 across the EA10. To place the value of 7.19 in perspective, the combination of all shocks in the model would translate into a long-term rise in lending by 7.19% if the whole of the initial change was the result of unanticipated shocks, assuming that there are no further shocks and that the EA10's macroeconomic response is the same as it has been in the past. In model $\tilde{M}_2$, the effect is a bit more pronounced in the reduced model where a 1% shock would have a 7.28% persistent effect. Individual country effects vary in size, while the effect is statistically significant for all countries excluding Germany, Ireland and Portugal.

The breakdown of the aggregate macro system-wide shocks both at the country as well as the EA level, using the $\tilde{M}_2$ specification, are presented in Table 6. As the estimates suggest, the effects of policy shocks do not exhibit significant persistence in any country, while there exists no statistically significant persistence for the EA aggregate either. On the contrary, a system-wide credit risk shock provides significant persistence in the EA level while it is mostly insignificant in the country level, with the exceptions being Belgium, Spain, France and the Netherlands. System-wide output shocks are not statistically significant, neither at the EA nor at the country level.

The persistent effects of a system-wide deposits shock are very strong both in the aggregate and individual level (except Germany, Belgium, Ireland and Portugal) and, along with the credit risk shock, capture most of the persistence caused by macro shocks. This suggests that in the occurrence of a bank liquidity unanticipated shock a persistent change in lending should be expected. The permanent effects of a change in deposits can be viewed simply as the contemporaneous impact of this shock on bank lending and the subsequent propagation of this through time. Similar to Bernanke (1983), this result suggests lack of liquidity during downturns can further deteriorate future prospects about the state of the economy. Thus, macro-prudential policies aiming at controlling the level of lending should also emphasise in the liquidity aspect and not just credit risk or lending itself.

Table 6
Aggregate and decomposition of Individual Country and Aggregate Persistence Measures by Type of Shock – Bank Lending as a dependent variable

	Policy	Credit Risk	GDP	Deposits	Total Macro	Other Shocks	Total
Germany	0.77 (1.25)	66.83 (58.98)	0.84 (2.07)	59.89 (55.75)	62.88 (55.65)	1.38 (0.18)	17.2 (12.94)
Belgium	1.91 (1.62)	2.91 (1.16)	1.23 (3.15)	2.51 (3.02)	1.61 (0.30)	1.61 (0.30)	1.61 (0.30)
Ireland	0.06 (0.10)	6.82 (5.92)	0.35 (0.46)	10.01 (6.12)	8.49 (5.37)	3.55 (1.47)	8.47 (5.31)
Spain	0.04 (0.03)	9.07 (2.83)	0.02 (0.06)	3.82 (1.79)	7.80 (2.51)	4.93 (2.17)	7.8 (2.51)
France	0.07 (0.15)	12.20 (7.09)	0.14 (0.27)	12.72 (6.48)	12.21 (6.50)	1.72 (0.28)	11.82 (6.00)
Italy	0.03 (0.03)	3.13 (2.15)	0.02 (0.05)	4.09 (1.95)	3.64 (1.89)	1.37 (0.24)	3.64 (1.88)
Netherlands	0.00 (0.02)	1.92 (0.76)	0.00 (0.03)	2.71 (0.72)	2.39 (0.68)	0.95 (0.13)	2.38 (0.67)
Austria	0.76 (0.61)	60.64 (35.79)	2.11 (1.09)	56.78 (34.47)	56.74 (33.56)	1.72 (0.29)	35.58 (15.41)
Portugal	0.05 (0.13)	10.27 (10.86)	0.08 (0.22)	13.4 (9.82)	12.04 (9.68)	4.39 (1.32)	11.98 (9.51)
Finland	0.02 (0.02)	0.47 (1.15)	0.01 (0.03)	2.71 (0.91)	2.49 (0.59)	1.78 (0.33)	2.49 (0.59)
EA-10	**0.04** **(0.04)**	**7.66** **(2.75)**	**0.08** **(0.09)**	**7.19** **(1.6)**	**7.29** **(2.02)**	**2.68** **(0.59)**	**7.28** **(2.01)**

Note: Results refer to Model 2 as defined in the text and are estimated in the 1999q1 – 2014q3 period. Individual country persistence measures are estimated using equation (5) and the aggregate persistence measures is obtained using a vector of ones in the place of e_i and e_j . Figures in brackets represent asymptotic standard errors.

As indicated above, Ireland has no significant persistence in the specific macroeconomic shocks, other than the deposits shocks at the 10% level. Similarly, no macro shocks provide statistically significant persistence in Portugal or Germany. In these three countries, bank lending exhibits significant persistence only to other, unspecified, shocks. In Belgium, the results indicate that credit risk is a more important driver than the level of deposits, while in Austria, Finland, France and Italy the opposite holds. Both credit risk and liquidity shocks register significant persistence in the cases of Spain and the Netherlands.

Overall, the findings presented in this Section suggest that monetary policy has no direct persistent effects on bank lending either on the EA or the country level. On the other hand, deposit and credit risk shocks appear to be much more important in determining the persistence of changes in bank lending. Since the results show no direct effect of policy on bank lending, to study whether any other transmission channels of monetary policy exist the next section tests for the presence of any persistent indirect effects on the macroeconomic variables of the model.

3.2. Indirect effects of monetary policy

The results in Table 6 provide an estimate of the direct effects of monetary policy. However, it can be argued that changes in the policy rate may have indirect effects on the level of lending. To this respect, the effect of the policy on the level of the two variables which affect lending decisions (as also partially suggested in Table 6), i.e. the level of deposits and credit risk is examined.

Table 7 presents estimates of persistence to credit risk, through the system-wide macro shocks of policy rate, deposits, output and lending. Again, in this specification, the policy rate does not have statistically significant persistence in the EA aggregate and neither at the country level with the exceptions of the Netherlands and Austria. The findings of Table 7 bear much similarity to the ones presented by Guerello (2014) who finds that monetary policy does not have any effects on bank credit risk.

Table 7
Aggregate and decomposition of Individual Country and Aggregate Persistence Measures by Type of Shock –Credit Risk as dependent variable

	Policy	Deposits	GDP	Loans	Total Macro	Other Shocks	Total
Germany	0.22 (0.34)	1.63 (1.52)	2.26 (1.25)	-1.64 (0.51)	1.26 (0.33)	0.74 (0.07)	0.92 (0.24)
Belgium	0.56 (0.73)	3.98 (1.00)	3.23 (1.53)	0.19 (1.03)	0.89 (0.23)	0.9 (0.1)	0.9 (0.1)
Ireland	0.11 (1.04)	2.81 (2.38)	2.06 (2.57)	0.1 (1.33)	1.04 (0.32)	1.04 (0.05)	1.04 (0.05)
Spain	0.46 (1.31)	1.28 (3.52)	0.17 (3.26)	1.5 (1.03)	1.02 (0.4)	1.2 (0.15)	1.19 (0.15)
France	0.43 (0.86)	0.32 (1.78)	0.71 (1.85)	2.88 (1.4)	2.21 (0.96)	0.88 (0.1)	1.13 (0.32)
Italy	1.87 (2.33)	1.37 (6.76)	3.41 (6.8)	1.09 (3.33)	1.53 (0.71)	1.39 (0.19)	1.39 (0.19)
Netherlands	1.24 (0.49)	1.52 (1.07)	0.95 (1.04)	0.4 (0.48)	1.67 (0.22)	1.00 (0.00)	1.2 (0.14)
Austria	1.23 (0.31)	0.05 (0.83)	0.66 (0.75)	0.3 (0.31)	1.58 (0.14)	1.00 (0.00)	1.28 (0.11)
Portugal	1.06 (0.83)	2.43 (2.41)	1.73 (2.48)	1.84 (0.86)	1.33 (0.21)	1.31 (0.17)	1.31 (0.17)
Finland	0.22 (0.49)	1.31 (2.20)	3.71 (1.75)	0.59 (1.79)	2.27 (0.49)	1.37 (0.22)	1.79 (0.45)
EA 10	**0.85** **(0.89)**	**2.60** **(1.79)**	**3.89** **(1.85)**	**1.91** **(1.91)**	**1.27** **(0.87)**	**1.20** **(0.13)**	**1.21** **(0.18)**

Results refer to Model 2 as defined in the text and are estimated in the 1999q1 – 2014q3 period. Individual country persistence measures are estimated using equation (5) and the aggregate persistence measures is obtained using a vector of ones in the place of e_i and e_j . Figures in brackets represent asymptotic standard errors

Another interesting finding of Table 7 is that credit risk is not greatly affected by lending itself as the level of loans does not present statistically significant persistence in the aggregate or the country level (exceptions are Germany, France and Portugal). As the results suggest, the main driver of credit risk persistence are output shocks which are the only ones which are significant at the aggregate level. Overall, system-wide macroeconomic shocks have approximately the same persistence as other, "unidentified" shocks at the EA level, however, with considerable variation in country responses and with only the latter being statistically significant. This provides support to the view that country idiosyncrasies are important determinants of shock outcomes and, in addition, also supports the tested proposition that monetary policy is not a persistent determinant of credit risk.

Table 8
Aggregate and decomposition of Individual Country and Aggregate Persistence Measures by Type of Shock – Deposits as the dependent variable

	Policy	Loans	Credit Risk	GDP	Total Macro	Other Shocks	Total
Germany	0.58 (0.77)	0.85 (0.76)	1.63 (1.04)	1.70 (1.12)	0.84 (0.07)	0.84 (0.07)	0.84 (0.07)
Belgium	0.00 (0.01)	1.31 (0.18)	0.02 (0.03)	0.69 (0.65)	1.13 (0.15)	0.74 (0.06)	1.13 (0.15)
Ireland	0.02 (0.07)	1.41 (0.56)	0.25 (0.35)	3.75 (0.92)	3.04 (0.71)	1.74 (0.38)	3.02 (0.71)
Spain	0.16 (0.47)	0.47 (10.02)	0.03 (0.3)	7.43 (13.5)	7.11 (9.00)	2.47 (0.86)	6.91 (7.81)
France	0.64 (1.34)	34.07 (35.10)	2.65 (1.34)	-25.43 (37.36)	31.65 (29.45)	1.00 (0.09)	5.84 (3.4)
Italy	0.90 (2.25)	20.58 (30.07)	1.05 (2.81)	-17.16 (29.77)	19.03 (26.56)	0.79 (0.07)	2.57 (1.69)
Netherlands	0.02 (0.01)	1.80 (0.47)	0.00 (0.02)	0.21 (0.72)	1.72 (0.36)	0.96 (0.18)	1.72 (0.36)
Austria	0.01 (0.02)	0.96 (0.14)	0.07 (0.07)	1.83 (0.22)	1.51 (0.16)	0.91 (0.04)	1.51 (0.16)
Portugal	0.00 (0.01)	0.98 (0.13)	0.01 (0.02)	1.00 (0.07)	1.73 (0.06)	1.00 (0.00)	1.73 (0.06)
Finland	0.21 (0.84)	10.53 (10.73)	1.93 (1.19)	-9.89 (11.68)	9.22 (8.87)	0.69 (0.05)	2.02 (1.31)
EA 10	**0.01 (0.03)**	**1.27 (0.68)**	**0.05 (0.06)**	**1.05 (0.92)**	**1.14 (0.34)**	**0.91 (0.07)**	**1.14 (0.33)**

Results refer to Model 2 as defined in the text and are estimated in the 1999q1 – 2014q3 period. Individual country persistence measures are estimated using equation (5) and the aggregate persistence measures is obtained using a vector of ones in the place of e_i and e_j . Figures in brackets represent asymptotic standard errors

In Table 8, the effects of system-wide macro shocks to the level of deposits are presented. Again, the policy rate is statistically insignificant both at the EA as well as the country level. Furthermore, system-wide shocks in credit risk and GDP also exhibit insignificant persistence. At the country level, output shocks have significant persistence on deposits only in Ireland and Austria. In contrast, system-wide loan shocks present significant persistence on deposits at the aggregate level and are significant at the country level for half of the sample countries (Belgium, Ireland, the Netherlands, Austria and Portugal). These findings complement those of Table 6 in that monetary policy does not have an indirect effect on lending through deposits, and are in accordance with the credit creation theory (see Werner, 2014). In addition, the bi-directionality of the lending and deposit relationship is also suggested: while an increase in lending increases deposits (Werner, 2014) a change in deposits, i.e. the liquidity in the system, also affects lending capability. As such, the importance of liquidity during downturns is especially emphasised.

Overall, the findings presented in Tables 7 and 8 suggest that changes in the interest rate do not have a permanent effect on the variables which affect bank lending, i.e. there are no permanent indirect effects of monetary policy. In the countries where credit risk is permanently affected by monetary policy changes (Austria and the Netherlands), there is only significant indirect feedback from credit risk to lending in the case of the Netherlands in Table 6. Similarly, the policy rate does not have a permanent effect on deposits. On the whole, as the aggregate results of sections 3.1 and 3.2 suggest, there are no persistent effects, either direct or indirect, of the policy rate on bank lending neither at the aggregate nor at the country level, with the Netherlands posing the only exception through an indirect channel of transmission.

4. Policy Implications and Conclusions

As the previous section has shown, there are no direct, persistent effects of the policy rate on bank lending in the euro area. In addition, the policy rate does not have significant aggregate persistence in either credit risk or the level of deposits, with the exception of the Netherlands in the former case. Our results are supportive the findings of Miron *et al* (1994), Perez (1998) and Boivin *et al* (2010) who conclude that no bank lending channel exists or if it does it is so weak it cannot be captured by models.

The combination of direct and indirect effects does not yield a statistically significant effect for any country in the sample (other than the Netherlands for the indirect case), while it is insignificant in the aggregate. Overall, while the policy rate may have very limited and idiosyncratic effects in specific economies, its persistence is insignificant in the aggregate both directly and indirectly. Furthermore, these idiosyncratic effects on bank lending are weak and limited to countries where a persistent change in credit risk occurs.

The findings suggest that since changes in the policy rate do not have persistent effects, then they either affect decisions only in the very short-run, (which, as O'Rourke and Taylor, 2013, comment is the time-frame of policy) or have very little (if any) effect on lending decisions in general. As such, a loose monetary policy is not harmful by itself. In other words, changes in monetary policy should not be expected to provide persistent changes in bank lending behaviour. While the interest rate can be important for inflation targeting, it appears that it does not have persistent effects on bank risk taking, an argument similar to Blanchard *et al* (2010) who also suggest the policy rate is a weak tool to deal with excessive risk taking. Our results are supportive Blanchard *et al* (2010), as well as Guerello (2014) since only one out of ten sample countries has persistent indirect effects on credit risk resulting from a change in the policy rate.

Another important implication is that deposits have a persistent effect on bank lending behaviour, opening a channel for potential macro-prudential policy actions. For example, if excessive risk taking cannot be affected by the policy rate, then regulation on the sources of bank liquidity (be it central banking, inter-banking or deposit-taking), could perhaps be more useful in preventing excess lending in the economy. In the opposite case, where the economy faces a downturn, macro-prudential policy can be aimed at increasing liquidity in the economy to boost future prospects. Here it should again be mentioned that the policy rate does not have a statistically significant, persistent effect on deposits in any specific country and is insignificant in the aggregate.

Summing up, in the course of this paper macro data were employed in order to examine whether monetary policy, measured through changes in the policy rate, has any persistent effects on bank lending. There were no statistically significant aggregate effects and very limited and weak idiosyncratic indirect effects. In addition, the results indicate that there is no aggregate persistence in the effects of the policy rate on credit risk. On the whole, the evidence presented in this paper indicates that the interest rate, as previously suggested in the literature, is not very well suited to persistently impact the properties of the variables of interest. This outcome implies that policies aimed at affecting credit risk and bank lending behaviour would have no persistent effects if only the interest rate is employed. Macro-prudential policy should perhaps focus on other factors which affect lending decisions and notably the liquidity channel, which appears to be an important determinant of the level of lending.

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Appendix

Variable Description

The data source for all series is the European Central Bank's Statistical Data Warehouse (SDW) and Eurostat. Definitions of the variables referred to in the paper are presented below.

1. Bank lending (L) is defined as total maturity, outstanding amounts at the end of the period, in all currencies, by euro area (changing composition) monetary financial institutions (MFIs) excluding ESCB reporting sector, denominated in euros (balance sheet code: A20). Counterpart sector is non-MFIs excluding general government. Monthly data were aggregated at the quarterly level using the end-of-quarter values.
2. Real GDP (Y) is defined as the seasonally adjusted real output in millions of euros using non-transformed data under the ESA 2010 statistical definition.
3. Policy rate (I) is created using the ECB's main refinancing operations (MRO) rate. In the case where there has been more than one change in the rate during the same month the average rate has been used. A quarterly average of the policy rate was then employed in the estimation.
4. Deposits (D) are defined as total maturity outstanding amounts at the end of the period (stocks) by MFIs, excluding ESCB reporting sector, all currencies combined - euro area (changing composition) denominated in euros. Counterpart sector is non-MFIs. Monthly data were aggregated at the quarterly level using the end-of-quarter values.
5. Credit risk (R) is defined as the ratio of bank lending (L) to total bank assets as obtained by the ECB's SDW. The ratios were created at a monthly frequency and then averaged at the quarterly level.