Modelling the Time-Variation in Euro Area Lending Spreads[1]

Appendix

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A. Data sources

Data for EONIA, as well as data on long-term lending spreads, have been obtained through the ECB statistical warehouse. Data for the shadow short rate (SSR) has kindly been provided by Marcello Pericoli and Marco Taboga from their paper Pericoli and Taboga (2015), and obtained through Prof. Jing Cynthia Wu's website[2] and from the website of the Reserve Bank of New Zealand. Data on government bond yields has been obtained from the FRED database. Data on the weighted average cost of liabilities was kindly provided by Anamaria Illes, Marco Lombardi and Paul Mizen from their paper Illes et al. (2015).

Data on the variables for the probit model have kindly been collected by Anamaria Illes and Diego Urbina at the Bank for International Settlements from various sources, namely Bloomberg, Datastream, Eurostat, Markit, IMF IFS, ECB and national data. Data on CDS spreads were obtained from Markit, and data on bank stock prices from Datastream. The VIX, MOVE and VSTOXX indices were obtained from Bloomberg. These financial markets data series were converted from daily to monthly data by taking month-averages. The quarterly data on government debt-to-GDP ratios, net foreign asset positions as a percentage of GDP and the SSR from Pericoli and Triboga, and the semi-annual data on nonperforming loans, were interpolated to obtain monthly data with a quadratic match average method in Eviews. The other variables are at monthly frequency. For the net foreign asset position as a percentage of GDP, we checked that the results were robust to the method of interpolation. For the government debt-to-GDP ratio, the results were robust to using a cubic match average method, but not to a match-last-observation method, which shows that interpolation is not ideal. The longest data series span the period from January 2003 to March 2015.

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[2] Available at http://faculty.chicagobooth.edu/jing.wu/ .

B. List of trigger variables

Country-specific variables:

Bank stock indices

CDS spreads

Borrowing within ECB's Main Refinancing Operations (MROs)

Borrowing within ECB's Long-Term Refinancing Operations (LTROs)

Industrial production growth

HICP inflation

Net-foreign asset position expressed as a percentage of nominal gross domestic product

Debt-to-GDP ratio measured as general government gross debt as a percentage of nominal gross domestic product

Non-performing loans

Contagion variables:

VSTOXX financial volatility indicator

VIX financial volatility indicator

MOVE financial volatility index

European policy uncertainty index [Baker et al. (2015)]

Policy announcement variables

Dummy variable for the announcements of the LTROs. June, September, November 2009 - Fixed Rate Full Allotment programme.

Dummy variable for ECB announcements: June, July and August 2012 – "Whatever it takes speech" and OMT announcements.

C. State Contingent Residual Diagnostics

	Jarque-Bera Test. Null Hypothesis: "*ε* is normally distributed with unspecified mean and standard deviation".							
	Italy		**Spain**		**Ireland**		**Portugal**	
Regime	**(1)**	**(2)**	**(1)**	**(2)**	**(1)**	**(2)**	**(1)**	**(2)**
p-value	0.03* 0.00* 0.20	0.50 0.08 0.50	0.30 0.05 0.50	0.10 0.02* 0.42	0.02* 0.18 0.50	0.50 0.50 0.17	0.04* 0.00* 0.00*	0.00* 0.50 0.03*
	T-test for zero means. Null Hypothesis: "*ε* has a mean different from zero".							
p-value	0.92 0.93 0.89	0.72 0.78 0.90	0.76 0.55 0.48	0.89 0.71 0.66	0.99 0.89 0.81	0.79 0.91 0.88	0.96 0.81 0.96	0.79 0.96 0.99

Table C.1: Residual diagnostics – Jarque-Bera and t-test. A star indicates rejection at the 5% level.

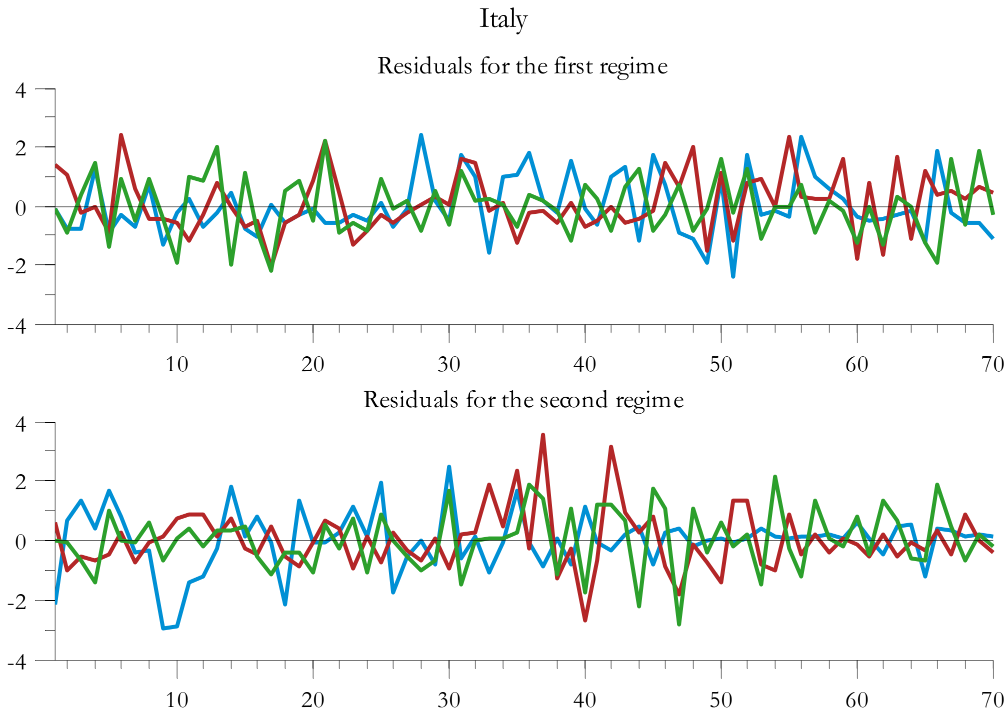

Figure C.1: Residuals for regime one (top) and regime two (bottom), for Italy.

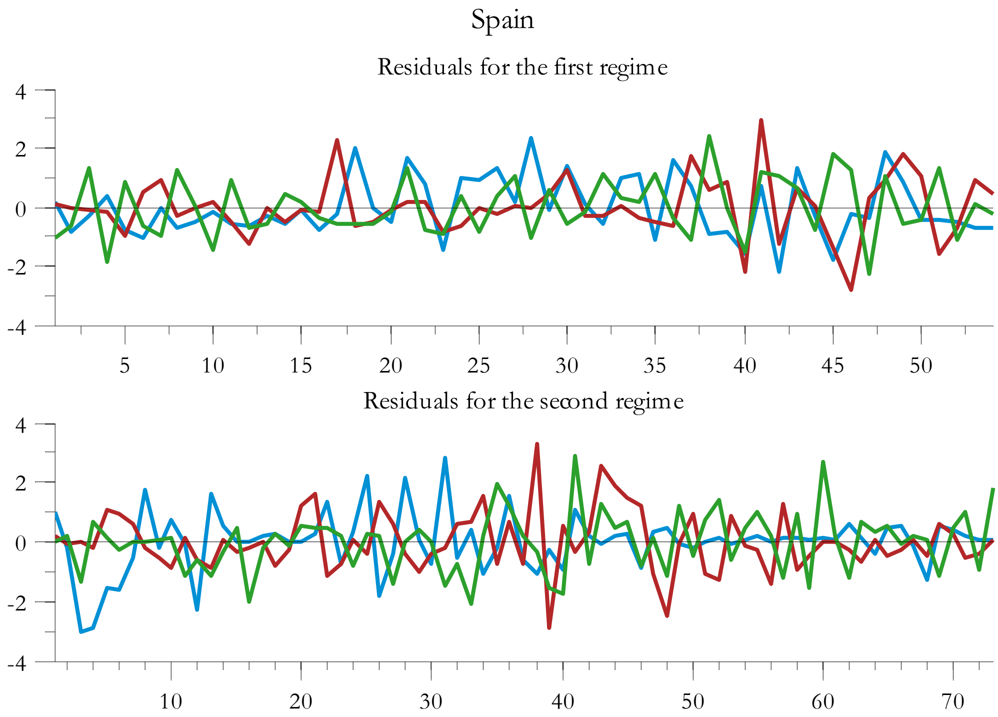

Figure C.2: Residuals for regime one (top) and regime two (bottom), for Spain.

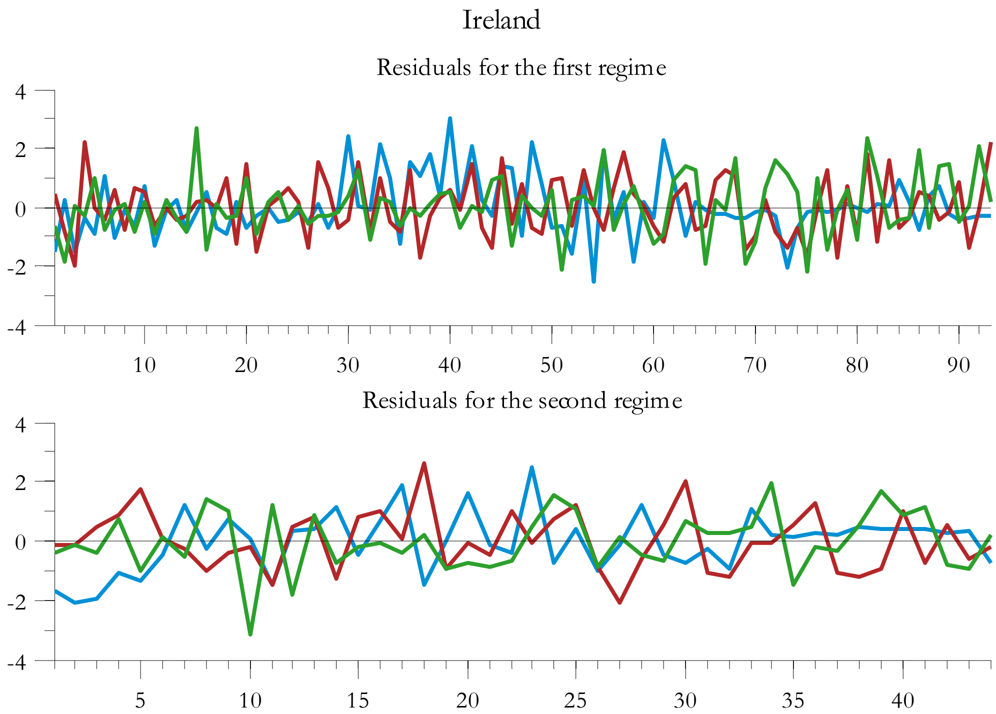

Figure C.3: Residuals for regime one (top) and regime two (bottom), for Ireland.

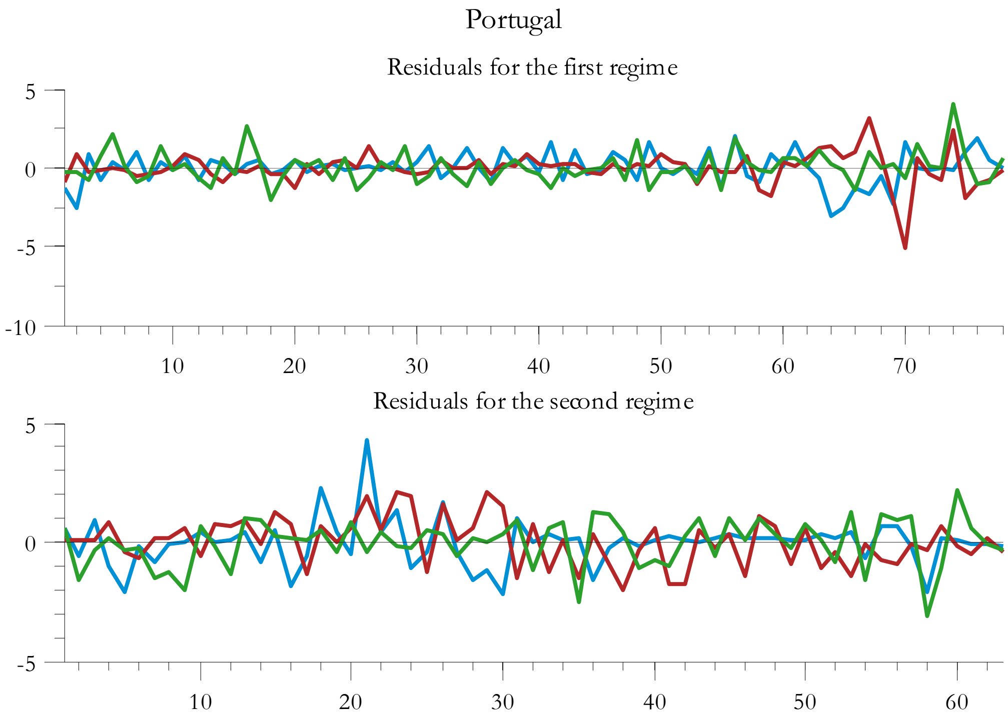

Figure C.4: Residuals for regime one (top) and regime two (bottom), for Portugal.

D. Impulse Responses for the EONIA Specification

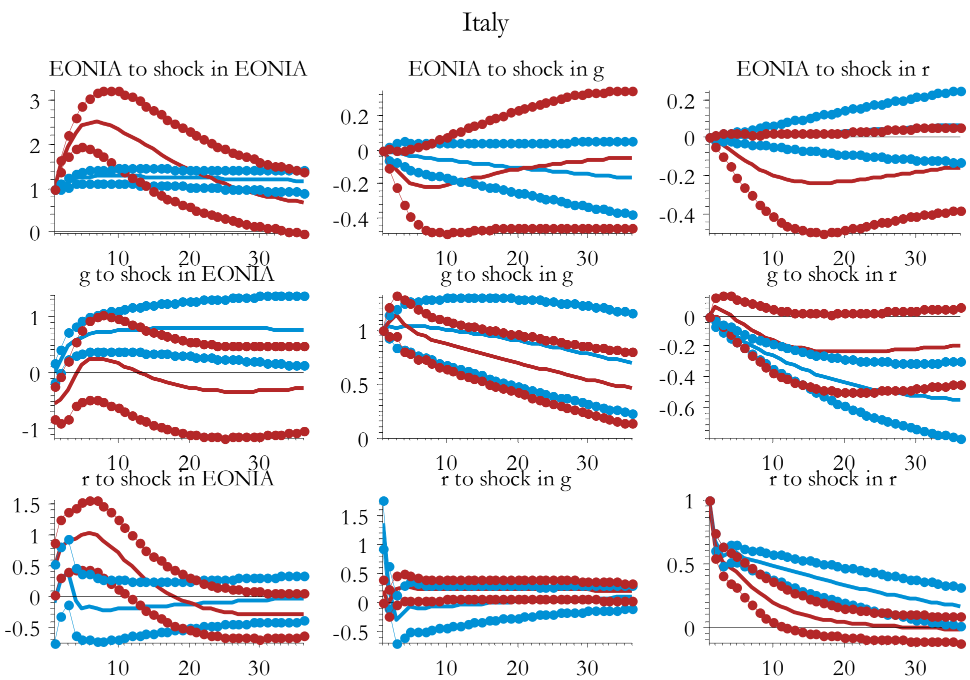

Figure D.1: Normalized state-contingent impulse responses for the first (blue) and second (red) regime. The interest rate pass-through may be inferred from the lower left corner, which plots the response of the lending spread to a shock in EONIA. Italy exhibits a change in the monetary policy transmission to lending rates, since the spread reacts differently across regimes. These findings are amplified due to the zero lower bound, which is evident from the response of EONIA to a shock in itself in the second regime.

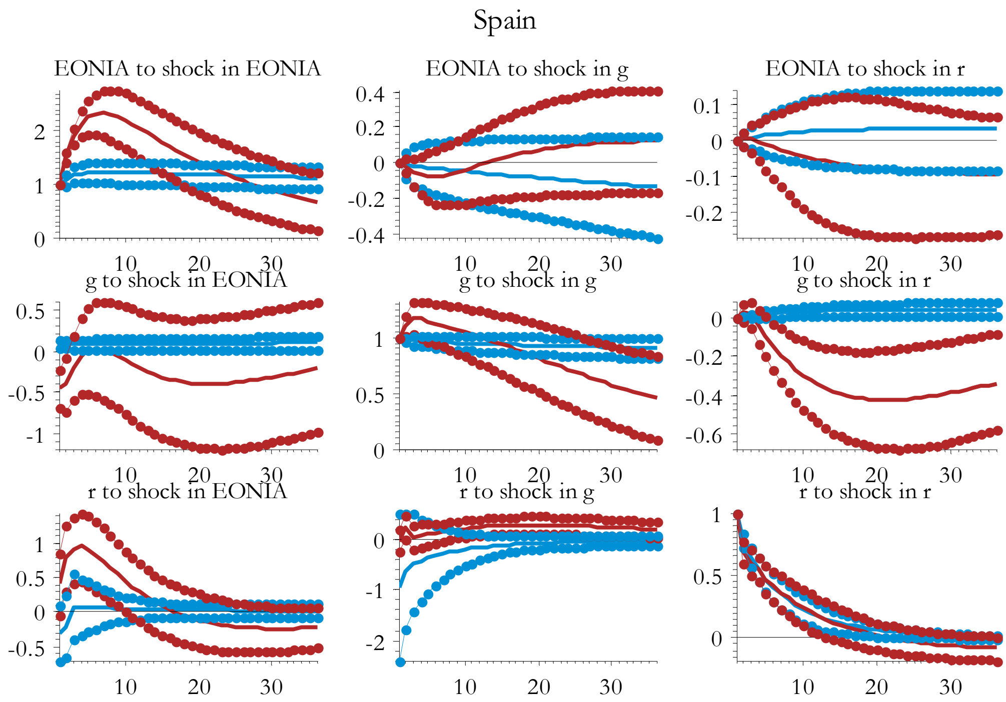

Figure D.2: Normalized state-contingent impulse responses for the first (blue) and second (red) regime. The interest rate pass-through may be inferred from the lower left corner, which plots the response of the lending spread to a shock in EONIA. Spain exhibits a change in the monetary policy transmission to lending rates, since the spread reacts differently across regimes.

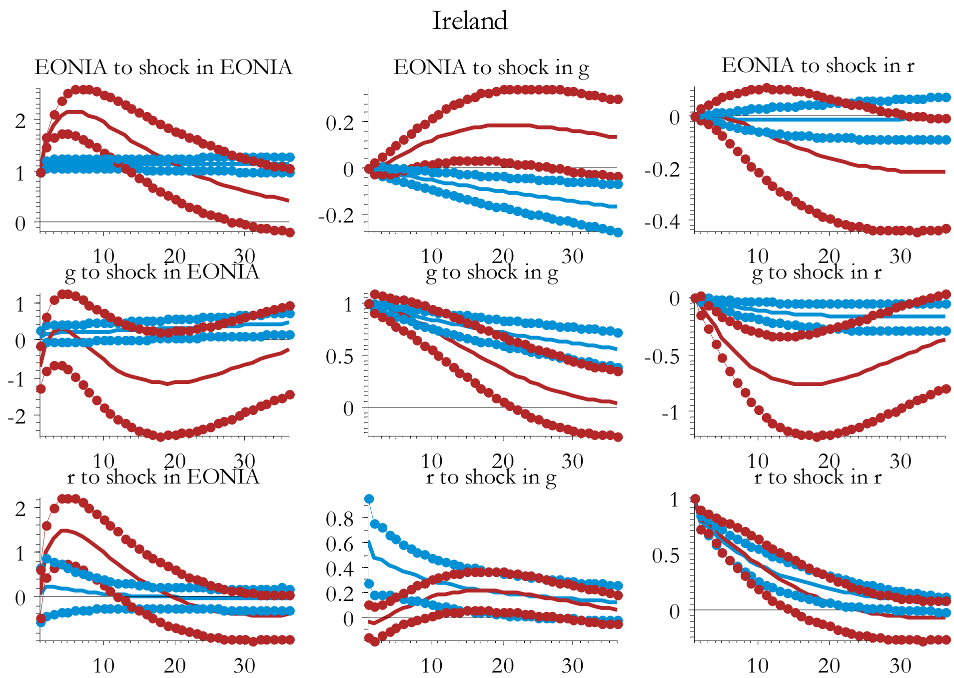

Figure D.3: Normalized state-contingent impulse responses for the first (blue) and second (red) regime. The interest rate pass-through may be inferred from the lower left corner, which plots the response of the lending spread to a shock in EONIA. Ireland exhibits a change in the monetary policy transmission to lending rates, since the spread reacts differently across regimes.

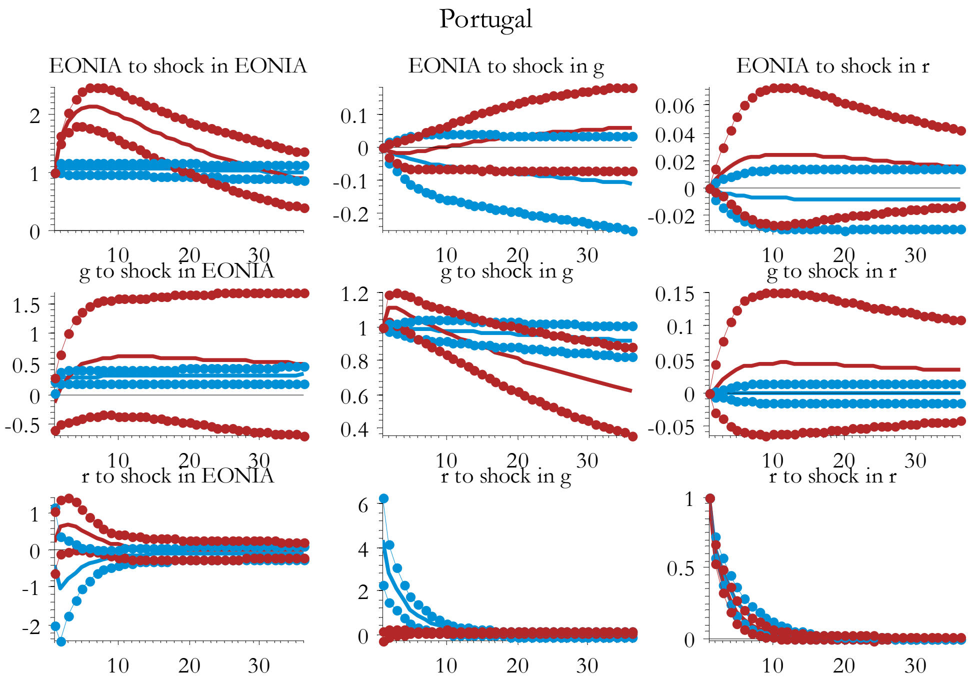

Figure D.4: Normalized state-contingent impulse responses for the first (blue) and second (red) regime for Portugal. The model does not identify distinctive responses of the lending rate spread to a shock in the policy rate.

E. Correlation tables for the Z variables

Italy	VSTOXX	Pol. Unc.	MOVE	Bank Stocks	CDS Spreads	Ind.Prod.	MRO	LTRO	NFA-to-GDP	Debt-to-GDP	r_PT	r_ES	r_IE	r_IT
VSTOXX	1,00													
Pol. Unc.	0,45	1,00												
MOVE	0,69	0,04	1,00											
Bank Stocks	-0,35	-0,71	-0,07	1,00										
CDS Spreads	0,20	0,79	-0,18	-0,69	1,00									
Ind.Prod.	-0,27	-0,13	-0,25	0,17	-0,12	1,00								
MRO	0,03	-0,05	-0,04	0,14	0,16	-0,06	1,00							
LTRO	0,12	0,10	0,01	0,08	0,19	-0,16	0,71	1,00						
NFA-to-GDP	-0,43	-0,07	-0,45	-0,20	0,10	0,08	-0,11	-0,10	1,00					
Debt-to-GDP	-0,20	0,42	-0,44	-0,57	0,51	0,07	-0,32	-0,24	0,50	1,00				
r_PT	0,10	0,53	-0,17	-0,56	0,63	0,04	0,00	0,05	0,07	0,52	1,00			
r_ES	-0,14	0,50	-0,40	-0,31	0,63	-0,03	-0,05	0,01	0,38	0,59	0,47	1,00		
r_IE	-0,16	0,49	-0,44	-0,41	0,65	-0,02	0,08	0,10	0,50	0,58	0,54	0,81	1,00	
r_IT	-0,14	0,45	-0,35	-0,33	0,63	-0,08	0,03	0,11	0,50	0,61	0,43	0,84	0,82	1,00

Table E.1: Correlation among the trigger variables for Italy. Highlighted are values above 0.5 in absolute value.

Spain	VSTOXX	Pol. Unc.	MOVE	Bank Stocks	CDS Spreads	Ind.Prod.	MRO	LTRO	NFA-to-GDP	Debt-to-GDP	r_PT	r_ES	r_IE	r_IT
VSTOXX	1,00													
Pol. Unc.	0,44	1,00												
MOVE	0,71	0,06	1,00											
Bank Stocks	-0,32	-0,75	-0,04	1,00										
CDS Spreads	0,23	0,84	-0,17	-0,78	1,00									
Ind.Prod.	-0,37	-0,16	-0,33	0,10	-0,06	1,00								
MRO	0,07	0,32	-0,07	-0,31	0,37	-0,06	1,00							
LTRO	0,01	0,65	-0,28	-0,70	0,77	-0,02	0,31	1,00						
NFA-to-GDP	-0,04	0,63	-0,32	-0,84	0,71	0,09	0,22	0,83	1,00					
Debt-to-GDP	-0,10	0,61	-0,40	-0,75	0,67	0,08	0,18	0,80	0,94	1,00				
r_PT	0,14	0,58	-0,13	-0,64	0,65	-0,08	0,15	0,53	0,62	0,64	1,00			
r_ES	-0,09	0,54	-0,37	-0,39	0,58	0,03	0,34	0,70	0,55	0,68	0,46	1,00		
r_IE	-0,16	0,50	-0,43	-0,44	0,60	0,01	0,34	0,70	0,58	0,72	0,54	0,82	1,00	
r_IT	-0,08	0,47	-0,31	-0,42	0,51	0,00	0,33	0,73	0,57	0,69	0,42	0,82	0,83	1,00

Table E.2: Correlation among the trigger variables for Spain. Highlighted are values above 0.5 in absolute value.

Ireland	VSTOXX	Pol. Unc.	MOVE	Bank Stocks	CDS Spreads	Ind.Prod.	MRO	LTRO	NFA-to-GDP	Debt-to-GDP	r_PT	r_ES	r_IE	r_IT
VSTOXX	1,00													
Pol. Unc.	0,43	1,00												
MOVE	0,70	0,02	1,00											
Bank Stocks	-0,33	-0,70	-0,06	1,00										
CDS Spreads	0,32	0,67	-0,01	-0,55	1,00									
Ind.Prod.	0,02	-0,03	-0,10	0,00	-0,02	1,00								
MRO	0,48	0,31	0,34	-0,25	0,53	-,01	1,00							
LTRO	0,41	0,64	0,15	-0,49	0,73	-0,04	0,46	1,00						
NFA-to-GDP	NA	NA	NA	NA	NA	NA	NA	NA	NA					
Debt-to-GDP	0,05	0,76	-0,31	-0,74	0,58	0,04	0,13	0,61	NA	1,00				
r_PT	0,12	0,57	-0,16	-0,58	0,53	0,04	0,21	0,40	NA	0,68	1,00			
r_ES	-0,10	0,55	-0,39	-0,34	0,25	0,06	-0,07	0,18	NA	0,71	0,46	1,00		
r_IE	-0,16	0,51	-0,44	-0,41	0,30	0,02	-0,20	0,09	NA	0,71	0,54	0,81	1,00	
r_IT	-0,11	0,49	-0,35	-0,35	0,18	0,04	-0,15	0,16	NA	0,69	0,43	0,83	0,83	1,00

Table E.3: Correlation among the trigger variables for Ireland. Highlighted are values above 0.5 in absolute value.

F. Empirical distributions of representative Z variables

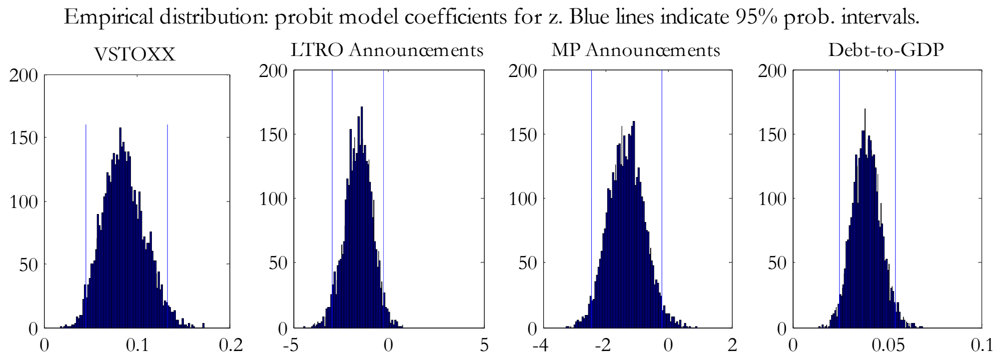

Figure F.1: Histogram of the γ coefficients in the probit equation for Italy. Blue lines indicate 95% probability intervals. Positive coefficient increases the probability to switch from the first to the second regime. Negative coefficient increases the transition probability to switch from the second to the first regime.

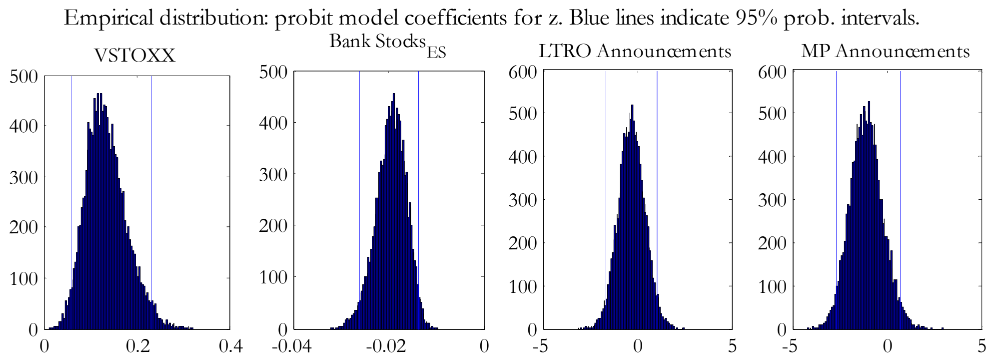

Figure F.2: Histogram of the γ coefficients in the probit equation for Spain. Blue lines indicate 95% probability intervals. A positive coefficient increases the probability to switch from the first to the second regime. Negative coefficient increases the transition probability to switch from the second to the first regime.

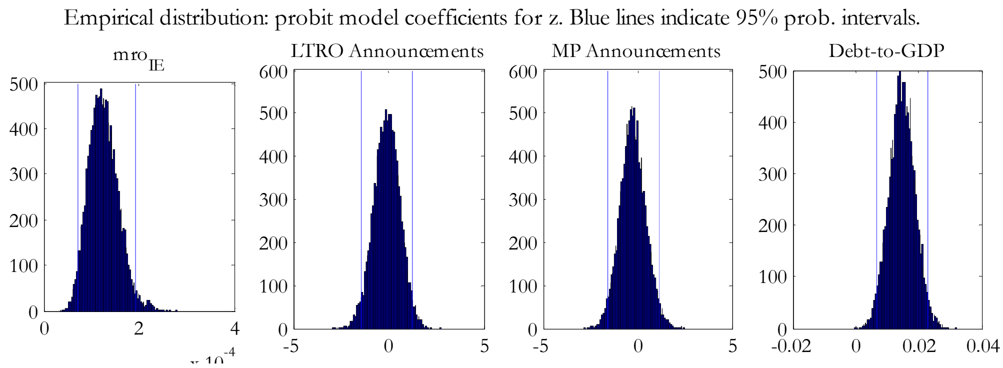

Figure F.3: Histogram of the γ coefficients in the probit equation for Ireland. Blue lines indicate 95% probability intervals. A positive coefficient increases the probability to switch from the first to the second regime. Negative coefficient increases the transition probability to switch from the second to the first regime.

G. Convergence Diagnostics for the EONIA Specification

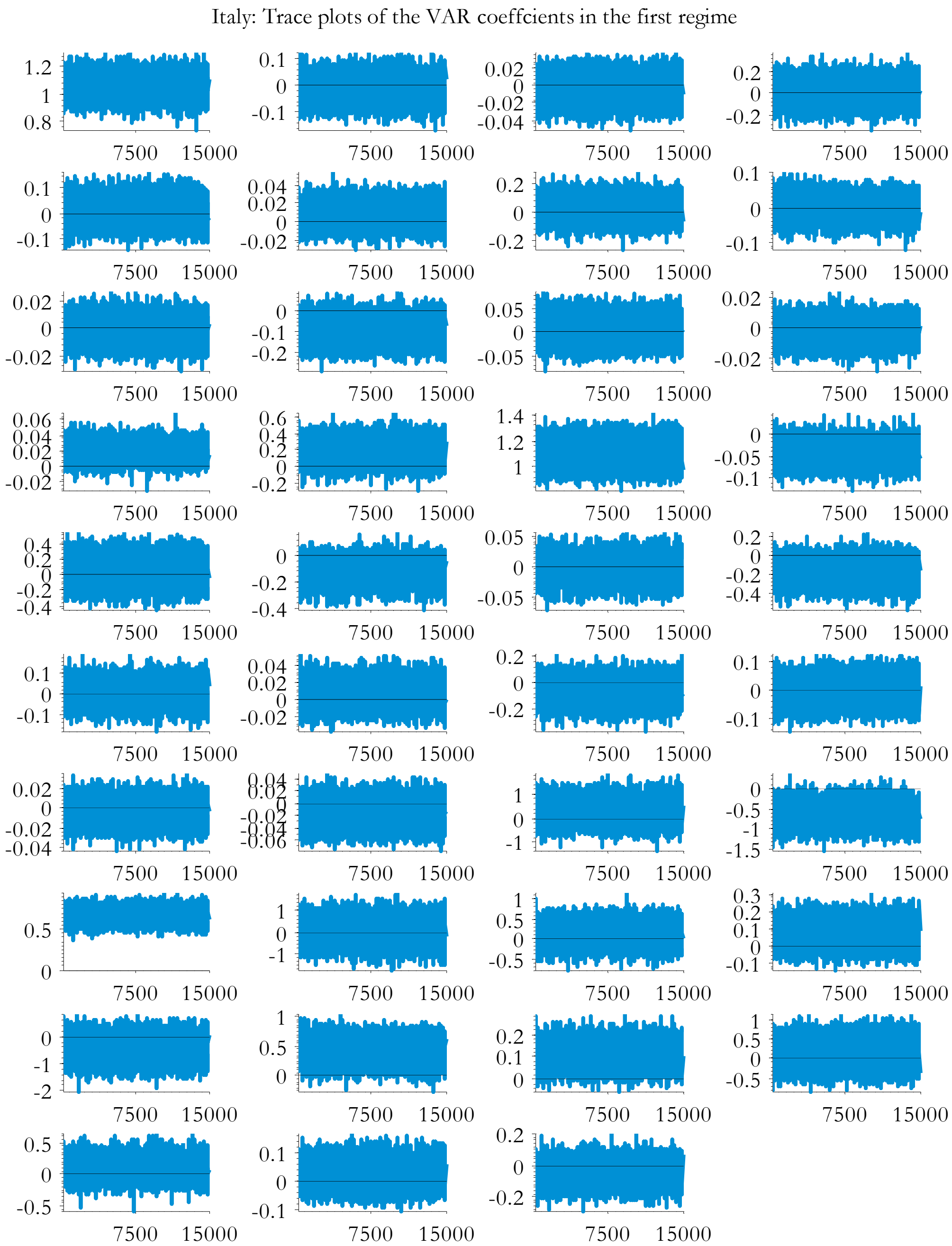

Figure G.1: Trace plots for the VAR coefficients. Under the central limit theorem converging coefficients should appear as white noise.

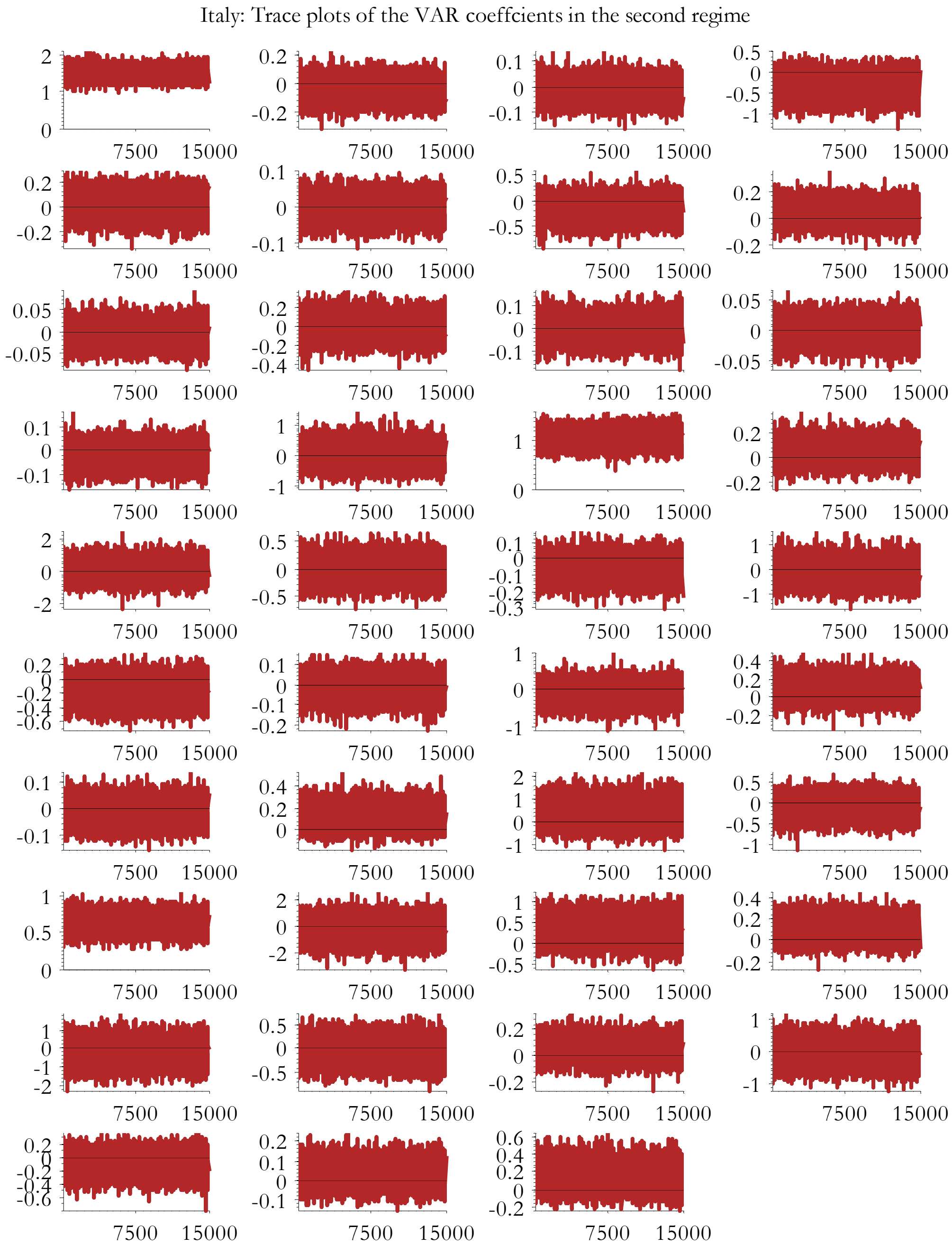

Figure G.2: Trace plots for the VAR coefficients. Under the central limit theorem converging coefficients should appear as white noise.

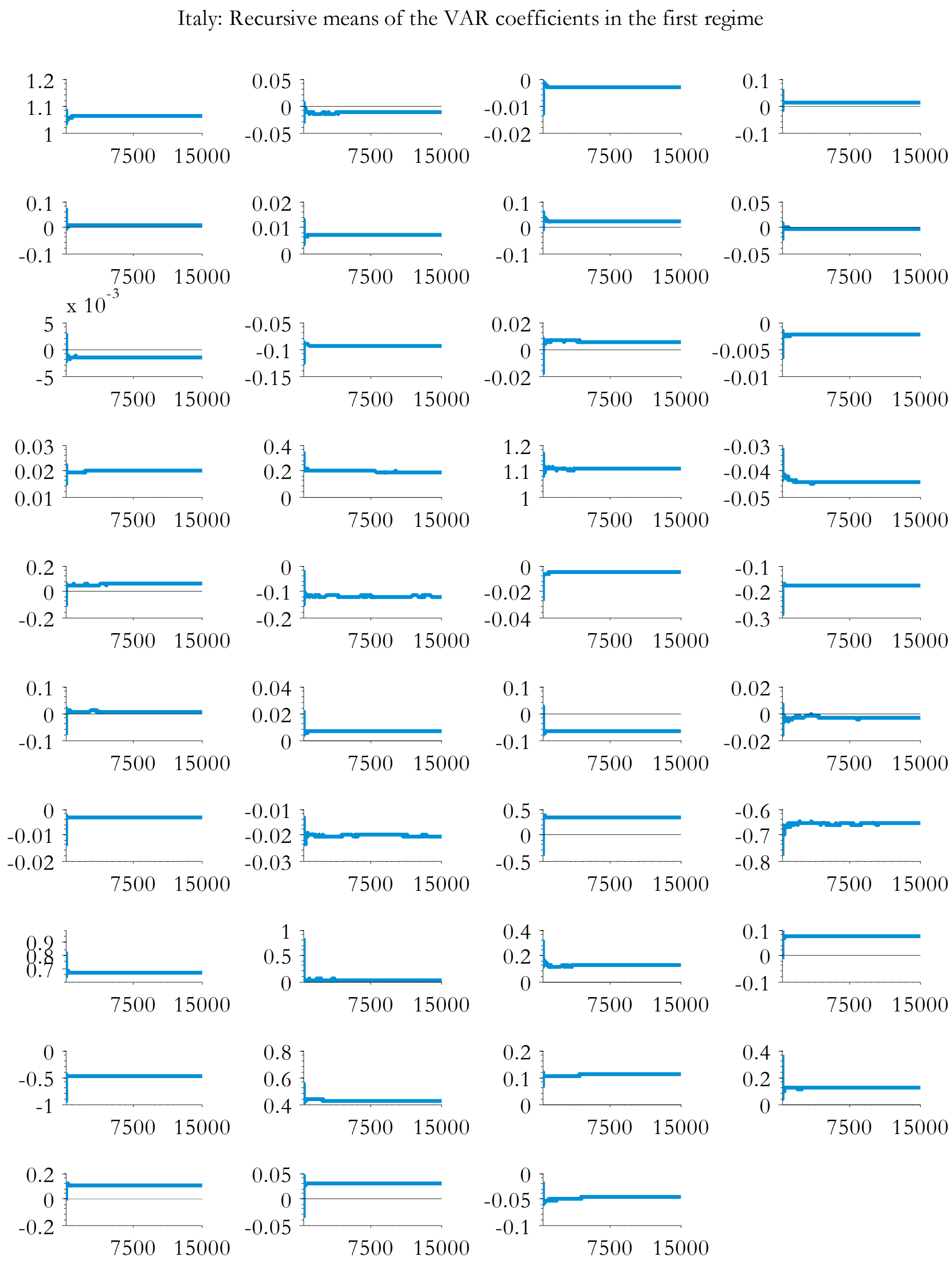

Figure G.3: Recursive means for the VAR coefficients. They should exhibit convergence.

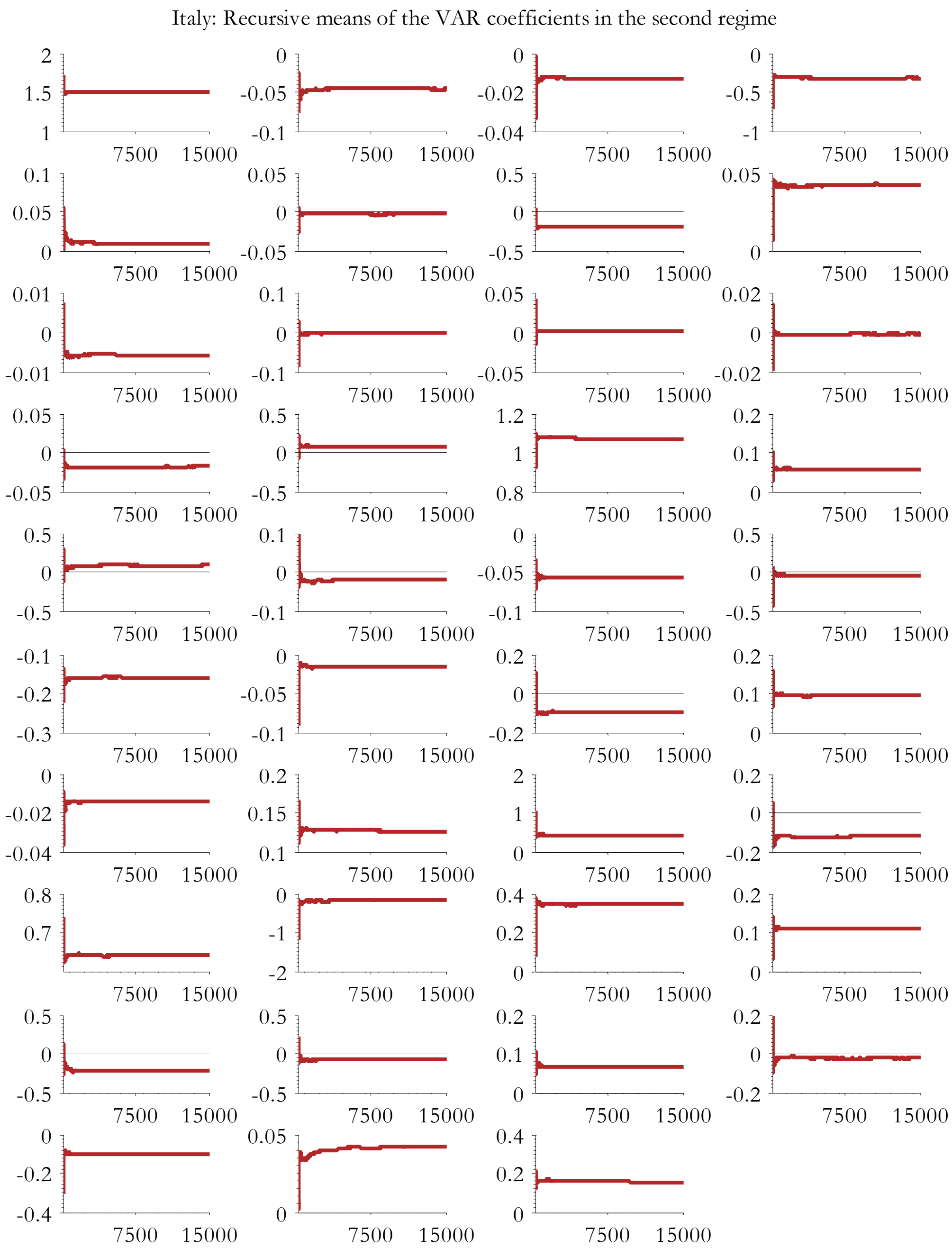

Figure G.4: Recursive means for the VAR coefficients. They should exhibit convergence.

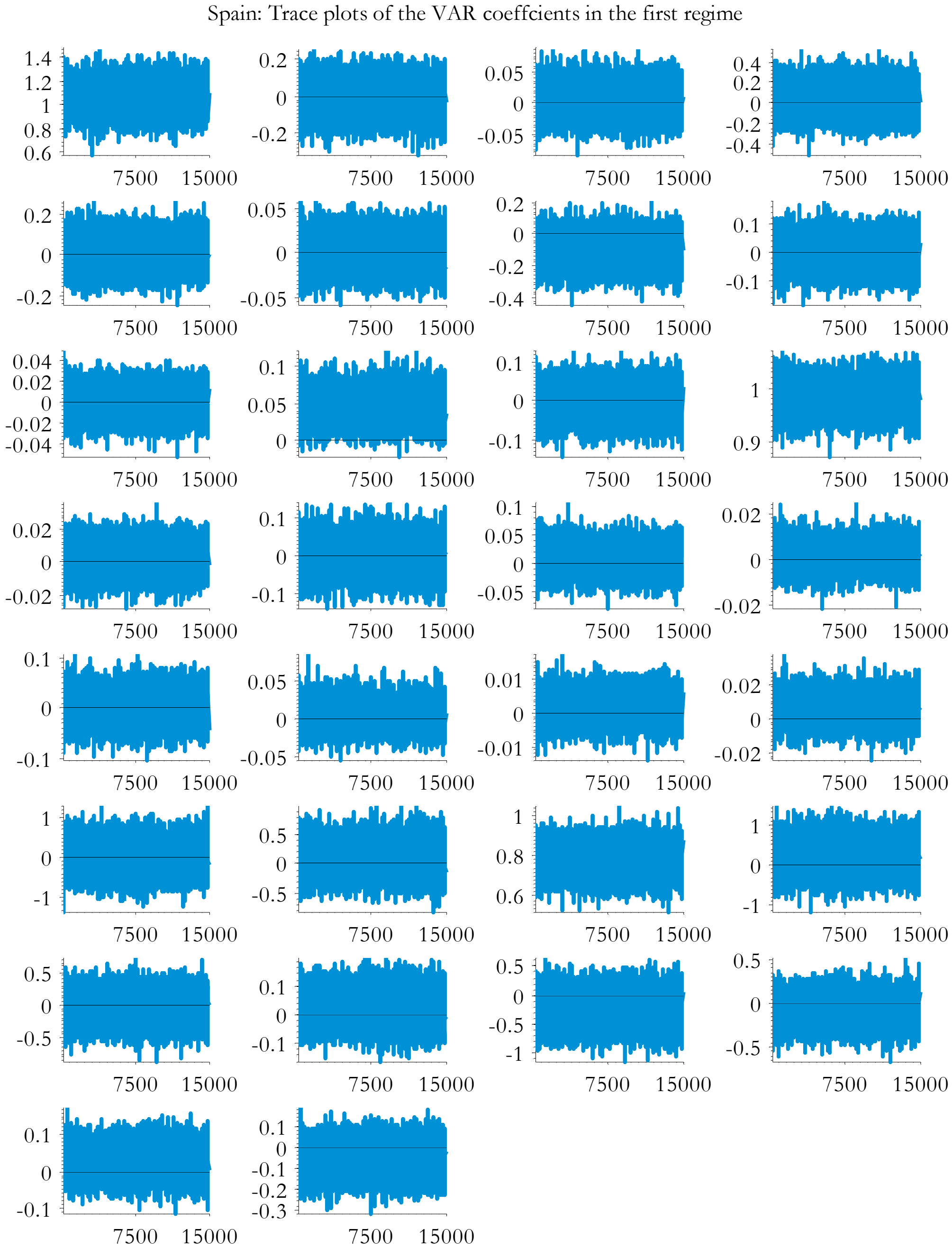

Figure G.5: Trace plots for the VAR coefficients. Under the central limit theorem converging coefficients should appear as white noise.

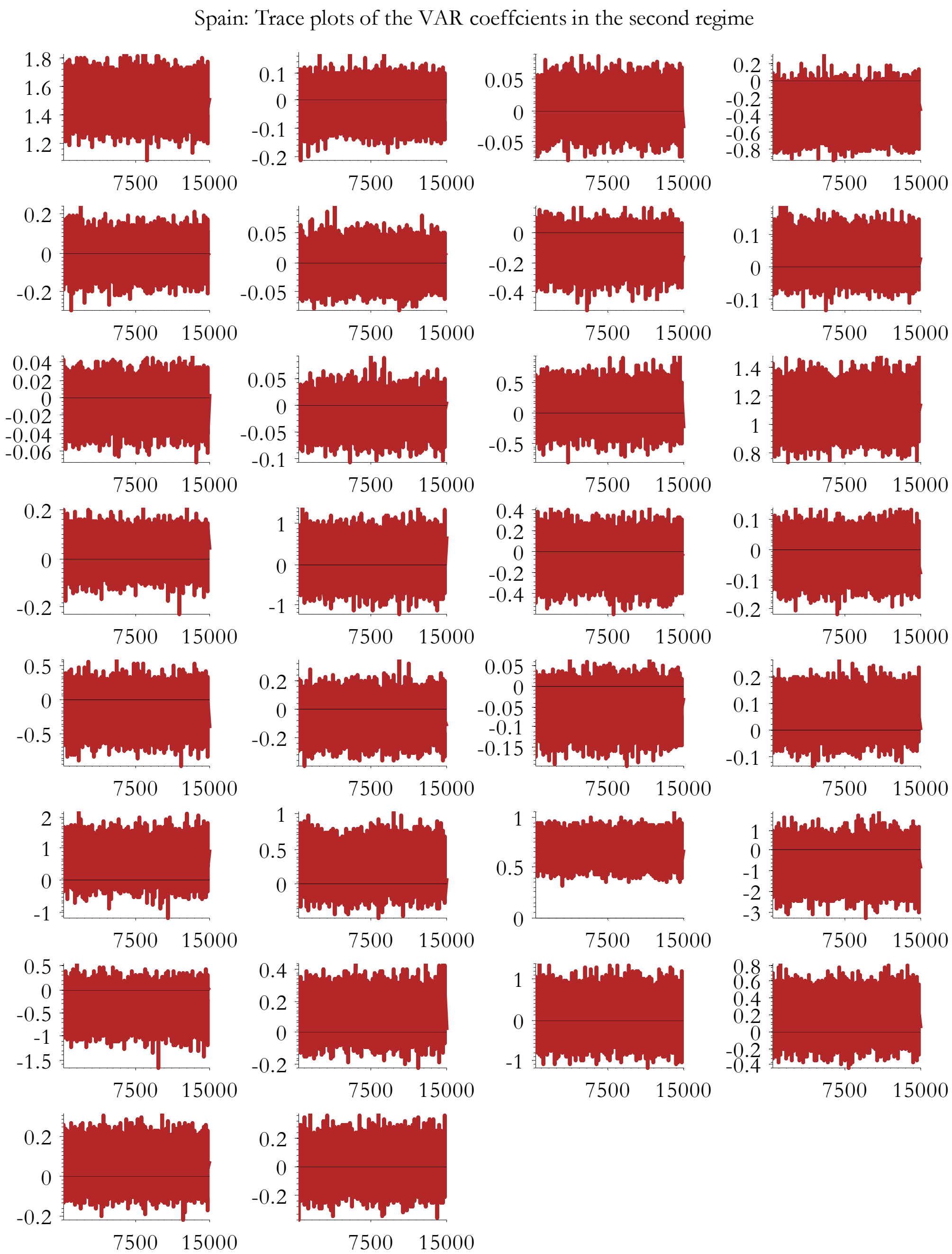

Figure G.6: Trace plots for the VAR coefficients. Under the central limit theorem converging coefficients should appear as white noise.

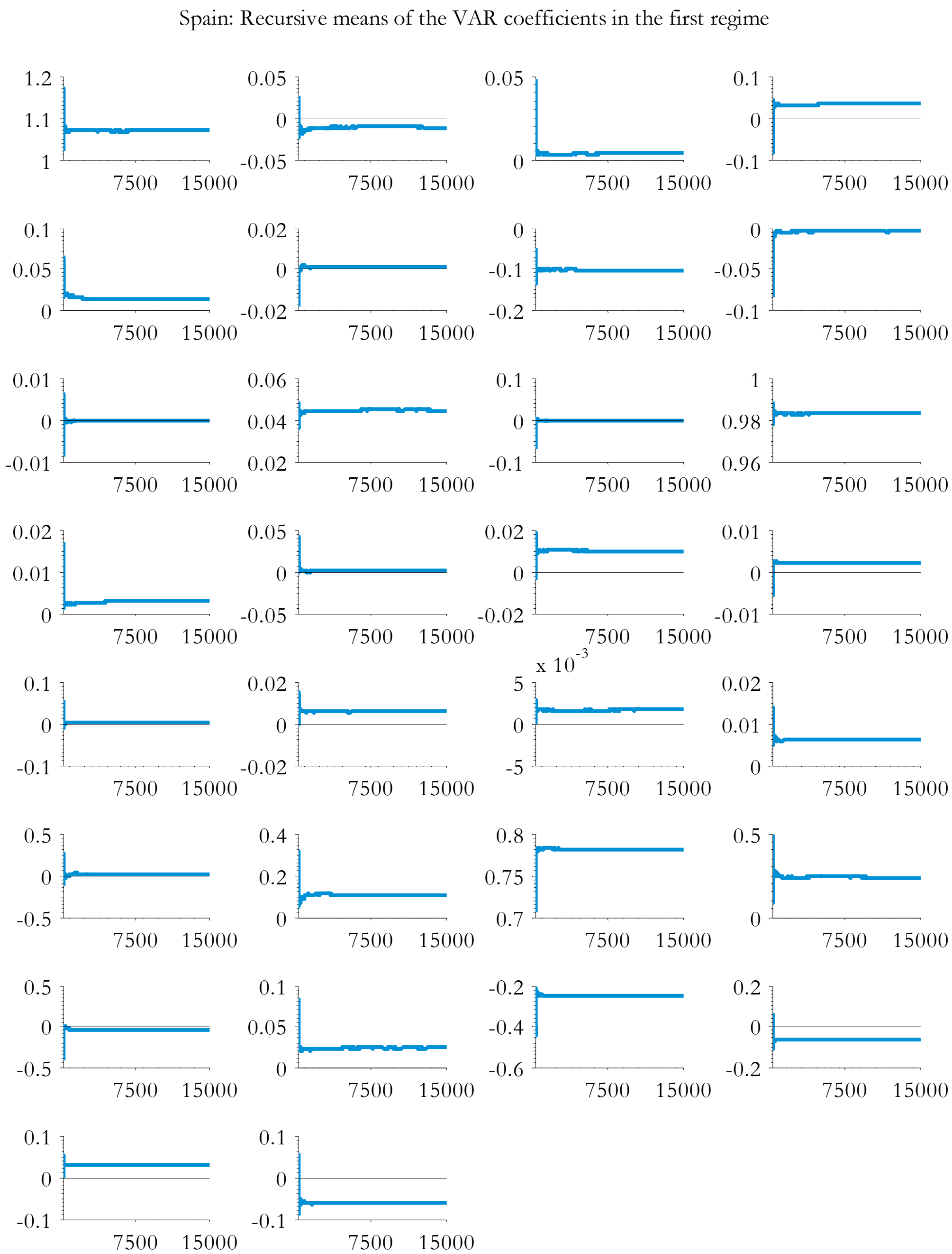

Figure G.7: Recursive means for the VAR coefficients. They should exhibit convergence.

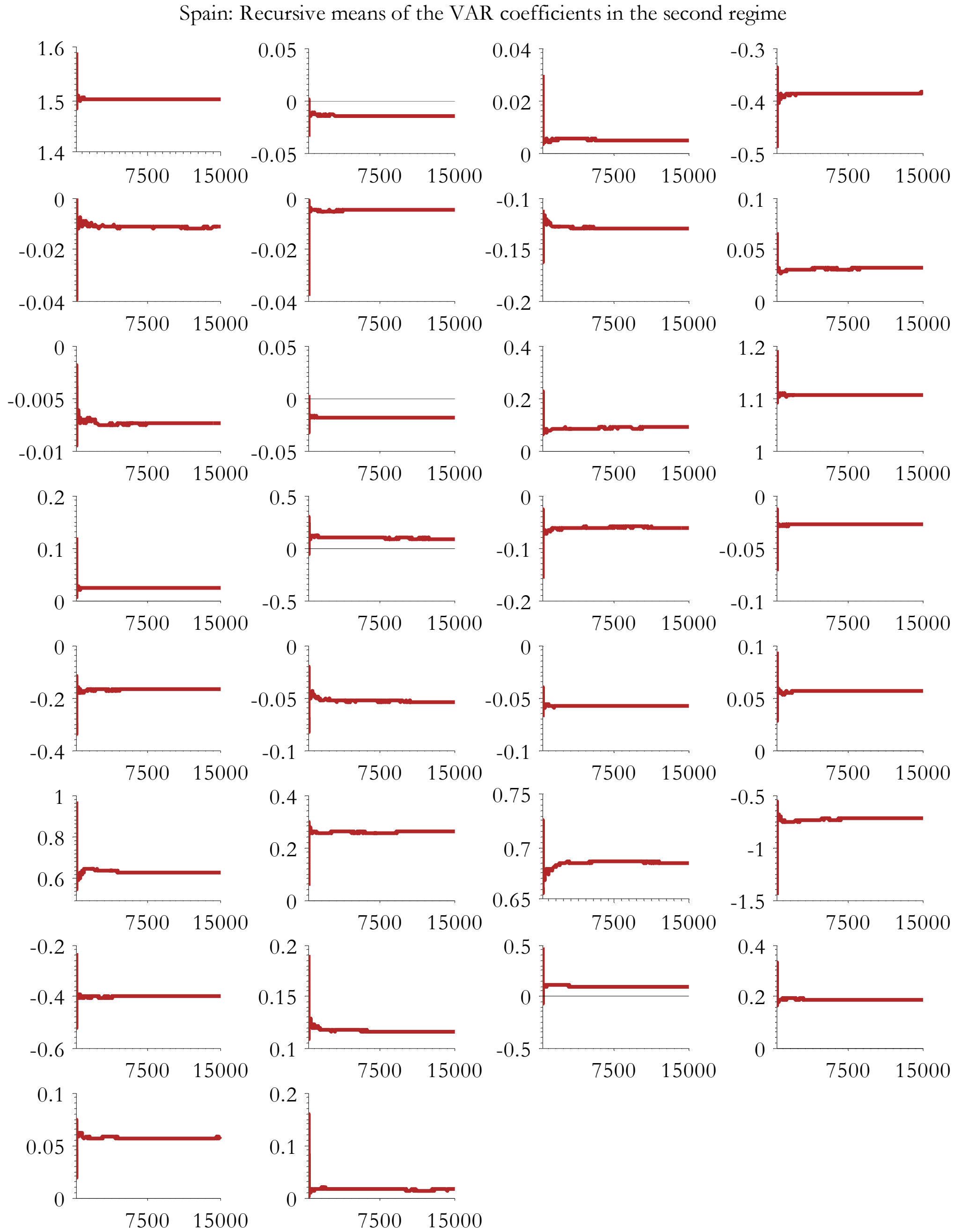

Figure G.8: Recursive means for the VAR coefficients. They should exhibit convergence.

Figure G.9: Trace plots for the VAR coefficients. Under the central limit theorem converging coefficients should appear as white noise.

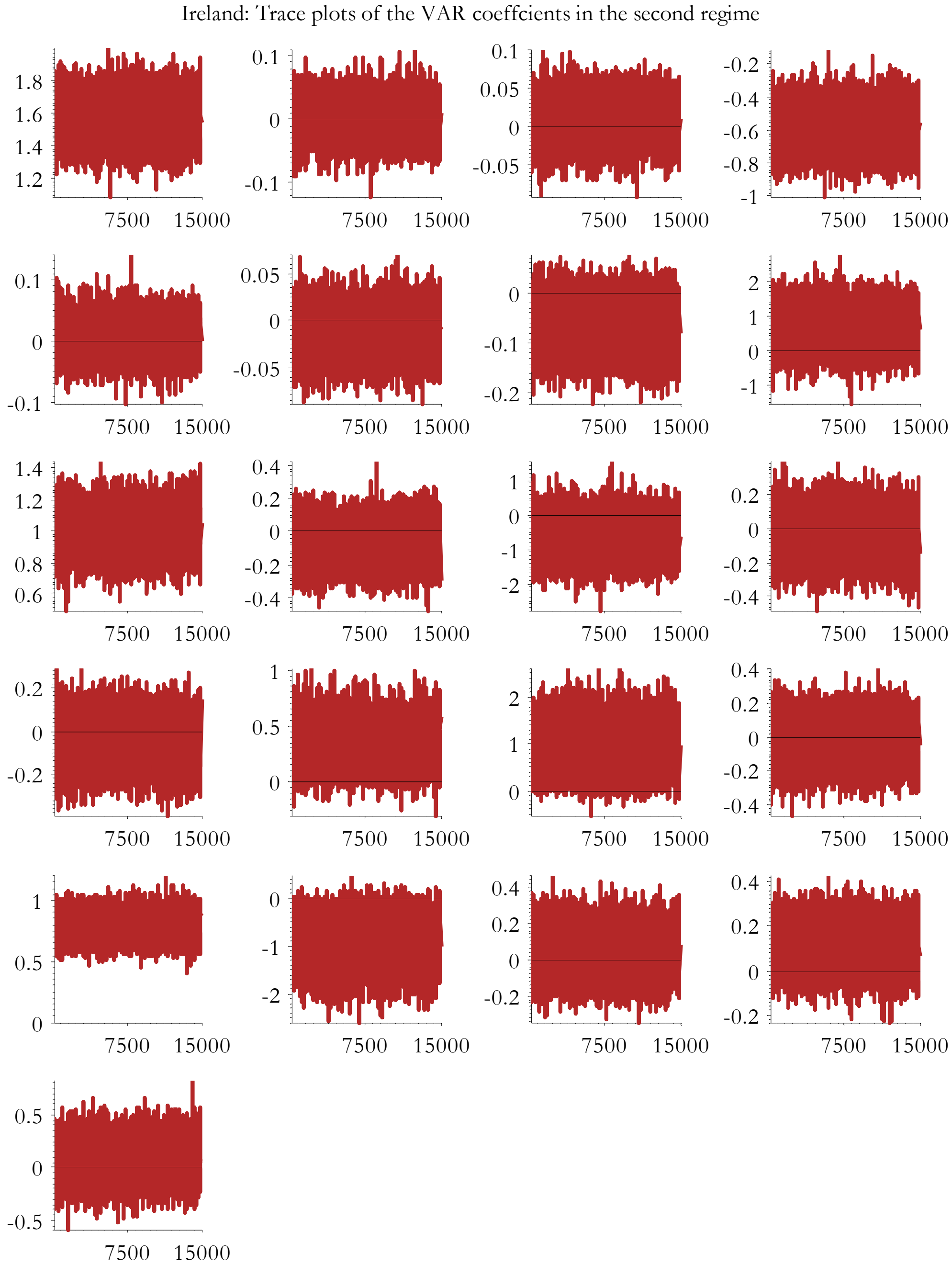

Figure G.10: Trace plots for the VAR coefficients. Under the central limit theorem converging coefficients should appear as white noise.

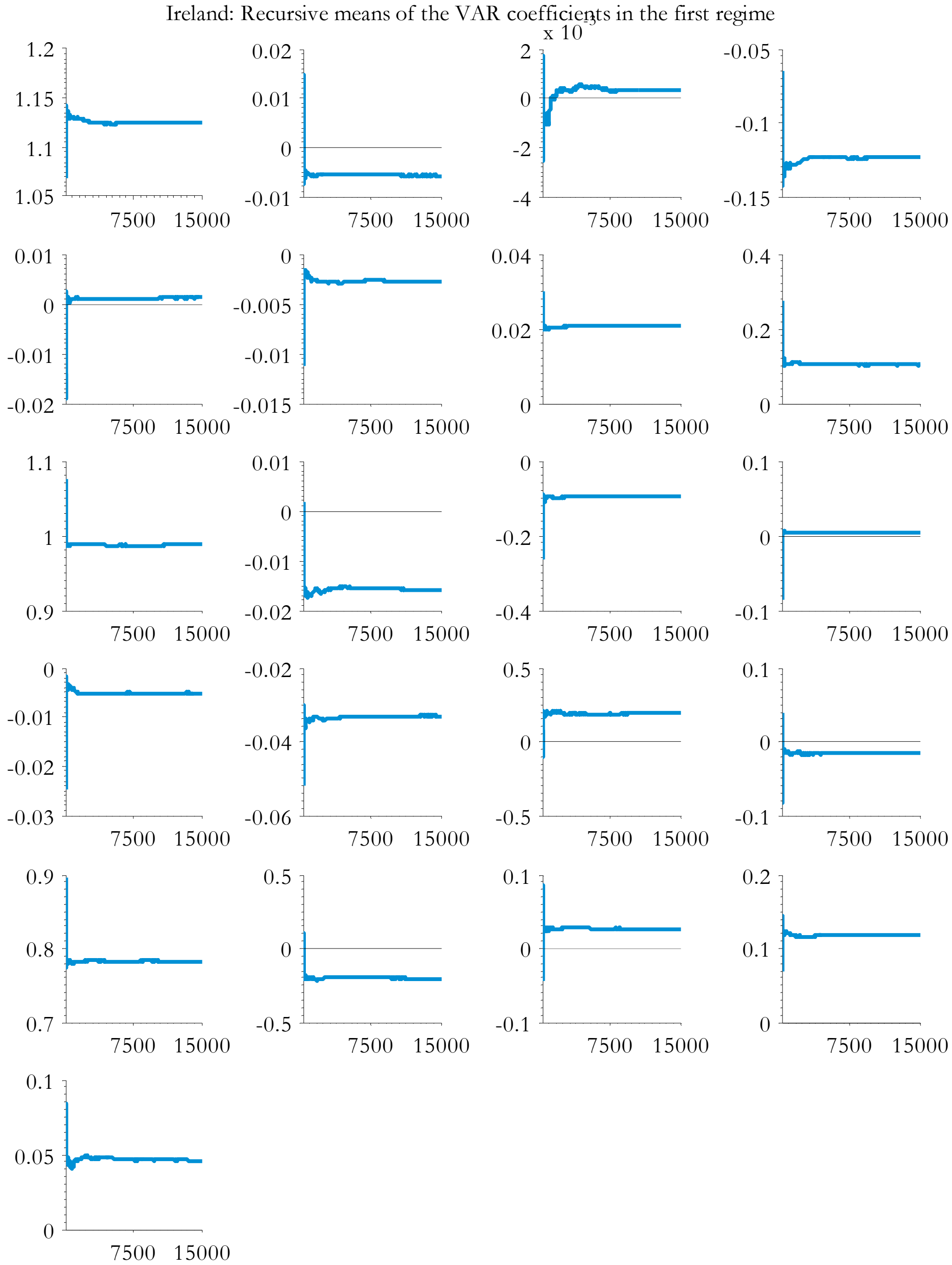

Figure G.11: Recursive means for the VAR coefficients. They should exhibit convergence.

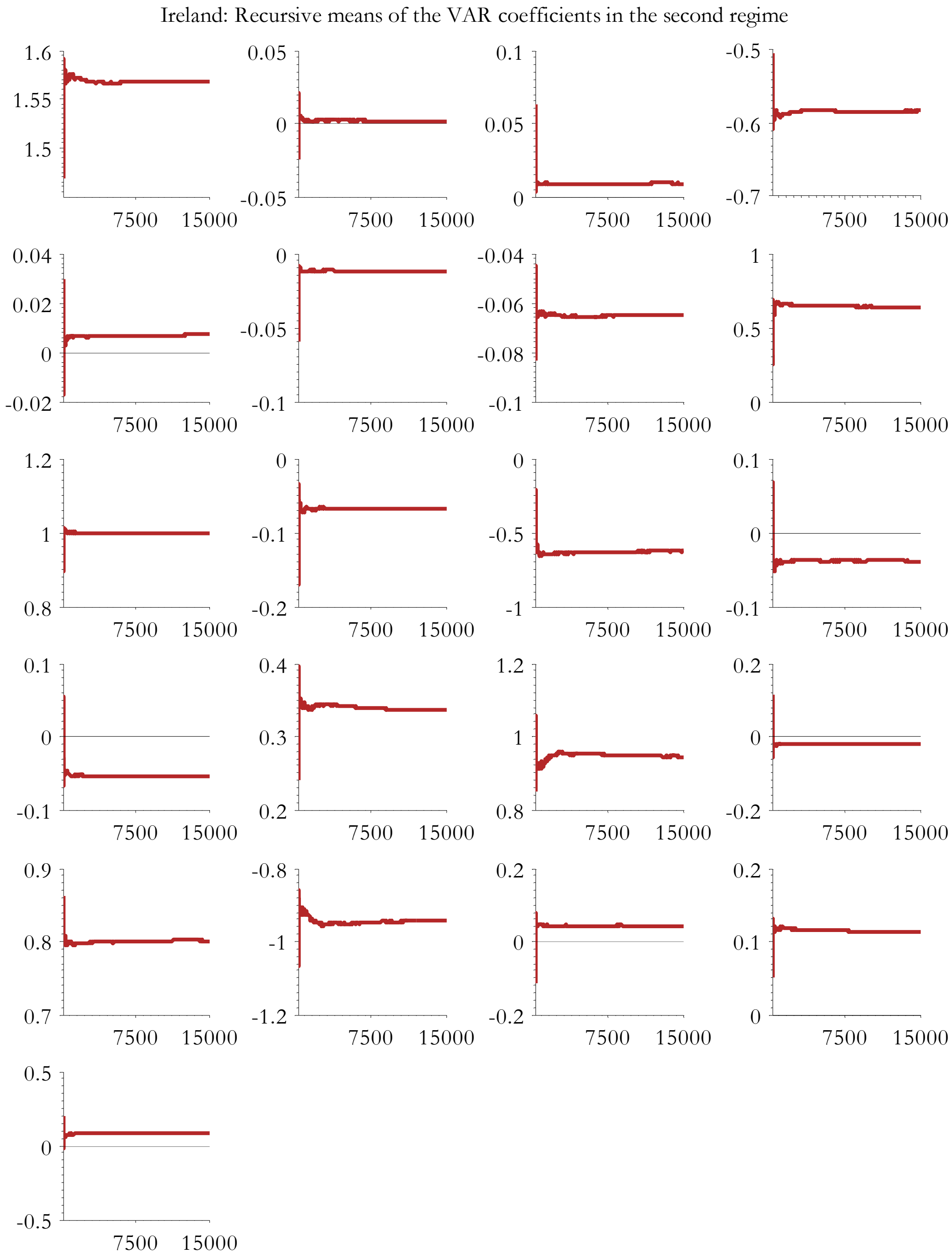

Figure G.12: Recursive means for the VAR coefficients. They should exhibit convergence.

Figure G.13: Trace plots for the VAR coefficients. Under the central limit theorem converging coefficients should appear as white noise.

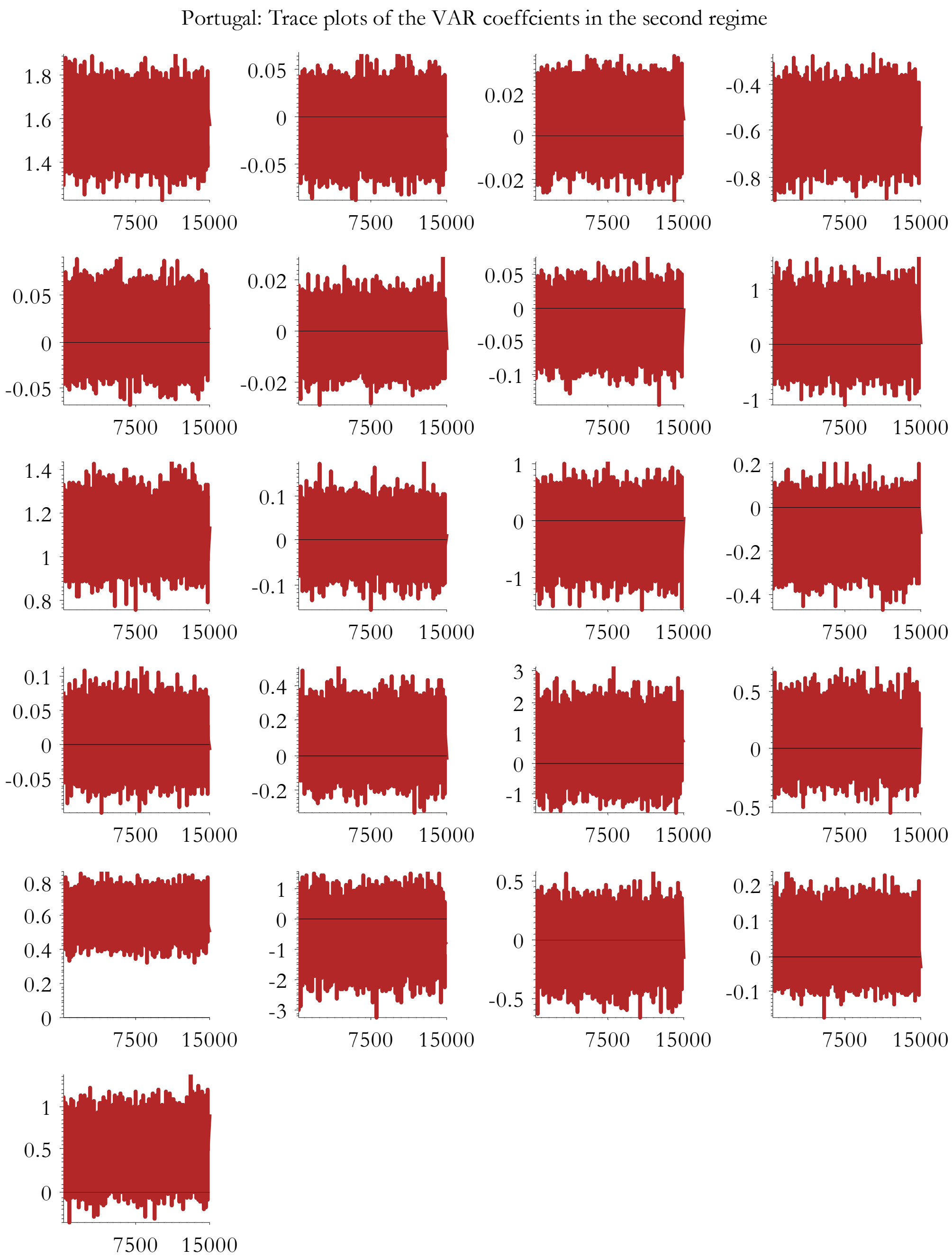

Figure G.14: Trace plots for the VAR coefficients. Under the central limit theorem converging coefficients should appear as white noise.

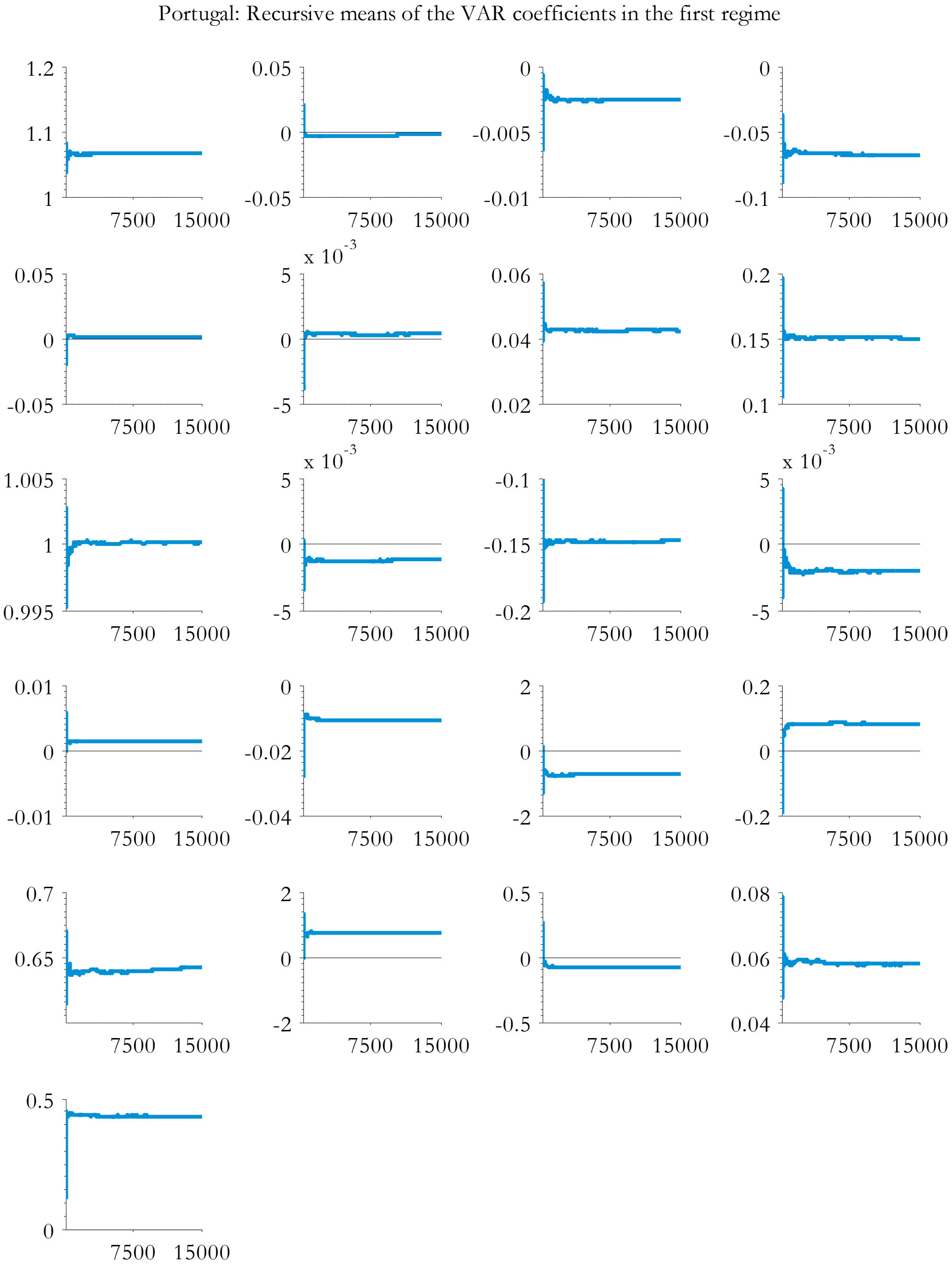

Figure G.15: Recursive means for the VAR coefficients. They should exhibit convergence.

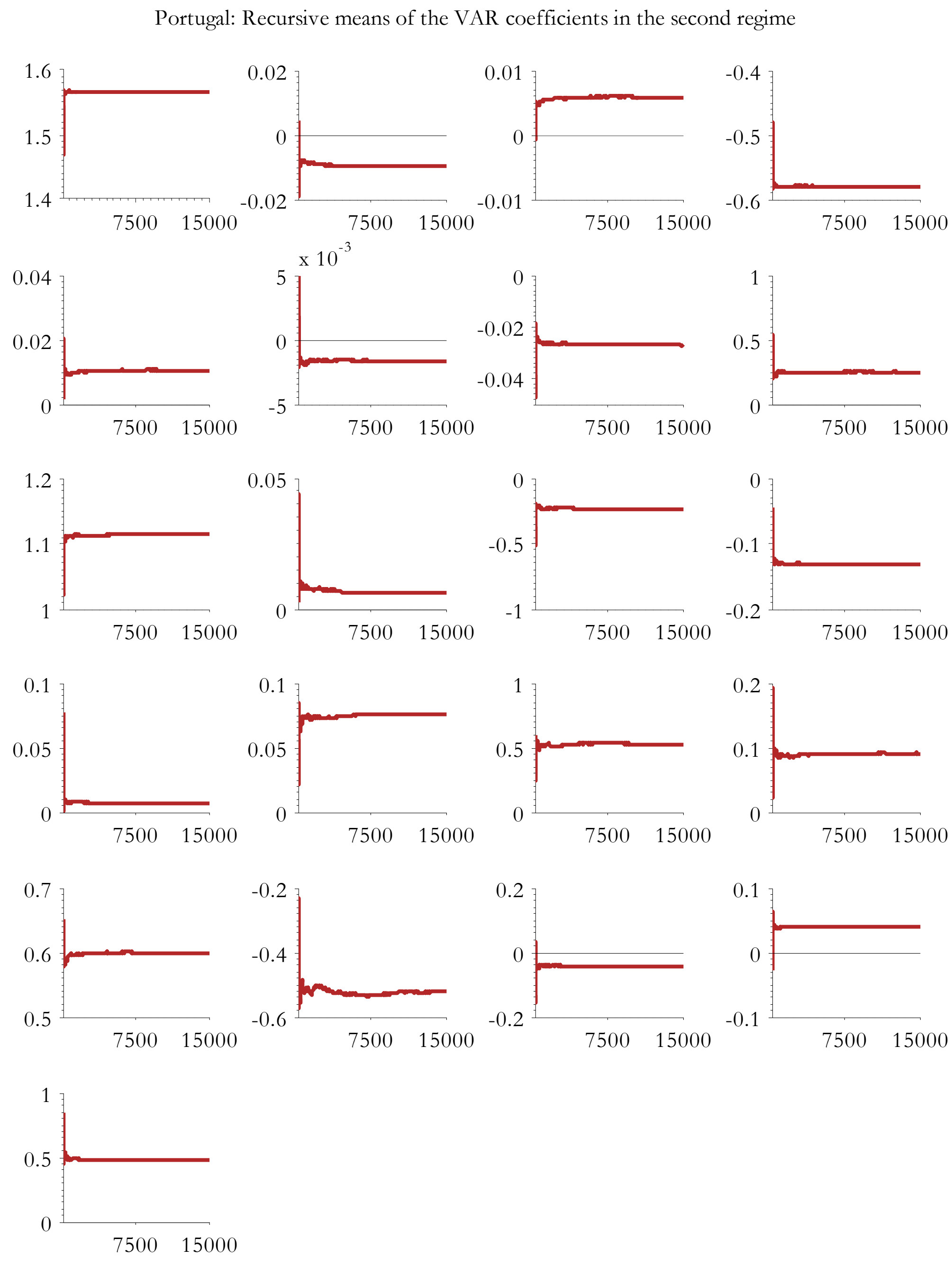

Figure G.16: Recursive means for the VAR coefficients. They should exhibit convergence.

H. Shadow short rate estimates

There are various approaches in the literature to estimating shadow rates. Wu and Xia (2014) construct the rate as a linear function of three latent variables (factors), which follow a VAR(1) process. The latent factors and the shadow rate are estimated with an extended Kalman filter based around forward rates for n = 0.25, 0.5, 1, 2, 5, 7, and 10 years ahead. These forward rates are constructed with end-of-month Nelson-Siegel-Svensson yield curve parameters. Whenever the Wu-Xia shadow rate is above 0.25 per cent, it is exactly equal to the model implied one-month interest rate.

Krippner (2014), in turn, has suggested a modification to the Black (1995) approach to allow for closed-form solutions to the option pricing problem. This allows for considerable simplification when estimating the shadow rate. Pericoli and Taboga (2015) also use a modification of the approach of Black (1995). However, they employ an exact Bayesian method for their shadow short rate estimation. This method relies on discretizing the pricing equation, effectively discretizing the state space of the model, without introducing too high numerical errors.

Figure 10 (in the main paper) reveals a large discrepancy between the different shadow rates at the end of the sample period. According to Krippner (2014), the shadow rate has been negative since 2011, falling to minus five per cent in 2014 and 2015, much further below the estimate of Wu and Xia (2014), which was around zero to minus one per cent. For the same period, Pericoli and Taboga (2015) estimate values lower than minus six per cent. Considering the disagreement between the three rates, one has to take these estimates with a grain of salt.

Another issue that has to be taken into account is the different sample sizes of the SSR estimates. For example, the shadow rate of Wu and Xia starts in June 2004, while the estimates provided by Krippner date back to 1995. We control for that by estimating both models starting in June 2004, yet this is also an imperfect solution. First of all, the results are not directly comparable to sections 4.1 to 4.4 (in the main paper), because the sample size is significantly shorter. Second, the SSR is model dependent, and extending the dataset forward or backward would also alter the original estimates. Hence, a shadow rate that starts in 1995, and is truncated to June 2004, would not be equal to the same rate estimated by the same model with data starting in June 2004.

I. Robustness Check Using the Weighted Average Cost of Liabilities (WACL) measure

Illes et. al. (2015) make the point that since the outbreak of the crisis, interbank rates might not be a good approximation for bank funding costs. Therefore, they create a benchmark for funding costs for each country, both in the short and the long term, and show that when this is taken into account, there is no breakdown in the interest rate pass-through. They construct a weighted average cost of liabilities (WACL), which consists of several components of bank funding including covered bonds, five-year credit default swaps, deposit liabilities and open market operations. Therefore, this variable can be used to address two issues at hand, since it incorporates changes in bank funding costs and market expectations indirectly through its building blocks. In the following robustness exercise we introduce WACL as a VAR variable in place of sovereign bond yields, to act both as a connection between short-term and long-term rates, and to approximate bank funding conditions. Since the variable is available by country, we calculate the long-term funding costs relative to Germany: ${rWACL_t}^h = WACL_t^h - WACL_t^{DE}$.

Our findings remain largely unchanged (see Figures I.1 to I.4). For Italy and Ireland we again identify a change in interest rate pass-through. The identified second regime has a lower persistence than in the government bond yield case for Italy, and a higher persistence for Ireland. For Spain we also identify the same impulse responses of lending rate spreads as in the baseline scenario. A difference to the government bond yield scenario is that the realisation of the second regime also appears before 2008. We also find a breakdown of the pass-through in Portugal, although the results are not robust.

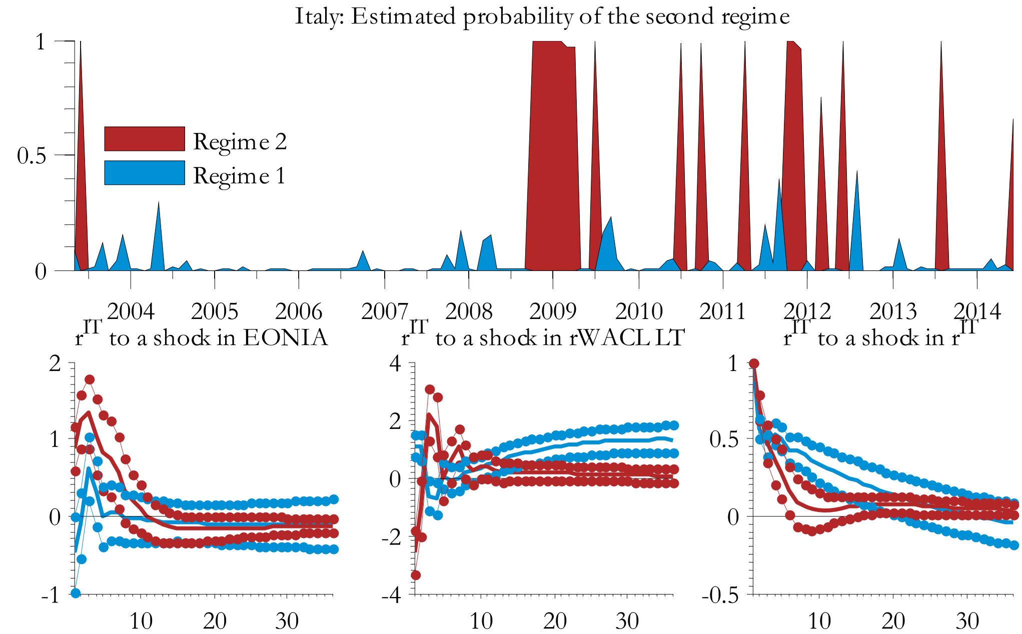

Figure I.1: Normalized state-contingent impulse responses for the first (blue) and second (red) regime using the weighted average cost of liabilities as an explanatory variable in place of sovereign bond yields. After controlling for banks' funding conditions, the model identifies different responses of the lending rate to a shock in the policy rate (lower left corner).

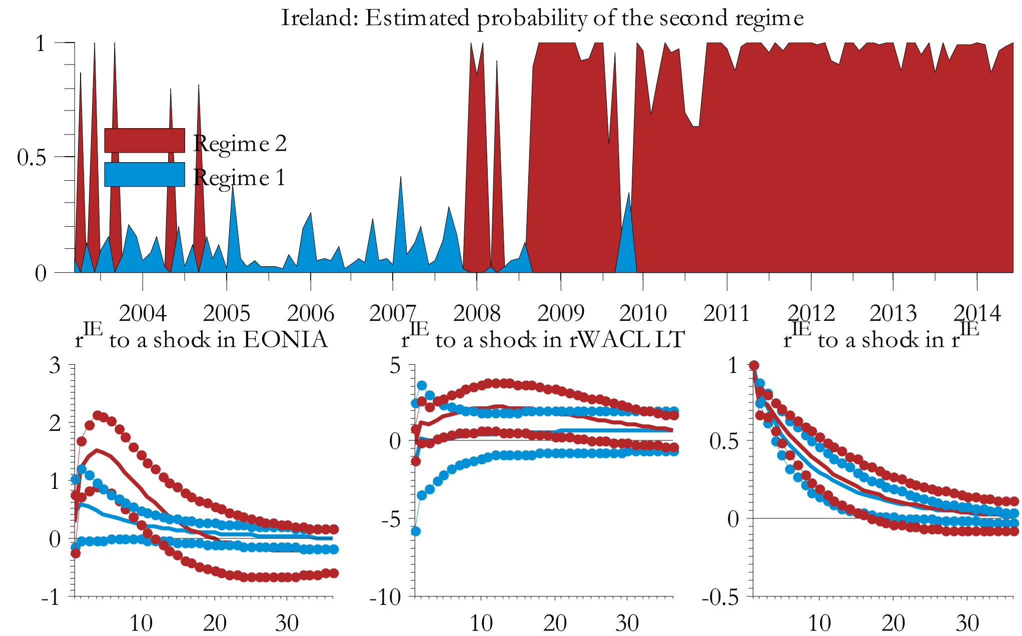

Figure I.2: Normalized state-contingent impulse responses for the first (blue) and second (red) regime using the weighted average cost of liabilities as an explanatory variable in place of sovereign bond yields. After controlling for banks' funding conditions, the model identifies different responses of the lending rate to a shock in the policy rate (lower left corner).

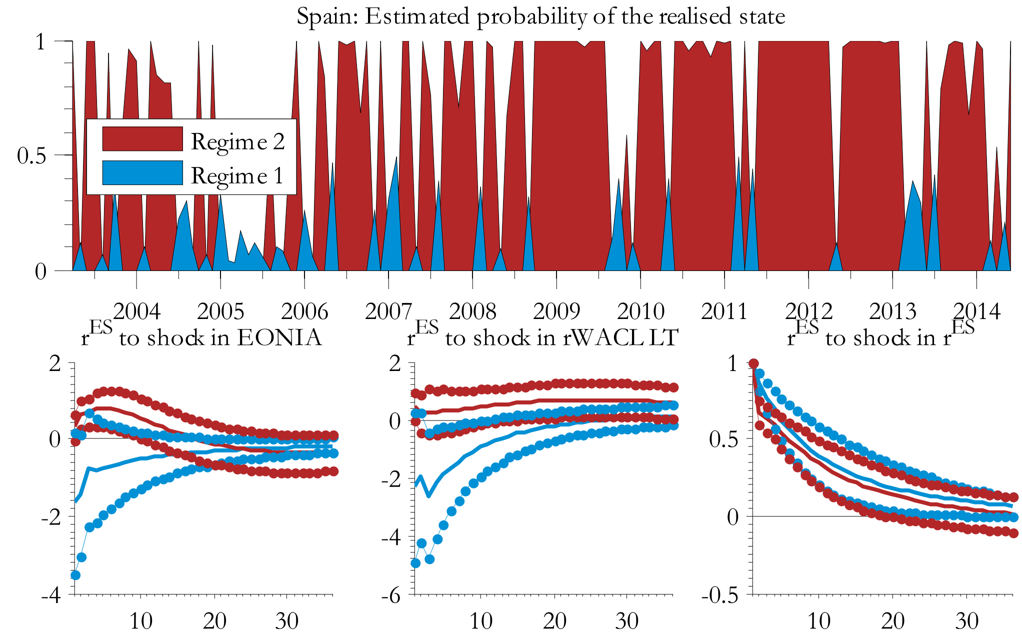

Figure I.3: Normalized state-contingent impulse responses for the first (blue) and second (red) regime using the weighted average cost of liabilities as an explanatory variable in place of sovereign bond yields. After controlling for banks' funding conditions, the model identifies different responses of the lending rate to a shock in the policy rate (lower left corner).

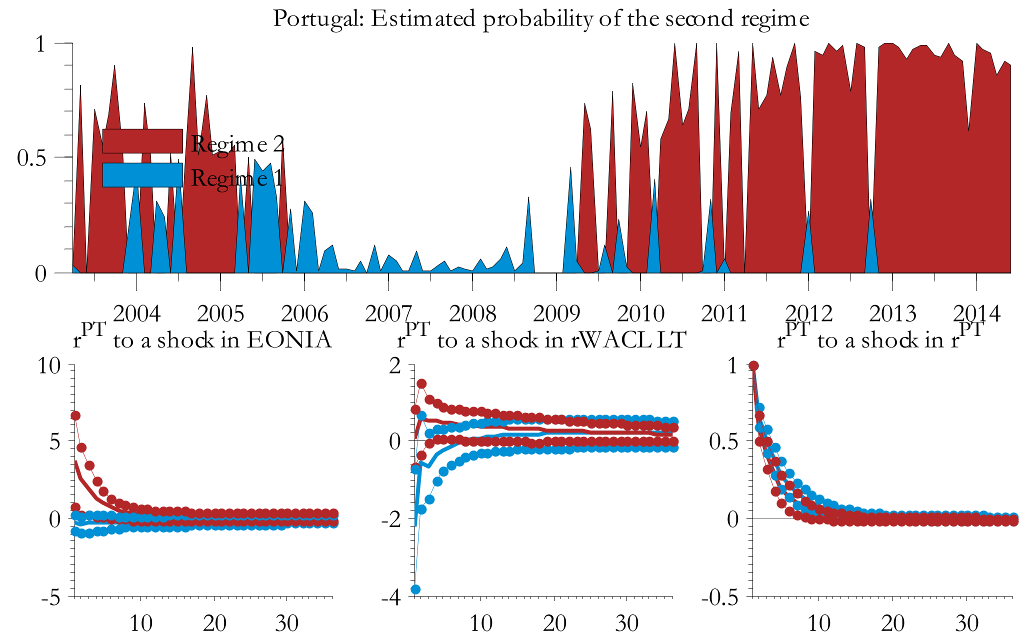

Figure I.4: Normalized state-contingent impulse responses for the first (blue) and second (red) regime using the weighted average cost of liabilities as an explanatory variable in place of sovereign bond yields. After controlling for banks' funding conditions, the model identifies different responses of the lending rate to a shock in the policy rate (lower left corner).

References

Baker, Scott R., Nicholas Bloom, and Steven J. Davis. 2015. *Measuring Economic Policy Uncertainty*.

Black, F. (1995) "Interest Rates as Options", The Journal of Finance 50, 1371–76.Illes, Anamaria, Marco Lombardi, and Paul Mizen. 2015. *Why Did Bank Lending Rates Diverge from Policy Rates after the Financial Crisis? BIS Working Paper No. 468*.

Krippner, L. (2014) "Measuring the Stance of Monetary Policy in Conventional and Unconventional Environments", Centre for Applied Macroeconomic Analysis, CAMA Working Paper 6/2014.

Pericoli, Marcello, and Marco Taboga. 2015. *Understanding Policy Rates at the Zero Lower Bound: Insights from a Bayesian Shadow Rate Model*. *Mimeo*.

Wu, J.C. and F.D. Xia (2014) "Measuring the Macroeconomic Impact of Monetary Policy at the Zero Lower Bound", Chicago Booth Research Paper No. 13.