The Maturity of Sovereign Bond Issuance in the Euro Area

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Motivation and overview

- What determines debt maturity choice of govts. in Eurozone?
- Eliciting policymakers' preferences from data on composition of debt stock is difficult – changes in maturity are slow-moving
- Unique dataset of Eurozone sovereign debt auctions 1999-2017
- New debt issuances provide opportunity to move maturity composition into preferred direction
- Our debt auction data should provide information on maturity preferences

Motivation and overview

- Start with theoretical framework with trade-off between short and long maturity in the face liquidity preference shocks, shocks to risk aversion and to repayment capacity (roll-over risk)

- Relationship between maturity and yield curve

- Study effects of underlying shocks to liquidity preference, risk aversion and repayment capacity
  - Univariate regressions
  - Panel vector auto-regression

Model

- Combines approach Broner et al. (2013), which trades off higher cost of longer debt against lower roll-over risk, with adding liquidity services of short risk-free debt (Greenwood et al., 2015)

- Roll-over risk is relevant for euro-area:

  – CACs since 2013
  – Haircut 2012 privately-held Greek government debt
  – Ongoing discussions about sovereign debt restructuring framework

Model

- Three periods: 0, 1, 2
- Government maximizes $U = E_0\left[u(G_1) + \sum_{j=1}^{S} Pr(j = s)u(G_{2s})\right]$
- Period 0, government can restructure debt subject to

$$P_{01}B_{01} + P_{02}B_{02} = P_{01}\overline{B_{01}} + P_{02}\overline{B_{02}}$$

- Period 1 government budget constraint is

$$B_{01} + G_1 = P_{12}B_{12}$$

Model

- Period 2: government received exogenous fiscal revenues y

$y = \bar{y}$ with probability $\pi > 0$ *repayment*

$y = 0$ with probability $1 - \pi$ *default*

- Utility international investor

$$U = C_0 + E_0[m_1 C_1 + m_1 m_2 C_2] + v(B_{01})$$

- Zero risk-free rate in both periods: $E_0[m_1] = E_1[m_2] = 1$

Model

- Period 0 short-term debt is riskless:

$$P_{01} = E_0[m_1] + v'(B_{01}) = 1 + v'(B_{01}).$$

- Investors risk-neutral w.r.t. investment period 1:

$$P_{12} = \pi$$

- Price period-0 long bonds is $P_{02} = E_0[P_{12}m_1] = E_0[\pi m_1]$. With π and m_1 negatively correlated,

$$P_{02} = \sigma\pi_0,$$

Model: timing

- Period 0: govt. chooses optimal maturity structure (B_{01}, B_{02}); investors choose bond holdings; prices short and long debt materialize.

- Period 1: prob. π of a good state in period 2 materializes; government determines period-1 public consumption; combined with amount maturing debt, this determines amount short debt issued in period 1.

- Period 2: state materializes; govt. repays as much debt as possible; remainder, if any, spent on public consumption.

- Solution by working backward

Proposition 1

- Higher risk aversion (lower σ) produces in period 0:
  - a shortening of the mature structure
  - an upward shift in the yield curve level (fall in P_{01} and P_{02})
  - no unambiguous effect on the slope can be established.

- Risk aversion $\uparrow \rightarrow$ risk premium long bond $\uparrow \rightarrow$ to restore equilibrium, liquidity services short debt $\uparrow$

Proposition 2

- Reduced expected repayment prob. π_0 leads in period 0 to:
  - lengthening of the maturity structure
  - increase in the yield curve slope (P_{01} rises, P_{02} falls)
  - no unambiguous effect on the yield curve level can be established

- P2: $\pi_0 \downarrow \rightarrow$ government less wealthy $\rightarrow$ relative risk aversion $\uparrow$ $\rightarrow$ given variance repayment probability around π_0, (exp.) marg. utility govt. in periods 1 and 2 is higher if $\pi < \pi_0 \rightarrow$ govt. issues more long debt to limit fluctuations in marginal utility

Proposition 3

- Assume that $v(B_{01}) = \gamma f(B_{01})$ and suppose γ rises – then in period 0:
  - the maturity structure shortens
  - the slope of the yield curve increases (P_{01} rises, P_{02} remains unchanged)
  - the yield curve level shifts down

- P3: marg. utility liquidity services $\uparrow \rightarrow$ to restore optimal trade-off, issue relatively more short

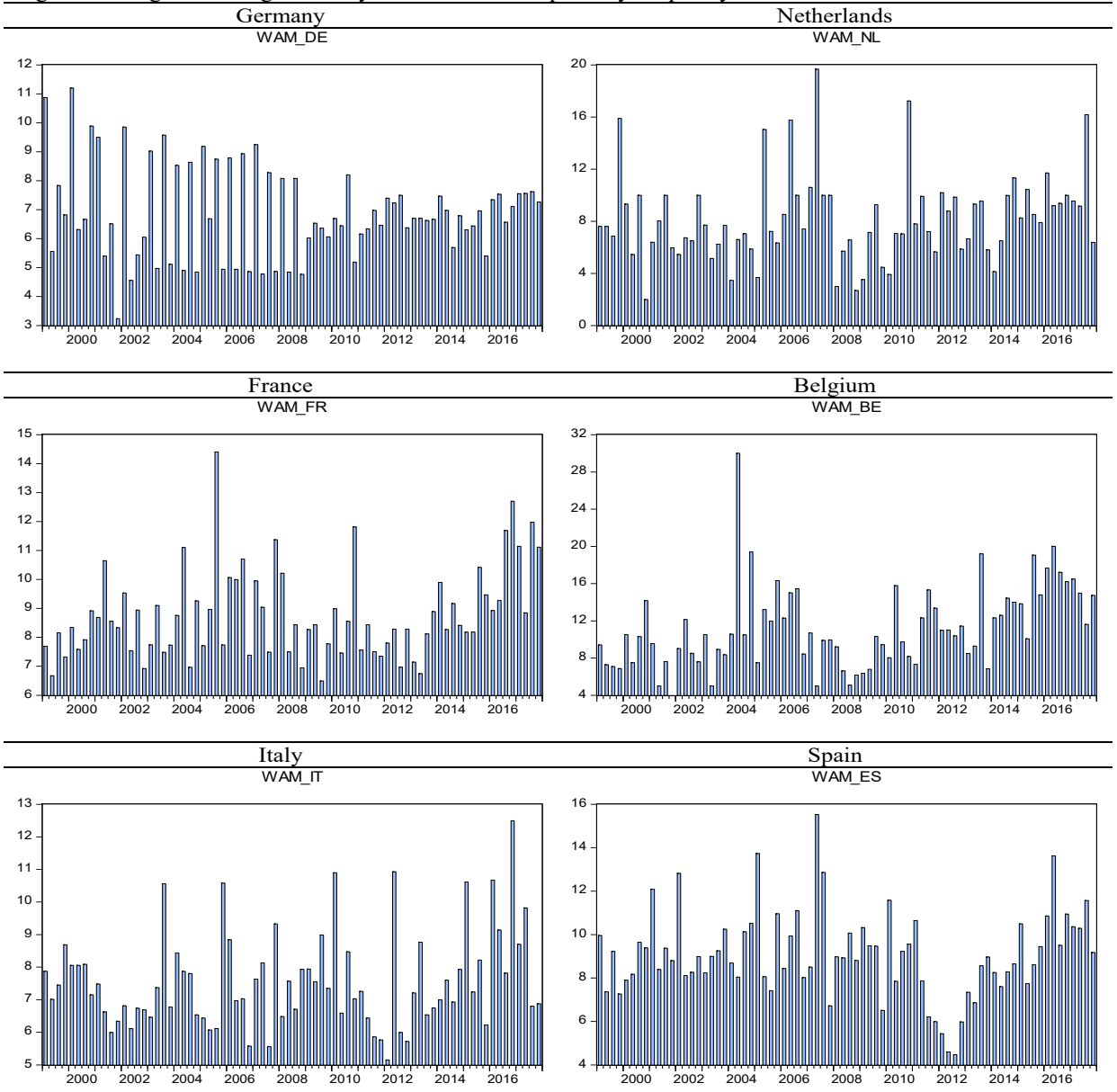
Data

- Sovereign debt auctions Germany, Netherlands, France, Italy, Spain, Belgium
- Period is 1 January 1999 tot 31 december 2017
- Selection of issues
  - Issues of maturity more than 1 year (distinction bill and bond issue; short debt used as bridge and shock buffer)
  - No foreign currency debt
  - No inflation linked debt
- Quarterly weighted average maturity (WAM):

$$WAM_t = \frac{\sum_{m=2}^{50} m * AUC\_S_{m,t}}{\sum_{m=2}^{50} AUC\_S_{m,t}},$$

Weighted average maturity new debt issues

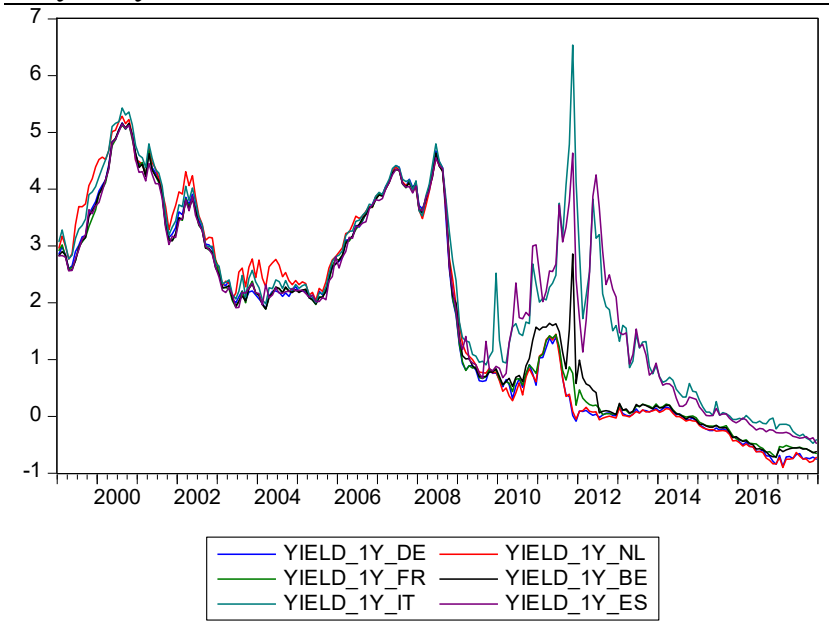
Figure 1: Weighted average maturity of bond issues at quarterly frequency



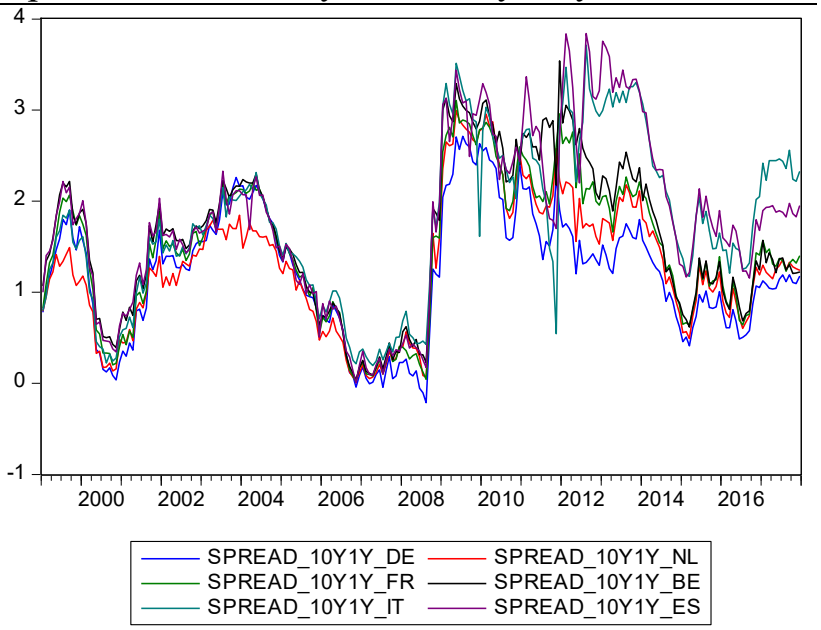
Secondary market yields

Figure 2: Secondary market yields

1-year yields



Spread between 10-year and 1-year yields



Relationship WAM – yield curve

Table 1: WAM and yield curve

$$WAM_{i,t} = c_i + \delta_i t + \mu \sum_{j=1}^{s} D_{j,t} + \beta_1 LEVEL_{i,t-1} + \beta_2 SLOPE_{i,t-1} + \varepsilon_{i,t}$$

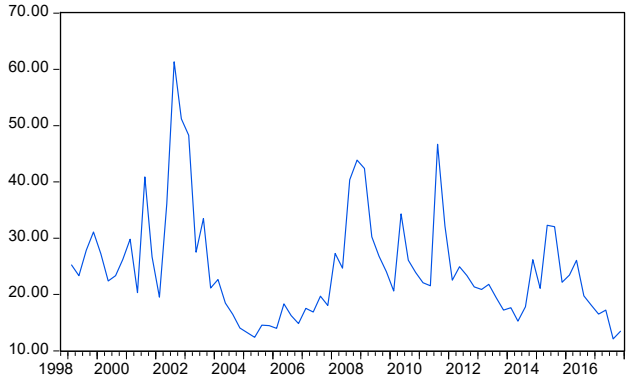
	Germany	Netherlands	France	Belgium	Italy	Spain	Panel	Panel GNFB	Panel IS
β_1	-0.36***	-0.70	-0.46	-1.80**	-0.55***	-0.67**	-0.73***	-0.87***	-0.63***
β_2	-0.58*	-2.55**	-1.61***	-1.11	-0.47	-1.71***	-1.33***	-1.53***	-1.14***
Adj. R^2	0.35	0.085	0.14	0.17	0.13	0.24	0.32	0.32	0.32
Obs.	76	76	76	75	76	76	455	303	152

Notes: Estimation is for the period January 1, 1999 – December 31, 2017. Estimation method is Ordinary Least Squares (OLS) with Newey-West adjusted standard errors. The columns under the headers "Full panel", "Panel GNFB" and "Panel IS" report panel OLS regressions estimated with country fixed effects. Further, *, ** and *** denote significance at the 10%-, 5%-, and 1%-levels, respectively. Finally, "Panel GNFB" is the sub-panel formed by Germany, Netherlands, France and Belgium, and "Panel IS" is the sub-panel formed by Italy and Spain.

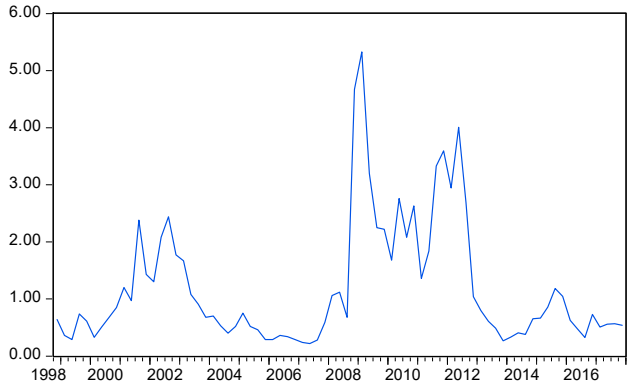
Explanatory variables

Figure 3: Additional variables

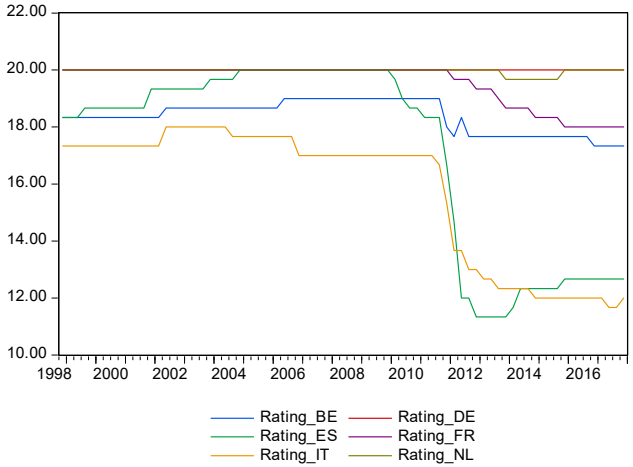
VSTOXX



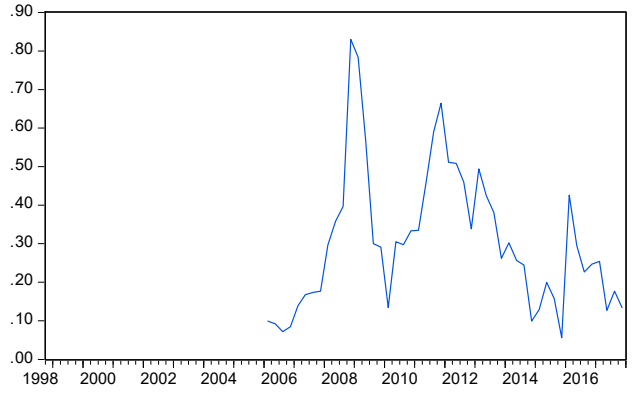
Short- and long-term safety premia



Credit rating



10-year KfW-bund spread



Relationship yield curve – underlying shocks

Table 4: Yield curve and underlying shock sources

$Y_{i,t} = c_i + \delta_i t + \mu \sum_{j=1}^{s} D_{j,t} + \beta X_{i,t-1} + \varepsilon_{i,t}$

	$Y_{i,t} = LEVEL_{i,t}$			$Y_{i,t} = SLOPE_{i,t}$		
	Full panel	Panel GNFB	Panel IS	Full panel	Panel GNFB	Panel IS
ST Safety	0.20***	0.016	0.50***	0.21***	0.18***	0.24***
VSTOXX	-0.028***	-0.019***	-0.041***	0.0010	0.0029	-.00028
Rating	0.026	0.40***	-0.038	-0.037***	0.15***	-0.053***
MRO	0.57***	0.56***	0.56***	-0.20***	-0.22***	-0.19***
Adj. R^2	0.87	0.94	0.72	0.65	0.64	0.64
Obs.	450	300	150	450	300	150

Notes: See *Notes* to Table 1.

Estimates

- VSTOXX: downward level shift: against theory; no prediction about slope
- Better rating: predicts less steep slope: conflicting findings; no prediction about level
- ST Safety: bbb-aaa corporate debt; rise in level goes against theory; increase in slope in line with theory

Relationship WAM – underlying shocks

Table 5: WAM and underlying shock sources

$$WAM_{i,t} = c_i + \delta_i t + \mu \sum_{j=1}^{s} D_{j,t} + \beta X_{i,t-1} + \varepsilon_{i,t}$$

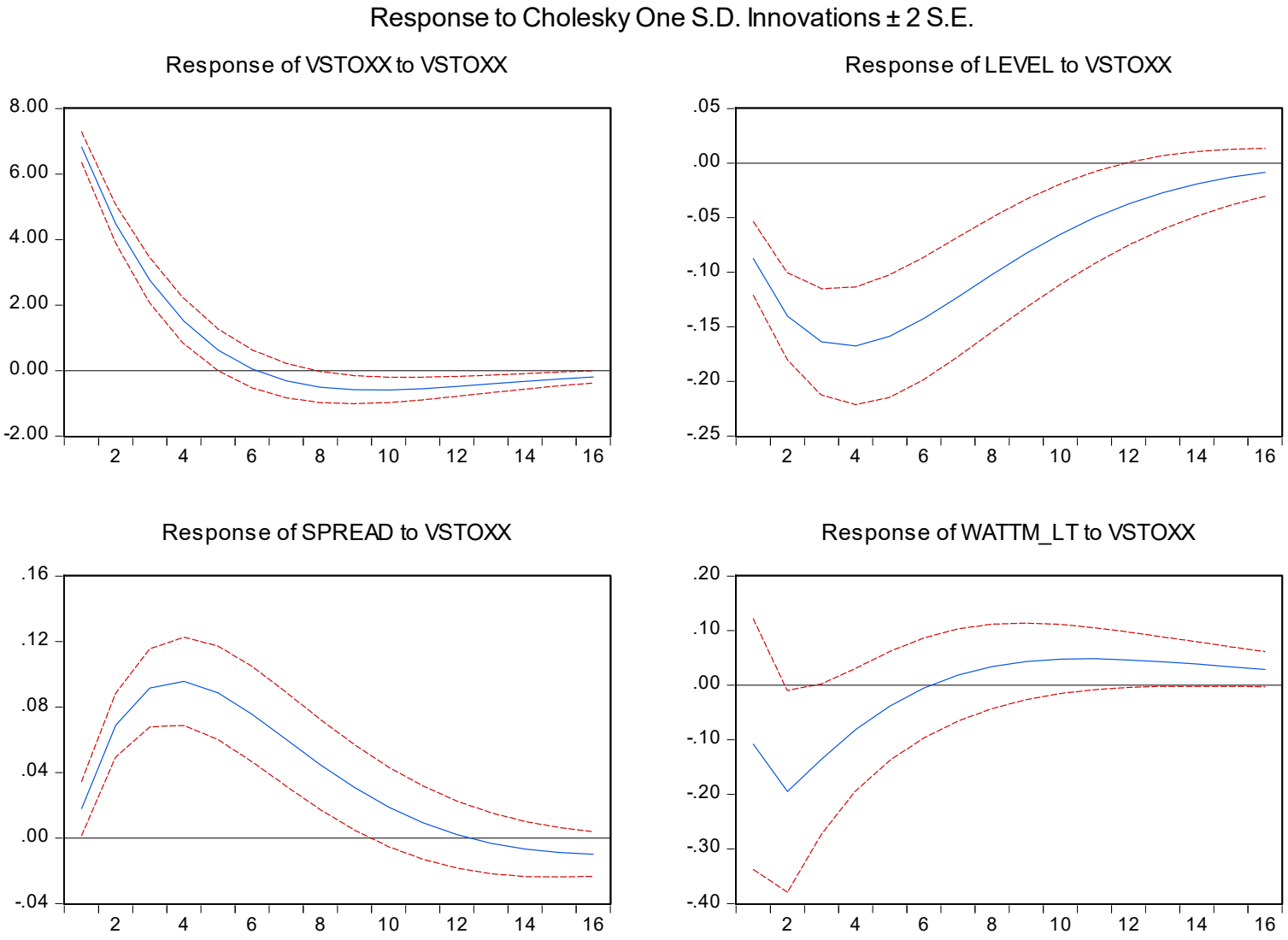
	Full panel	Panel GNFB	Panel IS
ST Safety	-0.49***	-0.32	-0.62***
VSTOXX	-0.0089	-0.032	0.025
Rating	0.19	-0.62	0.22**
MRO	-0.32**	-0.36*	-0.11
Adj. R^2	0.31	0.33	0.22
Obs.	449	299	150

Notes: See *Notes* to Table 1.

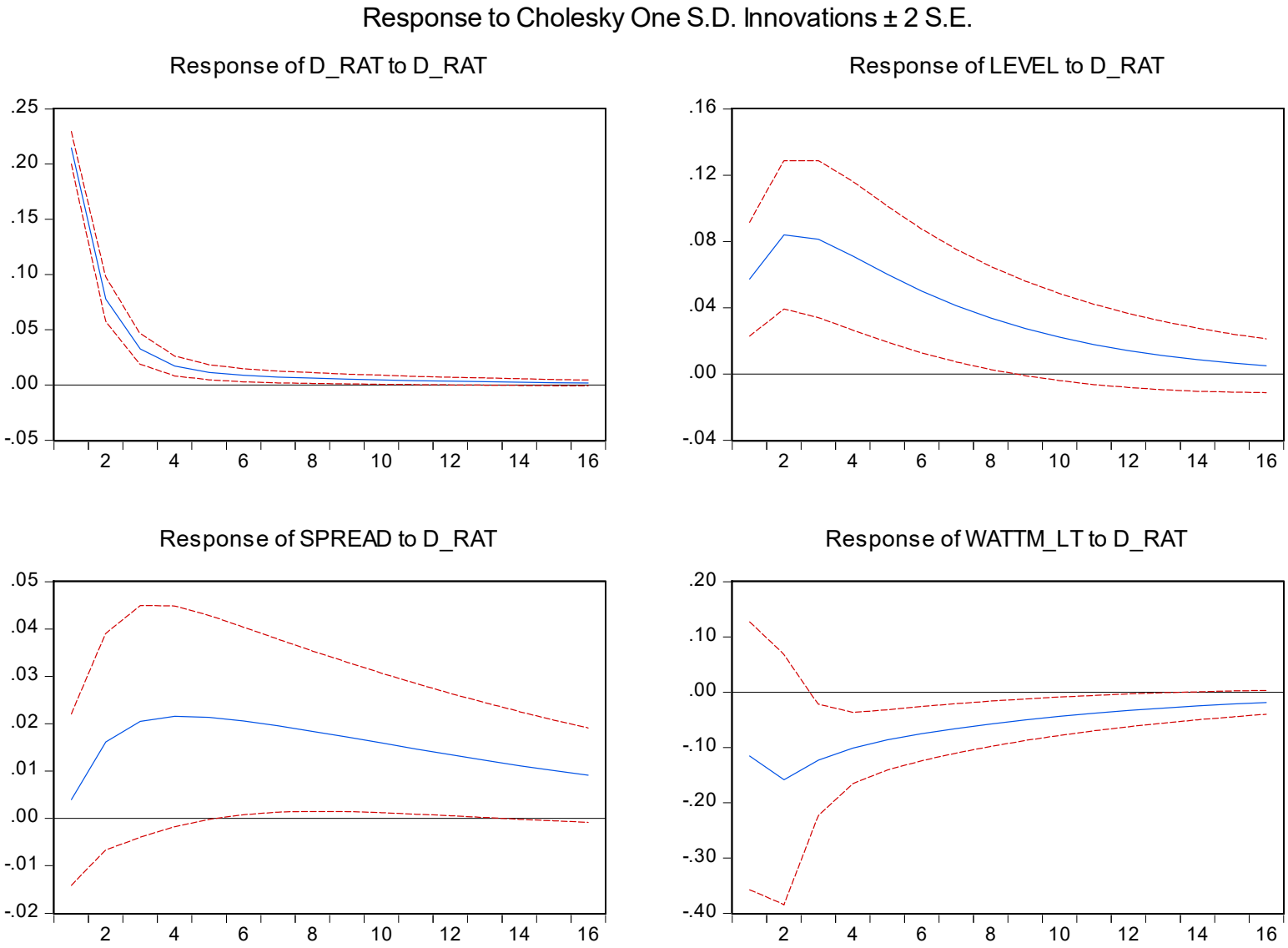
Estimates

- VSTOXX: theory predicts shortening – no evidence
- Better rating: theory predicts shortening – no evidence
- ST Safety: shortening in line with theory

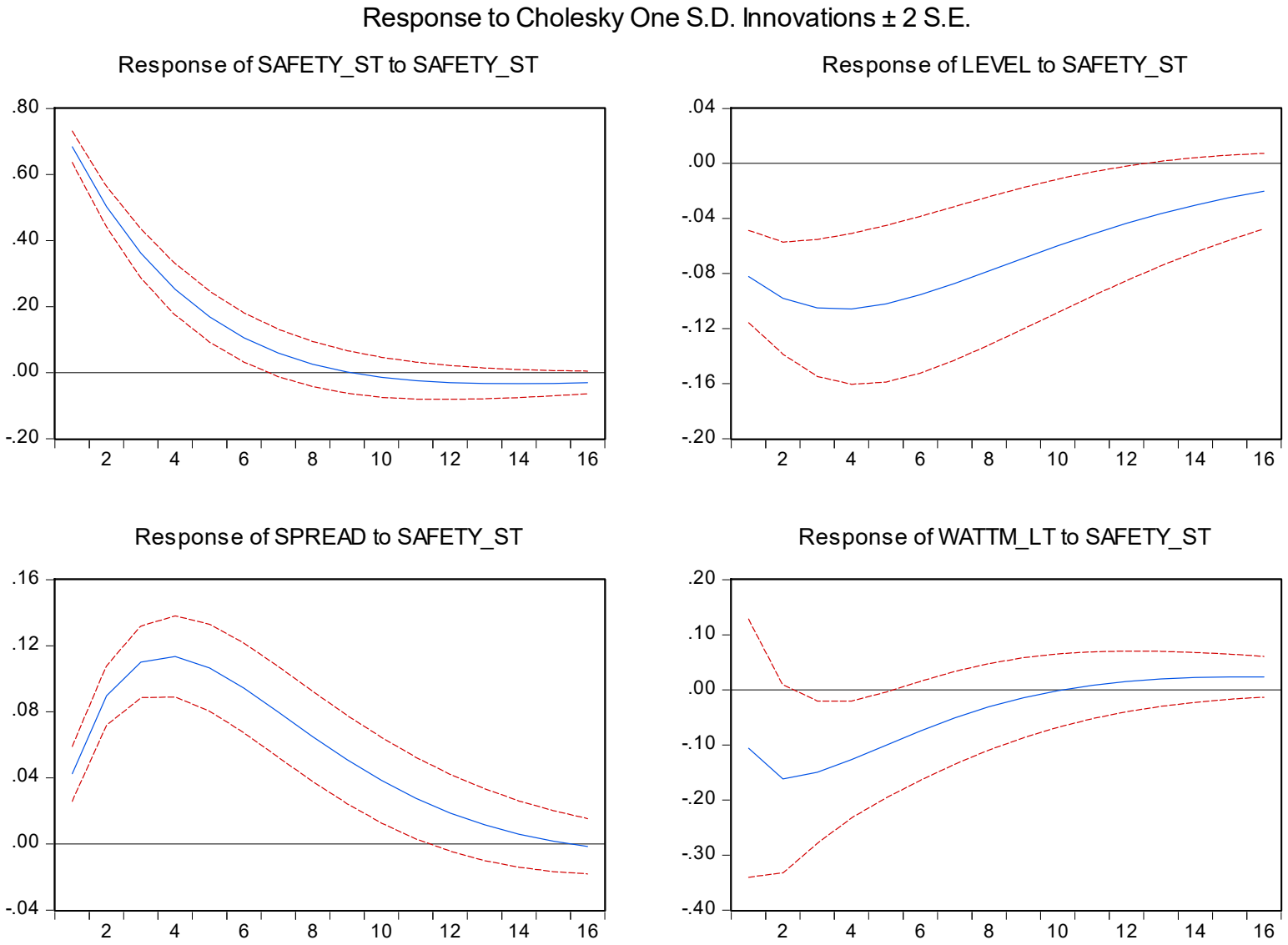
Impulse response shock VSTOXX



Impulse response positive rating shock



Impulse response positive liquidity preference shock



Concluding remarks

- Dataset of new debt issues provides unique opportunity to elicit maturity preferences
- Theoretical framework trading off short and long maturity in face liquidity pref. shocks, shocks to risk aversion and roll-over risk
- Strong negative link WAM and level and slope yield curve
- Mixed evidence shock sources – liquidity preference seems most relevant

ADDITION SLIDES

Relationship WAM – yield curve: contemporaneous variables

Table 2: WAM and yield curve – contemporaneous explanatory variables

$$WAM_{i,t} = c_i + \delta_i t + \mu \sum_{j=1}^{s} D_{j,t} + \beta_1 LEVEL_{i,t} + \beta_2 SLOPE_{i,t} + \varepsilon_{i,t}$$

	Germany	Netherlands	France	Belgium	Italy	Spain	Panel	Panel GNFB	Panel IS
β_1	-0.49***	0.075	-0.20	-2.01***	-0.43***	-0.63**	-0.62***	-0.77***	-0.55***
β_2	-0.97**	-2.12*	-1.41***	-2.47**	-0.42	-1.75***	-1.59***	-1.96***	-1.16***
Adj. R^2	0.37	0.072	0.10	0.21	0.075	0.23	0.32	0.33	0.30
Obs.	76	76	76	75	76	76	455	303	152

Notes: See *Notes* to Table 1.

Relationship WAM – yield curve: IV estimates

Table 3: Instrumental variables regression

$WAM_{i,t} = c_i + \delta_i t + \mu \sum_{j=1}^{s} D_{j,t} + \beta_1 LEVEL_{i,t} + \beta_2 SLOPE_{i,t} + \varepsilon_{i,t}$,

	Full panel	Panel GNFB	Panel IS
β_1	-0.94***	-1.26***	-0.50**
β_2	-1.87***	-2.41***	-1.42***
Adj. R^2	0.32	0.32	0.29
Obs.	449	299	150

Notes: Estimation method is Instrumental Variables (IV) regression with Newey-West adjusted standard errors, where $LEVEL_{i,t}$ and $SLOPE_{i,t}$ are instrumented with the first lags of the short-term safety premium, the VSTOXX, the credit rating and the interest rate on Main Refinancing Operations. Further, see *Notes* to Table 1.

Relationship WAM – yield curve: sample split

Table A.1: Split between before-crisis and crisis periods

$$WAM_{i,t} = \delta_i t + \mu \sum_{j=1}^{s} D_{j,t} + DPRE * \left(c_{1,i} + \beta_1 LEVEL_{i,t-1} + \beta_2 SLOPE_{i,t-1}\right) + (1 - DPRE)\left(c_{2,i} + \gamma_1 LEVEL_{i,t-1} + \gamma SLOPE_{i,t-1}\right) + \varepsilon_{i,t}$$

	Quarterly		
	Full panel	Panel GNFB	Panel IS
β_1	-0.17	-0.14	-0.18
β_2	-0.44	-0.35	-0.57
γ_1	-0.50***	-0.40*	-0.60***
γ_2	-0.78**	-0.57	-0.98**
$\beta_1 = \gamma_1$	3.81*	1.12	4.89**
$\beta_2 = \gamma_2$	0.28	0.063	0.32
Joint test	2.21	0.61	2.91*
Adj. R^2	0.36	0.36	0.31
Obs.	455	303	152

Notes: $DPRE$ is a dummy with value 1 over the period January 1, 1999 – June 30, 2007. Further, see *Notes* to Table 1.

Correlations

Table A.2: Correlations between variables

	VSTOXX	ST_SAFETY	RAT_BE	RAT_DE	RAT_ES	RAT_FR	RAT_IT	RAT_NL
VSTOXX	1.00							
ST_SAFETY	0.60	1.00						
RAT_BE	0.25	0.27	1.00					
RAT_DE	0.08	0.19	0.42	1.00				
RAT_ES	0.22	0.14	0.91	0.51	1.00			
RAT_FR	0.26	0.28	0.84	0.49	0.85	1.00		
RAT_IT	0.26	0.14	0.88	0.52	0.97	0.92	1.00	
RAT_NL	0.08	0.19	0.42	1.00	0.51	0.49	0.52	0.90

Notes: Correlation at monthly frequency. The credit rating instruments are relative credit ratings. "RR_X" denotes the relative credit rating of country X.

Yield curve and shocks: KfW Bund spread

Table A.4: Yield curve and underlying shock sources – KfW-Bund spread replaces short-term safety premium

$Y_{i,t} = c_i + \delta_i t + \mu \sum_{j=1}^{s} D_{j,t} + \beta X_{i,t-1} + \varepsilon_{i,t}$

	$Y_{i,t} = LEVEL_{i,t}$			$Y_{i,t} = SLOPE_{i,t}$		
	Full panel	Panel GNFB	Panel IS	Full panel	Panel GNFB	Panel IS
KfW spread	0.80***	-0.27	2.72***	1.44***	1.19***	1.70***
VSTOXX	-0.026***	-0.021***	-0.039**	0.0027	0.0037	-0.0012
Rating	-0.018	0.34***	-0.029	-0.015	0.36***	-0.029
MRO	0.36***	0.46***	0.20	-0.29***	-0.28***	-0.27***
Adj. R^2	0.86	0.95	0.70	0.73	0.75	0.70
Obs.	282	188	94	282	188	94

Notes: See *Notes* to Table 1.

WAM and shocks: KfW Bund spread

Table A.5: WAM and underlying shock sources – KfW-Bund spread replaces ST and LT Safety variables

$$WAM_{i,t} = c_i + \delta_i t + \mu \sum_{j=1}^{s} D_{j,t} + \beta X_{i,t-1} + \varepsilon_{i,t}$$

	Quarterly		
	Full Panel	Panel GNFB	Panel IS
KfW	-3.34***	-3.27**	-3.21**
VSTOXX	-0.012	-0.025	0.020
Rating	0.31**	-0.27	0.29*
MRO	-0.099	-0.32	0.30
Adj. R^2	0.41	0.45	0.19
Obs.	282	188	94

Notes: See *Notes* to Tables 1.