Macroeconomic Implications of Money Market Uncertainty

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The views expressed in this paper are those of the authors and do not necessarily reflect those of the European Central Bank and the Eurosystem.
1. Introduction
   • The question
   • Measurement of money market uncertainty
   • Preview of results

2. Empirics
   • BVAR - Impulse-Response Analysis
   • Robustness to identification assumptions

3. Implications of the results
   • Relevance for structural models of the business cycle
   • The debate on the macroeconomic effects of uncertainty
   • Policy relevance

4. Conclusions
The financial sector and business cycle fluctuations

Financial crisis (and subsequent economic recession and sovereign debt crisis)

- Revived interest in the study of the role of the financial sector for business cycle fluctuations
- Financial shocks and financial frictions (amplification of effects of all exogenous shocks)
- E.g. see surveys in Brunnermeier, Eisenbach and Sannikov (2012) – Christiano, Motto and Rostagno (2013)

The role of **financial intermediaries** for business cycles

- This issue is relevant in general
- Particular importance for the euro area
The euro area is a bank based system

Indicators of financial structure in the euro area and the United States (end 2007)

- Bank credit to non-banks in euro area 137% of GDP (62% in the US)
- Loans to non-financial corporations 50% of GDP (17% in the US)


The situation has not changed much recently (see also De Fiore and Uhlig, 2011)
The funding side of euro area banks: retail and wholesale

The money market is a very important source of funding

- Roughly as much as deposits of households and firms in 1999
- About double as much just before the crisis
- Recent marked drop (particularly non-resident flows, see Colangelo et al. 2014)
- Still relevant source of funding
The question of the paper

- Euro area is a strongly bank based system
- Relevance of the money market for bank funding

We aim to investigate if and through which channels the money market may affect business cycle fluctuations in the euro area.

In particular, we address a more specific, narrower aspect:

Do changes in uncertainty in the money market rates affect the euro area economy?

Our measure of uncertainty in the money market is a measure of dispersion of the distribution of future interbank rates (more details later).

It captures the uncertainty surrounding the expected prices of interbank liquidity, which might induce banks to limit wholesale funding activities.
Transmission mechanisms: intuition

Uncertainty surrounding the future pricing of interbank liquidity

e.g.: associated to increase in cross-section dispersion of future interbank rates due to (i) imperfect knowledge of heterogeneous counterparty risk exposures; (ii) idiosyncratic liquidity shocks; (iii) ...

Funding Problems

Deleveraging

Strains in the interbank market

balance sheet adjustment

lending margins increase

Adverse macro effects

Akin to a standard sit-and-wait strategy where firms limit and/or postpone their investment plans because of high economic uncertainty.
Money market uncertainty: measurement

Option-implied probability density function of the three-months Euribor (interbank rate) in one year (futures contracts)

Our measure of money market uncertainty is obtained by taking the difference between the 75th and the 25th percentiles of the option implied density

Focus on future expected term rates (3m Euribor) rather than spot overnight EONIA

• EONIA volatility in spot market mostly driven by policy actions
• attempt at capturing other phenomena like counterparty risk
Money market uncertainty: description and chronology

Realised and Implied Volatility

Option-implied probability density functions for 3m EURIBOR 1y ahead

Note: LHS: Realised Volatility refers to the 1-month standard deviation of the 3m-in-1y Eonia Forward; Implied Volatility is measured by the difference between the 75th and the 25th percentile of the Option-Implied Probability Density Functions of the 3-month Euribor in 1-year. RHS: Option-Implied Probability Density Functions of the 3-month Euribor in 1-year at different dates.
Short answer to our question

Does money market uncertainty matter for macroeconomic fluctuations?

YES!!

Relevant elasticity of macroeconomic variables to money market uncertainty

- The effects of economic shocks may be amplified/dampened by changes in money market uncertainty

Exogenous changes in money market uncertainty (money market uncertainty shocks) do not seem to be too important to explain macroeconomic fluctuations
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Empirical strategy

The potential endogeneity of money market uncertainty complicates the estimation of the elasticity of other variables to our measure of uncertainty.

Our strategy: look for an exogenous trigger of money market uncertainty, i.e. changes in money market uncertainty “per se”.

Tool: identification of an exogenous “money market uncertainty” shock in a (B)VAR.

Our estimate of “elasticities” are given by the impulse response functions to the shock.
Benchmark VAR Model Specification

\[ X_t = \nu + A_1 X_{t-1} + \cdots + A_p X_{t-p} + \epsilon_t \]
\[ \epsilon_t \sim N(0, \Sigma) \]

Sample: since the onset of the EMU (January 1999 – February 2014)
Frequency: Monthly
Data transformation: (log-)_level; Lags: 13

Variables:

1. Industrial Production
2. Unemployment Rate
3. HICP
4. Loans to private sector
5. Composite Lending rate to the private sector
6. EONIA
7. Euribor-OIS spread
8. 3m-in-1y Eonia OIS Forward
9. 3m-in-2y Eonia OIS Forward
10. 3m-in-3y Eonia OIS Forward
11. Option implied volatility of 3m-in-1y Euribor
12. Future Implied bond volatility

Curse of dimensionality?
Estimation uncertainty makes the model unstable/unreliable → Need to limit variability owing to estimation error
**Handling the curse of dimensionality**

**IDEA: Mixed estimation**

\[
\text{Data} \quad + \quad \text{Prior} \\
\text{(Complex/Rich)} \quad \text{(Parsimonious/Naïve)}
\]

→ **Stable and reliable estimation of complex model if data comove (as typically macroeconomic data)**

**Comovement:** sample information in all variables “massively” points in the same direction against the prior

For details see:

De Mol, Giannone and Reichlin (2008)

Banbura, Giannone and Reichlin (2010)
How do we control for overfitting, in practice?

In practice, we shrink the coefficient of the model toward those of the random walk models in levels with drift:

\[ y_{i,t} = c_i + y_{i,t-1} + \varepsilon_{i,t} \]

i.e. we use the Minnesota prior (random walk, plus an inverse-Wishart prior on the covariance matrix \( \Sigma \)). Litterman (1980)

We also use two types of priors on the sum of coefficients originally proposed by Doan, Litterman, and Sims (1984) and Sims (1993).
We treat the parameters describing the tightness of the BVAR prior distributions (hyper-parameters) as random variables (Giannone, Lenza and Primiceri, 2012)

We draw the hyper-parameters from their posterior distribution (in the spirit of hierarchical models)

This allows us to take into account the uncertainty surrounding the prior selection.

The hyper-priors (prior distributions on the hyper-parameters) are informative, but results do not change if we use flat hyper-priors
Identification assumptions

How do we get our exogenous trigger of money market uncertainty? Recursive ordering

- Variables ordering:
  1. Industrial Production
  2. Unemployment Rate
  3. HICP
  4. Loans to private sector
  5. Composite Lending rate to private sector
  6. EONIA
  7. Euribor-OIS spread
  8. 3m-in-1y Eonia OIS Forward
  9. 3m-in-2y Eonia OIS Forward
  10. 3m-in-3y Eonia OIS Forward
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  12. Future Implied bond volatility

Idea:

- macro slower to react than financial variables (like our measure of money market uncertainty)

- harder to judge on other financial variables
  - conservative choice for estimate of our shock: control out contemporaneous correlation with all other variables (except bond market volatility) to eliminate endogeneity as much as possible
Interbank market tensions and deleveraging

Euribor Implied Volatility

Spread Euribor-OIS

Bank Loans to the private sector

Lending rate margins
Adverse macro impact

Industrial Production

Unemployment Rate

HICP Price index

EONIA

www.ecb.europa.eu
Spillover to other market uncertainty

![Graph of implied bond market volatility over time. The x-axis represents months after shock, while the y-axis shows implied volatility.](https://www.ecb.europa.eu)
Robustness: ordering of the variables

Industrial Production

Unemployment Rate

HICP Price Index

Loans
Historical decomposition

Contribution of money market uncertainty shock – bank loans
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Importance of modelling frictions on the bank funding side. Some examples:

Gertler and Kiyotaki (2010):
- the first signals of a crisis are often strains in the interbank market
- financial institutions subject to idiosyncratic "liquidity" shocks
- surplus and deficits of funds across financial institutions
- frictions in wholesale and retail financial market (agency problem)

Brunnermeier and Pedersen (2009):
- market liquidity declines as fundamental uncertainty increases
- liquidity spirals induce volatility increases.

Our results show that changes in money market uncertainty may have non-trivial macroeconomic effects

importance of modelling specific frictions on bank funding (money market uncertainty accelerator)
The debate on the macroeconomic effects of uncertainty

Growing literature on the macroeconomic effects of uncertainty


- **Index of policy uncertainty** - Baker, Bloom, and Davis (2011)

- **Impact of uncertainty is amplified in a context of economic policy changes** Baker et al. (2011); Fernández-Villaverde et al. (2011), *and at times of financial distress* (Romer, 1990; Bloom, 2009).

This paper seems to identify an additional source of macro relevant uncertainty

- Macroeconomic fluctuations amplified by changes in money market uncertainty (significant elasticity)

Is it money market uncertainty that matters or the elasticities we estimate simply reflect the omission of other measures of uncertainty?
Common measures of general economic uncertainty

- Bond Implied Volatility
- Stock Implied Volatility
- Expected Default Frequency
- Composite Indicator Systemic Stress
- Inflation disagreement
- GDP disagreement
- News Uncertainty Index
Common measures of general economic uncertainty

![Graph showing economic uncertainty measures](www.ecb.europa.eu)
Cross-correlation between Euribor volatility at time $t$ and the principal component of general economic uncertainty measures at time $t+k$ evaluated recursively from January 2008 to January 2014.
Cross-correlation between Euribor volatility at time $t$ and the principal component of general economic uncertainty measures at time $t+k$ evaluated recursively from January 2008 to January 2014.
Robustness: other variables

Additional Variables:
1. Excess Liquidity
2. Bond Securities Issuance by Banks
3. Bank bonds spreads
4. Eonia Volume
5. Euribor Future Volume

Other measures of uncertainty
1. Implied Stock market volatility (VIX)
2. Composite Indicator of Systemic Stress (CISS)
3. Volatility of macroeconomic news

Results are confirmed! The elasticity estimations are robust to the inclusion of additional variables.

Money market uncertainty does not simply reflect other sources of uncertainty
The actions of the monetary policymaker can (at least in part) affect money market uncertainty and, hence, the economy through the channel identified in this paper.

- **Example:** fixed rate full allotment (post-Lehman): the Eurosystem committed to offer *as much liquidity as needed by the banks* at fixed rate to restore the pass-through of the policy rate to money market rates (and lending rates).

- Among other things, the Eurosystem absorbed risk by standing between banks (substitution of interbank liquidity with central bank liquidity, see Lenza, Pill and Reichlin, 2009).

**In order to give some example of the possible relevance of this channel, policy counterfactual on the V-Long Term Refining Operations at end 2011**

- Idea of exercise: permanent change in money market uncertainty post-VLTRO (size more or less five times the standard deviation of our shock) due to policy.

- Compare observed macroeconomic outcomes with those that would prevail had the drop in money market uncertainty not materialized.
Spot market: uncertainty influenced by policy interventions

Policy rates corridor

Excess liquidity: Current Account - Reserve requirements + Deposit Facilities - Marginal Lending Facilities. Corridor: [0 0.25 0.75]; 14 May 2014: EONIA 0.17; Excess Liquidity 113 bn
Conclusions

Changes in money market uncertainty play a role to amplify/dampen the effects of macroeconomic shocks (while exogenous shocks to money market uncertainty do not play a relevant role)

Macroeconomic effects remain robust after controlling for a number of measures of uncertainty, stock market volatility, financial stress indicators, and volatility of macroeconomic news

- **Implications for theory**: importance of frictions on the funding side of banks! Affecting the economy (also) through changes in money market uncertainty

- **Implications for the literature on uncertainty**: uncertainty on money market rates contains information on the macroeconomic environment over and above standard economic uncertainty measures. A new measure of uncertainty? Relationships with the other measures?

- **Implications for policy**: monetary policy can contribute to reduce this uncertainty and, hence, this can be seen as a supplementary channel through which standard and non-standard monetary policy affect the economy.
Background
**Relevance:**
The % of users that have set an alert for the particular event.
Ex.: 97% of the users have set an alert to be notified before scheduled release of the FOMC Rate Decision.

**Publication Lag:** depends on the variable

**Employment report:**
Change in Nonfarm Payrolls
Change in Private Payrolls
Unemployment Rate
Average Hourly Earning
Real-time measure of economic uncertainty

Real-time Uncertainty: square root of the weighted average of the squared (daily) macroeconomic surprises

Jan08  Jan09  Jan10  Jan11  Jan12  Jan13  Jan14
Lehman  LTRO   OMT    FG
The panel comprised 161 credit institutions.
Policy counterfactual
## The timing of the LTROs operations

<table>
<thead>
<tr>
<th>Operation</th>
<th>Announcement - policy</th>
<th>Announcement - operation</th>
<th>Allotment</th>
<th>Settlement</th>
<th>Maturity</th>
<th>Maturity</th>
<th>First date for early repayment</th>
</tr>
</thead>
<tbody>
<tr>
<td>One-year LTRO</td>
<td>07 May 2009</td>
<td>23 Jun 2009</td>
<td>24 Jun 2009</td>
<td>25 Jun 2009</td>
<td>1 Jul 2010</td>
<td>12 months</td>
<td>-</td>
</tr>
<tr>
<td>One-year LTRO</td>
<td>07 May 2009</td>
<td>29 Sep 2009</td>
<td>30 Sep 2009</td>
<td>1 Oct 2009</td>
<td>30 Sep 2010</td>
<td>12 months</td>
<td>-</td>
</tr>
<tr>
<td>One-year LTRO</td>
<td>07 May 2009</td>
<td>15 Dec 2009</td>
<td>16 Dec 2009</td>
<td>17 Dec 2009</td>
<td>23 Dec 2010</td>
<td>12 months</td>
<td>-</td>
</tr>
</tbody>
</table>
Financial fragmentation in the euro area (median absolute deviations)

Sources: ECB, ECB calculations.

Notes: “m.a.d.” stands for median absolute deviation across selected euro area countries for which historical data are available. The “m.a.d.” is computed as the cross-country dispersion of the time-averages for each of the four periods. The dispersion measure for banks cost of financing and the composite lending rates to households and NFCs have been scaled by 10 for better visualisation.
(i) the start of the global financial crisis in September 2008 (Lehman collapse);

(ii) the start of the euro area sovereign debt crisis in May 2010 (Greek crisis);

(iii) the re-intensification of the euro area sovereign debt crisis, coupled with increased banking sector strain from mid-2011 on.
Central role of OIS in pricing other rates: overview

EONIA

Expectations + forward premia

Forward rates

OIS rates

Spread

Arbitrage

Other ‘risk-free’ rates

Credit risk and other spreads

Euribor and IRS

Fixed-rate loans: (Heuristic) pricing

Floating-rate loans: Indexation

Lending rates

56% of total NFC loans floating-rate – 80% of which use EURIBOR reference

80% of fixed-rate loans priced off EURIBOR

Source: ECB graphic. Fact finding exercise of the STC’s Working Group on Monetary and Financial Statistics (preliminary results)
Relation between EONIA and OIS market

EONIA:
- Overnight reference rate for euro unsecured money market
- Volatile and overall decreasing EONIA trading inter alia due to
  - Shrinking EONIA participation panel
  - Market fragmentation
  - “Crowding out” from increased central bank intermediation

Overnight index swap (OIS) market:
- Swap fixed rate against geometric average of EONIA over maturity
- Trading motives
  - Managing interest rate risk (hedging)
  - Taking positions on levels of future short rates
- Participation at low cost, over-the-counter trading, no funding needed
  ⇒ Potentially large number of participants – even at thin EONIA trading
Theoretical guidance

Funding Problems
- Bank bond yields and Volumes
- ECB liquidity

Deleveraging
- Freezing of the interbank market

Imperfect knowledge of Counterparty Risk Exposure
- ImpVol; Euribor-OIS
- Interbank market volumes

Imperfect knowledge of Counterparty Risk Exposure
- ImpVol; Euribor-OIS
- Interbank market volumes

Balance sheet adjustment
- lending margins increase
- Lonas to NFCs
- MIR

Adverse macro effects
- Y, P, Unemployment

Akin to a standard sit-and-wait strategy where firms limit and/or postpone their investment plans because of high economic uncertainty.
The effect of Uncertainty shock

Index of policy uncertainty - Baker, Bloom, and Davis (2011)

Figure 8: Estimated Industrial Production after a Policy Uncertainty Shock

Notes: This shows the impulse response function for Industrial Production and employment to an 124 unit increase in the policy-related uncertainty index, the increase from 2006 (the year before the current crisis) until the first 8 months of 2011. The central (black) solid line is the mean estimate, while the dashed (red) outer lines are the one-standard-error bands. Estimated using a monthly Cholesky Vector Auto Regression (VAR) of the uncertainty index, log (S&P 500 index), federal reserve funds rate, log employment, log industrial production and time trend. Data from 1985 to 2011.
Source and definitions for data on bank systems.

Sources: ECB, Eurostat, Dealogic, Thomson Financial Datastream and Federal Reserve Board of Governors.

Notes: Total bank financial assets refers to the aggregated MFI sector for the euro area and to the sum of commercial banks, savings institutions, credit unions, money market mutual funds, and security brokers and dealers for the United States.