TECHNICAL APPENDIX — Eberhardt and Presbitero (2015, *JIE*)

TA-I Selective Review of the Empirical Literature

In the following we provide a selective review of recent studies in the empirical literature of debt and growth. Table TA1 provides an overview of characteristics related to the sample (N) and its makeup, the period and time-series dimension of the data (T) and whether and how any data aggregation over time was carried out: until the most recent contributions which use annual data all studies investigated averaged the data over time, in line with the standard practice in the cross-country growth literature. Further details provided cover the empirical model setup, namely the dependent variable and covariates (including proxies for debt stock and debt service), as well as the empirical specification. We focus on the most general parametric and semi-parametric results in each paper. Most studies reviewed carried out a large number of regressions (robustness checks), including some adopting nonparametric methods; results for these are sometimes indicated but we abstract from a more detailed discussion for conciseness. The final column of the table indicates which specific regression results we base our discussion on. Regarding the variables entering the model there are minor differences across studies, although investment, trade openness (trade/GDP) and a measure of human capital are typically included. With regard to the latter, it is particularly notable that all papers reviewed adopt a pooled partial adjustment model (PAM) which includes some lagged level of GDP or GDP per capita as covariate and GDP growth or the per capita equivalent as the dependent variable. Pooled here indicates that it is assumed the equilibrium relationship is the same across all countries in the sample. Implementations are again typical of the standard in the cross-country growth literature, including OLS, FE and various instrumentation strategies (including Arellano and Bond (1991)-type estimators). All studies consider non-linearities in the debt-growth relationship.

In our synthetic review we use subscript i for countries and t for time periods, *also* for averaged time periods (see column on averaging; in few cases time-periods overlap (indicated as OL), but typically periods are non-overlapping). LD refers to 'long differences' (e.g. t-$(t-30)$). Other abbreviations used are defined as follows:

Sample: LDCs – less developed economics; LICs – low income countries; MICs – middle income countries; HICs – high income countries; EMEs – emerging economies; EAC – Euro Area countries. n refers to the number of observations in the regression (may be time-averaged); n refers to the number of observations; since this at times differs across specifications we provide ballpark figures.

Averaging: Time-period over which data is averaged; annual – no averaging. Note that the 'convergence term' ($\ln(Y/L)_{i,t-1}$, i.e. lagged level of log per capita GDP) is typically the value for the first year in a three or five-year period rather than an average value (annual data obviously excepted).

Dependent Variables: Y – real GDP; Y/L – real GDP per capita; Δln(Y/L) – real GDP per capita growth.

Debt Variables: ED/Y – external debt to GDP ratio; ED/EX – external debt to exports ratio; similarly for Total Debt (TD). FV and NPV refer to face- and net present value of debt.

Other Variables: Inv/Y – investment to GDP ratio; HC – human capital proxy (typically Barro & Lee, 2013); ΔL – population growth; ΔTOT – changes in terms of trade; [EX+IM]/Y – trade openness; (LL/Y) – liquid liabilities to GDP ratio; fin/Y — financial openness; FB/Y – fiscal balance over GDP; IR – interest rate; REER – real effective exchange rate; inf – (CPI) inflation; DR – dependency ratio; FCDebt/Debt – foreign currency debt to total debt ratio; D – dummy for certain events (crises; EMU membership) amongst others; σ^{inf} – inflation volatility; σ^{Y} – GDP pc growth volatility; Credit/GDP – private credit to GDP ratio; Aid/Y – foreign aid to GDP ratio, inst — institutional quality/good governance. * Values are decadal averages with the exception of the 'initial income' variable, which is the value for the first year of each decade; 'lags' are 5-year averages for the 5 years immediately preceding a decade.

Model: PAM – partial adjustment model (growth regressed on lagged level of dependent variables and contemporaneous covariates); MRW – cross-section convergence regression model following Mankiw, Romer & Weil (1992) with the panel aspect unexploited in the empirics.

Estimators: OLS – ordinary least squares; FE – one-way fixed effects; BE – between groups estimator (cross-section of averages); DGMM – Arellano & Bond (1991); SGMM – Blundell & Bond (1998); — STR-GMM – structural threshold regression model combined with GMM approach; PTSR – Panel Smooth Transition Regression.

Table TA1: Selective Review of the Literature

Authors	Sample	Period	Averaging	Dep. Var.	Debt stock	Debt service	Covariates†	Model	Estimator(s)	non-linearity	Reference
Clements, Bhattacharya & Nguyen (2003)	55 LICs (n≈270)	1970-99	3-year	Δln(Y/L)$_{it}$	ln(ED/Y)$_{it}$, ln(ED/Y)$^2_{it}$ or ln(ED/EX)$_{it}$, ln(ED/EX)$^2_{it}$ (FV, NPV)	(TDS/EX)$_{it}$	ln$Y_{i,t-1}$, ΔTOT, ΔL, HC, Inv/Y, FB/Y, [EX+IM]/Y	Pooled PAM*	FE, SGMM	Squared debt term	Table 1
					significant, concave	insignificant				negative beyond 30-37% (ED/Y), 115-120% (ED/EX) threshold	
Pattillo, Poirson & Ricci (2004)	61 LDCs (n≈450)	1969-98	3-year	Δln(Y/L)$_{it}$	ln(ED/Y)$_{it}$, ln(ED/Y)$_{it}$ $\times D$ (threshold dummy)	(TDS/EX)$_{it}$	ln$(Y/L)_{i,t-1}$, ln(Inv/Y), ln(HC), ln(ΔL), ΔTOT, [EX+IM]/Y, FB/Y	Pooled PAM	OLS, IV (lags), FE, DGMM, SGMM	spline regression (dummy), determined by R^2	Table 2
					significant, negative beyond threshold	insignificant				negative beyond 18% (ED/Y) threshold	
Imbs & Ranciere (2005)	87 LDCs (n≈600 in 1&2)	1969-2002	3/5-year	Δln(Y/L)$_{it}$	ln(ED/Y)$_{it}$ or ln(ED/EX)$_{it}$ (FV, different versions NPV)		ln$(Y/L)_{i,t-1}$, ln(ΔL), ln(Inv/Y), ln(HC), ΔTOT, [EX+IM]/Y	Pooled PAM	OLS, FE, SGMM; kernel estimators	kernel estimation	Tables 1-3, Figures 1-5
					mostly insignificant					error bands commonly contain zero	
Presbitero (2008)	110 LDCs (n≈380)	1980-2004	5-year	Δln(Y/L)$_{it}$	ln(ED/Y)$_{it}$, ln(ED/Y)$^2_{it}$; or ln(ED/EX)$_{it}$, ln(ED/EX)$^2_{it}$; CPIA interactions (NPV; filtered Y)		ln$(Y/L)_{i,t-1}$, ln(Inv), ln(HC), ΔL, ΔTOT, ln([EX+IM]/Y), CPIA, σ^{inf}	Pooled PAM	SGMM	Squared debt term; interactions with 'good' CPIA score	Tables 4, 5
					negative significant (linear) only in high CPIA; concave relation washed out by CPIA interaction					inverted-U relation disappears with CPIA-interaction	
Caner, Grennes & Koehler-Geib (2010)	26 HICs & 75 LDCs ($n = 101$)	1980-2008	LR average	$\Delta ln(Y)_i$ (LR average)	(TD/Y)$_i$ (LR average)		ln$(Y/L)_{i,1970}$ (pre-sample levels value), [EX+IM]/Y, infl (both LR averages)	MRW	OLS	endogenous threshold regression (cross-section); restricted LDC sample	Tables 1, 3
					significant positive (negative) before (beyond) threshold					threshold at 77% debt/GDP; 64% in LDC sample	

(Continued)

Table TA1: Continued

Authors	Sample	Period	Averaging	Dep. Var.	Debt stock	Debt service	Covariates†	Model	Estimator(s)	non-linearity	Reference
Cordella, Ricci & Ruiz-Arranz (2010)	79 LDCs ($n \approx 700$)	1970-2002	3-year	Δln(Y/L)$_{it}$	ln(ED/Y)$_{it}$, ln(ED/Y)$^2_{it}$, ln(ED/Y)$_{it}$ $\times D$, ln(ED/Y)$^2_{it}$ $\times D$ (NPV)	(TDS/EX)$_{it}$, (TDS/EX)$_{it}$ $\times D$	ln$(Y/L)_{i,t-1}$, ln(Inv/Y), ln(HC), ln(ΔL), ΔTOT, [EX+IM]/Y, FB/Y, Aid/Y, High-Debt Dummy	Pooled PAM	OLS, SGMM	Squared debt term; spline regression (dummy), split at median	Table 2
					OLS: overhang → irrelevance as ED ↑ (SGMM all insignificant); differs by institutional quality	insignificant				[later endogenous threshold regressions: 18%, 72% (ED/Y)]	
Kumar & Woo (2010)	38 HICs and EMEs ($n \approx 179$)	1970-2007	5-year LD, 4-year lags	ln(Y/L)$_{it}$ − ln(Y/L)$_{i,t-\tau}$	ln(TD/Y)$_{i,t-\tau}$ (average) and interactions ($<30\%, 30-90\%, >90\%$)		ln$(Y/L)_{i,t-\tau}$, ΔTOT, (HC)$_{i,t-\tau}$, D$^{\text{crisis}}$, ln(1+inf)$_{i,t-\tau}$, (C$^{\text{gov}}/Y)_{i,t-\tau}$, FD, ln([EX+IM]/Y)$_{i,t-\tau}$, ln(LL/Y)$_{i,t-\tau}$; also: ln(Inv)$_{i,t-\tau}$, L$_{i,t-\tau}$, …	Pooled PAM	OLS, BE, FE, SGMM	Interactions ($<$ 30%, $30-90\%$, $>$ 90% of GDP)	Tables 1, 5
					negative significant (linear); some evidence of overhang >90%					some evidence of overhang >90%	
Cecchetti, Mohanty & Zampolli (2011)	18 HICs ($n \approx 360$)	1980-2010	5-year (OL)	Δln(Y/L)$_{it}$	(TD/Y)$_{it}$, also corporate, hh and total (all three) debt; threshold interactions		ln$(Y/L)_{i,t-1}$, (Sav/Y), HC, ΔL, DR, D$^{\text{crisis}}$, inf, ([EX+IM]/Y), (LL/Y)	Pooled PAM	FE	threshold regression	Tables 5, 6 (gov debt)
					negative linear effect driven by threshold					debt detrimental beyond threshold at 96% debt/GDP	
Pattillo, Poirson & Ricci (2011)	93 LDCs ($n \approx 630$)	1969-98	3-year	Δln(Y/L)$_{it}$	ln(ED/Y)$_{it}$, ln(ED/Y)$^2_{it}$; ln(ED/EX)$_{it}$, ln(ED/EX)$^2_{it}$ (FV or NPV)	(TDS/EX)$_{it}$	ln$(Y/L)_{i,t-1}$, ln(HC), ln(Inv/Y), ln(ΔL), ΔTOT, [EX+IM]/Y, FB/Y	Pooled PAM	FE, SGMM	Squared debt term (also spline regression)	Table 4
					significant, concave relationship in most models	insignificant				growth-retarding threshold >35% (ED/Y), >160% (ED/EX)	

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Table TA1: Continued

Authors	Sample	Period	Averaging	Dep. Var.	Debt stock	Debt service	Covariates†	Model	Estimator(s)	non-linearity	Reference
Calderon & Fuentes (2012)	116 countries ($n \approx 740$)	1970-2010	5-year	Δln(Y/L)$_{it}$	ln(TD/Y)$_{it}$		ln$(Y/L)_{i,t-1}$, ln(HC), ln([Credit/GDP]*100), ln(Inst), ln(inf)$_{it}$, (FB/Y)*100, ln(100*[EX+IM]/Y), ln([fin/Y]*100); σ^Y, debt-interactions	Pooled PAM	SGMM	Squared debt term; debt-interactions	Tables 2, 3
					negative significant, mitigated in rich, financially-developed countries with good institutions					inverted-U; debt negative for Y/L>$7k	
Checherita-Westphal & Rother (2012)	12 EAC ($n \approx 390$)	1970-2008	annual (also: 5-year)	Δln(Y)$_{it}$	(TD/Y)$_{it}$, (TD/Y)$^2_{it}$		ln$(Y/L)_{i,t-1}$, Inv/Y, ΔL, tax, FB/Y, IR, REER, [EX+IM]/Y, ΔTOT, inf, DR	Pooled PAM	FE, 2SLS (lags); (also GMM)	Squared debt term	Tables 1, 3
					significant, concave relationship					inverted-U with 90-100% debt/GDP threshold	
Minea & Parent (2012)	20 HICs ($n \approx 1,300$)	1945-2009	annual	Δln(Y)$_{it}$	ln(TD/Y)$_{it}$		–	Pooled	PSTR	multiple smooth thresholds	Table 1 & Figure 2
										non-linear debt-growth relation, +ve above 115%	
Presbitero (2012)	92 LICs & MICs ($n \approx 320$)	1990-2007	3-year	Δln(Y/L)$_{it}$	ln(TD/Y)$_{it}$; ln(TD/Y)$^2_{it}$; also at $t-1$		ln$(Y/L)_{i,t-1}$, ln(Inv), ln(HC), ΔTOT, ln([EX+IM]/Y), CPIA, σ^{inf}	Pooled PAM	SGMM	Squared debt term; spline regression (dummy); CPIA interactions	Tables 3, 4
					debt irrelevance threshold >90%; overhang only in high CPIA economies					inverted-U relation driven by a few observations	
Panizza & Presbitero (2014)	17 OECD	1970-2008	annual	forward Δln(Y/L)$_{it}$ ($t+1$ to $t+6$)	(TD/Y)$_{it}$, also corporate, hh and total (all three) debt; threshold interactions		ln$(Y/L)_{it}$, (Sav/Y), HC, ΔL, DR, D$^{\text{crisis}}$, inf, ([EX+IM]/Y), (LL/Y), (FCDebt/Debt)$_{i,t-1}$, REER$_{i,t-1}$	Pooled PAM	OLS, IV (valuation effect on debt)	threshold regression	Table 3
					negative linear effect disappears with instrumentation					no significant effect found	

(Continued)

Table TA1: Continued

Authors	Sample	Period	Averaging	Dep. Var.	Debt stock	Debt service	Covariates†	Model	Estimator(s)	non-linearity	Reference
Afonso & Jalles (2013)	155 countries ($n \approx 1,600$)	1970-2008	annual (also: 5-year)	Δln(Y/L)$_{it}$	ln(TD/Y)$_{it}$, ln(TD/Y)$_{it}$ $\times C/Y_{it}$ (FV); vast number of proxies and debt interactions		ln$(Y/L)_{i,t-1}$, Inv/Y, (HC), Inv^{pub}/Y, ln(ΔL), [EX+IM]/Y	Pooled PAM	OLS, LAD, FE, DGMM, SGMM	Sample splitting; threshold dummies at various cut-offs; threshold regressions	Table 1
					negative significant; later results interpreted as non-linear debt-growth relation					endog. threshold 59%, +ve <30%, -ve >90%	
Baum, Checherita-Westphal & Rother (2013)	12 EAC ($n \approx 250$)	1990-2010	annual	Δln(Y)$_{it}$	(TD/Y)$_{i,t-1}$, threshold interaction		Δln$(Y/L)_{i,t-1}$, Inv/Y, [EX+IM]/Y, EMU dummy; add. covariates for robustness	Pooled growth AR(1)	GMM Δln$(Y/L)_{i,t-1}$ instrumented with lags	endogenous panel threshold regression	Tables 2, 3
					static and dynamic models indicate debt threshold(s), leading to inverted-U in most general model					+ve (-ve) up to (beyond) 96%; two thresholds: +ve <66%, -ve >96%	
Egert (2015)	20 HICs ($n \approx 1,000$)	1946-2009	annual	Δln(Y)$_{it}$	$ln(TD/Y)_{it-1}$, $\Delta ln(TD/Y)_{it-1}$		–			endogenous threshold regressions	Table 7
										threshold between 20% and 60%, very sensitive to model specifications	
Kourtellos, Stengos & Tan (2013)	82 countries ($n = 246$)	1980-2009	decadal*	Δln(Y/L)$_{it}$	ln(TD/Y)$_{it}$		ln$(Y/L)_{i,t-1}$, ln(Inv/Y), ln(HC), ln(ΔL+0.05)	MRW	STR-OLS, STR-SGMM, linear versions	endogenous threshold regressions	Table 4
					negative in low democracy sample (ln$(Y/L)_{i,t-1}$ insign.!)					endogenous threshold, growth-retarding for low democracy sample	
Dreger & Reimers (2013)	18 HICs ($n \approx 360$)	1991-2011	annual	Δln(Y/L)$_{it}$	ln(TD/Y)$_{it}$		Inv/Y, [EX+IM]/Y, ΔL, IR	Pooled PAM	FE	threshold regressions, thresholds are country specific according to a sustainability rule	Tables 1-2
							regressors are forecasted at $t-1$			-ve when debt is unsustainable, but only for EAC	

Table TA2: Sample details

wbcode	Country	Income	Obs	Coverage	Missing
ARG	Argentina	Upper MIC	36	1961-2006	1963-70
AUS	Australia	HIC: OECD	52	1961-2012	
AUT	Austria	HIC: OECD	43	1970-2012	
BDI	Burundi	LIC	48	1965-2012	
BEL	Belgium	HIC: OECD	38	1970-2012	1980-82, 89, 90
BFA	Burkina Faso	LIC	34	1979-2012	
BGD	Bangladesh	LIC	33	1980-2012	
BHR	Bahrain	HIC non-OECD	30	1981-2012	1990-91
BHS	Bahamas, The	HIC non-OECD	33	1977-2012	1989-91
BLZ	Belize	Upper MIC	32	1980-2011	
BOL	Bolivia	Lower MIC	42	1971-2012	
BRA	Brazil	Upper MIC	34	1979-2012	
BRB	Barbados	HIC non-OECD	34	1971-2008	1974-77
BTN	Bhutan	Lower MIC	28	1983-2012	1993-94
BWA	Botswana	Upper MIC	40	1973-2012	
CAF	Central African Republic	LIC	36	1977-2012	
CAN	Canada	HIC: OECD	52	1961-2012	
CHE	Switzerland	HIC: OECD	42	1971-2012	
CHL	Chile	HIC: OECD	40	1971-2012	1999-2000
CHN	China	Upper MIC	28	1985-2012	
CIV	Cote d'Ivoire	Lower MIC	29	1980-2008	
CMR	Cameroon	Lower MIC	38	1975-2012	
COL	Colombia	Upper MIC	47	1961-2012	1970-72, 96-97
COM	Comoros	LIC	27	1983-2009	
CRI	Costa Rica	Upper MIC	50	1961-2012	1999-2000
DEU	Germany	HIC: OECD	40	1971-2012	1976-77
DMA	Dominica	Upper MIC	33	1978-2012	1990-91
DNK	Denmark	HIC: OECD	45	1966-2012	1997-98
DOM	Dominican Republic	Upper MIC	42	1971-2012	
DZA	Algeria	Upper MIC	42	1971-2012	
ECU	Ecuador	Upper MIC	46	1965-2012	1970-71
EGY	Egypt	Lower MIC	40	1971-2012	2002-03
ESP	Spain	HIC: OECD	43	1970-2012	
ETH	Ethiopia	LIC	31	1982-2012	
FIN	Finland	HIC: OECD	49	1961-2012	1979-81
FJI	Fiji	Upper MIC	38	1971-2008	
FRA	France	HIC: OECD	40	1970-2012	1978-80
GAB	Gabon	Upper MIC	42	1971-2012	
GBR	United Kingdom	HIC: OECD	52	1961-2012	
GHA	Ghana	Lower MIC	44	1967-2012	1990-91

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Table TA2: Sample details

wbcode	Country	Income	Obs	Coverage	Missing
GIN	Guinea	LIC	22	1991-2012	
GMB	Gambia, The	LIC	32	1981-2012	
GNB	Guinea-Bissau	LIC	26	1987-2012	1990-92
GRC	Greece	HIC: OECD	48	1961-2012	1976-79
GRD	Grenada	Upper MIC	32	1978-2012	1996-98
GTM	Guatemala	Lower MIC	50	1961-2012	1999-2000
GUY	Guyana	Lower MIC	49	1964-2012	
HND	Honduras	Lower MIC	52	1961-2012	
HUN	Hungary	Lower MIC	49	1961-2012	1993-95
IDN	Indonesia	Lower MIC	34	1979-2012	
IND	India	Lower MIC	46	1961-2012	1991-93
IRL	Ireland	HIC: OECD	42	1971-2012	
IRN	Iran	Upper MIC	37	1971-2007	
ISL	Iceland	HIC: OECD	50	1961-2012	1980-81
ISR	Israel	HIC: OECD	37	1973-2012	1981-83
ITA	Italy	HIC: OECD	52	1961-2012	
JOR	Jordan	Upper MIC	28	1976-2012	1982-90
JPN	Japan	HIC: OECD	52	1961-2012	
KEN	Kenya	LIC	46	1964-2012	1977-79
KNA	St. Kitts and Nevis	HIC non-OECD	23	1990-2012	
KOR	Korea	HIC: OECD	50	1961-2012	1970-71
LBN	Lebanon	Upper MIC	22	1991-2012	
LCA	St. Lucia	Upper MIC	31	1982-2012	
LKA	Sri Lanka	Lower MIC	48	1965-2012	
LSO	Lesotho	Lower MIC	37	1974-2012	1991-92
LUX	Luxembourg	HIC: OECD	36	1975-2012	1990-91
MAR	Morocco	Lower MIC	46	1967-2012	
MDG	Madagascar	LIC	48	1961-2012	1973-74
MEX	Mexico	Upper MIC	50	1961-2012	1981-82
MLI	Mali	LIC	42	1971-2012	
MRT	Mauritania	Lower MIC	33	1978-2012	2004-05
MUS	Mauritius	Upper MIC	34	1977-2012	2000-01
MWI	Malawi	LIC	38	1973-2012	2002-02
MYS	Malaysia	Upper MIC	50	1961-2012	1990-91
NER	Niger	LIC	33	1980-2012	
NGA	Nigeria	Lower MIC	32	1981-2012	
NIC	Nicaragua	Lower MIC	42	1971-2012	
NLD	Netherlands	HIC: OECD	43	1970-2012	
NOR	Norway	HIC: OECD	49	1961-2012	1981-83
NPL	Nepal	LIC	38	1975-2012	

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Table TA2: Sample details

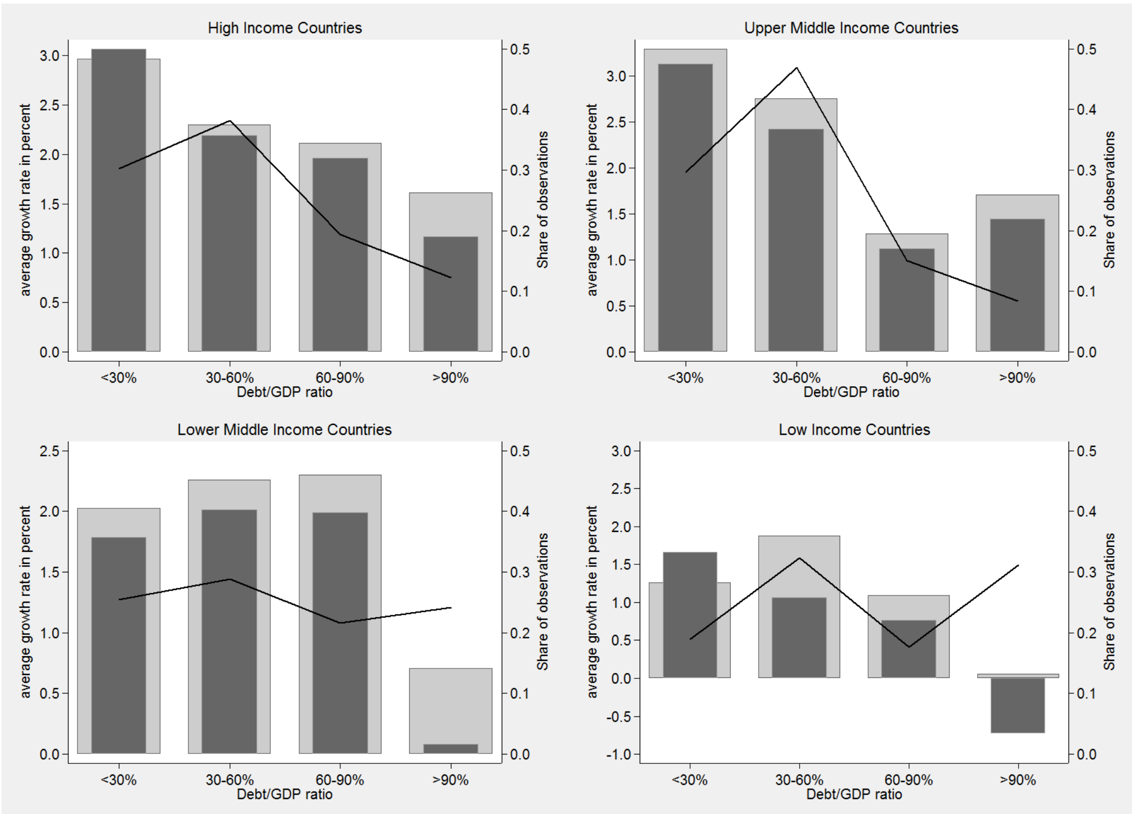
wbcode	Country	Income	Obs	Coverage	Missing
NZL	New Zealand	HIC: OECD	40	1971-2012	2002-03
OMN	Oman	HIC non-OECD	21	1974-2001	1983-89
PAK	Pakistan	Lower MIC	48	1961-2012	1991-94
PAN	Panama	Upper MIC	33	1980-2012	
PER	Peru	Upper MIC	40	1971-2012	2005-06
PHL	Philippines	Lower MIC	47	1961-2012	1990-94
PNG	Papua New Guinea	Lower MIC	31	1974-2004	
POL	Poland	HIC: OECD	22	1991-2012	
PRT	Portugal	HIC: OECD	43	1970-2012	
PRY	Paraguay	Lower MIC	22	1991-2012	
ROM	Romania	Upper MIC	22	1991-2012	
RWA	Rwanda	LIC	42	1971-2012	
SAU	Saudi Arabia	HIC non-OECD	21	1992-2012	
SEN	Senegal	Lower MIC	40	1971-2012	2000-01
SGP	Singapore	HIC non-OECD	49	1964-2012	
SLV	El Salvador	Lower MIC	44	1966-2012	1970-72
SUR	Suriname	Upper MIC	29	1977-2005	
SWE	Sweden	HIC: OECD	50	1961-2012	2003-04
SWZ	Swaziland	Lower MIC	42	1971-2012	
SYR	Syria	Lower MIC	37	1971-2007	
TCD	Chad	LIC	31	1982-2012	
TGO	Togo	LIC	32	1980-2011	
THA	Thailand	Upper MIC	45	1966-2012	2000-01
TON	Tonga	Upper MIC	24	1986-2012	1993-95
TTO	Trinidad and Tobago	HIC non-OECD	43	1964-2008	1980-81
TUN	Tunisia	Upper MIC	40	1971-2012	1977-78
TUR	Turkey	Upper MIC	45	1968-2012	
TZA	Tanzania	LIC	21	1990-2012	2003-04
UGA	Uganda	LIC	24	1983-2012	1987-92
URY	Uruguay	HIC non-OECD	42	1971-2012	
USA	United States	HIC: OECD	50	1961-2012	1979-80
VCT	St. Vincent and the Grenadines	Upper MIC	36	1977-2012	
VEN	Venezuela	Upper MIC	46	1961-2012	1970-72, 92-94
VUT	Vanuatu	Lower MIC	29	1983-2011	
ZAF	South Africa	Upper MIC	52	1961-2012	
ZAR	DR Congo	LIC	37	1971-2009	2000-01
ZMB	Zambia	Lower MIC	42	1971-2012	
ZWE	Zimbabwe	LIC	44	1965-2012	1978-89, 2004-5

Notes: Economies are divided among income groups according to 2013 gross national income (GNI) per capita, calculated using the World Bank Atlas method (see http://tinyurl.com/pc8rpn): LIC — Low-Income Country ($1,025 or less); Lower MIC — Lower Middle-Income Country ($1,026-4,125); Upper MIC — Upper Middle-Income Country ($4,126-12,745); HIC – High-Income Country ($12,746 or above). 'Obs' indicates the time-series observations available.

TA-III Descriptive Analysis of the Debt-Growth Nexus

We conduct a similar descriptive analysis to that pursued in Reinhart & Rogoff (2010) for our sample of countries, with results presented in Figure TA1: within each income group (High, Upper- and Lower-Middle, Low Income) all observations are divided into four bins based on the debt-to-GDP ratio. The means (dark grey bars) and medians (light grey) for different income groups by level of indebtedness provide clear evidence of a negative correlation between higher levels of debt and growth in the High and Low Income Countries, respectively. Results for the two Middle Income Country groups are somewhat less straightforward, but in either case the growth performance beyond a 90% debt-to-GDP threshold is substantially lower than at moderate levels of debt.

Figure TA1: The Reinhart and Rogoff (2010b) approach in our dataset



Notes: In each plot the light-grey bars represent median growth rates, the dark-grey bars the mean growth rates (both left axis), the black line the share of total observations (right axis) for each group respectively. For High Income Countries we have a total of 1,496 observations (36 countries), for the Upper Middle Income, Lower Middle Income and Low Income Countries these figures are 1,255 (33), 1,072 (27) and 765 (22), respectively. Income classification follows the World Bank approach.

TA-IV Stationarity Testing

Table TA3: Panel Stationarity Testing

PANEL A: MADDALA AND WU (1999) FISHER TEST

deterministics: constant

Lags	**GDP pc**	(p)	**Debt pc**	(p)	**Cap pc**	(p)
0	359.60	0.00	353.04	0.00	1105.72	0.00
1	241.20	0.39	335.35	0.00	308.29	0.00
2	255.49	0.18	337.48	0.00	291.61	0.01
3	222.19	0.73	434.19	0.00	284.10	0.02
4	221.85	0.74	329.72	0.00	268.35	0.07

deterministics: constant and trend term

Lags	**GDP pc**	(p)	**Debt pc**	(p)	**Cap pc**	(p)
0	153.05	1.00	190.55	0.99	320.88	0.00
1	253.59	0.21	235.05	0.51	452.83	0.00
2	245.65	0.32	184.96	0.99	327.97	0.00
3	224.47	0.70	256.13	0.18	317.91	0.00
4	192.21	0.98	245.11	0.33	356.43	0.00

PANEL B: PESARAN (2007) CIPS TEST

deterministics: constant

Lags	**GDP pc**	(p)	**Debt pc**	(p)	**Cap pc**	(p)
0	0.71	0.76	7.07	1.00	4.46	1.00
1	0.08	0.53	4.36	1.00	0.95	0.83
2	0.64	0.74	4.60	1.00	1.68	0.95
3	0.23	0.59	4.83	1.00	2.00	0.98
4	3.58	1.00	5.29	1.00	4.26	1.00

deterministics: constant and trend

Lags	**GDP pc**	(p)	**Debt pc**	(p)	**Cap pc**	(p)
0	5.99	1.00	7.85	1.00	16.06	1.00
1	1.30	0.90	4.98	1.00	0.20	0.58
2	3.12	1.00	6.15	1.00	5.69	1.00
3	1.25	0.89	5.84	1.00	6.10	1.00
4	6.28	1.00	8.70	1.00	8.99	1.00

Notes: All variables in logarithms. For the Maddala and Wu (1999) test we report the Fisher statistic and associated p-value, for the Pesaran (2007) test the standardised Z-tbar statistic and its p-value. The null hypothesis for both tests is that all series are nonstationary. Lags indicates the lag augmentation in the Dickey Fuller regression employed. Augmentation of the Dickey Fuller regressions with a constant or a constant and trend as indicated. We used the Stata routine `multipurt` by Markus Eberhardt, which wraps the routines `xtfisher` and `pescadf` written by Scott Merryman and Piotr Lewandowski respectively.

TA-V Cross-Section Dependence

Table TA4: Cross-Section Correlation

	Panel A: Levels				Panel B: First Differences		
	y_{it}	debt_{it}	cap_{it}		Δy_{it}	Δdebt_{it}	Δcap_{it}
avg ρ	0.453	0.341	0.461	avg ρ	0.09	0.11	0.09
avg $\|\rho\|$	0.694	0.53	0.764	avg $\|\rho\|$	0.20	0.19	0.32
CD	214.35	167.98	222.57	CD	41.80	51.49	45.08
p-value	0.00	0.00	0.00	p-value	0.00	0.00	0.00
	Panel C: Heterog. AR(2)				**Panel D: Heterog. AR(2) CCE**		
	y_{it}	debt_{it}	cap_{it}		y_{it}	debt_{it}	cap_{it}
avg ρ	0.083	0.073	0.038	avg ρ	0.00	0.00	0.01
avg $\|\rho\|$	0.188	0.167	0.175	avg $\|\rho\|$	0.17	0.16	0.17
CD	38.91	33.14	17.47	CD	1.69	-0.29	2.91
p-value	0.00	0.00	0.00	p-value	0.09	0.77	0.00

Notes: We present the average and average absolute correlation coefficients across the $N(N-1)$ sets of correlations. CD reports the Pesaran (2004) cross-section dependence statistic, which is distributed $N(0,1)$ under the null of cross-section independence. Panels A and B test the variable series in levels and first differences respectively. In Panel C each of the three variables in levels is entered into a time-series regression $z_{it} = \pi_{0,i} + \pi_{1,i} z_{i,t-1} + \pi_{2,i} z_{i,t-2} + \pi_{3,i} t + \varepsilon_{it}$, conducted separately for each country i. In Panel D the country-regressions are augmented with cross-section averages of all variables (in the Pesaran (2006) CCE fashion) instead of a linear trend. The correlations and cross-section dependence statistics in Panels C and D are then based on the residuals from these AR(2) regressions. We used the Stata routine `xtcd` written by Markus Eberhardt. The contrast between results in Panel C and D show the power of the simple cross-section average approach in addressing residual cross-section dependence.

TA-VI Weak Exogeneity Testing in the Panel

We adopt a simplified empirical setup of the common factor model with a single covariate x and single factors f and g. Let

$$y_{it} = \beta_i x_{it} + u_{it} \qquad u_{it} = \alpha_i + \lambda_i f_t + \varepsilon_{it} \tag{1}$$

$$x_{it} = \varrho_i f_t + \pi_i g_t + \psi_i \varepsilon_{it} + \phi_i + e_{it} \tag{2}$$

Then provided there exists a cointegrating relationship between variables the Granger Representation Theorem (Engle & Granger, 1987) states that these series can be represented in the form of a dynamic ECM. For a pair of cointegrated variables x and y we can write

$$\Delta y_{it} = c_{1i} + \lambda_{1i}\hat{e}_{i,t-1} + \sum_{j=1}^{K}\psi_{11ij}\Delta y_{i,t-j} + \sum_{j=1}^{K}\psi_{12ij}\Delta x_{i,t-j} + \varepsilon_{1it} \tag{3}$$

$$\Delta x_{it} = c_{2i} + \lambda_{2i}\hat{e}_{i,t-1} + \sum_{j=1}^{K}\psi_{21ij}\Delta y_{i,t-j} + \sum_{j=1}^{K}\psi_{22ij}\Delta x_{i,t-j} + \varepsilon_{2it} \tag{4}$$

where $\hat{e}_{i,t-1}$ represents the 'disequilibrium term' $\hat{e} = y - \hat{\beta}_i x - \hat{d}$ constructed using the estimated long-run (cointegrating) relationship between these two variables (d represents deterministic terms). Equations (3) and (4) further include lagged differences of the variables in the cointegrating relationship. In the above example there are only two equations, since we have two variables in the cointegrating relationship. The Granger Representation Theorem implies that for a long-run equilibrium relationship to exist between y and x at least one of λ_{1i} and λ_{2i} must be non-zero: if (and only if) $\lambda_{1i} \neq 0$ then x has a causal impact on y, if (and only if) $\lambda_{2i} \neq 0$ then the causal impact is reversed. If both λ_{1i} and λ_{2i} are non-zero they determine each other jointly.

In Table TA5 we present the weak exogeneity test results for the MG and various CMG models – models refer to the column numbering in Table 1 of the main text. For each estimator we provide weak exogeneity tests using specifications with one or two lags (results for 3 lags available on request), in each case providing three sets of results: for an output equation, a capital stock equation and a debt stock equation. If the empirical models analysed represent augmented production functions, rather than investment demand or debt demand equations, thus (informally) allowing us to argue for a causal relation from capital and debt stock to output and not vice-versa, we would expect a pattern whereby the various test statistics for the output equation reject the null of no causal relation from 'inputs' to output, whereas those in the two 'input' equations cannot reject their respective nulls.

Taking in the results as a whole, there appears to be fairly convincing evidence for the setup described: p-values for the statistic constructed from averaged t-statistics are typically below 10 percent in the output and close to unity in the input equations; the t-statistics on the averaged λ_i coefficients are typically very large in the former and typically below 1.96 in the latter.

Table TA5: Weak Exogeneity Testing

			Panel A: Without CA				Panel B: With CA			
Model	**Equation**	**lags**	**GM-t**	p	**Avg. $\hat{\lambda}_i$**	**t-stat**	**GM-t**	p	**Avg. $\hat{\lambda}_i$**	**t-stat**
2FE [1]	Output	2	$\underline{-0.61}$	$\underline{0.54}$	-0.051	-3.95	$\underline{-0.690}$	$\underline{0.49}$	-0.084	-4.17
	Capital	2	0.59	0.55	$\underline{0.019}$	$\underline{3.68}$	0.672	0.50	$\underline{0.032}$	$\underline{5.58}$
	Debt stock	2	0.04	0.97	0.012	0.25	-0.217	0.83	$\underline{-0.115}$	$\underline{-1.79}$
	Output	1	$\underline{-0.75}$	$\underline{0.46}$	-0.064	-5.61	$\underline{-0.880}$	$\underline{0.38}$	-0.085	-5.31
	Capital	1	0.69	0.49	$\underline{0.025}$	$\underline{5.20}$	0.873	0.38	$\underline{0.034}$	$\underline{6.73}$
	Debt stock	1	0.06	0.95	0.006	0.14	0.050	0.96	0.024	0.48
CCEP [2]	Output	2	$\underline{-1.27}$	$\underline{0.21}$	-0.154	-8.06	$\underline{-0.817}$	$\underline{0.41}$	-0.127	-4.83
	Capital	2	0.18	0.86	$\underline{0.009}$	$\underline{1.95}$	0.541	0.59	$\underline{0.028}$	$\underline{3.94}$
	Debt stock	2	0.22	0.83	0.087	1.41	-0.050	0.96	-0.087	-1.02
	Output	1	$\underline{-1.43}$	$\underline{0.15}$	-0.159	-9.06	$\underline{-1.070}$	$\underline{0.28}$	-0.115	-6.25
	Capital	1	0.32	0.75	$\underline{0.015}$	$\underline{3.13}$	0.695	0.49	$\underline{0.030}$	$\underline{5.06}$
	Debt stock	1	0.27	0.79	$\underline{0.092}$	$\underline{1.79}$	0.201	0.84	$\underline{0.051}$	$\underline{0.77}$
MG [3]	Output	2	$\underline{-1.48}$	$\underline{0.14}$	-0.282	-11.17	$\underline{-1.182}$	$\underline{0.24}$	-0.246	-8.00
	Capital	2	0.16	0.87	0.006	0.87	0.299	0.77	$\underline{0.017}$	$\underline{2.11}$
	Debt stock	2	-0.52	0.60	$\underline{-0.389}$	$\underline{-3.84}$	-0.550	0.58	$\underline{-0.414}$	$\underline{-3.65}$
	Output	1	-1.74	0.08	-0.281	-11.84	$\underline{-1.575}$	$\underline{0.12}$	-0.276	-10.30
	Capital	1	0.12	0.90	-0.001	-0.13	0.227	0.82	0.010	1.32
	Debt stock	1	-0.63	0.53	$\underline{-0.461}$	$\underline{-4.92}$	-0.617	0.54	$\underline{-0.440}$	$\underline{-4.45}$
Standard CMG (lagged CA) [4]	Output	2	-1.73	0.08	-0.32	-11.88	$\underline{-1.117}$	$\underline{0.26}$	-0.263	-7.95
	Capital	2	0.06	0.95	0.00	0.43	0.665	0.51	$\underline{0.024}$	$\underline{2.51}$
	Debt stock	2	0.10	0.92	0.07	0.64	-0.167	0.87	-0.143	-1.13
	Output	1	-1.92	0.05	-0.31	-12.58	$\underline{-1.501}$	$\underline{0.13}$	-0.267	-9.42
	Capital	1	0.11	0.91	0.01	1.08	0.446	0.66	$\underline{0.018}$	$\underline{2.58}$
	Debt stock	1	0.00	1.00	0.02	0.20	-0.155	0.88	-0.128	-1.13
CMG w/ one lag of CA [5]	Output	2	-1.80	0.07	-0.36	-13.00	$\underline{-0.980}$	$\underline{0.33}$	-0.306	-6.70
	Capital	2	-0.13	0.90	0.00	-0.55	0.388	0.70	$\underline{0.027}$	$\underline{1.95}$
	Debt stock	2	-0.06	0.95	-0.04	-0.41	-0.255	0.80	$\underline{-0.365}$	$\underline{-1.89}$
	Output	1	-1.98	0.05	-0.36	-12.63	-1.713	0.09	-0.320	-11.58
	Capital	1	-0.07	0.95	0.00	0.14	0.259	0.80	$\underline{0.015}$	$\underline{1.94}$
	Debt stock	1	-0.12	0.91	-0.12	-1.24	-0.235	0.81	$\underline{-0.264}$	$\underline{-2.53}$
CMG w/ two lags of CA [6]	Output	2	-1.74	0.08	-0.394	-12.47	$\underline{-1.304}$	$\underline{0.19}$	-0.316	-9.33
	Capital	2	-0.17	0.86	$\underline{-0.015}$	$\underline{-1.85}$	0.178	0.86	0.011	1.00
	Debt stock	2	-0.08	0.93	0.041	0.38	-0.169	0.87	-0.161	-1.39
	Output	1	-1.91	0.06	-0.397	-12.24	$\underline{-1.632}$	$\underline{0.10}$	-0.337	-11.13
	Capital	1	-0.13	0.90	-0.007	-0.98	0.174	0.86	0.008	0.94
	Debt stock	1	-0.17	0.87	-0.050	-0.45	-0.258	0.80	$\underline{-0.212}$	$\underline{-1.77}$

Notes: Numbers in brackets correspond to the columns in Table 1 of the maintext. For the tests in Panel B cross-section averages (CA) of all variables are added to the estimation equation (3) or (4), whereas in Panel A we do not include these. In each case the 'disequilibrium term' included is estimated using the indicated empirical setup (2FE, CCEP, MG, various CMG). 'Equation' refers to the ECM regression where the named variable is on the LHS, 'lags' reports the number of lagged differences included in the regression. 'GM-t' gives the group-mean average of country-specific t-ratios for the coefficient on the disequilibrium term ($\hat{\lambda}_i$) which is distributed $N(0,1)$, p indicates the corresponding p-value. 'Avg $\hat{\lambda}_i$' refers to the robust mean coefficient on the ECM term, t-stat the corresponding t-statistic. All results are for $N = 118$ countries, with the exception of the specifications with three lags in panel B, where due to the dimensionality problem only $N = 107$ countries are included. Underlined test statistics statistics indicate evidence *against* the hypothesis of a well-specified production function.

TA-VII Asymmetric Dynamic Regressions

Table TA6: Asymmetric Dynamic Models

	[1]	[2]	[3]	[4]	[5]	[6]
	MG	**CMG**	**CMG**	**CMG**	**CMG**	**CMG**
country trends	×		×			
asymmetry	LR, SR	LR, SR	LR, SR	LR	LR, SR	LR, SR
lagged CA					1 lag	2 lags
60% threshold						
ALR debt >60% GDP	-0.008	0.016	-0.020	-0.001	0.009	0.019
	[0.020]	[0.025]	[0.020]	[0.023]	[0.029]	[0.025]
ALR debt <60% GDP	-0.014	0.018	0.007	0.026	0.022	0.034
	[0.020]	[0.023]	[0.025]	[0.024]	[0.027]	[0.024]
$y_{i,t-1}$	-0.459	-0.529	-0.602	-0.529	-0.562	-0.575
	[0.037]***	[0.044]***	[0.041]***	[0.041]***	[0.043]***	[0.047]***
t-statistic$^\flat$	-12.54	-12.14	-14.71	-12.84	-13.07	-12.16
$\bar{t}$-statistic	-3.24	-3.28	-3.49	-3.37	-3.15	-3.10
RMSE	0.032	0.026	0.024	0.027	0.023	0.023
CD Test	10.76	0.46	-0.09	1.09	0.62	0.86
Obs (N)	2,153 (54)	2,153 (54)	2,153 (54)	2,153 (54)	2,055 (53)	2,055 (53)
90% threshold						
ALR debt >90% GDP	-0.035	-0.009	-0.056	-0.003	-0.028	-0.009
	[0.032]	[0.033]	[0.032]*	[0.030]	[0.032]	[0.034]
ALR debt <90% GDP	-0.021	0.005	0.014	0.004	0.022	-0.001
	[0.024]	[0.021]	[0.020]	[0.022]	[0.021]	[0.026]
$y_{i,t-1}$	-0.425	-0.553	-0.612	-0.543	-0.570	-0.578
	[0.053]***	[0.064]***	[0.067]***	[0.067]***	[0.059]***	[0.065]***
t-statistic$^\flat$	-7.99	-8.68	-9.17	-8.08	-9.68	-8.94
$\bar{t}$-statistic	-2.99	-3.11	-3.26	-3.42	-2.98	-2.78
RMSE	0.030	0.025	0.023	0.026	0.023	0.022
CD Test	1.74	-1.17	-0.91	-0.85	-0.71	-1.49
Obs (N)	1,080 (28)	1,080 (28)	1,080 (28)	1,080 (28)	1,027 (27)	1,027 (27)

Notes: We present average long-run coefficients (based on country-specific long-run results) for debt from models which allow for asymmetry in the debt coefficients, adapted to the panel from the time-series approach by Shin, Yu & Greenwood-Nimmo (2013). The dependent variable is the GDP per capita growth rate. Three thresholds are adopted to split the data into two (high/low debt) 'regimes': 59.9% (sample mean) and 90% debt/GDP ratio. Countries are only included in the analysis if they have at least 25% of their observations in one of the two regimes (below/above threshold), resulting in 54 and 28 countries, respectively. Models [2]-[6] add cross-section averages to the regressions, those in [5] and [6] further add lags of the cross-section averages in the spirit of Chudik & Pesaran (2014). All models allow for long-run (LR) and short-run (SR) asymmetry, with the exception of model [4], which only allows for long-run asymmetry. $\flat$ For the coefficient on lagged GDP per capita we report the Pesaran & Smith (1995) nonparametric t-statistics as well as the average of country-specific t-statistics ($\bar{t}$), the CD Test is distributed $N(0,1)$ under the null of cross-section independence. RMSE is the root-mean squared error.

TA-VIII Summability, Balance and Co-Summability

TA-VIII.1 Theory

In the following we discuss the fundamental difficulties arising for conventional empirical analysis when assuming a non-linear model in the presence of integrated variables and introduce a novel time series approach to deal with these issues. Suppose a single time series relationship $y_t = f(x_t, \theta) + u_t$ for a nonstationary covariate $x_t \sim I(1)$, stationary u_t and some non-linear function $f(\cdot)$.[1] In this context, it becomes difficult to apply our standard notion of integration to $f(\cdot)$, given that integration is a linear concept: although we may be able to determine the order of integration of x_t, the order of integration of $f(x_t, \theta)$ (and thus y_t) may not be well defined for many non-linear transformations $f(\cdot)$. Assuming for illustration $f(x_t) = \theta x_t^2$ we can make this point somewhat clearer: let $x_t = x_{t-1} + \varepsilon_t$ and $\varepsilon_t \sim i.i.d.(0, \sigma_\varepsilon^2)$, then we know that

$$\mathbb{V}[x_t - x_{t-1}] \;=\; \sigma_\varepsilon^2 \quad \Rightarrow x_t \sim I(1) \tag{5}$$

In words, we can show that the Engle & Granger (1987) characterisation of a stationary process holds for Δx_t (finite variance is one of five characteristics, albeit the crucial one for our illustration), such that x_t can be concluded to follow an I(1) process. Now investigate the same property for Δx_t^2:

$$\mathbb{V}[x_t^2 - x_{t-1}^2] \;=\; \mathbb{E}[\varepsilon_t^4] + 4(t-1)\sigma_\varepsilon^4 - \sigma_\varepsilon^4 \quad \Rightarrow x_t^2 \sim I(?)$$

We can see that the finite variance characteristic is violated, given that it is a function of time t – further differencing does not change this outcome. Although we can define x_t within the integration framework, we cannot state the order of integration of x_t^2, which creates fundamental problems if the empirical analysis of $y_t = f(x_t, \theta) + u_t$ is to be based on arguments of cointegration.

Berenguer-Rico & Gonzalo (2013*b*) develop an alternative approach, based on the 'order of summability' $S(\delta)$ of linear or non-linear processes: "[t]he order of summability, δ, gives a summary measure of the stochastic properties – such as persistence – of the time series without relying on linear structures" (p.3). Using OLS we estimate for each country i

$$Y_{ik}^* = \beta_i^* \log k + U_{ik}^* \tag{6}$$

where $k = 1, \ldots, T$, $Y_{ik}^* = Y_{ik} - Y_{i1}$, $U_{ik}^* = U_{ik} - U_{i1}$ and $Y_{ik} = \log\left(\sum_{t=1}^{k}(y_{it} - m_t)\right)^2$, with m_t the country-specific partial mean of y_{it}, namely $m_t = (1/t)\sum_{j=1}^{t} y_j$. This is the definition for m_t in the 'intercept only' case. Given the trending nature of our data we further investigate the 'constant and linear trend' case, where $m_t = (1/t)\sum_{j=1}^{t} y_{ij} - (2/t)\sum_{j=1}^{t}\left(y_{ij} - (1/j)\sum_{\ell=1}^{j} y_{i\ell}\right)$.

[1] Our discussion in this section as well as the implementation follow Berenguer-Rico & Gonzalo (2013*a*) and Berenguer-Rico & Gonzalo (2013*b*).

This implies

$$\hat{\beta}_i^* = \frac{\sum_{k=1}^{T} Y_{ik}^* \log k}{\sum_{k=1}^{T} \log^2 k} \tag{7}$$

from which we then obtain our estimate of the order of summability $\hat{\delta}_i^* = (\hat{\beta}_i^* - 1)/2$. This approach essentially investigates the rate of convergence of a rescaled sum constructed from the variable series y_{it}. In the single time series inference can be established using confidence intervals constructed via estimation in subsamples; here, in the panel, where there is no natural ordering of countries in the cross-section dimension we take random draws of $\sqrt{N}$ countries (and in each country the full time series T), each time capturing the mean and median summability statistic, to create subsample estimates for inference.

It bears emphasising that summability is a more general concept than integration, but that that latter is closely related to the former in the following fashion: if a time series x_t is integrated of order d, $I(d)$ with $d \geq 0$, then it is also summable of order d, $S(d)$. It is the breakdown of the reverse of this condition in cases where x_t is a non-linear transformation which necessitates our adoption of the concept of summability. In our empirical application we will analyse the order of summability of all variables entering the polynomial specifications.

Next, in analogy to the analysis of integrated variables, the 'balance' of the empirical relationship needs to be tested, namely the condition that both sides of the empirical equation of interest have the same order of summability: $S(\delta_y) = S(\delta_z)$ for $z = f(x_t, \theta) = \theta f(x_t)$ – see below for a comment on the linearity in parameters we assume here. Such a test of balance is equivalent to testing the null of $\beta_{ni} \equiv (\beta_{yi} - \beta_{zi}) = 0$ in the country-specific regression

$$Y_{yik}^* - Y_{zik}^* = \underbrace{(\beta_{yi} - \beta_{zi})}_{\beta_{ni}} \log k + (U_{yik} - U_{zik}) \tag{8}$$

where Y_{yik}^* is for the LHS variable y and defined as in the summability analysis above, and Y_{zik}^* is the partially demeaned sum of all RHS processes $Y_{zik} = \log\left(\sum_{t=1}^{k}(z_{it} - m_t)\right)^2$, accounting for initial conditions in the same fashion as above by taking the deviation from the first observation. In practice, all elements of z (RHS variables) are summed, appropriately partially demeaned and their estimated order of summability is subtracted from that for y and the result divided by 2.[2] Again inference in the single time series test is based on subsample estimation. In the panel we employ the same strategy to create subsample estimates and thus confidence bands as detailed above. Under the null of balance the resulting confidence interval includes zero and balancedness is a necessary but not sufficient condition for a valid empirical specification.[3]

[2]Given $\hat{\delta}_y^* = (\hat{\beta}_y^* - 1)/2$ and $\hat{\delta}_z^* = (\hat{\beta}_z^* - 1)/2$ it is easy to see that $\hat{\delta}_y^* - \hat{\delta}_z^* = (\hat{\beta}_y^* - \hat{\beta}_z^*)/2$.

[3]Again the parallels with the theory of integration and cointegration may help to illustrate this point: the seminal Granger & Newbold (1974) paper investigated spurious regression by regressing two independent random walks, Y_t and X_t. Since both processes are I(1) the regression equation $Y_t = \beta_0 + \beta_1 X_t$ is balanced. Since they constitute independent processes, later work by Engle & Granger (1987) would suggest that the residual series from this regression are not I(0), so that Y_t and X_t are not cointegrated. Similarly, balancedness of $y_t = f(x_t, \theta)$ is a necessary prerequisite for co-summability between y_t and $f(x_t, \theta)$.

Finally, let $\hat{e}_t$ be the OLS residuals from a balanced country-specific regression $y_{it} = \hat{\theta} g(x_{it}) + \hat{e}_{it}$, then 'strong co-summability' will imply the order of summability of $\hat{e}_{it}$, $S(\delta_{\hat{e}_{it}})$, is statistically close to zero. We employ the above approach to estimate the order of summability for $\hat{e}_{it}$ which enables us to determine whether our balanced model is co-summable or not. Note that the residual series $\hat{e}_{it}$ as defined above will sum to zero by default of the least squares principle, we therefore in practice do not subtract the estimate for the intercept term in each country regression. Inference in the original time series and in our panel application follow the same principles as the previous two testing procedures.

The above routines imply a sequence of tests (summability, balance, co-summability) which in principle bear close resemblance to the integration-cointegration concepts and testing procedures. The simplicity of the above approach is marred by the presence of deterministic components in the variable evolution. Intercept and trend terms are addressed by repeated partial demeaning of the variable series as suggested in Berenguer-Rico & Gonzalo (2013*b*).[4] We assume non-linearity in variables but not in parameters:

$$y_t = g(x_t, \theta) + \varepsilon_t = \theta g(x_t) + \varepsilon_t \tag{9}$$

The econometric theory of the approach is at present being extended to non-linearity in parameters. However, the restriction to linearity in parameters is in line with the standard implementations in the literature adopting debt thresholds (endogenous or endogenous debt/GDP threshold with subsequent analysis splitting observations into separate below/above threshold values/terms) or non-linearities through polynomial functions (linear, squared and cubed debt terms).

We provide an extension to the above panel versions of the balance and co-summability tests, whereby in the spirit of the recent panel time series literature we include the cross-section averages (CA) of all variables in the specification of the empirical test (Pesaran, 2006; Chudik & Pesaran, 2014). The motivation for this approach is the same we provided for our panel models above: country-by-country investigation of the variable and specification properties assumes these to be cross-sectionally independent. Both theorising and empirical practice have shown that in a globalising world where countries trade and are subject to similar social, economic and/or cultural heritage this assumption is likely to be violated.

We adopt two variants of the cross-section average augmentation: (i) a standard approach such as that outlined above, (ii) an approach where in addition to the CA of all model variables we also include the CA of 'other covariates,' similar to the approach in the dynamic heterogeneous panel estimations (Chudik & Pesaran, 2014).

[4]We do not pursue the analysis of a quadratic trend due to the limited time-series dimension of our panel.

TA-VIII.2 Test Results

Table TA7 presents the summability results, with models assuming a constant term in the left panel and constant and trend terms in the right panel, with the latter a more natural choice given the trending nature of our data. It appears that all of these variables in levels reject summability of order 0, S(0), which justifies our concern about time series properties — recall the analogy with unit root tests, whereby integrated data of order 1 or higher provides evidence for nonstationarity. In the lower panel we carry out summability testing for the growth rates of per capita GDP, debt stock and capital stock. For the former two we can broadly conclude that these first difference series are S(0), while the capital stock growth rate appears to reject this null hypothesis.

Table TA7: Estimated Order of Summability

Deterministics	Constant				Constant and Trend			
Variable	y_{it}	debt_{it}	debt^2_{it}	cap_{it}	y_{it}	debt_{it}	debt^2_{it}	cap_{it}
Lower CI band	0.914	0.936	0.951	0.889	0.719	0.904	0.804	0.249
Mean	1.076	1.119	1.133	1.096	0.937	1.418	1.174	1.064
Upper CI band	1.237	1.301	1.314	1.304	1.155	1.931	1.543	1.878
Lower CI band	0.934	0.942	0.991	1.074	0.672	0.852	0.769	0.183
Median	1.085	1.100	1.128	1.226	0.853	1.377	1.130	0.926
Upper CI band	1.236	1.259	1.265	1.378	1.035	1.902	1.492	1.669
Deterministics	Constant				Constant and Trend			
Variable	Δy_{it}	Δdebt_{it}		Δcap_{it}	Δy_{it}	Δdebt_{it}		Δcap_{it}
Lower CI band	-0.025	0.095		0.244	0.011	0.071		0.029
Mean	0.091	0.218		0.397	0.177	0.312		0.604
Upper CI band	0.208	0.342		0.550	0.344	0.554		1.178
Lower CI band	-0.083	0.059		0.246	-0.114	-0.003		0.031
Median	0.048	0.196		0.429	0.107	0.282		0.608
Upper CI band	0.179	0.334		0.612	0.329	0.567		1.184

Notes: The table presents the panel statistics for $N = 118$ country-specific estimates of the order of summability $\hat{\delta}^*$ (see main text for further details). All variables are in logarithms. We account for the constant term by partial demeaning, and for the additional linear trend term by double partial demeaning as detailed in Berenguer-Rico & Gonzalo (2013*b*). For each variable we present two sets of statistics: the upper (lower) panel presents mean (median) $\hat{\delta}^*$ across the panel as well as the mean- (median-)based subsampling results (lower and upper 95% confidence bands). Each of the $N - b + 1 = 107$ subsamples of size $b = \text{int}(\sqrt{N}) + 1 = 12$ countries is a random draw of countries from our full sample of $N = 118$.

Table TA8: Estimated Balance

Panel A – Standard Specification

	Constant			Constant & Trend	
	[1]	[2]		[3]	[4]
non-linearity	-	debt_{it}^2	non-linearity	-	debt_{it}^2
Lower CI band	-0.410	-0.198	Lower CI band	-1.561	-0.512
Mean	-0.229	-0.062	Mean	-0.913	-0.210
Upper CI band	-0.049	0.074	Upper CI band	-0.265	0.091
Lower CI band	-0.480	-0.150	Lower CI band	-1.577	-0.443
Median	-0.275	-0.018	Median	-0.953	-0.145
Upper CI band	-0.069	0.114	Upper CI band	-0.329	0.154

Panel B – Specification with CA

	Constant			Constant & Trend	
	[1]	[2]		[3]	[4]
non-linearity	-	debt_{it}^2	non-linearity	-	debt_{it}^2
Lower CI band	-0.323	-0.358	Lower CI band	-1.275	0.300
Mean	-0.151	-0.191	Mean	-0.677	0.738
Upper CI band	0.022	-0.024	Upper CI band	-0.080	1.175
Lower CI band	-0.375	-0.329	Lower CI band	-1.282	0.333
Median	-0.160	-0.155	Median	-0.668	0.766
Upper CI band	0.055	0.019	Upper CI band	-0.054	1.198

Panel C – Specification with One Additional Lag of CA

	Constant			Constant & Trend	
	[1]	[2]		[3]	[4]
non-linearity	-	debt_{it}^2	non-linearity	-	debt_{it}^2
Lower CI band	-0.289	-0.393	Lower CI band	-2.029	-1.348
Mean	-0.118	-0.227	Mean	-1.111	-0.715
Upper CI band	0.052	-0.061	Upper CI band	-0.193	-0.082
Lower CI band	-0.280	-0.450	Lower CI band	-1.976	-1.417
Median	-0.088	-0.236	Median	-1.085	-0.767
Upper CI band	0.104	-0.022	Upper CI band	-0.193	-0.116

Panel D – Specification with Two Additional Lags of CA

	Constant			Constant & Trend	
	[1]	[2]		[3]	[4]
non-linearity	-	debt_{it}^2	non-linearity	-	debt_{it}^2
Lower CI band	-0.127	-0.226	Lower CI band	-0.028	0.131
Mean	0.131	0.027	Mean	0.483	0.549
Upper CI band	0.388	0.280	Upper CI band	0.995	0.966
Lower CI band	-0.284	-0.330	Lower CI band	-0.124	0.050
Median	0.026	-0.075	Median	0.431	0.470
Upper CI band	0.335	0.181	Upper CI band	0.986	0.890

Notes: The table presents distributional statistics for $N = 118$ country-specific estimates of the balance in the indicated regression models ($\hat{\delta}_y - \hat{\delta}_g$) (see text for further details). The dependent variable is y_{it}, the RHS of each model always includes cap_{it} and debt_{it} (all variables in logarithms) as well as deterministic components as indicated. We account for a deterministic terms by (repeated) partial demeaning following Berenguer-Rico & Gonzalo (2013*b*). CA refers to the augmentation of the static country regression with cross-section averages following Pesaran (2006): in Panel B we include the model variables, in Panel C (D) we further include CA one (two) additional lag(s) of these cross-section averages. Underlined mean or median balance statistics indicate evidence *against* the hypothesis of a balanced regression model, $(\hat{\delta}_y - \hat{\delta}_g) = 0$.

Table TA8 presents the results from balance tests, with (unaugmented) 'standard' specifications in Panel A, specifications augmented in the common correlated effect fashion in Panel B and specifications which add further lags of the cross-section averages in Panels C and D. Recall that for the two sides of the equation to be balanced, i.e. be made up of variables with the same order of summability, the balance statistic should be close to zero. We highlight all those specifications where this requirement is statistically rejected by underlining the estimate and 95% confidence bands. In each of the four panels we provide results for a specification with a constant and a specification with a constant and trend term, where again the latter appears *a priori* the more suitable choice. Results appear quite sensitive to our assumptions about deterministic trends and/or our inclusion of (lags of) cross-section averages. If we adopt the same set of lagged cross-section averages as in the main part of the paper (Panel D), there appears to be fairly convincing evidence for balanced regression equations for a linear specification, and somewhat less so for a non-linear specification.

In the co-summability results presented in Table TA9 we highlight those specifications for which there was some evidence of balance (see row marked 'Bal & Co-Sum'). We again have four blocks of results, for a standard panel version of co-summability (equivalent to Panel A in the balance results in Table TA8), for a version which includes cross-section averages of all model variables (Panel B) and for a version which in addition to these cross-section averages includes their first or first and second lagged values (Panels C and D). Our model with two lagged cross-section averages in Panel D remains as the only specification for which we can obtain some evidence of balance and co-summability, whether we investigate the linear or non-linear specification.

We draw three conclusions from this analysis: first, there is strong evidence for significant persistence in the data investigated, which as argued above may seriously impact estimation and inference. Second, it appears that results from an approach which assumes cross-section independence yields very different results from one which relaxes this assumption. In the context of the recent panel econometric literature this finding is not at all surprising, given the importance of accounting for cross-section correlation in the analysis of macro panel datasets. Further investigation of this result is beyond the scope of this article and left for future research. Third, the only empirical specifications tested for which we found fairly convincing evidence for balance and co-summability were the linear and non-linear models augmented with standard and additional lags of cross-section averages. This reiterates the important role played by unobservabled heterogeneity and the choice of strategy to deal with their distorting impact on empirical estimation and inference. It bears reminding that the purpose of this exercise was to identify linear or non-linear specifications which represent long-run equilibrium relationships. Whatever the identification strategy of existing studies in the literature, these results suggest that the adoption of linear and squared debt terms in a flexible specification to model debt thresholds may represent a seriously misspecified empirical model, which could lead to spurious regression results, unless unobserved hetergeneity is suitably accounted in the analysis.

Table TA9: Co-Summability

Panel A	**Standard**		**Panel B**	**With CA**	
	[1]	[2]		[3]	[4]
non-linearity	-	debt_{it}^2	non-linearity	-	debt_{it}^2
CA	-	-	CA	×	×
Bal & Co-sum	no	yes	Bal & Co-sum	yes	no
Lower CI band	$\underline{0.835}$	$\underline{0.845}$	Lower CI band	$\underline{0.271}$	$\underline{0.240}$
Mean	$\underline{1.005}$	$\underline{0.994}$	Mean	$\underline{0.482}$	$\underline{0.462}$
Upper CI band	$\underline{1.175}$	$\underline{1.143}$	Upper CI band	$\underline{0.693}$	$\underline{0.684}$
Lower CI band	$\underline{0.842}$	$\underline{0.859}$	Lower CI band	$\underline{0.115}$	$\underline{0.104}$
Median	$\underline{0.988}$	$\underline{1.038}$	Median	$\underline{0.326}$	$\underline{0.333}$
Upper CI band	$\underline{1.133}$	$\underline{1.218}$	Upper CI band	$\underline{0.538}$	$\underline{0.562}$

Panel C	**1 Add. Lag of CA**		**Panel D**	**2 Add. Lags of CA**	
	[1]	[2]		[3]	[4]
non-linearity	-	debt_{it}^2	non-linearity	-	debt_{it}^2
CA	×	×	CA	×	×
Bal & Co-sum	yes	no	Bal & Co-sum	yes	yes
Lower CI band	$\underline{0.220}$	$\underline{1.007}$	Lower CI band	$\underline{0.142}$	$\underline{0.229}$
Mean	$\underline{0.390}$	$\underline{1.181}$	Mean	$\underline{0.343}$	$\underline{0.461}$
Upper CI band	$\underline{0.560}$	$\underline{1.355}$	Upper CI band	$\underline{0.543}$	$\underline{0.693}$
Lower CI band	$\underline{0.112}$	$\underline{0.974}$	Lower CI band	-0.004	-0.081
Median	$\underline{0.302}$	$\underline{1.184}$	Median	0.232	0.218
Upper CI band	$\underline{0.491}$	$\underline{1.393}$	Upper CI band	0.467	0.518

Notes: The table presents distributional statistics for $N = 118$ country-specific order of summability estimates for the respective model residuals: in Panel A this is a standard MG model, in Panels B-D various permutations of the Pesaran (2006) CMG model. The RHS of each model always includes cap_{it} and debt_{it}. All variables are in logarithms. CA refers to the augmentation of the static country regression with cross-section averages following Pesaran (2006), in Panels C and D we further add lags of these cross-section averages (1 lag in Panel C and 2 lags in Panel D) to the regression model as described in the text. We account for a constant term by partial demeaning as detailed in Berenguer-Rico & Gonzalo (2013*b*). Underlined mean or median co-summability statistics indicate evidence *against* the hypothesis of a co-summable model specification, $\hat{\delta}_\varepsilon = 0$. 'Bal & Co-sum': Since co-summability is conditional on balance, we indicate those specification which we have convincing evidence from the balance testing in Table TA8.

TA-IX Present Value of Public External Debt in Developing Countries

This section presents our baseline results obtained using data on present value (PV) of public and publicly guaranteed (PPG) external debt, as constructed by Dias, Richmond & Wright (2014). The authors put together a dataset on a sample of 100 countries, but data constraints (limited time series for investment and/or per capita GDP) force us to drop 11 countries (Cape Verde, Equatorial Guinea, Haiti, Jamaica, Liberia, Maldives, Oman, Samoa, Sao Tome & Principe, The Seychelles and the Solomon Islands), so that our analysis of present value public external debt covers 89 developing countries. We report the results using the 5% discount rate to compute the PV of public external debt. Results are qualitatively similar using 10% as alternative discount rate. We defer to Dias, Richmond & Wright (2014) for a detailed discussion of how the PV of public external debt is calculated. As an additional robustness exercise, we run the analysis for 96 countries using PV PPG external debt data compiled by the World Bank. Results are again similar and available upon request.

TA-IX.1 Descriptive Statistics, Sample Makeup and Data Properties

Table TA10: Descriptive Statistics

PANEL A: RAW VARIABLES AND TRANSFORMATIONS						
variable	**type**	**mean**	**median**	**sd**	**min**	**max**
GDP	level	5.77E+10	7.22E+09	1.70E+11	1.57E+08	2.54E+12
GDP growth	%age growth rate	3.261	3.832	5.030	-69.812	30.176
GDP per capita	level	2,281	1,190	2,591	112	15,084
GDP pc growth	%age growth rate	1.229	1.777	5.053	-64.082	31.311
Population	level	4.46E+07	8.23E+06	1.60E+08	4.08E+04	1.31E+09
Population growth	%age growth rate	2.034	2.253	1.174	-7.597	11.181
Investment/GDP ratio	%age share of GDP	0.205	0.197	0.081	-0.024	0.748
Capital Stock	level	1.41E+11	1.75E+10	4.19E+11	4.72E+08	6.73E+12
Capital Stock growth	%age growth rate	3.571	3.341	3.019	-6.327	21.881
Capital Stock per capita	level	6.31E+03	3.23E+03	7.99E+03	2.29E+02	5.29E+04
Capital Stock pc growth	%age growth rate	1.537	1.451	3.133	-8.954	19.161
PV External Debt (5%)	level	3.39E+10	1.64E+08	1.51E+11	8.01E+03	2.05E+12
PV External Debt growth	%age growth rate	7.860	7.598	20.345	-144.709	174.448
PV External Debt (total) per capita	level	3.19E+02	2.37E+01	9.85E+02	6.45E-02	8.97E+03
PV External Debt pc growth	%age growth rate	5.826	5.394	20.363	-147.135	171.772
PV External Debt/GDP ratio	%age share of GDP	9.954	2.273	20.250	0.004	131.354
PANEL B: REGRESSION VARIABLES (IN LOGS OR FIRST DIFFERENCES OF LOGS)						
variable		**mean**	**median**	**sd**	**min**	**max**
Δy_{it}		0.012	0.018	0.051	-0.641	0.313
$y_{i,t-1}$		7.116	7.068	1.136	4.717	9.616
$\text{cap}_{i,t-1}$		8.002	8.060	1.272	5.387	10.841
Δcap_{it}		0.015	0.015	0.031	-0.090	0.192
$\text{debt}_{i,t-1}$ (5%)		3.197	3.129	2.404	-2.873	9.101
Δdebt_{it} (5%)		0.058	0.054	0.204	-1.471	1.718

Notes: We present descriptive statistics for the full sample of 2,319 observations from $N = 89$ countries (average T=26.1). In Panel A we added a number of standard transformations of the data applied, e.g. the PV public external debt/GDP ratio and the investment/GDP ratio as well as per capita GDP and its growth rate. Some of these variables are used in the post-estimation analysis. In Panel B we present descriptives for the error correction model regression variables, namely Δy_{it} — GDP per capita growth rate, $y_{i,t-1}$ — lagged level of GDP per capita (in logs), $\text{cap}_{i,t-1}$ — lagged level of capital stock per capita (in logs), $\text{debt}_{i,t-1}$ — lagged level of PV external debt stock per capita (in logs), Δcap_{it} — growth rate of capital stock per capita, Δdebt_{it} — growth rate of PV external debt stock per capita. We use present value of public external debt stocks computed by Dias, Richmond & Wright (2014) using a disocunt rate of 5%.

Table TA11: Sample details

wbcode	Country	Income	Obs	Coverage
ARG	ARGENTINA	Upper MIC	27	1980-2006
BDI	BURUNDI	LIC	27	1980-2006
BEN	BENIN	LIC	25	1982-2006
BFA	BURKINA FASO	LIC	27	1980-2006
BGD	BANGLADESH	LIC	27	1980-2006
BGR	BULGARIA	Upper MIC	26	1981-2006
BLZ	BELIZE	Upper MIC	27	1980-2006
BOL	BOLIVIA	Lower MIC	27	1980-2006
BRA	BRAZIL	Upper MIC	27	1980-2006
BRB	BARBADOS	HIC	27	1980-2006
BWA	BOTSWANA	Upper MIC	27	1980-2006
CAF	CENTRAL AFRICAN REPUBLIC	LIC	27	1980-2006
CHL	CHILE	HIC	27	1980-2006
CHN	CHINA	Upper MIC	27	1980-2006
CIV	COTE D'IVOIRE	Lower MIC	27	1980-2006
CMR	CAMEROON	Lower MIC	27	1980-2006
COG	CONGO, REP.	Lower MIC	27	1980-2006
COL	COLOMBIA	Upper MIC	27	1980-2006
COM	COMOROS	LIC	26	1981-2006
CRI	COSTA RICA	Upper MIC	27	1980-2006
DJI	DJIBOUTI	Lower MIC	16	1991-2006
DMA	DOMINICA	Upper MIC	27	1980-2006
DOM	DOMINICAN REPUBLIC	Upper MIC	27	1980-2006
DZA	ALGERIA	Upper MIC	27	1980-2006
ECU	ECUADOR	Upper MIC	27	1980-2006
EGY	EGYPT	Lower MIC	27	1980-2006
ETH	ETHIOPIA	LIC	25	1982-2006
FJI	FIJI	Upper MIC	27	1980-2006
GAB	GABON	Upper MIC	27	1980-2006
GHA	GHANA	Lower MIC	27	1980-2006
GIN	GUINEA	LIC	20	1987-2006
GMB	GAMBIA, THE	LIC	26	1981-2006
GNB	GUINEA-BISSAU	LIC	27	1980-2006
GRD	GRENADA	Upper MIC	27	1980-2006
GTM	GUATEMALA	Lower MIC	27	1980-2006
GUY	GUYANA	Lower MIC	27	1980-2006
HND	HONDURAS	Lower MIC	27	1980-2006
HUN	HUNGARY	Upper MIC	27	1980-2006
IDN	INDONESIA	Lower MIC	27	1980-2006
IND	INDIA	Lower MIC	27	1980-2006

Continued on the following page.

Table TA19: Sample details

wbcode	Country	Income	Obs	Coverage
JOR	JORDAN	Upper MIC	27	1980-2006
KEN	KENYA	LIC	27	1980-2006
KNA	ST. KITTS & NEVIS	HIC	17	1990-2006
LCA	ST. LUCIA	Upper MIC	26	1981-2006
LKA	SRI LANKA	Lower MIC	27	1980-2006
LSO	LESOTHO	Lower MIC	27	1980-2006
MAR	MOROCCO	Lower MIC	27	1980-2006
MDG	MADAGASCAR	LIC	27	1980-2006
MEX	MEXICO	Upper MIC	27	1980-2006
MLI	MALI	LIC	27	1980-2006
MLT	MALTA	HIC	27	1980-2006
MOZ	MOZAMBIQUE	LIC	26	1981-2006
MRT	MAURITANIA	Lower MIC	27	1980-2006
MUS	MAURITIUS	Upper MIC	27	1980-2006
MWI	MALAWI	LIC	27	1980-2006
MYS	MALAYSIA	Upper MIC	27	1980-2006
NER	NIGER	LIC	27	1980-2006
NGA	NIGERIA	Lower MIC	26	1981-2006
NIC	NICARAGUA	Lower MIC	27	1980-2006
NPL	NEPAL	LIC	27	1980-2006
PAK	PAKISTAN	Lower MIC	27	1980-2006
PAN	PANAMA	Upper MIC	27	1980-2006
PER	PERU	Upper MIC	27	1980-2006
PHL	PHILIPPINES	Lower MIC	27	1980-2006
PNG	PAPUA NEW GUINEA	Lower MIC	25	1980-2004
POL	POLAND	HIC	16	1991-2006
PRY	PARAGUAY	Lower MIC	16	1991-2006
RWA	RWANDA	LIC	27	1980-2006
SDN	SUDAN	Lower MIC	27	1980-2006
SEN	SENEGAL	Lower MIC	27	1980-2006
SLE	SIERRA LEONE	LIC	27	1980-2006
SLV	EL SALVADOR	Lower MIC	27	1980-2006
SWZ	SWAZILAND	Lower MIC	27	1980-2006
SYR	SYRIA	Lower MIC	27	1980-2006
TCD	CHAD	LIC	23	1982-2006‡
TGO	TOGO	LIC	27	1980-2006
THA	THAILAND	Upper MIC	27	1980-2006
TON	TONGA	Upper MIC	25	1982-2006
TTO	TRINIDAD & TOBAGO	HIC	27	1980-2006
TUN	TUNISIA	Upper MIC	27	1980-2006

Continued on the following page.

Table TA19: Sample details

wbcode	**Country**	**Income**	**Obs**	**Coverage**
TUR	TURKEY	Upper MIC	27	1980-2006
TZA	TANZANIA	LIC	17	1990-2006
UGA	UGANDA	LIC	24	1983-2006
URY	URUGUAY	HIC	27	1980-2006
VCT	ST. VINCENT &	Upper MIC	27	1980-2006
VCT	THE GRENADINES	Upper MIC	27	1980-2006
VEN	VENEZUELA	Upper MIC	27	1980-2006
VUT	VANUATU	Lower MIC	24	1983-2006
ZAR	CONGO, DEM. REP.	LIC	27	1980-2006
ZMB	ZAMBIA	Lower MIC	27	1980-2006

Notes: Economies are divided among income groups according to 2013 gross national income (GNI) per capita, calculated using the World Bank Atlas method (see http://tinyurl.com/pc8rpn): LIC — Low-Income Country ($1,025 or less); Lower MIC — Lower Middle-Income Country ($1,026-4,125); Upper MIC — Upper Middle-Income Country ($4,126-12,745). 'Obs' indicates the time-series observations available..

Table TA20: Cross-Section Correlation

	Panel A: Levels				Panel B: First Differences		
	y_{it}	debt$_{it}$	cap$_{it}$		Δy_{it}	Δdebt$_{it}$	Δcap$_{it}$
CD	74.74	142.37	56.99	CD	21.61	66.10	21.12
p-value	0.00	0.00	0.00	p-value	0.00	0.00	0.00
	Panel C: Heterog. AR(2)				Panel D: Heterog. AR(2) CCE		
	y_{it}	debt$_{it}$	cap$_{it}$		y_{it}	debt$_{it}$	cap$_{it}$
CD	14.15	40.73	7.92	CD	-2.26	0.70	-0.99
p-value	0.00	0.00	0.00	p-value	0.02	0.49	0.32

Notes: y, debt and cap refer to GDP, PV public external debt stock and capital stock, all in logarithms of per capita terms. CD reports the Pesaran (2004) cross-section dependence statistic, which is distributed $N(0,1)$ under the null of cross-section independence. Panels A and B test the variable series in levels and first differences respectively. In Panel C each of the three variables in levels is entered into a time-series regression $z_{it} = \pi_{0,i} + \pi_{1,i} z_{i,t-1} + \pi_{2,i} z_{i,t-2} + \pi_{3,i} t + \varepsilon_{it}$, conducted separately for each country i. In Panel D the country-regressions are augmented with cross-section averages of all variables (in the Pesaran (2006) CCE fashion) instead of a linear trend. The cross-section dependence statistics in Panels C and D are then based on the residuals from these AR(2) regressions. We used the Stata routine `xtcd` written by Markus Eberhardt. The contrast between results in Panel C and D show the power of the simple cross-section average approach in addressing residual cross-section dependence.

Table TA21: Panel Stationarity Testing

PANEL A: MADDALA AND WU (1999) FISHER TEST

deterministics: constant

Lags	GDP pc	(*p*)	Debt pc	(*p*)	Cap pc	(*p*)
0	131.21	1.00	665.96	0.00	314.62	0.00
1	137.61	0.99	329.01	0.00	169.43	0.67
2	139.99	0.98	274.48	0.00	166.43	0.72
3	118.10	1.00	288.53	0.00	161.35	0.81
4	97.33	1.00	278.68	0.00	158.62	0.85

deterministics: constant and trend term

Lags	GDP pc	(*p*)	Debt pc	(*p*)	Cap pc	(*p*)
0	230.67	0.01	296.90	0.00	262.41	0.00
1	268.83	0.00	211.22	0.05	348.72	0.00
2	258.63	0.00	150.72	0.93	246.32	0.00
3	232.41	0.00	183.81	0.37	256.74	0.00
4	188.47	0.28	163.92	0.77	232.51	0.00

PANEL B: PESARAN (2007) CIPS TEST

deterministics: constant

Lags	GDP pc	(*p*)	Debt pc	(*p*)	Cap pc	(*p*)
0	0.55	0.71	-0.91	0.18	3.95	1.00
1	-1.79	0.04	0.76	0.78	-1.32	0.09
2	-1.47	0.07	3.13	1.00	1.06	0.86
3	-1.86	0.03	5.32	1.00	0.64	0.74
4	2.31	0.99	7.75	1.00	4.95	1.00

deterministics: constant and trend

Lags	GDP pc	(*p*)	Debt pc	(*p*)	Cap pc	(*p*)
0	3.25	1.00	0.69	0.76	10.09	1.00
1	-0.43	0.34	3.17	1.00	2.21	0.99
2	1.67	0.95	5.79	1.00	5.55	1.00
3	1.81	0.97	8.87	1.00	5.57	1.00
4	4.88	1.00	10.82	1.00	9.33	1.00

Notes: All variables in logarithms. For the Maddala and Wu (1999) test we report the Fisher statistic and associated *p*-value, for the Pesaran (2007) test the standardised Z-tbar statistic and its *p*-value. The null hypothesis for both tests is that all series are nonstationary. Lags indicates the lag augmentation in the Dickey Fuller regression employed. Augmentation of the Dickey Fuller regressions with a constant or a constant and trend as indicated. We also tested all variables in first differences; here tests for all lag length augmentations rejected the null of a unit root in all series for each of the three variables. We used the Stata routine `multipurt` by Markus Eberhardt, which wraps the routines `xtfisher` and `pescadf` written by Scott Merryman and Piotr Lewandowski respectively.

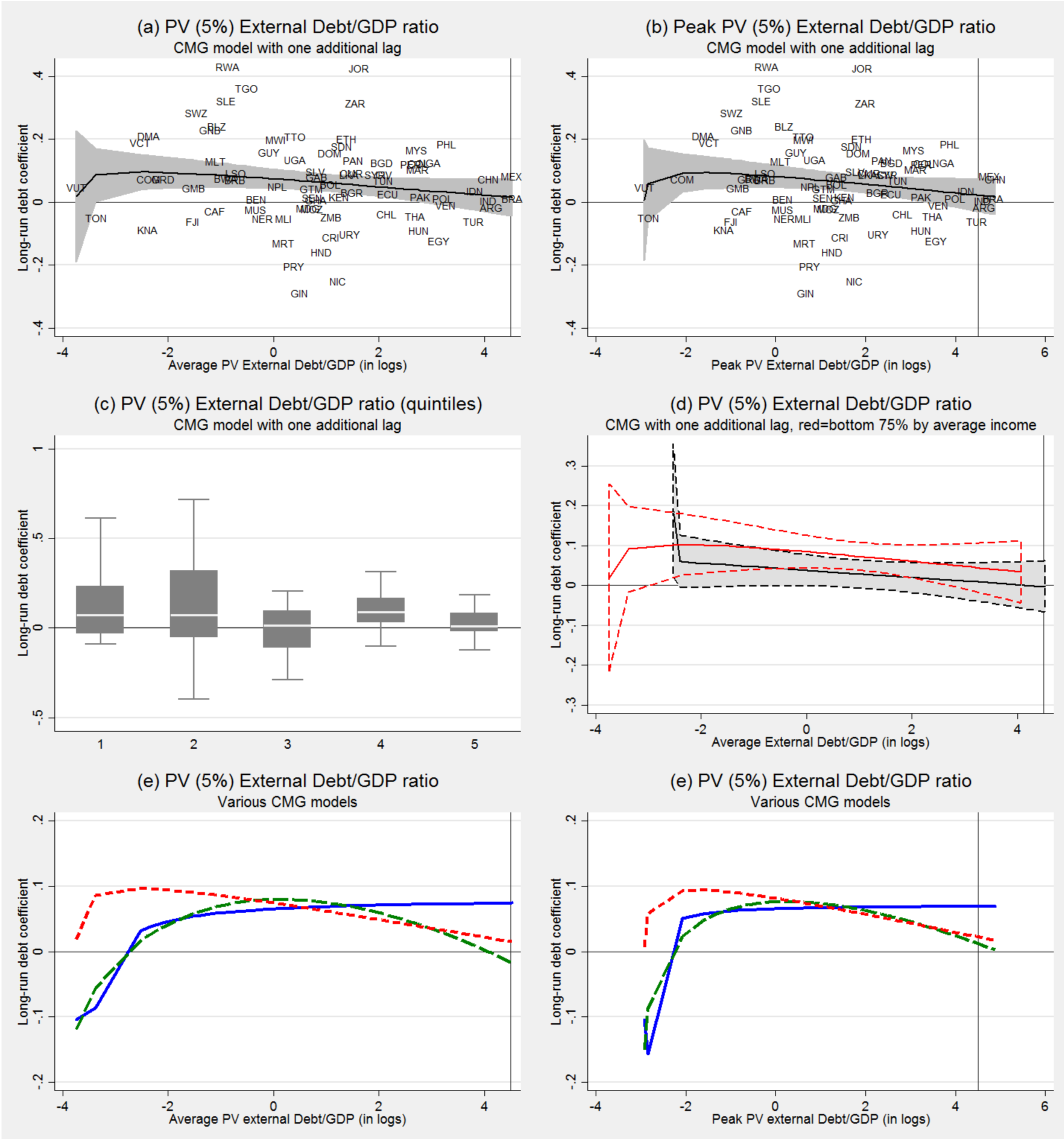
TA-IX.2 Linear Dynamic Models of PV Public External Debt and Growth

Table TA22: Linear Dynamic Models: PV Public External Debt ($\rho = 5\%$)

	[1] **2FE**	[2] **CCEP**	[3] **MG**†	[4] **CMG**	[5] **CMG w/ trend**	[6] **CMG**‡
additional lagged CA						2nd lag
External Debt coefficients						
LRA	0.028	0.054	0.022	0.056	0.028	0.044
	[0.027]	[0.014]***	[0.015]	[0.014]***	[0.013]**	[0.015]***
ALR			0.022	0.059	0.025	0.056
			[0.017]	[0.017]***	[0.014]*	[0.016]***
SR	0.049	0.065	0.032	0.045	0.040	0.045
	[0.009]***	[0.011]***	[0.006]***	[0.008]***	[0.008]***	[0.009]***
Capital coefficients						
LRA	0.520	0.195	0.075	0.216	0.232	0.272
	[0.082]***	[0.077]**	[0.096]	[0.092]**	[0.095]**	[0.095]***
ALR			0.073	0.203	0.292	0.270
			[0.104]	[0.100]**	[0.092]***	[0.103]***
SR	0.616	0.819	1.086	1.284	1.304	1.361
	[0.088]***	[0.085]***	[0.099]***	[0.118]***	[0.121]***	[0.139]***
EC coefficient						
$y_{i,t-1}$	-0.131	-0.448	-0.505	-0.728	-0.813	-0.811
	[0.020]***	[0.036]***	[0.034]***	[0.039]***	[0.037]***	[0.045]***
t-statistic♭	6.59	12.45	14.98	18.58	21.80	18.15
$\bar{t}$-statistic			-3.18	-3.55	-4.02	-3.32
Implied half-life (years)	4.94	1.17	0.99	0.53	0.41	0.42
Diagnostics♯						
RMSE	0.042	0.036	0.029	0.021	0.019	0.017
CD test	-2.49	0.15	11.38	1.01	0.64	0.05
Observations	2,319	2,319	2,319	2,319	2,319	2,248

Notes: Results for full sample of $N = 89$ countries, based on an error correction model with the first difference of log real GDP per capita as dependent variable. The debt variable refers to the per capita present value public external debt stock (5% coupon-equivalent face values) constructed from the data created by Dias, et al (2014). The results for 10% and 0% are qualitatively very similar (available on request). We report the robust mean of coefficients across countries in the heterogeneous parameter models in [3]-[6] (Hamilton, 1992); standard errors in these models are constructed non-parametrically following Pesaran & Smith (1995).
† This model is augmented with country-specific linear trend terms; we also augmented the various CMG models with results qualitatively identical (result available on request).
‡ The CMG estimator (Pesaran, 2006; Chudik & Pesaran, 2014) is implemented using further cross-section averages (CA) of additional lags as indicated – see main text for details.
'LRA' refers to the long-run average coefficient, which is calculated directly from the pooled model ECM results in [1] and [2] and the robust mean estimates of the heterogeneous model ECM results (standard errors computed via the Delta method) in [3]-[6].
'ALR' refers to the average long-run coefficient in the heterogeneous models, whereby the long-run coefficients are computed from the ECM results in each country first and then averaged across the panel. 'SR' refers to the short-run coefficients.
♭ The first set of t-statistics are non-parametric statistics derived from the country-specific coefficients following Pesaran & Smith (1995). The second set represent averages across country-specific t-statistics.
*, ** and *** indicate significance at 10%, 5% and 1% level respectively.
♯ RMSE is the root mean squared error, CD test reports the Pesaran (2004) test, which under the null of cross-section independence is distributed standard normal.

Figure TA2: Patterns for CMG Debt Coefficients (Dias, et al., 2014: PV 5%)



Notes: We plot the country specific long-run coefficients for debt in each country, taken from the dynamic CMG model with one additional lag (in column [6] of Table 1 in the main text) against (a) the country-specific average external debt/GDP ratio (in logs), and (b) the country-specific peak value for PV public external debt/GDP (in logs) — for both plots we reduce the number of countries as detailed below to improve illustration. In both cases we added fitted fractional polynomial regression lines along with 5% and 95% confidence bands (shaded area). We further provide (c) box plots for all 89 country-estimates divided into quintiles of the average country debt/GDP ratio distribution — outliers are omitted from these box plots. In (d) we split the sample into the top 25% and bottom 75% by average income and fit fractional polynomial regression lines alongside 5% and 95% confidence bands for each grouping (reduced sample in the plot for illustration). The final set of plots in (e) and (f) presents fitted fractional polynomial regression lines of long-run debt coefficients against average debt/GDP ratio and peak debt/GDP for all CMG models (columns [4]-[6]), respectively.

In each case (as in the first two scatter plots) we omit those countries (based on the estimated long-run debt coefficient) which the robust regression method (Hamilton, 1992) indicates as outliers, resulting in 78 countries out of a possible 89. In all plots we add a horizontal line to mark zero, in most plots we also add a vertical line at 4.5 log points (≡90%) of the debt/GDP ratio.

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