

A Work Project, presented as part of the requirements for the award of a Masters Degree in Finance from the Faculdade de Economia da Universidade Nova de Lisboa.



# **The Impact of Foreign Currency Debt on Credit Risk**

Analyzing Exchange Rate Risk in International Credit Markets

**-Supplementary Appendix-**

January 6<sup>th</sup>, 2017

Nadja Christina Merz  
Student Number: 24986

## Arellano-Bond Difference GMM

The difference GMM estimator following Arellano and Bond (1998) is designed for panels with many groups and few periods, where the model describes a linear relationship between a dynamic dependent variable and explanatory variables. Furthermore, the estimation allows for time-invariant fixed effects and heteroskedasticity as well as autocorrelation within countries. When compared to standard OLS techniques, the main advantage of difference GMM is that it allows for endogenous as well as predetermined variables in the context of a dynamic model.

Equation (1.a), (1.b) and (2.a), (2.b) describe the models to be estimated in this paper, covering a sample of 62 countries over the period 2000 to 2014.

$$NPL_{i,t} = \beta_0 + \beta_1 NPL_{i,t-1} + \beta_2 REER_{i,t} + \beta_3 IC_{i,t} + \beta_4 (REER_{i,t} \cdot IC_{i,t}) + \beta_5 X'_{i,t} + \mu_i + \varepsilon_{i,t} \quad (1.a)$$

$$NPL_{i,t} = \beta_0 + \beta_1 NPL_{i,t-1} + \beta_2 REER_{i,t} + \beta_3 IC_{i,t} + \beta_4 (REER_{i,t} \cdot IC_{i,t}) \cdot highIC_{i,t} + \beta_5 (REER_{i,t} \cdot IC_{i,t}) \cdot lowIC_{i,t} + \beta_6 X'_{i,t} + \mu_i + \varepsilon_{i,t} \quad (1.b)$$

$$NPL_{i,t} = \beta_0 + \beta_1 NPL_{i,t-1} + \beta_2 V\_REER_{i,t} + \beta_3 IC_{i,t} + \beta_4 (V\_REER_{i,t} \cdot IC_{i,t}) + \beta_5 X'_{i,t} + \mu_i + \varepsilon_{i,t} \quad (2.a)$$

$$NPL_{i,t} = \beta_0 + \beta_1 NPL_{i,t-1} + \beta_2 V\_REER_{i,t} + \beta_3 IC_{i,t} + \beta_4 (V\_REER_{i,t} \cdot IC_{i,t}) \cdot highIC_{i,t} + \beta_5 (V\_REER_{i,t} \cdot IC_{i,t}) \cdot lowIC_{i,t} + \beta_6 X'_{i,t} + \mu_i + \varepsilon_{i,t} \quad (2.b)$$

The Arellano and Bond (1991) estimation is based on the following orthogonality conditions that apply to all four specifications (Bun and Windmeijer, 2010; Bond, Hoeffler and Temple, 2001):

$$E(NPL_{i,t-s} \Delta \varepsilon_{i,t}) = 0 \quad \text{for } t = 2002, \dots, T \text{ and } 2001 \leq s \leq T - 1; \quad (\text{GMM.1})$$

Where  $NPL_{i,t-s}$  are the suitable lags for the dependent variable. The instrument matrix following from condition (GMM.1) is represented in  $\bar{Z}_i$ .

$$\bar{Z}_i = \begin{bmatrix} NPL_{i,1} & 0 & 0 & \dots & 0 & \dots & 0 \\ 0 & NPL_{i,1} & NPL_{i,2} & \dots & 0 & \dots & 0 \\ \vdots & \vdots & \vdots & \dots & \vdots & \vdots & \vdots \\ 0 & 0 & 0 & \dots & NPL_{i,1} & \dots & NPL_{i,T-2} \end{bmatrix} \quad (\text{GMM.2})$$

Condition (GMM.1) implies that lagged levels of date  $(t - 2)$  and earlier may be employed as valid instruments for the model in first differences (Arellano and Bond, 1991).

The rationale towards endogenous explanatory variables follows a similar intuition. Let  $x_{i,t}$  denote an endogenous variable in the specification. The moment condition can be written as:

$$E(x_{i,t-s} \Delta \varepsilon_{i,t}) = 0 \quad \text{for } t = 2001, \dots, T \text{ and } 1 \leq s \leq T - 1 \quad (\text{GMM.4})$$

GMM.4 implies that lagged values of endogenous variables may validly be used as instruments for contemporaneous values.

In order to verify the validity of the approach, all estimations include the Arellano-Bond test for autocorrelation of order one and two (Arellano and Bond, 1991). Basically, the differenced error term must be uncorrelated to the second and higher lags of the dependent variable:

$$E(NPL_{i,t-j} \Delta \varepsilon_{i,t}) = 0 \quad \text{for } j \geq 2 \quad (\text{GMM.5})$$

If the condition above were not to hold, endogeneity would again bias the estimates. Therefore, a valid specification must not reject the null hypothesis of no autocorrelation of order two and higher.

Moreover, a Sargan-Test is employed to test the validity of instruments (Arellano and Bond, 1991). Following an asymptotic  $\chi^2$  - distribution, the test assesses the overidentifying restrictions implied by the instrument matrices (GMM.2) and (GMM.4). In order to prove the power of the instruments, the test must not reject the null of instrument validity. However, too many instruments can easily over-fit endogenous variables, leading to unrealistically high p-values in the Sargan Test (Roodman, 2009).

In order to verify the assumption of mean stationarity, Augmented Dickey-Fuller unit-root tests as well as Im-Persean-Shin tests were performed (Dickey and Fuller, 1981; Im, Persean and Shin, 2003).

Lastly, I calculate a pseudo  $R^2$  to measure the fit of model, calculated as the squared correlation of actual values and fitted values of the dependent variable.

$$pseudo R^2 = corr(NPL_{i,t}, \widehat{NPL}_{i,t})^2 \quad (GMM.6)$$

The most important criteria when assessing the validity of the model, however, are autocorrelation of order two and higher and the validity of instruments.

**Table A.1** List of Countries Including in the Sample

Argentina	Germany	Paraguay
Armenia	Greece	Peru
Australia	Hungary	Philippines
Belgium	Iceland	Poland
Bolivia	India	Romania
Brazil	Indonesia	Russia
Bulgaria	Ireland	Singapore
Canada	Israel	Slovak Republic
Chile	Italy	Slovenia
China	Japan	South Africa
Colombia	Korea	Spain
Costa Rica	Latvia	Sweden
Croatia	Lithuania	Switzerland
Czech Republic	Macedonia, FYR	Thailand
Denmark	Malaysia	Uganda
Dominican Republic	Malta	Ukraine
Estonia	Mexico	United Kingdom
Finland	Moldova	United States
France	Morocco	Uruguay
Gabon	Netherlands	Venezuela
Georgia	Norway	

**Table A.2** Data Sources

Indicator	Sources
Non-performing loans	• World Bank –World Development Indicators
Real Effective Exchange Rate	• Bank of International Settlements – BIS effective exchange rate indices (broad indices) • International Monetary Fund – International Financial Statistics
International Claims	• Bank of International Settlements – Consolidated Banking Statistics (A – All reporting banks, A – International claims; cross-border claims in all currencies and local claims in non-local currencies)
Real Gross Domestic Product	• World Bank –World Development Indicators
Lending Interest Rate	• World Bank –World Development Indicators
Trade	• World Bank –World Development Indicators
Unemployment	• World Bank –World Development Indicators
Banking Crisis Dummy	• World Bank - Global Financial Development Database
Financial Market Development	• World Economic Forum’s Global Competitive Index Historical Dataset

**Table A.3** Institute of International Finance Loan Classification Scheme

<b>Loan Category</b>	<b>Definition</b>
<b>Standard</b>	Credit is sound and all principal and interest payments are current. Repayment difficulties are not foreseen under current circumstances and full repayment is expected.
<b>Watch</b>	Asset subject to conditions that, if left uncorrected, could raise concerns about full repayment. These require more than normal attention by credit officers.
<b>Substandard</b>	Full repayment is in doubt due to inadequate protection (e.g., obligor net worth or collateral) and/or interest or principal or both are more than 90 days overdue. These assets show underlying, well- defined weaknesses that could lead to probable loss if not corrected and risk becoming impaired assets.
<b>Doubtful</b>	Assets for which collection/liquidation in full is determined by bank management to be improbable due to current conditions and/or interest or principal or both are overdue more than 180 days. Assets in this category are considered impaired, but are not yet considered total losses because some pending factors may strengthen the asset's quality (merger, new financing, or capital injection).
<b>Loss</b>	An asset is downgraded to loss when management considers the facility to be virtually uncollectible and/or principal or interest or both are overdue more than one year.

Source: Krueger (2002)

**Table A.4** Descriptive Statistics of NPL Ratios

<b>Country Name</b>	<b>Mean</b>	<b>Std. Dev.</b>	<b>Min</b>	<b>Max</b>	<b>N</b>
Argentina	7.10	6.29	1.40	18.10	15
Armenia	6.45	6.38	1.90	24.40	15
Australia	1.03	0.69	0.20	2.13	15
Belgium	2.74	0.94	1.16	4.24	15
Bolivia	7.78	6.15	1.50	17.70	15
Brazil	3.89	1.43	2.85	8.30	15
Bulgaria	8.06	6.68	2.00	17.30	15
Canada	0.90	0.41	0.42	1.60	15
Chile	1.70	0.69	0.70	2.93	15
China	9.52	10.25	0.95	29.80	15
Colombia	4.66	2.89	2.50	11.00	15
Costa Rica	1.94	0.65	1.20	3.50	15
Croatia	9.42	3.80	4.75	16.71	15
Czech Republic	6.93	6.74	2.37	29.30	15
Denmark	2.18	1.93	0.20	5.95	15

N represents the number of available data points. NPLs statistics are based on annual data between 2010-2014.

**Table A.4** Descriptive Statistics of NPL Ratios (continued)

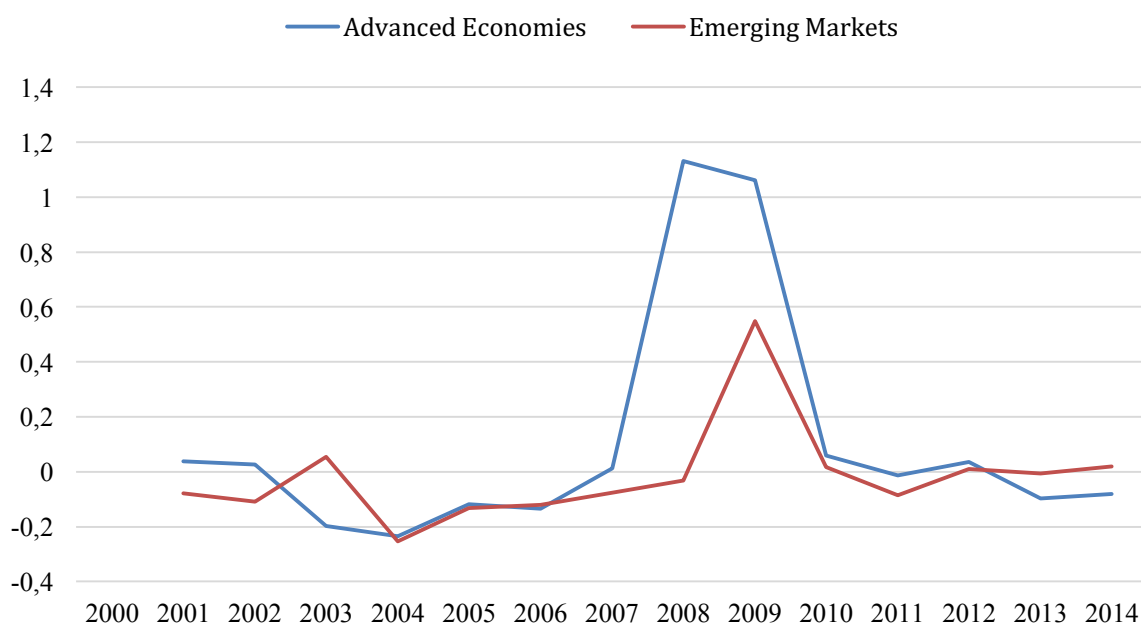
<b>Country Name</b>	<b>Mean</b>	<b>Std. Dev.</b>	<b>Min</b>	<b>Max</b>	<b>N</b>
Estonia	1.78	1.76	0.20	5.38	15
Finland	0.46	0.13	0.20	0.60	13
France	4.01	0.73	2.70	5.00	15
Gabon	8.09	4.58	2.50	16.00	15
Georgia	4.08	3.02	0.81	11.60	14
Germany	3.65	0.99	2.34	5.20	15
Greece	11.98	9.76	4.60	33.78	15
Hungary	6.97	5.85	1.80	16.83	15
Iceland	5.23	5.79	0.80	18.30	13
India	5.56	3.62	2.21	12.80	15
Indonesia	9.03	11.23	1.69	34.40	15
Ireland	8.41	9.83	0.48	25.71	14
Israel	3.09	1.94	1.40	8.20	15
Italy	9.30	3.97	5.78	18.03	15
Japan	3.36	2.13	1.50	8.40	15
Korea	1.73	2.19	0.48	8.90	15
Latvia	5.33	5.40	0.50	15.93	15
Lithuania	9.26	7.94	0.60	23.99	15
Macedonia, FYR	15.39	9.11	6.71	34.80	15
Malaysia	7.94	5.73	1.65	17.80	15
Malta	9.12	4.01	5.45	18.00	14
Mexico	2.98	1.17	1.50	5.80	15
Moldova	10.27	4.88	3.70	20.60	14
Morocco	10.87	5.90	4.80	19.40	15
Netherlands	2.27	0.79	0.80	3.23	14
Norway	1.21	0.43	0.50	2.00	15
Paraguay	6.82	7.18	1.15	20.60	15
Peru	5.69	3.69	2.20	14.80	15
Philippines	9.39	8.27	2.02	27.70	15
Poland	9.77	6.66	2.82	21.20	15
Romania	8.26	6.48	1.40	21.87	15
Russia	5.48	2.19	2.40	9.53	15
Singapore	3.17	2.54	0.76	8.00	15
Slovak Republic	5.72	3.32	2.49	13.70	15
Slovenia	6.74	4.36	1.80	15.18	15
South Africa	3.34	1.49	1.10	5.94	15
Spain	3.37	3.11	0.70	9.38	15
Sweden	0.92	0.53	0.08	1.90	15

N represents the number of available data points. NPLs statistics are based on annual data between 2010-2014.

**Table A.4** Descriptive Statistics of NPL Ratios (continued)

Country Name	Mean	Std. Dev.	Min	Max	N
Switzerland	1.17	0.97	0.30	4.10	15
Thailand	8.07	5.19	2.30	17.70	15
Ukraine	26.45	16.68	3.88	59.76	15
United Kingdom	2.42	1.07	0.90	3.96	15
United States	2.16	1.41	0.70	5.00	15
Uruguay	6.79	8.90	0.51	33.90	14
Venezuela	3.35	2.98	0.70	9.20	14
Total	5.86	6.65	0.08	59.76	919

N represents the number of available data points. NPLs statistics are based on annual data between 2010-2014. Source: World Bank and author's calculations

**Figure A.1** Growth of NPL Ratio (%)

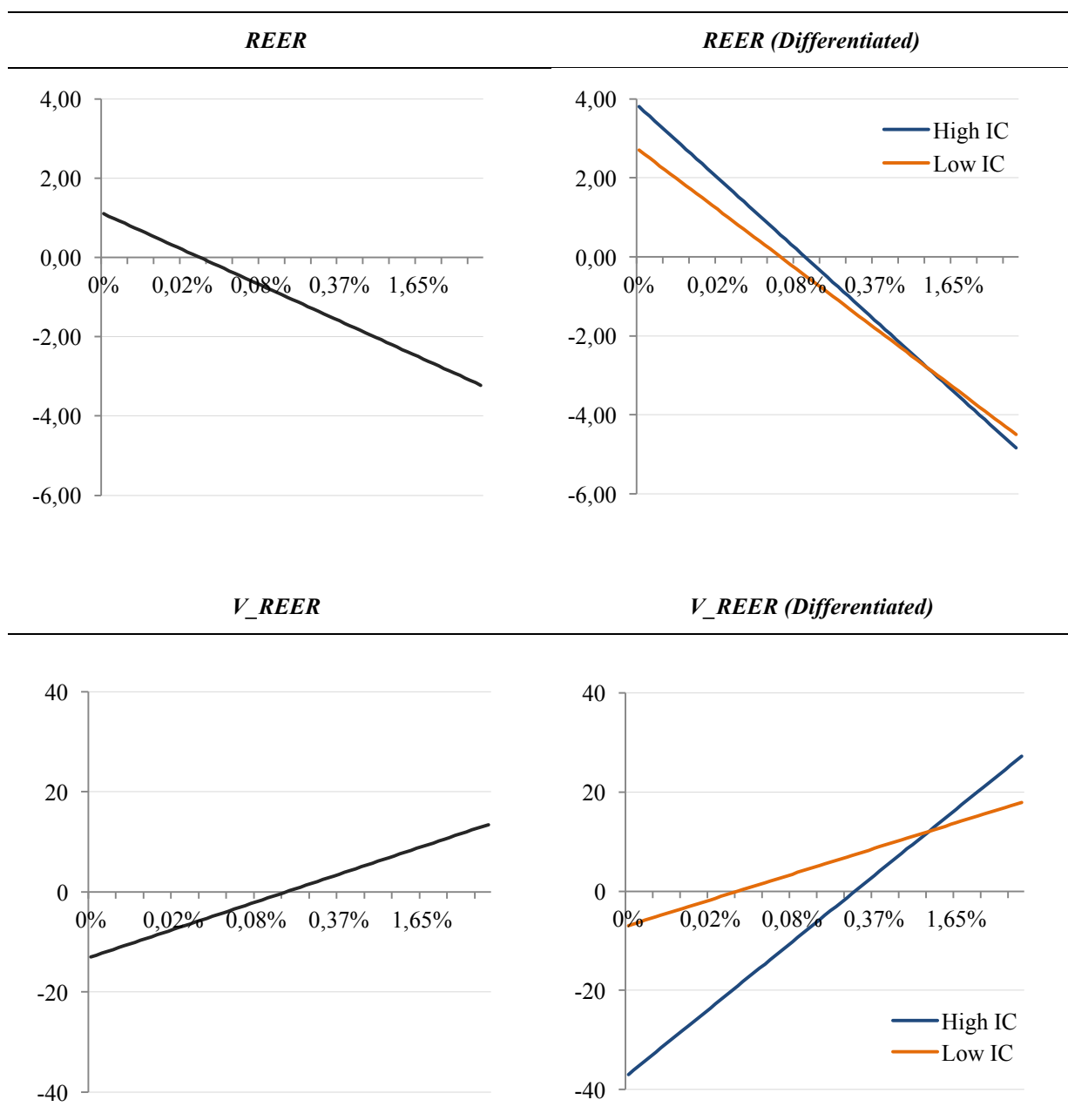
Source: World Bank and author's calculations

**Table A.5** Selected Descriptive Statistic

<b>Variables</b>	<b>N</b>	<b>Mean</b>	<b>Std. Dev.</b>	<b>Min.</b>	<b>Max.</b>
<b>Dependent Variable</b>					
NPL	919	5.86	6.65	0.08	59.76
<b>Independent Variables</b>					
GDPGrowth	929	3.39	3.86	-14.81	18.29
REER	930	97.78	15.00	53.91	275.79
V_REER	930	0.02	0.02	0.00	0.28
IC	929	0.32	0.44	0.00	4.99
IntRate	790	12.16	10.07	0.50	118.38
Unemp	930	8.96	6.07	0.70	37.30
Trade	926	87.98	54.50	20.26	439.66
BankingCrisis	744	0.13	0.34	0	1

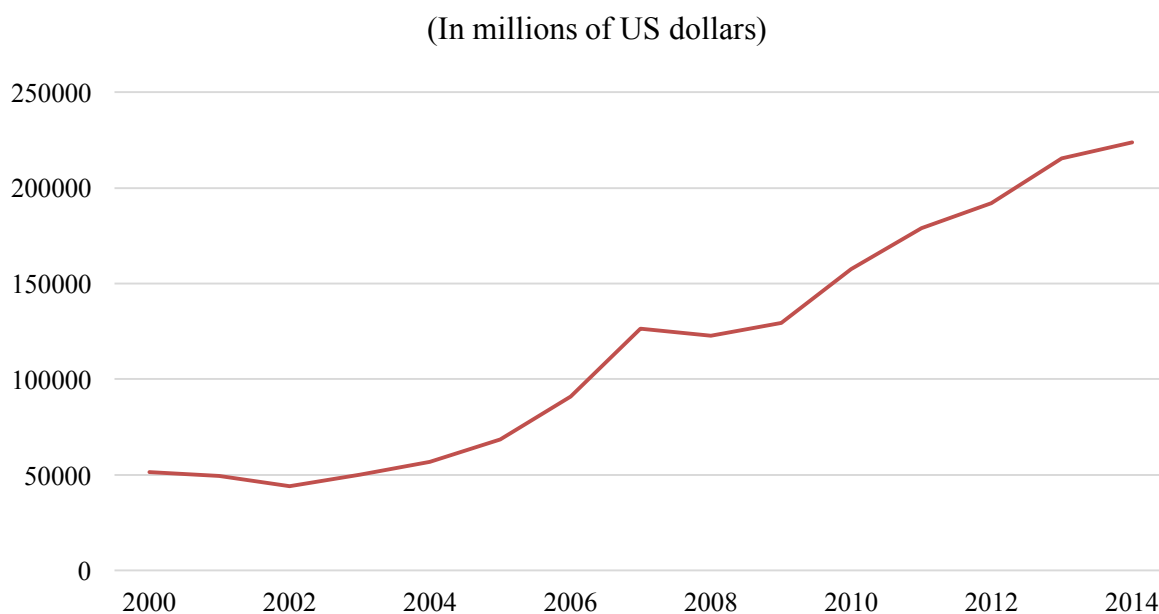
Note that the variables above are reported without any transformation.

**Figure A.2** Marginal Effects of Exchange Rate Movements on NPLs Conditional on Different Levels of International Claims



The vertical axis shows the percentage change of the growth rate of non-performing loans given a percentage change in REER or V\_REER; the horizontal axis shows the ratio of international claims to GDP on a logarithmic scale.

**Figure A.3** Average International Claims of Emerging Markets



Source: BIS consolidated banking statistics and author's calculations

**Table A.6** List of Emerging Markets including in the subsample

Argentina	India	Poland
Brazil	Indonesia	Romania
Chile	Israel	Russia
China	Malaysia	South Africa
Colombia	Mexico	Thailand
Czech Republic	Peru	Ukraine
Hungary	Philippines	Venezuela

**Table A.7** Determinants of NPLs – Emerging Markets

	<b>(3.a)</b> REER			<b>(3.b)</b> V_REER	
	OLS	GMM		OLS	GMM
L.NPL	-0.242 (0.055)***	-0.065 (0.081)***	L.NPL	-0.227 (0.036)***	-0.108 (0.095)***
REER	-0.035 (0.024)	-0.097 (0.010)***	V_REER	-23.458 (18.625)	-9.338 (13.781)
L.REER	0.011 (0.005)**	-0.006 (0.008)	L.V_REER	19.648 (4.486)***	18.059 (5.483)***
IC	0.857 (0.802)	3.833 (0.538)***	IC	0.102 (0.105)	0.375 (0.135)***
REER · IC	-0.007 (0.008)	-0.032 (0.004)***	V_REER · IC	-7.012 (5.498)	-3.888 (3.615)
L.REER · IC	0.001 (0.001)	-0.003 (0.002)	L.V_REER · IC	6.547 (1.118)***	5.716 (1.798)***
IntRate	0.018 (0.010)*	0.042 (0.009)***	IntRate	0.023 (0.008)**	0.027 (0.008)***
GDPGrowth	-0.016 (0.011)	-0.040 (0.012)***	GDPGrowth	-0.026 (0.009)***	-0.030 (0.008)***
Trade	-0.776 (0.424)*	-0.191 (0.182)	Trade	-0.407 (0.218)*	-0.405 (0.175)**
FinDev	-0.700 (0.398)*	-1.444 (0.664)**	FinDev	-0.339 (0.533)	-0.114 (0.284)
Constant	4.056 (2.653)	12.664 (1.916)***	Constant	0.863 (0.860)	0.812 (0.460)*
<i>Observations</i>	<i>178</i>	<i>156</i>		<i>178</i>	<i>156</i>
<i>Countries</i>	<i>21</i>	<i>20</i>		<i>21</i>	<i>20</i>
<i>No of Instruments</i>		<i>39</i>			<i>39</i>
<i>AR(1) p-value</i>		<i>0.04</i>			<i>0.02</i>
<i>AR(2) p-value</i>		<i>0.80</i>			<i>0.30</i>
<i>Sargan p-value</i>		<i>0.99</i>			<i>1.00</i>
<i>R<sup>2</sup> / Pseudo R<sup>2</sup></i>	<i>0.43</i>	<i>0.70</i>		<i>0.49</i>	<i>0.81</i>

The dependent variable is the first difference of NPLs in natural logarithm. Standard Errors in parentheses.

\* significance at 10%; \*\* significance at 5%; \*\*\* significance at 1%. NPL, IC, and FinDev are considered in logarithmic terms, Trade is employed in logarithmic differences. An increase in REER suggests an appreciation. OLS: Fixed effects estimation with robust standard errors. Difference GMM: AR(1) and AR(2) are the Arellano-Bond tests for first and second order autocorrelation of the residuals. The Sargan-Test tests for overidentifying restrictions. P-values suggest that the instruments are appropriate.

**Figure A.4** Non-Performing Loans ratio (%) of Iceland

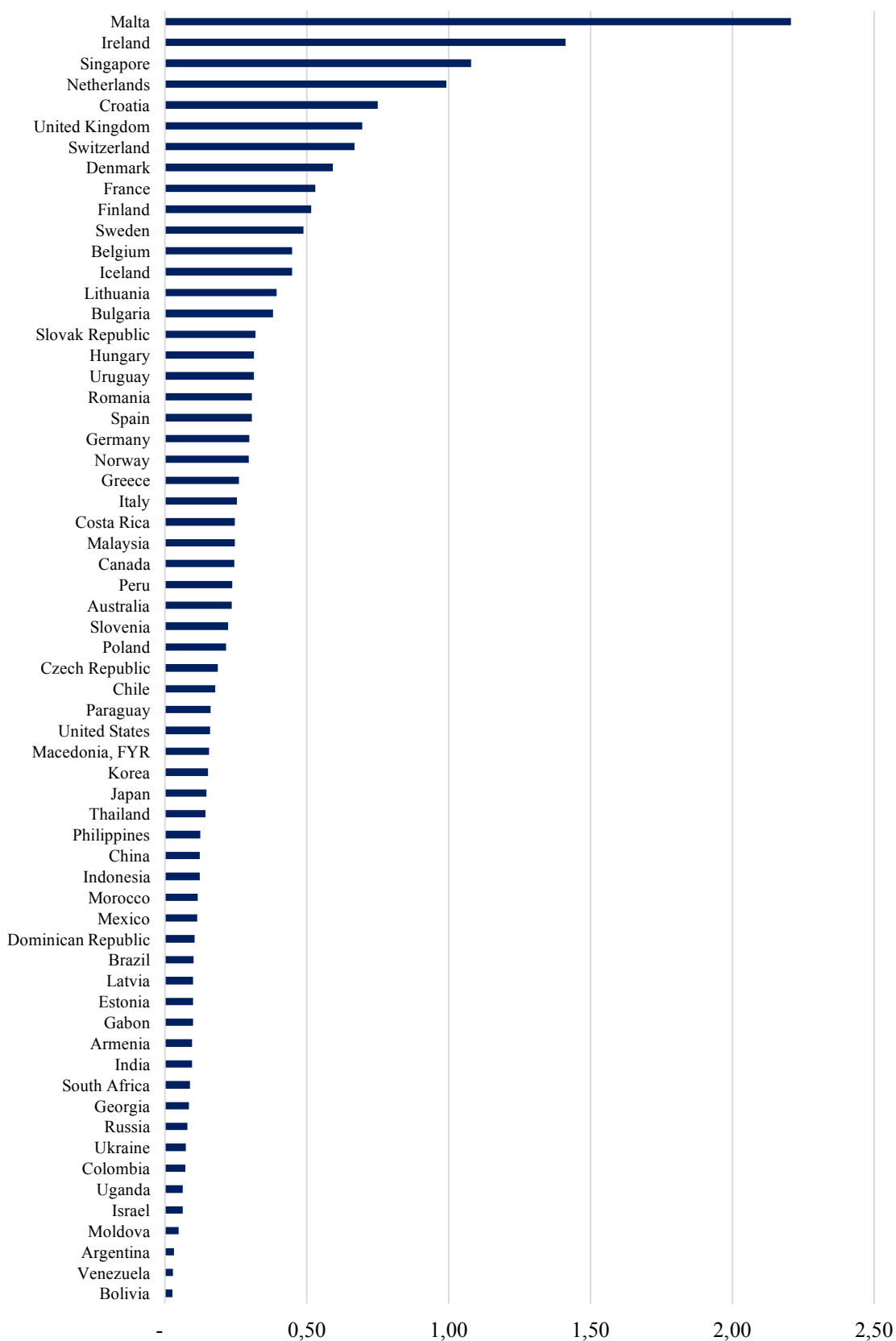
---



---

Source: World Bank - World Development Indicators

**Figure A.5** International Claims relative to GDP in 2014



Source: Bank of International Settlement and author's calculation

**Table A.8** List of Abbreviations

---

BCBS	Basel Committee for Banking Supervision
BIS	Bank of International Settlements
CDS	Credit Default Swaps
GDP	Gross domestic product
GMM	Generalized method of moments
IC	International claims
IMF	International Monetary Fund
IntRate	Lending interest rate
LLP	Loan loss provisions
NPLs	Non-performing loans
OLS	Ordinary Least Squares
REER	Real effective exchange rate
Unemp	Unemployment
V_REER	Real effective exchange rate volatility

---