Interbank Markets and Bank Bailout Policies amid a Sovereign Debt Crisis

Appendix (not intended for publication)

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1 Empirical Motivation and Evidence

Core Countries		**Periphery Countries**	
$\rho(R_b$ EA,Euribor)	0.85	$\rho(R_b$ Greece,Euribor)	-0.45
$\rho(R_b$ EA,EONIA)	0.72	$\rho(R_b$ Greece,EONIA)	-0.55
$\rho(R_b$ Germany,Euribor)	0.91	$\rho(R_b$ Ireland,Euribor)	0.36
$\rho(R_b$ Germany,EONIA)	0.86	$\rho(R_b$ Ireland,EONIA)	-0.18
$\rho(R_b$ France,Euribor)	0.91	$\rho(R_b$ Italy,Euribor)	0.72
$\rho(R_b$ France,EONIA)	0.85	$\rho(R_b$ Italy,EONIA)	0.25
ρ(average core R_b,Euribor)	0.87	ρ(average periphery R_b,Euribor)	0.32
ρ(average core R_b,EONIA)	0.78	ρ(average periphery R_b,EONIA)	-0.16

Table 1.1: Interbank Rates and Bond Yields - The Data

	Benchmark	**Equity Injections**	**Direct Lending**	**Equity Injections**	**Direct Lending**
		No Haircut		**Endogenous Haircut**	
$\rho(\frac{1}{q}, R^m)$	0.9556	0.8031	0.7906	0.615	0.9401
$\rho(\frac{1}{q}, R^d)$	0.4597	0.7351	0.8952	0.7822	0.961
$\rho(R^d, R^m)$	0.2321	0.5184	0.9715	0.7186	0.9689
$\rho(\frac{1}{q}, \frac{credit}{GDP})$	-0.9075	-0.7904	-0.06	-0.547	-0.2544
$\rho(\frac{1}{q^*}, R^{m*})$	0.9914	0.8734	0.7909	0.8412	0.8928
$\rho(\frac{1}{q^*}, R^{d*})$	0.6495	0.5109	0.9079	0.6451	0.9647
$\rho(R^{d*}, R^{m*})$	0.6433	0.674	0.8981	0.779	0.9624
$\rho(\frac{1}{q^*}, \frac{credit^*}{GDP^*})$	-0.8221	-0.3506	-0.3194	0.0511	-0.2232

Table 1.2: Interbank Rates and Bond Yields - The Model

	Average Haircut (%)			
	Dec-10	Dec-12	Dec-14	Dec-16
Portugal	2.67	7.46	8.59	9.48
Italy	4.91	4.78	3.90	3.79
Ireland	2.38	3.21	2.56	2.69
Greece	7.02	41.27	24.45	41.97
Spain	4.26	4.15	3.46	3.61
Periphery Average	4.86	10.89	5.78	6.81
France	5.65	5.55	4.49	4.42
Germany	3.66	4.24	3.69	3.64
Core Average	4.83	5.05	4.16	4.12

Table 1.3: Average Haircut in percentage points from the Eurosystem collateral data.

2 Robustness Analysis

The sensitivity of the steady-state values and the impulse responses for selected variables with respect to the parameters ϕ_{Bp}, ϕ_{Bp*}, ϕ_{Bc} and ϕ_{Bc*}, χ, π, σ and ξ are shown in tables A.1-A.8, respectively. The first four parameters pin down the adjustment costs to bond holdings. The following patterns emerge from the robustness analysis with respect to all the parameters in the bonds adjustment cost functions. All patterns arise consistently from the model for all parameter values.

Importantly, we have allowed for the widest possible range in the values of these parameters. Going beyond this range would have meant counterfactual steady-state values. For example, some interest rates or the $(R^d - R^m)$ spread would have become negative, or yields in the core would exceed those in the periphery.

2.1 Capital Quality Shocks and the "portfolio switching effect"

- Due to the negative effect of the shock on the quality of capital, banks start switching away from lending to the private sector to lending to the government (i.e. B_p rises). This causes bond prices (q) in the periphery to rise.

- In the domestic (periphery) country, this leads to an increase in the nominal value of bond holdings, the collateral constraint relaxing, a reduction in spreads. This is what we call the "portfolio switching effect". This increase in the value of the portfolio is consistent across all parameterizations.

- Consistently across all calibratios, the net worth of the domestic banking sector is still falling, which makes the effects of the shock on real variables a negative one, of course. However, the portfolio switching effect partially offsets this negative effect.

- **International Transmission:** By a standard arbitrage argument, the price of foreign (core) bonds (q^*) also increases.
- In the foreign country, where the quality of assets held by banks against the private sector has not changed, the demand for both types of bonds (B^c and B^{c*}) falls as their price rises.
- The value of the bond portfolio in the core falls and that drives down bank equity.
- The negative effect of the shock is transmitted internationally in this way, and lending, employment, investment, output and consumption all fall in the core country even without any exogenously imposed transmission of the capital quality shock from the periphery country.
- All these effects happen consistently across all values in the sensible range for the eight parameters that we conduct robustness checks on.

2.2 Shocks to Bond Returns

- The exogenous drop in bond returns endogenously lowers the price of bonds issued by the sovereign of the periphery.
- This lowers the demand for these bonds by domestic banks B_p.
- By an arbitrage argument, the price of bonds issued in the core also falls.
- The net effect is a drop in the value of domestic banks' bond portfolio and equity, a drop in their lending, and therefore a reduction in employment, investment, capital, output and consumption.
- **International Transmission:** In the core country, banks react by raising both types of bond holdings (B_c and B_{c*}). However, the price effect dominates, bond portfolios and equity fall in value, lending contracts and real negative effects follow.
- This is consistent across all values of the parameters that we study. In other words, the dynamics of bond portfolios in both countries are not sensitive to various elasticities of demand of bond holdings as determined by these parameters.

Table 2.1: Sensitivity to Parameter ϕ_{B^p}
(All responses in levels)

ϕ_{B^p}	**0.095**	**0.115**	**0.135**
Steady-State Values			
R^d	1.0309	1.0309	1.0309
R^m	1.0222	1.0185	1.0151
Z	0.0569	0.0571	0.0571
R_i^k	1.0564	1.0667	1.0759
R_n^k	1.0222	1.0185	1.0151
$\frac{1}{q}$	1.0566	1.0592	1.0616
q	0.9464	0.9441	0.942
R^{d*}	1.0309	1.0309	1.0309
R^{m*}	1.0006	1.0001	0.9998
Z^*	0.0559	0.0558	0.0558
R_i^{k*}	1.1131	1.1142	1.115
R_n^{k*}	1.0006	1.0001	0.9998
$\frac{1}{q^*}$	1.048	1.0467	1.0456
q^*	0.9542	0.9554	0.9564
ψ shock - period t=1 response			
q	0.0018	0.0021	0.0023
q^*	0.0018	0.0021	0.0023
B_p	0.0009	0.0008	0.0007
B_p^*	0.0008	0.0008	0.0008
B_c	-0.0045	-0.0049	-0.0054
B_c^*	-0.002	-0.002	-0.002
bondvalue	0.0028	0.0028	0.0028
bondvalue*	-0.0051	-0.0053	-0.0055
N	-0.1216	-0.1269	-0.1327
N^*	-0.0732	-0.078	-0.0822
ψ_{Bg} shock - period t=1 response			
q	-0.0105	-0.0104	-0.0104
q^*	-0.001	-0.001	-0.001
B_p	-0.0003	-0.0003	-0.0003
B_p^*	-0.0007	-0.0007	-0.0007
B_c	0.0008	0.0009	0.0009
B_c^*	0.0006	0.0005	0.0005
bondvalue	-0.0045	-0.0043	-0.0041
bondvalue*	-0.0016	-0.0016	-0.0016
N	-0.0115	-0.0118	-0.0122
N^*	-0.0187	-0.019	-0.0193

These simulations are run for the benchmark values of the other parameters in the bonds adjustment cost functions.
$\phi_{B^{p*}} = 0.1$ - $\phi_{B^c} = 0.11$ - $\phi_{B^{c*}} = 0.2$

Table 2.2: Sensitivity to Parameter $\phi_{B^{p*}}$
(All responses in levels)

$\phi_{B^{p*}}$	**0.06**	**0.08**	**0.1**	**0.12**	**0.14**
			Steady-State Values		
R^d	1.0309	1.0309	1.0309	1.0309	1.0309
R^m	1.0268	1.0225	1.0185	1.0145	1.0107
Z	0.0565	0.0569	0.0571	0.0571	0.0569
R_i^k	1.043	1.0554	1.0667	1.0774	1.0876
R_n^k	1.0268	1.0225	1.0185	1.0145	1.0107
$\frac{1}{q}$	1.0624	1.0607	1.0592	1.0578	1.0564
q	0.9413	0.9428	0.9441	0.9454	0.9466
R^{d*}	1.0309	1.0309	1.0309	1.0309	1.0309
R^{m*}	1.0014	1.0006	1.0001	0.9999	0.9999
Z^*	0.056	0.0559	0.0558	0.0558	0.0558
R_i^{k*}	1.1113	1.1131	1.1142	1.1148	1.1148
R_n^{k*}	1.0014	1.0006	1.0001	0.9999	0.9999
$\frac{1}{q^*}$	1.0439	1.0454	1.0467	1.0479	1.049
q^*	0.9579	0.9566	0.9554	0.9543	0.9533
			ψ shock - period t=1 response		
q	0.0009	0.0015	0.0021	0.0026	0.0031
q^*	0.0009	0.0015	0.0021	0.0026	0.003
B_p	0.0009	0.0009	0.0008	0.0007	0.0006
B_p^*	0.0014	0.0011	0.0008	0.0006	0.0004
B_c	-0.005	-0.0049	-0.0049	-0.0049	-0.005
B_c^*	-0.0015	-0.0017	-0.002	-0.0023	-0.0025
bondvalue	0.0028	0.0028	0.0028	0.0028	0.0028
bondvalue*	-0.0055	-0.0054	-0.0053	-0.0052	-0.0051
N	-0.1238	-0.1248	-0.1269	-0.1299	-0.1338
N^*	-0.0816	-0.08	-0.078	-0.0755	-0.0728
			ψ_{Bg} shock - period t=1 response		
q	-0.0104	-0.0104	-0.0104	-0.0104	-0.0104
q^*	-0.0011	-0.001	-0.001	-0.001	-0.001
B_p	-0.0002	-0.0003	-0.0003	-0.0003	-0.0004
B_p^*	-0.0007	-0.0007	-0.0007	-0.0007	-0.0007
B_c	0.001	0.0009	0.0009	0.0008	0.0008
B_c^*	0.0005	0.0005	0.0005	0.0006	0.0006
bondvalue	-0.0042	-0.0042	-0.0043	-0.0044	-0.0045
bondvalue*	-0.0015	-0.0015	-0.0016	-0.0016	-0.0016
N	-0.0121	-0.0119	-0.0118	-0.0117	-0.0117
N^*	-0.0188	-0.0189	-0.019	-0.019	-0.019

These simulations are run for the benchmark values of the other parameters in the bonds adjustment cost functions.
$\phi_{B^p} = 0.115$ - $\phi_{B^c} = 0.11$ - $\phi_{B^{c*}} = 0.2$

Table 2.3: Sensitivity to Parameter ϕ_{B^c}
(All responses in levels)

ϕ_{B^c}	**0.06**	**0.09**	**0.11**	**0.13**
Steady-State Values				
R^d	1.0309	1.0309	1.0309	1.0309
R^m	1.0169	1.0175	1.0185	1.0211
Z	0.0571	0.0571	0.0571	0.057
R_i^k	1.0709	1.0694	1.0667	1.0594
R_n^k	1.0169	1.0175	1.0185	1.0211
$\frac{1}{q}$	1.0634	1.0609	1.0592	1.0568
q	0.9404	0.9426	0.9441	0.9463
R^{d*}	1.0309	1.0309	1.0309	1.0309
R^{m*}	1.0197	1.0087	1.0001	0.9853
Z^*	0.057	0.0568	0.0558	0.0525
R_i^{k*}	1.0632	1.0927	1.1142	1.1492
R_n^{k*}	1.0197	1.0087	1.0001	0.9853
$\frac{1}{q^*}$	1.0439	1.0458	1.0467	1.0467
q^*	0.9579	0.9562	0.9554	0.9554
ψ shock - period t=1 response				
q	0.0014	0.0019	0.0021	0.002
q^*	0.0014	0.0019	0.0021	0.002
B_p	0.0006	0.0007	0.0008	0.0009
B_p^*	0.0013	0.001	0.0008	0.0008
B_c	-0.0054	-0.0051	-0.0049	-0.005
B_c^*	-0.0015	-0.0018	-0.002	-0.0021
bondvalue	0.0028	0.0028	0.0028	0.0029
bondvalue*	-0.0056	-0.0054	-0.0053	-0.0054
N	-0.1369	-0.131	-0.1269	-0.1209
N^*	-0.0559	-0.0656	-0.078	-0.1153
ψ_{Bg} shock - period t=1 response				
q	-0.0106	-0.0105	-0.0104	-0.0104
q^*	-0.0012	-0.0011	-0.001	-0.0009
B_p	-0.0001	-0.0002	-0.0003	-0.0004
B_p^*	-0.0006	-0.0006	-0.0007	-0.0008
B_c	0.0008	0.0008	0.0009	0.0009
B_c^*	0.0004	0.0005	0.0005	0.0006
bondvalue	-0.004	-0.0042	-0.0043	-0.0044
bondvalue*	-0.0016	-0.0016	-0.0016	-0.0015
N	-0.0129	-0.0122	-0.0118	-0.0114
N^*	-0.0162	-0.0176	-0.019	-0.0212

These simulations are run for the benchmark values of the other parameters in the bonds adjustment cost functions.
$\phi_{B^p} = 0.115$ - $\phi_{B^{p*}} = 0.1$ - $\phi_{B^{c*}} = 0.2$

Table 2.4: Sensitivity to Parameter $\phi_{B^{c*}}$
(All responses in levels)

$\phi_{B^{c*}}$	**0.05**	**0.1**	**0.15**	**0.2**
Steady-State Values				
R^d	1.0309	1.0309	1.0309	1.0309
R^m	1.0187	1.0181	1.018	1.0185
Z	0.0571	0.0571	0.0571	0.0571
R_i^k	1.066	1.0678	1.068	1.0667
R_n^k	1.0187	1.0181	1.018	1.0185
$\frac{1}{q}$	1.0472	1.0522	1.056	1.0592
q	0.955	0.9504	0.9469	0.9441
R^{d*}	1.0309	1.0309	1.0309	1.0309
R^{m*}	1.0303	1.0189	1.0092	1.0001
Z^*	0.056	0.0571	0.0568	0.0558
R_i^{k*}	1.0327	1.0655	1.0914	1.1142
R_n^{k*}	1.0303	1.0189	1.0092	1.0001
$\frac{1}{q^*}$	1.055	1.0516	1.0489	1.0467
q^*	0.9478	0.951	0.9534	0.9554
ψ shock - period t=1 response				
q	0.0023	0.0022	0.0021	0.0021
q^*	0.0024	0.0023	0.0022	0.0021
B_p	0.0014	0.0011	0.0009	0.0008
B_p^*	-0.0003	0.0001	0.0005	0.0008
B_c	-0.0028	-0.0036	-0.0043	-0.0049
B_c^*	-0.003	-0.0026	-0.0023	-0.002
bondvalue	0.0025	0.0026	0.0027	0.0028
bondvalue*	-0.004	-0.0044	-0.0049	-0.0053
N	-0.1175	-0.122	-0.125	-0.1269
N^*	-0.0266	-0.0401	-0.0564	-0.078
ψ_{Bg} shock - period t=1 response				
q	-0.0104	-0.0105	-0.0105	-0.0104
q^*	-0.0009	-0.001	-0.001	-0.001
B_p	-0.0013	-0.0008	-0.0005	-0.0003
B_p^*	-0.0008	-0.0008	-0.0008	-0.0007
B_c	0.0011	0.001	0.001	0.0009
B_c^*	0.0016	0.001	0.0007	0.0005
bondvalue	-0.0054	-0.0049	-0.0045	-0.0043
bondvalue*	-0.0016	-0.0016	-0.0016	-0.0016
N	-0.0102	-0.011	-0.0115	-0.0118
N^*	-0.0098	-0.0127	-0.0157	-0.019

These simulations are run for the benchmark values of the other parameters in the bonds adjustment cost functions.
$\phi_{B^p} = 0.115$ - $\phi_{B^{p*}} = 0.1$ - $\phi_{B^c} = 0.1$

Table 2.5: Sensitivity to Parameter χ
(All responses in levels)

χ	**1.5**	**1.75**	**2**
	Steady-State Values		
R^d	1.0309	1.0309	1.0309
R^m	1.0296	1.0203	1.0185
Z	0.0561	0.057	0.0571
R_i^k	1.0348	1.0615	1.0667
R_n^k	1.0296	1.0203	1.0185
$\frac{1}{q}$	1.067	1.0605	1.0592
q	0.9372	0.9429	0.9441
R^{d*}	1.0309	1.0309	1.0309
R^{m*}	1.0197	1.0045	1.0001
Z^*	0.057	0.0564	0.0558
R_i^{k*}	1.0633	1.1035	1.1142
R_n^{k*}	1.0197	1.0045	1.0001
$\frac{1}{q^*}$	1.0546	1.0481	1.0467
q^*	0.9482	0.9541	0.9554
	ψ shock - period t=1 response		
q	0.0002	0.0017	0.0021
q^*	0.0001	0.0017	0.0021
B_p	0.0014	0.0009	0.0008
B_p^*	0.0012	0.0009	0.0008
B_c	-0.0038	-0.0047	-0.0049
B_c^*	-0.0014	-0.0019	-0.002
bondvalue	0.0025	0.0027	0.0028
bondvalue*	-0.0049	-0.0052	-0.0053
N	-0.1156	-0.1244	-0.1269
N^*	-0.0532	-0.0698	-0.078
	ψ_{Bg} shock - period t=1 response		
q	-0.0104	-0.0105	-0.0104
q^*	-0.001	-0.0011	-0.001
B_p	-0.0003	-0.0003	-0.0003
B_p^*	-0.0007	-0.0006	-0.0007
B_c	0.0009	0.0008	0.0009
B_c^*	0.0005	0.0005	0.0005
bondvalue	-0.0043	-0.0042	-0.0043
bondvalue*	-0.0016	-0.0016	-0.0016
N	-0.0118	-0.0117	-0.0118
N^*	-0.019	-0.0176	-0.019

Table 2.6: Sensitivity to Parameter π
(All responses in levels)

π	**0.25**	**0.275**	**0.3**
	Steady-State Values		
R^d	1.0309	1.0309	1.0309
R^m	1.0185	1.0228	1.0298
Z	0.0571	0.0568	0.0561
R_i^k	1.0667	1.0517	1.0337
R_n^k	1.0185	1.0228	1.0298
$\frac{1}{q}$	1.0592	1.0628	1.0673
q	0.9441	0.9409	0.937
R^{d*}	1.0309	1.0309	1.0309
R^{m*}	1.0001	1.0073	1.0174
Z^*	0.0558	0.0566	0.0569
R_i^{k*}	1.1142	1.0887	1.062
R_n^{k*}	1.0001	1.0073	1.0174
$\frac{1}{q^*}$	1.0467	1.0504	1.0549
q^*	0.9554	0.9521	0.948
	ψ shock - period t=1 response		
q	0.0021	0.0012	0
q^*	0.0021	0.0011	0
B_p	0.0008	0.0011	0.0016
B_p^*	0.0008	0.0012	0.0015
B_c	-0.0049	-0.0045	-0.004
B_c^*	-0.002	-0.0018	-0.0016
bondvalue	0.0028	0.0029	0.0029
bondvalue*	-0.0053	-0.0053	-0.0053
N	-0.1269	-0.1214	-0.1147
N^*	-0.078	-0.0683	-0.0583
	ψ_{Bg} shock - period t=1 response		
q	-0.0104	-0.0105	-0.0106
q^*	-0.001	-0.0012	-0.0012
B_p	-0.0003	-0.0002	-0.0001
B_p^*	-0.0007	-0.0005	-0.0004
B_c	0.0009	0.0007	0.0006
B_c^*	0.0005	0.0005	0.0004
bondvalue	-0.0043	-0.0039	-0.0036
bondvalue*	-0.0016	-0.0016	-0.0016
N	-0.0118	-0.0115	-0.0112
N^*	-0.019	-0.0162	-0.015

Table 2.7: Sensitivity to Parameter σ
(All responses in levels)

σ	**0.9**	**0.92**	**0.95**
Steady-State Values			
R^d	1.0309	1.0309	1.0309
R^m	1.0158	1.0154	1.0185
Z	0.0571	0.0571	0.0571
R_i^k	1.0741	1.0751	1.0667
R_n^k	1.0158	1.0154	1.0185
$\frac{1}{q}$	1.0588	1.058	1.0592
q	0.9444	0.9452	0.9441
R^{d*}	1.0309	1.0309	1.0309
R^{m*}	0.9999	0.9966	1.0001
Z^*	0.0559	0.0553	0.0558
R_i^{k*}	1.1152	1.1232	1.1142
R_n^{k*}	0.9999	0.9966	1.0001
$\frac{1}{q^*}$	1.0465	1.0455	1.0467
q^*	0.9556	0.9564	0.9554
ψ shock - period t=1 response			
q	0.0012	0.0017	0.0021
q^*	0.0012	0.0017	0.0021
B_p	0.0018	0.0013	0.0008
B_p^*	0.0024	0.0017	0.0008
B_c	-0.0061	-0.0058	-0.0049
B_c^*	-0.0025	-0.0024	-0.002
bondvalue	0.0047	0.004	0.0028
bondvalue*	-0.0074	-0.0067	-0.0053
N	-0.1213	-0.1259	-0.1269
N^*	-0.0936	-0.0973	-0.078
ψ_{Bg} shock - period t=1 response			
q	-0.0104	-0.0104	-0.0104
q^*	-0.001	-0.001	-0.001
B_p	-0.0002	-0.0002	-0.0003
B_p^*	-0.0006	-0.0006	-0.0007
B_c	0.0007	0.0008	0.0009
B_c^*	0.0005	0.0005	0.0005
bondvalue	-0.0041	-0.0042	-0.0043
bondvalue*	-0.0017	-0.0017	-0.0016
N	-0.0107	-0.0111	-0.0118
N^*	-0.0178	-0.0182	-0.019

Table 2.8: Sensitivity to Parameter ξ
(All responses in levels)

ξ	**0.001**	**0.003**	**0.005**
Steady-State Values			
R^d	1.0309	1.0309	1.0309
R^m	1.0159	1.0185	1.0163
Z	0.0571	0.0571	0.0571
R_i^k	1.0738	1.0667	1.0727
R_n^k	1.0159	1.0185	1.0163
$\frac{1}{q}$	1.0563	1.0592	1.0559
q	0.9467	0.9441	0.9471
R^{d*}	1.0309	1.0309	1.0309
R^{m*}	0.988	1.0001	0.9855
Z^*	0.0533	0.0558	0.0526
R_i^{k*}	1.1431	1.1142	1.1488
R_n^{k*}	0.988	1.0001	0.9855
$\frac{1}{q^*}$	1.0437	1.0467	1.0432
q^*	0.9582	0.9554	0.9586
ψ shock - period t=1 response			
q	0.0025	0.0021	0.0026
q^*	0.0025	0.0021	0.0026
B_p	0.0006	0.0008	0.0005
B_p^*	0.0008	0.0008	0.0007
B_c	-0.0057	-0.0049	-0.0057
B_c^*	-0.0022	-0.002	-0.0022
bondvalue	0.003	0.0028	0.0029
bondvalue*	-0.0057	-0.0053	-0.0056
N	-0.1303	-0.1269	-0.1302
N^*	-0.1148	-0.078	-0.1225
ψ_{Bg} shock - period t=1 response			
q	-0.0104	-0.0104	-0.0104
q^*	-0.001	-0.001	-0.001
B_p	-0.0003	-0.0003	-0.0003
B_p^*	-0.0007	-0.0007	-0.0007
B_c	0.0009	0.0009	0.0009
B_c^*	0.0005	0.0005	0.0005
bondvalue	-0.0043	-0.0043	-0.0043
bondvalue*	-0.0016	-0.0016	-0.0016
N	-0.0118	-0.0118	-0.0118
N^*	-0.0189	-0.019	-0.019