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REAL EXCHANGE RATE AND EXTERNAL PUBLIC DEBT IN EMERGING AND DEVELOPING COUNTRIES

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Abstract

Developing countries implement policies to maintain a stable exchange rate, with export-led growth strategies to spur economic growth and stability. The real exchange rate is a key factor of external competitiveness but can also cause economic and financial disruptions. These countries are dependent on external financing which impacts the real exchange rate movements over the medium and long run. We empirically explore the response of the real exchange rate to external public indebtedness in developing countries, from 1975 to 2017, using the iterative Bayesian shrinkage procedure to handle the cross-country differences in panel data. The contribution to the literature is twofold. First, we find that the change in the real exchange rate depends on the external public indebtedness in an inverted U-shape relationship in developing countries. Second, we determine an external debt threshold that minimizes changes in the real exchange rate for each country.

Keywords: Real Exchange Rate, External Debt, Developing Countries, Heterogeneity

JEL Codes: F31; F34; O16

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1 Introduction

Since the 1970s, the external competitiveness and promotion of manufactured exports have been crucial factors of economic growth in developing countries. East Asian countries (South Korea, Singapore, Taiwan) experienced considerable industrialization, expansion of their manufacturing sector and export diversification. Most emerging countries, which increased their manufactured exports, implemented export-led growth strategies with a consistent exchange rate policy. The main objective of an export-promoting exchange rate policy is to limit the misalignments[1] of real exchange rate (Edwards, 1989; Cottani et al., 1990; Ghura and Grennes, 1993; Razin and Collins, 1997; Rodrik, 2008, RER).[2]

The RER is a fundamental relative price in developing economies that concerns a wide range of non-tradable goods.[3] Production and investment choices are also influenced by RER shifts. A stable RER helps to promote manufactured exports. In addition, the RER is more appropriate than the nominal exchange rate to assess the change of the exchange rate over the medium or long run. Examining the RER requires considering the international macroeconomic context. For example, the Behavioral Equilibrium Exchange Rate (Clark and MacDonald, 1999, BEER) or the Natural Real Exchange Rate (Lim and Stein, 1998; Stein, 1998, NATREX) highlight key macroeconomic factors that influence the equilibrium RER over the medium or long run. The literature shows that the RER is determined by the interaction between

[1]The current real exchange rate persistently diverges from its long-run equilibrium value. The equilibrium real exchange rate is determined over a medium- or long-term horizon based on purchasing power parity approach, or a set of macroeconomic variables for example (see Section 2).

[2] Rodrik (2008) shows that an undervaluation of the currency promotes economic growth. Razin and Collins (1997) find that persistent misalignments of RER are associated with lower long-term growth rate.

[3]RER may also be defined as the domestic relative price of tradable to non-tradable goods, more appropriate for developing countries which are price-takers for tradable goods

trade factors and financial fundamentals, such as the country's net external position involving savings and public debt. In these models, the RER adjusts to ensure the internal and external macroeconomic equilibrium. External equilibrium refers to the situation in which there is a current account balance or an imbalance that is financed by a sustainable rate of capital flows (Artis and Taylor, 1993; Faruqee, 1995). Theoretically, the sustainability of the capital account depends on the "desired" stocks of external assets and liabilities between countries (Faruqee, 1995).[4] During the 1980's, the economic integration of developing countries, especially low- (LICs) and lower middle-income countries (LMICs), into global markets fostered private capital inflows.[5] For example, private capital inflows increased from USD 50 billion in 1987 to USD 150 billion per year in 1997 in developing countries (Lartey, 2008). The external indebtedness of developing countries has also significantly increased, as reflected in the debt crises of developing countries in 1982 and the Heavily Indebted Poor Countries initiative in 1996.[6]

The purpose of this paper is to explore the relationship between the external public indebtedness and the RER over the long run in developing countries. There is no common agreement in the theoretical and empirical literature about this relationship. On the one hand, some studies point out that a country in need of external financing experiences a real currency depreciation to reduce its current account deficit by generating a trade surplus. The real exchange rate depreciation is required to stabilize debt-to-GDP ratio.[7] On the other hand, empirical works show that external public

[4]A desired stock of external assets and liabilities represents the ideal level that a country aims to reach in terms of investments and debt to ensure external economic stability, while avoiding imbalances that could lead to balance of payments or debt crises.

[5]The income classification is defined according to the World Bank.

[6]The HIPC initiatives launched by the IMF, World Bank and Paris Club have resulted in a significant amount of debt cancellation for low-income countries that were considered over-indebted at the time.

[7]A real currency depreciation improves the current account deficit, which in turn reduces external

debt is associated with a real currency appreciation due to a bias of public spending towards non-tradable goods (Sekkat and Varoudakis, 2000). More recent studies show that the relationship between the public debt and the RER depend on the debt sustainability. The debt sustainability is assessed through the external public debt ratio relative to GDP in this study. The debt dynamics, or cointegration estimates between debt series and macroeconomic fundamentals are alternative approaches to assess debt sustainability.

We investigate the existence of a non-linear relationship between the external public debt and RER over the long run in developing countries. Only a few papers in the empirical literature assess this relationship. Most existing studies focus on developed rather than developing countries. We consider low- and lower middle-income countries, because they are mainly dependent on external financing. This study covers the time period from 1975 to 2017 for 34 developing countries. In order to deal with heterogeneity and handle the cross-country differences between developing countries, we estimate the relationships with the Pooled Mean Group estimator. Then, we apply the iterative Bayesian shrinkage procedure to estimate the relationship between the external public debt and RER country by country.[8] To our knowledge, this has never been done before in the literature.

We contribute new empirical findings to the literature. We find an inverted U-shape relationship between the external public debt and RER. A limited external public debt-to-GDP ratio induces an appreciation of the RER through the demand for non-tradable goods, whereas a high external debt ratio leads to a real currency depreciation. The depreciation of the RER is expected to restore external macroeconomic balance. Since the inverted U-shape relationship between the external public debt and RER is estimated country by country, we can determine a turning point for each country. In other

financing needs.

[8]Specifically, we consider the real effective exchange rate in the study.

words, we identify a public debt threshold at which the relationship between external public debt and RER shifts from positive to negative. We thus propose an alternative approach to define a *stabilizing* external public debt. This level of external public debt would minimize changes in the RER.

The rest of this paper is organized as follows. Section 2 discusses the literature on determinants of real exchange rate and external debt. Section 3 explains the data and issues related to estimating the real exchange rate. Section 4 presents the empirical strategy. Section 5 analyzes the results of the estimates with the Pooled Mean Group. Section 6 demonstrates the relationship between RER and external public debt country by country. Section 7 describes the robustness checks conducted to strengthen the study. Section 8 concludes.

2 Related Literature

There are several approaches to the determination of equilibrium exchange rate (Frenkel and Goldstein, 1986):

i. the monetary models and portfolio balance models,

ii. the purchasing power parity (PPP) approach where nominal exchange rate change is needed to offset price level ratio changes in order to maintain a constant RER.

For Faruqee (1995, p.81): "*it may be quite misleading to view the real exchange rate as an isolated measure of external competitiveness without further reference to developments within the overall macroeconomic environment*". This remark fits with the third approach of RER determination:

iii. the "*underlying balance models*". In these models, the equilibrium RER is not

steady and changes as a function of fundamentals. It adjusts to achieve internal and external macroeconomic balances over the medium or long run.

On the one hand, the equilibrium RER is the rate that would satisfy the desired internal and external macroeconomic balance. This is a normative approach to the equilibrium RER (Williamson, 1983; Williamson, 1994, Fundamental Equilibrium Exchange Rate).[9] On the other hand, the equilibrium RER can be defined with a positive approach where the RER changes depending on macroeconomic fundamentals, such as terms of trade, trade openness, productivity, and net foreign asset position, resulting in the exchange rate that is needed and relevant in the medium and long run. The Behavioral Equilibrium Exchange Rate[10] (Clark and MacDonald, 1999, BEER) and the Natural Real Exchange Rate[11] (Lim and Stein, 1998, NATREX) correspond to this approach. Internal balance corresponds to the situation when national economic output is at its potential level. External balance may refer to various situations. If the current account balance is positive, the country is a net lender or has a capacity of financing other countries, otherwise the country is a net borrower, with capital inflows. Therefore, over the medium run, the macroeconomic equilibrium is characterized by an internal balance and the condition of external balance where a current deficit is financed by sustainable capital inflows (excluding speculative capital flows). If the country's current account is in deficit, the RER becomes unsustainable in the long run because of an accumulation of external debt. A real currency depreciation, through a drop in the country's net wealth and consumption, allows for a trade surplus

[9]The FEER approach relies on significant normative conditions that are subject to discussions and hard to represent empirically, such as the determination of current account targets (considered as desired or sustainable).

[10]The BEER is easy to implement but its lack of underlying theoretical mechanisms has been called into question.

[11]The NATREX is based on robust equilibrium foundations. It allows us to estimate short-, medium- and long-term equilibrium exchange rates dynamically. The NATREX is a dynamic approach of FEER, in which the current account target is modeled based on its fundamental determinants.

to service the debt.

We will use the BEER approach, especially relevant for developing countries, to estimate the relationships between RER and macroeconomic fundamentals, such as external public debt over the medium and long run. In this approach, the country's external position is a key determinant of the real exchange rate in the medium and long term. Developing countries are characterized by negative net external positions that result in external public indebtedness. The countries' total public debt is divided into internal and external debt according to the type of creditors or the denominated currency. We consider the external public debt because financial markets are less deep in developing countries. Moreover, the debt is denominated in foreign currency (often in dollars or euros). External public financing is an economic opportunity for governments to increase investment, consumption and economic growth, but the debt burden is also a pressure on national income and budget (Bacha, 1990), therefore the sustainability of this indebtedness is an important issue. The debt sustainability can be assessed in several ways:

i. the debt burden is measured by calculating ratios between debt indicators and resource indicators (GDP, exports of goods and services, foreign exchange reserves). The public debt is considered as unsustainable if it exceeds a given threshold. For example, this ratio is set at 60% of GDP in the European Union. In the past, the IMF and the World Bank have considered situations of over-indebtedness (or debt distress) by looking at the present value of external debt in ratio to exports or revenues for example, especially for the Heavily Indebted Poor Countries initiative.

ii. An analysis of debt dynamics (a forward-looking approach) that relies on the pri-

mary deficit and the difference between the interest rate and the economic growth rate. According to these two elements, we can assess if the debt is sustainable or if it follows an explosive trajectory due to a snowball effect.

iii. A debt sustainability analysis using a cointegration relationship between a debt indicator and a set of macroeconomic fundamentals.

The literature, both theoretical and empirical, is not conclusive on the relationship between the RER and external public debt over the long run. Moreover, the literature highlights opposite effects induced by external indebtedness.

On the one hand, empirical works show a negative relationship between external public debt and RER in extension of the BEER approach and the Edwards' model (Edwards, 1988). Mongardini (1998) highlight that a current account deterioration due to an increasing debt-service ratio led to a real currency depreciation in Egypt from 1987 to 1996. Conversely, a reduction in the debt level increased the wealth in each period and the demand for tradable and non-tradable goods, which raised price level of non-tradables. Thus, debt reductions (from debt relief for example) led to a real currency appreciation. Moreover, Coudert (1999) produced estimates for a panel of emerging countries with the OLS method and showed that an increase in debt ratio of 1 point of GDP led to a depreciation of about 0.3-0.5%. It is also possible to assess the effects of debt policy on real exchange rate thanks to the New Open Economy Macroeconomics (NEOM) framework. The model developed by Ganelli (2005) as an extension of the Overlapping Generations (Blanchard, 1985) and Redux models (Obstfeld and Rogoff, 1995), showed that a debt-financed fiscal policy results in a real currency depreciation over the long term, due to a decline of net foreign assets.

On the other hand, some studies highlight a positive relationship between external financing and real exchange rate (Yano and Nugent, 1999; Sekkat and Varoudakis,

2000). Governments in developing countries that have access to capital markets use external funds to increase social expenditures (wealth, education or infrastructures). This generates an excess of demand in non-tradable goods, at the expense of tradable goods, that leads to a rise in relative price of non-tradable goods and a real appreciation. Empirically, Sekkat and Varoudakis (2000) show that a sustainable indebtedness results in an appreciation of the equilibrium real exchange rate over the long term.

Finally, some studies show that there is a non-linear relationship between the external public debt and RER that depends on the debt sustainability. Using a model based on the current account dynamics (Buiter, 1988; Frenkel and Razin, 1996), Sene and Wane (2013) show that a sustainable debt[12] is associated with an appreciation of the RER to ensure the adjustment towards equilibrium, while an unsustainable debt leads to a depreciation of the RER in the long run.[13] In addition, the NATREX model may also explain an inverted U-shape relationship between external public debt and RER. An internal shock causes external indebtedness (and a deterioration of the capital account) leading to a real currency appreciation. This currency appreciation reduces the investment ratio and thus the capital stock ratio. The consumption starts to decline when the external public debt reaches a critical high level.[14] The fall in consumption reduces the trade deficit which improves the current account. However, if these adjustment effects are weak, then a depreciation of the RER is required to improve the current account in the long run and stabilize the external debt ratio (Couharde et al., 2016).

The purpose of this paper is to investigate a potential link between the external

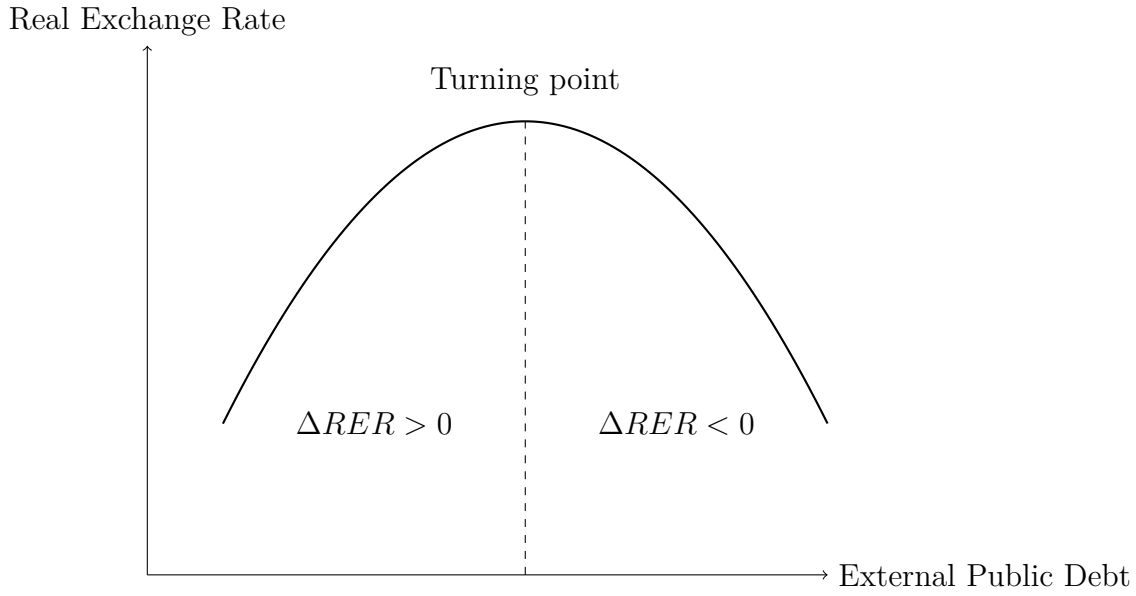
[12]The public debt is considered as unsustainable if the real interest of commitments is higher than the GDP growth rate.

[13]See Frenkel and Razin (1996) and Sene and Wane (2013) which describe the current account dynamics model and the long-run adjustment of the real exchange rate depending on the debt sustainability.

[14]The external indebtedness is accompanied by wealth de-accumulation.

public debt and the RER, in particular to determine if there exists an inverted U-shape relationship (see Figure 1).[15] In first instance, we highlight long-run relationships between the RER and macroeconomic fundamentals, including external debt, with the Pooled Mean Group estimator. If such a relationship exists, then the derivation of a turning point will allow us to define a *stabilizing* external public debt for each country, thanks to the Bayesian iterative procedure which allows us to get the country-by-country relationships. In other words, we derive a level of external public debt that minimizes changes in the RER. We assume that the turning point (i.e., the threshold of external indebtedness at which the real exchange rate shifts from an appreciation to a depreciation) varies between countries. In the following section, we present the data, and especially how the real exchange rate is defined.

Figure 1: An inverted U-shape relationship between RER and External Public Debt



[15]The purpose of this figure is to point out a dynamic relationship between the real exchange rate and the external public debt. Depending on the external public debt level, the real exchange rate depreciates or appreciates. However, we do not pretend to show an effect of the real exchange rate on the external public debt, nor that the real exchange rate values depend on the external public debt level (for example the same real exchange rate value for two distinct levels of external public debt).

3 Data and preliminary analysis

3.1 Data

We collected the outstanding external public and publicly guaranteed debt and debt service on total external public debt from the World Bank International Debt Statistics, and the Gross Domestic Product (in current USD) from World Development Indicators. In this paper, the external public debt and debt service to GDP ratios measure the indebtedness of developing countries and are included in the set of explanatory variables used to explore the effects of external public debt on real effective exchange rate (REER). We also collect from the IMF and World Bank databaset, GDP per capita relative to the United States as a proxy for productivity (Rodrik, 2008), the countries' trade openness (trade flows relative to GDP), the net foreign asset position relative to GDP, and the terms of trade.

The real effective exchange rate is the rate at which a country's currency trades against a basket of other currencies in real terms. We retrieved data on REER from the CEPII database "EQCHANGE" (Couharde et al., 2018). The database provides wide information (country and time coverage) on: (*i*) effective exchange rates (NEER and REER); (*ii*) estimates of equilibrium RER and currency misalignments. "*The REER of country i in period t is calculated as the weighted average of real bilateral exchange rate against each of its N trading partners*" (Couharde et al., 2018, p.9):

$$REER_{i,t} = \prod_{j=1}^{186} \left(\frac{NER_{i,t} \times P_{i,t}}{P_{j,t}} \right)_{ij,t}^{w_{i,t}} \tag{1}$$

where $\frac{NER_{i,t} \times P_{i,t}}{P_{j,t}}$ is an index of real exchange rate (base 100 = 2010) of the currency of country i vis-à-vis the currency of its trading partner j in period t. $P_{i,t}$ and $P_{j,t}$

are the price index of countries i and j, while $w_{ij,t}$ is the weight of the j-th partner in the bilateral trade of country i. An increase (decrease) in REER corresponds to a real currency appreciation (depreciation). We selected the broad index with 186 partners and the fixed weights system from 1973.[16] The authors show that their effective exchange rates are robust and consistent with those provided by the IMF, World Bank, or Bruegel institution. Moreover, the database provides more information on REER for developing countries, especially LICs, and a larger time period coverage than the IMF's International Financial Statistics.

3.2 Country panel and heterogeneity

All data are annual, cover the period from 1975 to 2017 and extend to 37 developing countries (Table A.1 in the Appendix): Bangladesh (BGD), Benin (BEN), Botswana (BWA), Burkina Faso (BFA), Burundi (BDI), Cameroon (CMR), Central African Republic (CAF), Chad (TCD), Republic of Congo (COG), Cote d'Ivoire (CIV), Dominican Republic (DOM), Egypt (EGY), El Salvador (SLV), Gabon (GAB), The Gambia (GMB), Guatemala (GTM), Guyana (GUY), Honduras (HND), Jamaica (JAM), Kenya (KEN), Lesotho (LSO), Madagascar (MDG), Mali (MLI), Mauritius (MUS), Mauritania (MRT), Nepal (NPL), Niger (NER), Pakistan (PAK), Panama (PAN), Paraguay (PRY), Philippines (PHL), Rwanda (RWA), Senegal (SEN), Sri Lanka (LKA), Thailand (THA), Togo (TGO) and Tunisia (TUN).

These Low- and Lower- Middle-Income Countries,[17] according to the World Bank classification, are heterogeneous in terms of country size, geographical position, economic performance or trade integration, and commodities endowment.[18] Moreover,

[16] See Couharde et al. (2018) for further methodological features about weighting scheme, narrow indexes, etc.

[17] We build a sub-sample of countries that are classified as LICS and LMICs throughout the time period (see Table A.1 in the Appendix).

[18] The World Bank classifies countries into four groups depending on the GNI per capita (in USD):

some countries are members of economic and monetary regional communities and unions. On the one hand, this regional integration leads to different levels of financial development or trade liberalization, and changes the effects of international capital flows, external position or public debt on RER.[19] On the other hand, these countries implement different exchange rate regimes. Members of the West African Economic and Monetary Union have kept their currency pegged to the French Franc and Euro, while the West African English-speaking countries have moved toward independently floating currencies. Therefore, the implications of external public debt on the REER may depend on the exchange rate arrangement implemented. RER adjustments are slower in fixed exchange rate regimes. However, a fixed exchange rate can enhance the appreciation effects of capital inflows on real exchange rates (Combes et al., 2012). Table A.2 in the Appendix describes the exchange rate regime arrangements implemented over the period. In addition, some countries in the panel have benefitted from debt reductions through the HIPC and MDRI initiatives (see Table A.3 in the Appendix). Heavily Indebted Poor Countries (HIPCs) have been granted debt reductions in order to recover sustainable debt levels.

3.3 Preliminary analysis

In order to explore the effects of external debt on real exchange rate, we collect available data on equilibrium real exchange rates from CEPII's "EQCHANGE" database. We seek to observe any correlations between external public debt-to-GDP ratio and equilibrium real exchange rate, over the medium or long term. We retrieve from the CEPII database the computed equilibrium exchange rates that are based on the BEER approach (Clark and MacDonald, 1999) which assesses long-run determinants (funda-

Low income, Lower middle income, Upper middle income, High income.

[19] Roy and Dixon (2016) show that trade openness mitigates the appreciation effect of remittances on real exchange rates. Acosta et al. (2009) find similar results with deeper financial systems.

mentals) of equilibrium real exchange rate.[20] Edwards (1988) and Elbadawi (1994) developed suitable models to explore the fundamentals underlying long-run movements of the RER of developing countries, such as the terms of trade, government consumption, trade restrictions, technological progress or external debt. Figure A.1 in the Appendix connects the changes of external public debt-to-GDP ratio and equilibrium real exchange rate (ERER) from 1975 to 2017 for 10 countries in the sample. We see, for Benin, that substantial external indebtedness is coupled with a decrease in the ERER from 1975 to the end of 1990s, whereas a low or limited external debt ratio is linked with an appreciation of ERER. For Burundi, an ERER depreciation is associated with a sharp increase of debt to GDP ratio. We observe the same path for other HIPCs (Cameroon, Central African Republic, Guyana, Madagascar, Mali) and non-HIPCs. Moreover, a decrease of external public debt level (due to debt relief or not) is related to an appreciation of ERER for all countries (except Kenya). Finally, the annual variation in the real exchange rate is connected to the level of external public debt for the full period and the sample of countries studied in Figure A.2 in the Appendix. We observe a negative relationship between the level of external public debt and variations in the real exchange rate. Changes in the real exchange rate become negative above a debt level of around 20% of GDP. The following section describes the empirical strategy.

[20]The authors include in their regressions as fundamentals of the RER: Balassa-Samuelson effect, the economy's net foreign asset position and the economy's terms of trade.

4 Real Exchange Rate and Economic Fundamentals: long-run relationship with Pooled Mean Group

As we have seen before, the panel of developing countries is characterized by heterogeneity, both between countries and over time. There may also be heterogeneity in changes in the real exchange rate or the external public debt of these countries. We assume that the macroeconomic fundamentals converge as countries develop economically, and their variations tend to be similar between countries over the long term. The pooled mean group (PMG) estimator, introduced by Pesaran et al. (1999), allows this assumption and econometric specification. This estimator allows that the intercepts and coefficients differ between countries over the short run, but the coefficients are constrained to be identical over the long run, unlike the mean group (MG) estimator that does not consider potential homogeneity across countries (Pesaran and Smith, 1995). As we discussed in Section 2, the real effective exchange rate can be explained in the long run by a set of macroeconomic fundamentals. In this section, we explore the long run relationship between the REER and the external public debt in addition to a set of fundamental macroeconomics with the following equation:

$$\text{REER}_{i,t} = \mu_i + \beta_i Z_{i,t} + \delta_t + \varepsilon_{i,t} \tag{2}$$

where $REER_{i,t}$ is the real exchange rate in logarithm for country i in period t, considering 186 trade partners and fixed weights for 1973-2017, as detailed in the previous section. $Z_{i,t}$ is a set of macroeconomic fundamentals and the external public debt-to-GDP ratio for each country i and period t, μ_i is the constant, δ_t corresponds to time fixed effects and $\varepsilon_{i,t}$ is the error term. We employ an unrestricted error-correction

autoregressive distributed lag (ARDL) model. The ARDL (1;1) can be written as the following equation:

$$\begin{aligned}\Delta REER_{i,t} = \phi_i(\text{REER}_{i,t-1} - \theta_0 - \theta_1 \text{TOT}_{i,t} - \theta_2 \text{Trade}_{i,t} - \theta_3 \text{Prod}_{i,t} \\ - \theta_4 \text{NFA}_{i,t} - \theta_5 \text{Debt}_{i,t}) - \delta_{1i} \Delta \text{TOT}_{i,t} - \delta_{2i} \Delta \text{Trade}_{i,t} \\ - \delta_{3i} \Delta \text{Prod}_{i,t} - \delta_{4i} \Delta \text{NFA}_{i,t} - \delta_{5i} \Delta \text{Debt}_{i,t} + \varepsilon_{i,t}\end{aligned} \tag{3}$$

The PMG estimator imposes that θ_i is the same for all countries. The terms in parentheses are the long run coefficients. ϕ_i is the coefficient of adjustment to long run equilibrium given by $\phi_i = -(1 - \lambda_i)$. The set of fundamental macroeconomics parameters is composed of the terms of trade ($\text{TOT}_{i,t}$), trade openness ($\text{Trade}_{i,t}$), productivity ($\text{Prod}_{i,t}$), and net foreign asset position ($\text{NFA}_{i,t}$). A rise in the terms of trade can lead to ambiguous effects: if the income effect dominates the substitution effect, such a rise increases the national domestic income and the demand for non-tradable goods which induces a real appreciation; otherwise (i.e., if the substitution effect dominates) the increase in national domestic income boosts demand for imported goods at the expense of non-tradable goods and generates a real currency depreciation. These two effects may cancel each other out and explain the absence of a terms of trade impact in some countries (Lartey et al., 2012). There is also an ambiguous effect of trade restrictions on the real exchange rate. The income effect has a negative influence on the REER: a rise in the imported goods price affects national income and reduces demand for tradable and non-tradable goods, leading to a real depreciation. If the substitution effect dominates, imported goods are substituted by non-tradable domestic goods inducing an appreciation of the equilibrium REER. It is commonly agreed that the income effect dominates the substitution effect (Edwards, 1988), hence restricting trade induces a fall of the price ratio of tradable to non-tradable goods, leading to a real appreciation.

Productivity attempts to capture the Balassa-Samuelson effect, which is proxied by the GDP per capita relative to the United States (Rogoff, 1996; Rodrik, 2008). The Balassa-Samuelson effect is positive on the REER as a country is economically growing. In particular, the tradable sectors grow faster than the non-tradable sectors which induces higher wages in tradable sectors, which in turn puts upward pressure on wages in non-tradable sectors. This rise of wages in non-tradable sectors raises the relative price for non-tradable sectors, because prices in tradable sectors are determined by international markets, and leads to a real appreciation. Finally, an increase in the net foreign asset position of the country has a positive influence on the REER.[21]

Including stock variables in the analysis implies that flow equilibrium must follow as a necessary condition.[22] In our model, we consider factors that impact the country's trade position on international markets and the propensity of the country to be net lender or borrower. Faruqee (1995) highlights that the interaction between structural components of both the current account and the capital account jointly determine the RER over the long run. Hence, $\text{Debt}_{i,t}$ corresponds to the logarithm of the external public debt-to-GDP ratio. We include in Equation 4 the squared variable of $\text{Debt}_{i,t}$ as a proxy for high external public debt levels in order to explore if the movements of the real effective exchange rate vary depending on the external debt-to-GDP ratio. The relevance of using a debt ratio is justified since we are looking for a statistical relationship between the debt ratio and the evolution of the RER.

[21] Lane and Milesi-Ferretti (2000) show that the net foreign asset position is an important determinant of the real exchange rate in both developing and developed countries.

[22] Faruqee (1995) illustrates this idea with the transfer problem: a fall in the NFA stock for a country leads to a decline in domestic spending and demand for domestic goods due to the redistribution of wealth. The international transfer of wealth must be accompanied by a real depreciation to improve the trade position in order to offset losses in interest revenues from abroad (external equilibrium).

$$
\begin{aligned}
\Delta REER_{i,t} = \phi_i(&\text{REER}_{i,t-1} - \theta_0 - \theta_1 \text{TOT}_{i,t} - \theta_2 \text{Trade}_{i,t} - \theta_3 \text{Prod}_{i,t} \\
&- \theta_4 \text{NFA}_{i,t} - \theta_5 \text{Debt}_{i,t} - \theta_6 \text{Debt}_{i,t}^2) - \delta_{1i} \Delta \text{TOT}_{i,t} \\
&- \delta_{2i} \Delta \text{Trade}_{i,t} - \delta_{3i} \Delta \text{Prod}_{i,t} - \delta_{4i} \Delta \text{NFA}_{i,t} \\
&- \delta_{5i} \Delta \text{Debt}_{i,t} - \delta_{6i} \Delta \text{Debt}_{i,t}^2 + \varepsilon_{i,t}
\end{aligned} \tag{4}
$$

Therefore, this model allows us to explore a non-linear relationship between the RER and the external public debt in the developing countries. The next section presents in detail the results of the estimates.

5 Results

Table A.4 in the Appendix displays unit root tests (Augmented Dickey-Fuller and IPS) on the REER, external public debt and other macroeconomic aggregates.[23] Unit root tests confirm that some variables are nonstationary and can be considered as integrated of order one. We assume the potential presence of cross-sectional dependence in the sample. Consequently, we also test the stationarity of the series using second-generation tests (Pesaran, 2003). Table 1 presents the estimates of the long-run relationship between REER and macroeconomic fundamentals.[24] Coefficients in columns 1-2 and 4-5 are estimated using the Pooled Mean Group method, while coefficients in columns 3 and 6 are estimated using a dynamic common-correlated effects model to control for the presence of cross-sectional dependence.

[23] IPS refers to the Im et al. (2003) unit root test. IPS introduced heterogeneity : the IPS test is a way to combine the evidence from N unit root tests for N different individuals.

[24] We note that the Hausman test confirms that the long-run parameters are homogeneous, hence the pooled mean group might be preferable to the mean group estimator and lead to more efficient estimates.

The error correction term is negative and statistically significant. This result is consistent with the existence of a cointegrating vector and excludes potential omitted variable bias. We note that, for the Low- and Low-Middle Income Countries panel, the speed of adjustment is statistically significant and higher than one for all countries.[25] Indeed, these countries are further from the equilibrium values relative to emerging countries. The relationship between the REER and its macroeconomic fundamentals is consistent with our expectations. Indeed, the Balassa-Samuelson effect, measured by the relative GDP per capita, is positive and statistically significant. The effect of the terms of trade on REER is also positive. The income effect tends to dominate the substitution effect. Regarding the implications of trade openness, we find that the estimated coefficient is not statistically significant. The lack of significance may support the idea that the income and substitution effects can cancel each other out. Finally, as expected, the NFA position has a positive and significant influence on the REER. In the same logic as NFA (i.e., a stock variable that measures the country's external position).

The results in Table 1 suggest a long-run, inverted U-shape relationship between external public debt and the REER for LICs and LMICs.We note that the estimated coefficients (in absolute value) associated with external public debt are higher for the LICs and LMICs panel. Relying on external funding allows for the financing of social expenditure (i.e., towards the non-tradable sector) which induce an appreciation of the REER. Conversely, a high external debt leads to a depreciation of the REER in order to ensure external balance and finance current account deficits.In order to ensure the sustainability of the external account, external public indebtedness is associated with a real currency depreciation to generate a trade surplus to service the debt.

[25]This result for a smaller and more homogeneous sample of countries is consistent with the presence of a cointegrating vector, and thus that it is appropriate to impose long-run homogeneity.

Table 1: Long-run relationship between the REER, external public debt and macroeconomic fundamentals

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable:	Log(Real Effective Exchange Rate)					
	PMG		DCCE	PMG		DCCE
Panel:	All countries			LICs and LMICs		
Error-correction term	-0.128***	-0.126***		-0.162***	-0.153***	
	(-8.80)	(-7.28)		(-8.52)	(-8.29)	
Log(Terms of Trade)	3.677***	2.939***	-1.723	0.242	2.533**	1.649
	(4.35)	(2.81)	(-0.2)	(0.21)	(2.47)	(0.17)
Log(Trade)	0.019	-0.047	-0.233*	0.160***	0.084	0.095
	(0.32)	(-0.96)	(-1.90)	(2.65)	(1.41)	(0.67)
Log(Productivity)	0.501***	0.516***	0.014	0.035	0.210***	0.105
	(7.17)	(9.64)	(0.07)	(0.53)	(4.57)	(0.47)
NFA	0.008***			0.001		
	(5.17)			(1.62)		
External Public Debt	-0.134***	0.283**	1.147**	-0.071***	0.419***	0.553
	(-3.81)	(2.47)	(2.11)	(-2.64)	(3.15)	(1.02)
External Public Debt^2		-0.062***	-0.169**		-0.078***	-0.086
		(-3.46)	(2.15)		(-3.87)	(-1.23)
Cointegration test						
Panel rho	2.066	3.479				
Group rho	2.508	3.842				
Observations	1411	1426	1391	949	949	940
No of countries	34	34	34	23	23	23

Notes: Numbers in parenthesis are t-statistics. Short-run relationships are not reported in the table. We follow the Pedroni (2004) cointegration tests. The null hypothesis assumes for each unit of the panel that the variables are not cointegrated. Pedroni's test allows for heterogeneous variances between countries in each period. The alternative hypothesis assumes for each unit of the panel that there is a cointegration vector, which can be different for each country. All specifications include a maximum of one lag. The total number of lags is chosen according to the Schwarz criterion (BIC). PMG and DCCE correspond to Pooled Mean Group and Dynamic Common Correlated Effects estimates respectively. *, ** and *** denote significance at 10%, 5% and 1% levels. Low and Lower Middle-income countries panel is composed by the 26 developing countries presented in section 3, excluding Botswana, Guyana and Lesotho.

Therefore, Pooled Mean Group estimates provide evidence of the long-run relationship between the real exchange rate and macroeconomic fundamentals. However, the main limit of the Pooled Mean Group is that it provides a unique coefficient (a single slope) for the entire sample, whereas, the real exchange rate needs to be considered separately for each country. Therefore, in the next section, we apply bayesian shrinkage estimators which allow both to control for heterogeneity between countries and to get coefficients country by country.

6 Real Exchange Rate and External Public Debt: an inverted U-shape relationship

In this section, we apply the Empirical Iterative Bayes' estimator suggested by Maddala et al. (1997), since it provides heterogeneous (country by country) estimates for the relationship between external public debt and real exchange rate. This long-term relationship is given by the following equation with a dynamic panel data model:

$$\Delta REER_{i,t} = c_i + \beta_i \, \text{REER}_{i,t-1} + \delta_i \, \text{Debt}_{i,t} + \theta_i \, (\text{Debt})^2_{i,t} + \varepsilon_{i,t} \tag{5}$$

where $\text{REER}_{i,t}$ is the real exchange rate (in logarithm) for country i in period t. $\text{Debt}_{i,t}$ corresponds to the external public debt to GDP ratio (in log). c_i and $\varepsilon_{i,t}$ are the constant and the error terms, respectively. We include the squared variable of $\text{Debt}_{i,t}$ as a proxy for high external public debt levels, in order to explore the potential inverted U-shape relationship between REER and external debt-to-GDP ratio. The inclusion in the model of the current variable (instead of the lagged variable) of external public debt to GDP, does not raise an issue, since in the dynamic panel data model framework, the empirical literature underlines that problems associated with time series are mainly

related to the handling of heterogeneity. Moreover, the recent empirical literature (Hsiao et al., 1998; Hsiao, 2022) argues in favor of shrinkage estimators that shrink the heterogeneous estimators towards the pooled estimator.[26]

The models also include the lagged independent variable in the set of explanatory variables, in order to capture the convergence of REER towards its long-run equilibrium value and potential effects of economic fundamentals on REER in the long term, such as productivity, terms of trade, economy's net wealth, etc., which are not included in the model. These estimations explore the relationship between REER and external public debt for 26 developing countries (LICs and LMICs in Table A.1 in Appendix), from 1975 to 2017, while considering some issues related to real exchange rate estimates, as discussed in the following.

The Empirical Iterative Bayes' estimator presented in more detail in Appendix B allows us to deal with some issues associated with the real exchange rate estimates.

i. Considering the dynamics of exchange rates: The real exchange rate of a country is supposed to converge towards its equilibrium value over time. A way to incorporate these dynamics is to include the lagged independent variable into the set of explanatory variables (Rogoff, 1996), although it can generate new sources of estimation bias and endogeneity. Using the Bayesian shrinkage estimator helps to resolve these problems. Indeed, for Maddala et al. (1997), the empirical iterative Bayes' estimators are preferred if the model contains lagged endogenous variables (as it is the case in dynamic models). These estimators have more plausible values than the heterogeneous estimators. Maddala and Hu (1996) presented some Monte Carlo evidence to suggest that the iterative procedure gives

[26]For instance, Baltagi et al. (2008) consider the dynamic version of the classical Tobin investment model.

better estimates for panel data models.

ii. Stationarity in heterogeneous panel data: non-stationary time series with traditional econometric techniques may generate spurious regression results (Nelson and Plosser, 1982). Empirical Bayes' estimators do not suffer from non-stationarity bias (Hsiao et al., 1998; Baltagi et al., 2008).

iii. Cross-country heterogeneity: in the previous section, we highlighted the cross-country heterogeneity in the panel due to economic and demographic characteristics or membership of various economic and monetary communities. Moreover, the real exchange rate may be defined as the ratio between tradable and non-tradable prices, thus domestic relative prices are different between countries. Coudert (1999) shows that indebtedness explains the changes of RER within a country more than differences between countries; thus, it legitimates using the empirical Bayes' estimator which provides country-by-country coefficients. These estimators allow to deal with heterogeneity and provide more stable, and less dispersed coefficients.

Tables B.1 and B.2 in the Appendix report the parameters obtained with the Bayesian shrinkage estimators for the model given by the Equation 5 for 1975-1999 and 1975-2017. For both estimations, we find some new empirical results. The coefficients δ_i associated with the external public debt-to-GDP ratio are positive and statistically significant.

Indeed, an increasing external debt-to-GDP ratio is associated with an appreciation of the REER in Low- and Lower Middle-Income Countries, only as long as the debt level remains limited. In other words, a limited external public indebtedness is associated with a real currency appreciation. Developing countries' external financing results in capital inflows into the country. Firstly, these funds denominated in hard

currency (US Dollars, Euros, Livres, Yen, etc.) are converted into domestic currency. Secondly, governments increase social expenditures. This spending increases the demand for non-tradable goods which raises the relative price of non-tradable to tradable goods and results in a real currency appreciation. The coefficients θ_i associated with the squared variable of external debt ratio are negative and statistically significant for both estimations. A high external public indebtedness is associated with a real currency depreciation in LICs and LMICs over the medium and long run. This result is consistent with the long-run determinants of real exchange rate models (Edwards, 1989, FEER and NATREX) which highlight that indebtedness is not sustainable over the long term and lead to a depreciation of the real exchange rate in order to improve external balance. Moreover, a significant debt burden requires the government to reduce social expenditures to service the debt. The drop in demand for non-tradables lowers the relative price of non-tradable goods and leads to a real currency depreciation. Hence, there is an inverted U-shape relationship between the external public debt and RER in developing countries: a low external public indebtedness is associated with a real currency appreciation, whereas a high external public debt induces a real currency depreciation.

The NATREX model provides some insight to explain the inverted U-shape relationship between external public debt and REER. Indeed, the adjustment process of the real exchange rate from its medium-term to the long-term value is not linear and depends on the speed of adjustment of the stock variables such as net foreign assets, and especially the dynamics of wealth accumulation. However, if these adjustment effects are weak, then a depreciation of the RER is required to improve the current account in the long run (as mentioned Section 2). Having identified an inverted U-shape relationship between external public debt and the RER, it is relevant to determine a turning point for each country. This turning point corresponds to a threshold of external public

debt to GDP ratio that minimizes the change in the RER.

7 Robustness checks: sensitivity to the country panel and external public debt threshold

In this section, we modify the panel of countries (see bottom panel in Table A.1 in the Appendix) in order to examine if we find similar relationships between the external public debt and the real exchange rate as in the previous section. Thus, we test the sensitivity of the results to the sample of countries.[27] The modified panel provides a broader representation of developing and emerging countries around the world and heterogeneity in terms of economic development, geographical characteristics, exchange rate regimes, etc. For this set of 26 countries, we again explore the relationship between the external public debt and the real effective exchange rate with the Empirical Iterative Bayes estimators, over the period from 1975 to 2017.

Table B.3 in the Appendix reports the coefficients get with the Bayesian shrinkage estimators for the model given by the Equation 5 which include the external public debt squared variable in the set of explanatory variables as a proxy of high or unsustainable external debt levels. We find that a low external public debt-to-GDP ratio induces a real currency appreciation, whereas a high external public debt-to-GDP ratio is associated with a depreciation of the REER. Therefore, even after including other developing countries with some heterogeneity in the panel, we find similar real exchange rate responses to external debt depending on the debt sustainability as in section 6.

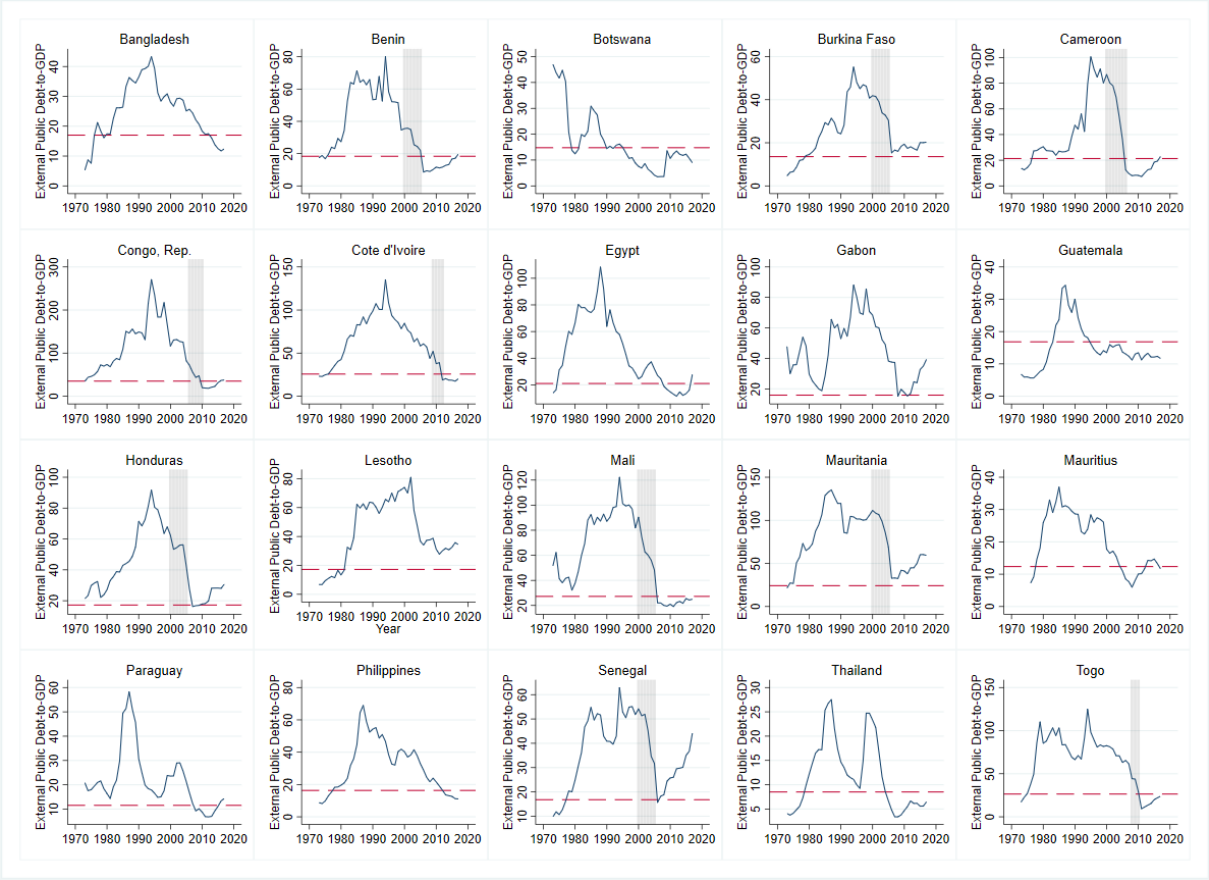
Figure 2 shows the countries' public external debt between 1975 and 2017 and the

[27]We keep Bangladesh, Benin, Botswana, Burkina Faso, Cameroon, Cote d'Ivoire, Honduras, Lesotho, Mali, Mauritania, Mauritius, Philippines, Republic of Congo, Senegal and Togo in the panel. And we add Dominican Republic, Egypt, El Salvador, Gabon, Guatemala, Jamaica, Panama, Paraguay, Sri Lanka, Thailand and Tunisia.

threshold levels for each country at which the relationship between external public debt and the RER shifts from positive to negative. The debt threshold (red dashed line) corresponds to the turning point in the relationship between external public debt and the real exchange rate. We derive this turning point from the estimated coefficients (Equation 5) reported in Table B.3 in the Appendix. The external public debt thresholds are also presented in this table for each country. Most of the time, developing countries have an external public debt-to-GDP ratio that exceeds the threshold.

Real currency appreciation occurs once the debt ratio falls below the threshold, which is the case for most developing countries. For example, for HIPCs, the external debt-to-GDP ratio drops below the threshold thanks to the debt relief granted under the HIPC and MDRI initiatives. The HIPC and MDRI debt relief period is represented by the gray area in Figure 2. The aim of the debt write-off was, on the one hand, to help these countries to recover sustainable debt levels and, on the other, to release a fiscal space to finance social expenditures and public investments. This spending may increase the demand for non-tradable goods and lead to an appreciation of the RER. At first glance, the external public debt-to-GDP ratios that minimize changes in RER may seem quite low (18 percent of GDP on average) compared to the historical external debt levels reached by some developing countries, especially HIPCs. However, they are relatively close to the external public debt levels at the end of the debt relief process that helped HIPCs to recover external debt sustainability. We will detail the implications for economic policy and external financing over the next few years in the conclusion.

Figure 2: The external public debt-to-GDP ratio and the real exchange rate's response from 1975 to 2017



Notes: The blue line represents the countries' public external debt-to-GDP ratio from 1975 to 2017. The red dash line is the threshold for the change in the real exchange rate response to external debt. External indebtedness above the line is associated with a real currency depreciation, while under the line it is associated with a real currency appreciation. This threshold is derived from the estimated coefficients in Equation 5 and reported in Table **??** in the Appendix. The grey zone indicates the years of debt relief granted to HIPCs. Dominican Republic, El Salvador, Panama, Sri Lanka, and Tunisia are not shown because their minimum debt ratio never crosses the threshold.

8 Conclusion

In this chapter, we seek to provide empirical evidence to inform the discussion about the real exchange rate's response to external public indebtedness in developing countries. We find an inverted U-shape relationship between the external public debt and the RER.

On the one hand, a limited external public debt-to-GDP ratio is associated with an appreciation of the RER. Capital inflows induced by external financing increase demand in the non-tradable sector and cause an appreciation of the real exchange rate. Although external financing helps governments to finance their development needs (Dornbusch, 1998) and offset the lack of savings, external public indebtedness leads to a real currency appreciation that results in a loss in external competitiveness and affects economic growth. Some developing countries, especially Sub-Saharan African and Latin America countries, experienced an associated increasing external debt and real currency appreciation during the 1980's and 1990's.

On the other hand, a high debt-to-GDP ratio is associated with a depreciation of the RER. Traditional approaches emphasize that external indebtedness is not sustainable for the current account over the long term. This real currency depreciation is expected to restore the external macroeconomic balance. Moreover, a high debt burden may lead the government to reduce social expenditures in order to service the debt. This results in a drop in the demand for non-tradable goods, and thus to a real currency depreciation.

The governments in developing countries must deal with the appreciation and depreciation of the RER based on the changes in external public debt-to-GDP ratio, through their economic policies. The RER is a fundamental relative price that guides investment choices between different sectors in an economy, i.e., tradable or non-tradable sectors.

In addition to the risks associated with a high debt burden, a fall in the RER may lead to an overvaluation of the currency for countries with fixed-exchange-rate regime, especially in a currency union. A depreciation of the RER can promote exports and manufacturing sectors, even though the discussions on the likely end of export-led growth strategies especially for developing countries are not yet over (Rodrik, 2016; Diao et al., 2021; Kruse et al., 2023). However, it may cause inflation and affect the labor productivity. Indeed, a real currency depreciation corresponds to a decrease in real income (in terms of tradable goods) for workers, and lead to inflation which affects the poor. The decline of real income may alter the health and the motivation of workers and reduce the returns of education.[28] It results in a decrease in labor productivity and the average level of education in the country or provoke a brain drain.[29] Therefore, real exchange rate stability remains an important growth lever (conditional convergence with education and skills). Growth and development opportunities are also possible through the farming sector and diversification in crop exports. Furthermore, a depreciation of the RER may also have detrimental effects for emerging market economies with domestic liability dollarization. The real depreciation makes it harder for firms in the non-tradable sector to repay their loans, and can trigger uncertainty about the banking sector solvency, or even banking panic (Calvo et al., 2008).

Therefore, there is a strong incentive for developing countries to ensure that their external public debt-to-GDP should converge towards the threshold that minimizes RER fluctuations. This threshold corresponds to the turning point in the relationship between external public debt and the RER. In the same way as studies that attempt to identify levels of external debt that do not affect economic growth, it is also possible to determine a level of external public debt to GDP that minimizes changes in the RER.

[28] See the "X-efficiency" developed by Leibenstein (1966)

[29] Guillaumont Jeanneney and Hua (2011) highlight transmission channels of RER on productivity in China.

We find that the ratio of external public debt-to-GDP, which stabilizes variations in the RER, is close to the debt levels at the end of HIPC initiatives, suggesting that governments have a *little room* for external indebtedness.

In 2017, HIPCs such as Benin, Cameroon and Mali reached this debt threshold, and Honduras and Senegal had already exceeded it. However, developing countries require large amounts of external financing to face economic turmoil and other challenges (climate change, digitalization, diversification), at the same time as funding costs are increasing. This means that developing countries will have to find and use financing sources that avoid returning to unsustainable debt levels, for example the use of the SDR allocation of August 2021. Or even implementing the conditions to attract private financing such as foreign direct investments or other non-debt creating flows.

Lastly, the debt threshold is not the same for all countries. The minimum debt threshold is 6.60 for Guatemala while the maximum is 35.06 for the Republic of Congo. Countries with lower debt thresholds have narrower margins for external public debt. These differences in debt thresholds could be the subject of future investigations.

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Appendix A

Table A.1: Country Panels

Full Sample			
Bangladesh	Egypt	Mali	Sri Lanka
Benin	El Salvador	Mauritius	Thailand
Botswana	Gabon	Mauritania	Togo
Burkina Faso	The Gambia	Nepal	Tunisia
Burundi	Guatemala	Niger	
Cameroon	Guyana	Pakistan	
Central African Republic	Honduras	Panama	
Chad	Jamaica	Paraguay	
Republic of Congo	Kenya	Philippines	
Cote d'Ivoire	Lesotho	Rwanda	
Dominican Republic	Madagascar	Senegal	
Low-Income and Lower-Middle Income Countries			
Bangladesh	Chad	Lesotho	Pakistan
Benin	Republic of Congo	Madagascar	Philippines
Botswana	Cote d'Ivoire	Mali	Rwanda
Burkina Faso	The Gambia	Mauritius	Senegal
Burundi	Guyana	Mauritania	Togo
Cameroon	Honduras	Nepal	
Central African Republic	Kenya	Niger	
Sensitivity Tests Sample (Robustness Checks)			
Bangladesh	Egypt	Lesotho	Senegal
Benin	El Salvador	Mali	Sri Lanka
Botswana	Gabon	Mauritania	Thailand
Burkina Faso	Guatemala	Mauritius	Togo
Cameroon	Honduras	Panama	Tunisia
Cote d'Ivoire	Lesotho	Paraguay	
Dominican Republic	Jamaica	Philippines	

Table A.2: Fine De Facto Exchange Rate Arrangement Classification

Exchange Rate Arrangement	Number of countries			
	1975	1990	2005	2016
No separate legal tender or currency union	12	11	11	11
Pre-announced peg or currency board arrangement	9	1	2	1
De facto peg	1	0	0	2
De facto crawling peg	1	4	5	4
De facto crawling band that is narrower than or equal to +/-2%	1	2	6	5
De facto crawling band that is narrower than or equal to +/-5%	1	3	1	2
De facto moving band +/-5%/ Managed floating	0	2	1	1
Freely floating	0	1	0	0
Freely falling	0	2	0	0
Dual market in which parallel market data is missing	1	0	0	0

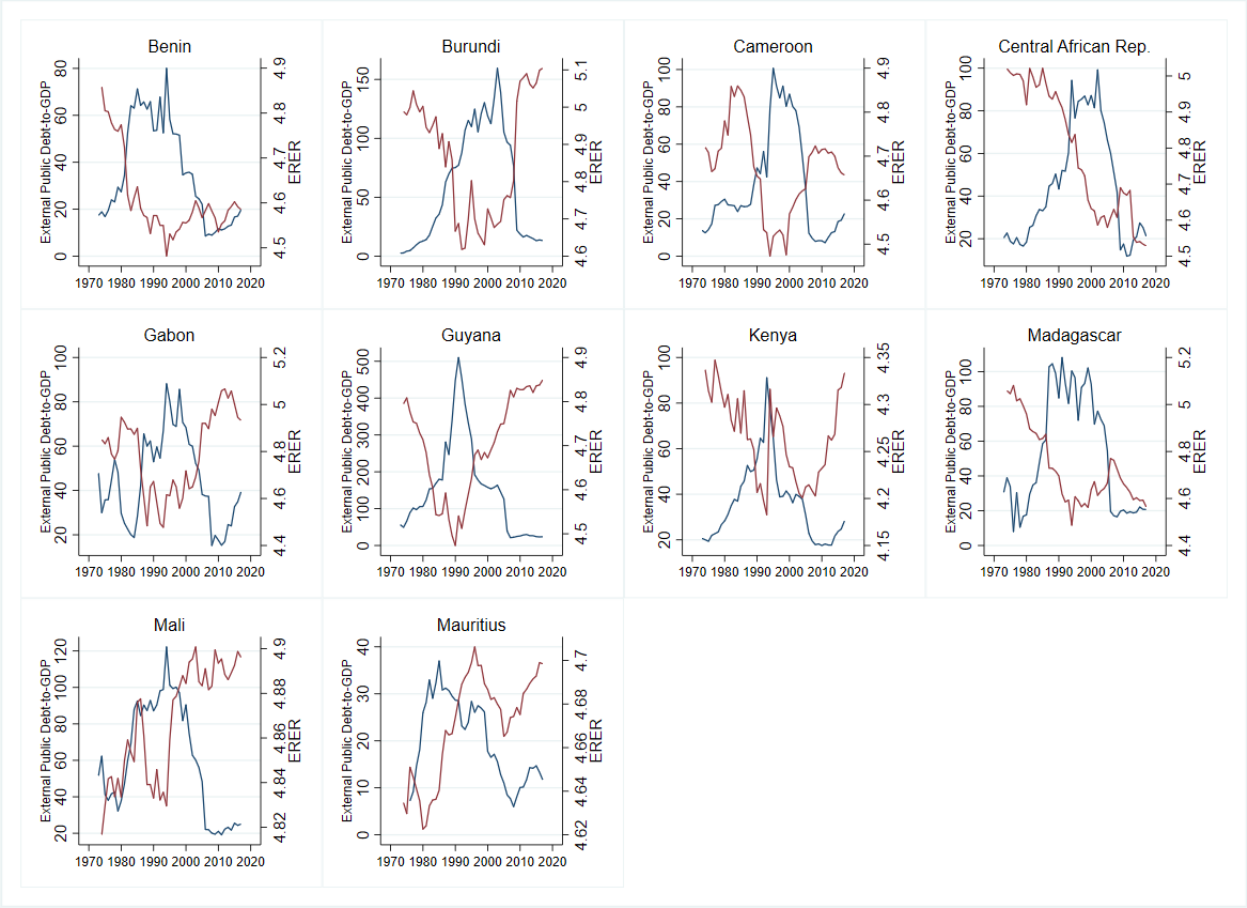
Notes: We remove the exchange rate arrangements that do not contain any country (from less to more flexible): Pre announced horizontal band that is narrower than or equal to +/-2%; Pre announced crawling peg, de facto moving band narrower than or equal to +/-1%; Pre announced crawling band that is narrower than or equal to +/-2% or de facto horizontal band that is narrower than or equal to +/-2%; Pre announced crawling band that is wider than or equal to +/-2%; Moving band that is narrower than or equal to +/-2%. Source: Ilzetzki et al. (2019).

Table A.3: Heavily Indebted Poor Countries

Countries	Decision Point	Completion Point	MDRI
	Entry	Exit	
Burkina Faso	2000	2002	2005
Benin	2000	2003	2005
Senegal	2000	2004	2005
Rwanda	2000	2005	2005
Guyana	2000	2003	2005
Honduras	2000	2005	2005
Mauritania	2000	2002	2005
Mali	2000	2003	2005
Niger	2000	2004	2005
Madagascar	2000	2004	2005
The Gambia	2000	2007	2007
Cameroon	2000	2006	2006
Chad	2001	2015	2015
Burundi	2005	2009	2009
Congo, Rep.	2006	2010	2010
Central African Rep.	2007	2009	2009
Togo	2008	2010	2010
Cote d'Ivoire	2009	2012	2012

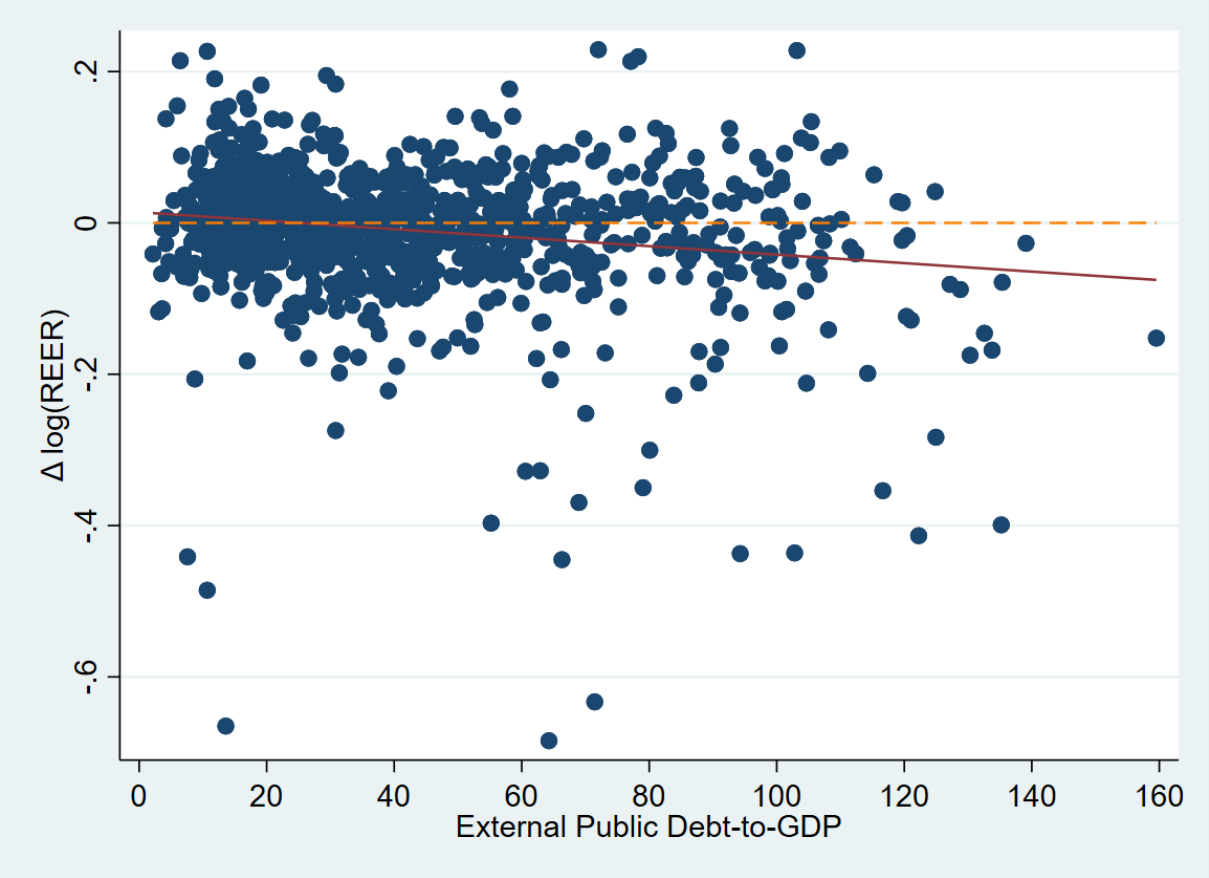
Source: International Monetary Fund.

Figure A.1: External public debt (in % of GDP) and Equilibrium Real Exchange Rate (in log) from 1975 to 2017



Notes: The blue line represents the country's external public debt-to-GDP, while the red line indicates movements in the equilibrium real exchange rate. Source: author's calculations; International Debt Statistics, World Development Indicators, CEPII's database "EQCHANGE".

Figure A.2: Real Exchange Rate movements and External public indebtedness (in % of GDP) from 1975 to 2017



Notes: The red line represents the fitted line from the dots. Source: author's calculations; International Debt Statistics, World Development Indicators, CEPII's database "EQCHANGE".

Table A.4: Unit root tests

	Level			First difference		
	IPS	ADF	CADF	IPS	ADF	CADF
REER	-3.219***	-3.041***	-5.512***	-29.472***	-21.767***	-16.664***
Terms of Trade	-2.340***	-1.322	-7.795***	-32.254***	-24.109***	-22.007***
Trade	-1.480	-1.187	-0.043	-35.068***	-22.827***	-17.016***
Productivity	-4.782***	-0.198***	0.204	-25.178***	-21.926***	-16.351***
NFA	-0.7620	-0.9633	-4.313***	-27.443***	-18.348***	-15.082***
External Public Debt	-0.944	-0.859	-2.159**	-30.036***	-19.214***	-15.307***
Debt Service	-8.080***	-6.171***	-7.389***	-43.290***	-25.703***	-21.082***

Notes: ** and *** denote significance at 5% and 1% levels. The null hypothesis is the presence of unit root.

Appendix B - Empirical Iterative Bayes Estimation

We apply the Empirical Iterative Bayes' estimator proposed by Maddala et al. (1997) since it provides a heterogeneous (country by country) estimation of the relationship between external public debt and real exchange rate. As Maddala et al. (1997) argued, in panel analysis, the problem with the two usual estimation methods of either pooling the data or obtaining separate estimates for each cross-section is that both are based on extreme assumptions. If the data are pooled, it is assumed that the parameters are all the same. On the other hand, if separate estimates are obtained for each country, it is assumed that the parameters are all different. The truth probably lies somewhere in between. The parameters are not the same, but there is some similarity between them. One way of allowing for the similarity is to assume that all the parameters come from a joint distribution with a common mean and a nonzero covariance matrix.

The authors argued that the resulting parameter estimates will be a weighted average of the overall pooled estimate and the separate time series estimates based on each cross-section. Thus, each cross-section estimate is "shrunk" toward the overall pooled estimate (i.e., "*shrinkage estimator*"). In this way, the solution relies on the use of a random-coefficient model in which the parameters are assumed to come from a common distribution.

According to Maddala et al. (1997), the shrinkage estimator should be preferred if the model contains lagged endogenous variables (as is the case in the dynamic models) because it gives much more reasonable parameter values than the heterogeneous estimators. Similarly, Hsiao et al. (1998) and Hsiao (2022) confirmed that, firstly, when the time-series dimension of panel sets is large, the heterogeneous estimators are more appropriate from an econometric point of view, and secondly, in the case of panel data models with coefficient heterogeneity, the Bayesian approach performs fairly well, even when the time dimension is small.

Let us consider the Bayesian approach to Equation 5, which can be rewritten in the framework of the random-coefficients model, with the following specification:

$$y_i = X_i\gamma_i + u_i \tag{6}$$

where y_i contains the annual change in the ratio of external public debt to GDP time series, X is the matrix with explanatory variables, and γ_i are slope coefficients. In the Bayesian framework, the prior distribution of γ_i is given by: $\gamma_i \sim N(\mu, \Sigma)$ where the parameters μ (mean of γ_i), Σ (variance of γ_i) and σ_i^2 (residual variance) are unknown. Therefore some assumptions have to be made on the prior specification of these parameters. Then we can derive the posterior distribution for the parameters, γ_i. On the other hand, if μ, Σ and σ_i^2 are all known, the posterior distribution of γ_i is normal and calculated by:

$$\gamma_i^* = \left[\frac{1}{\sigma_i^{*2}} X_i' X_i + \Sigma^{*-1}\right]^{-1} \left[\frac{1}{\sigma_i^{*2}} X_i{}' X_i \hat{\gamma}_i + \Sigma^{*-1}\mu^*\right] \tag{7}$$

where $\hat{\gamma}_i$ is the ordinary least squares (OLS) estimator of γ_i. The posterior distribution of mean γ_i and its variance are shown in Equations 8 and 9 respectively.

$$\mu^* = \frac{1}{N}\sum_{i=1}^{N} \gamma_i^* \tag{8}$$

$$V\left[\gamma_i^*\right] = \left[\frac{1}{\sigma_i^{*2}} X_i' X_i + \Sigma^{*-1}\right]^{-1} \tag{9}$$

Since in general, Σ and σ_i^2 are unknown parameters, one needs to specify priors for them. For this purpose, Smith (1973) suggested using the mode of the joint posterior distribution given by the following equations:

$$\sigma_i^{*2} = \frac{1}{T + \varsigma_i + 2}\left[\varsigma_i\lambda_i + \left(y_i - X_i\gamma_i^*\right)'\left(y_i - X_i\gamma_i^*\right)\right] \tag{10}$$

and

$$\Sigma^* = \frac{1}{T - k - 2 + \delta}\left[R + \sum_{i=1}^{N}\left(\gamma_i^* - \mu^*\right)\left(\gamma_i^* - \mu^*\right)'\right] \tag{11}$$

where the parameters $\varsigma_i, \lambda_i, \delta$ and R arise from the specification of the prior distributions. Moreover, Smith (1973) proposed the approximation of these parameters by setting $\varsigma_i = 0, \delta = 1$ and R as a diagonal matrix with small positive entries (e.g., 0.001). By doing so, the estimators take the following forms:

$$\sigma_i^{*2} = \frac{1}{T+2}\left[(y_i - X_i\gamma_i^*)'(y_i - X_i\gamma_i^*)\right] \tag{12}$$

$$\Sigma^* = \frac{1}{T-k-1}\left[R + \sum_{i=1}^{N}(\gamma_i^* - \mu^*)(\gamma_i{}^* - \mu^*)'\right] \tag{13}$$

$$\gamma_i^* = \left[\frac{1}{\sigma_i^{*2}}X_i{}'X_i + \Sigma^{*-1}\right]^{-1}\left[\frac{1}{\sigma_i^{*2}}X_i{}'X_i\hat{\gamma}_i + \Sigma^{*-1}\mu^*\right] \tag{14}$$

and

$$\mu^* = \frac{1}{N}\sum_{i=1}^{N}\gamma_i^* \tag{15}$$

$$V[\gamma_i^*] = \left[\frac{1}{\sigma_i^{*2}}X_i'X_i + \Sigma^{*-1}\right]^{-1} \tag{16}$$

Then Equations (12-16) must be solved iteratively, with the initial iteration using the OLS estimator $\hat{\gamma}_i$ to compute μ^*, Σ^* and $\sigma^*{}_i^2$. The second and subsequent iterations are based on the empirical iterative Bayes estimator $\gamma_i{}^*$.

Table B.1: Shrinkage estimators country by country from Eq.5 – 1975-1999

Country	Variable	Parameters	T-Stat	Country	Parameters	T-Stat
BGD	Const	0.6879	6.3465	KEN	1.3458	7.9578
	REER	-0.3069	-15.1709		-0.1730	-4.4413
	Debt	0.5602	4.1592		-0.2556	-1.2340
	Debt2	-0.0972	-4.4071		0.0217	0.6762
BEN	Const	1.0160	5.0206	LSO	1.0405	4.9842
	REER	-0.2392	-5.4946		-0.2251	-5.2645
	Debt	0.1544	0.6188		0.1289	0.4983
	Debt2	-0.0353	-0.9413		-0.0280	-0.7385
BWA	Const	0.9850	5.8613	MDG	0.5305	3.7341
	REER	-0.2345	-7.1780		-0.3234	-11.0388
	Debt	0.1992	0.9533		0.7633	4.3391
	Debt2	-0.0359	-1.1458		-0.1247	-4.8548
BFA	Const	1.0115	6.4672	MLI	0.9799	4.7570
	REER	-0.2320	-7.4405		-0.2369	-5.4005
	Debt	0.1635	0.8428		0.2043	0.8022
	Debt2	-0.0389	-1.2913		-0.0380	-1.0503
BDI	Const	0.9546	9.7399	MRT	1.1850	7.3383
	REER	-0.2437	-12.7794		-0.1892	-5.4334
	Debt	0.2355	1.9306		-0.0473	-0.2369
	Debt2	-0.0409	-2.2877		-0.0009	-0.0338
CMR	Const	1.0824	6.2020	MUS	0.9744	13.3274
	REER	-0.2239	-5.6084		-0.2470	-20.1404
	Debt	0.0733	0.3420		0.2052	2.2458
	Debt2	-0.0213	-0.6909		-0.0463	-2.8593
CAF	Const	0.6064	2.9802	NPL	1.0113	26.6401
	REER	-0.3170	-7.1179		-0.2458	-43.2371
	Debt	0.6650	2.6517		0.1575	3.3200
	Debt2	-0.1097	-3.0134		-0.0357	-4.1307
TCD	Const	1.0820	5.2194	NER	1.3371	8.6642
	REER	-0.2148	-4.9795		-0.1584	-5.2840
	Debt	0.0771	0.3009		-0.2366	-1.2338
	Debt2	-0.0277	-0.7128		0.0219	0.7519
COG	Const	1.1226	10.5553	PAK	1.4948	8.0949
	REER	-0.2130	-8.1949		-0.1304	-3.3473
	Debt	0.0253	0.1945		-0.4336	-1.9011
	Debt2	-0.0116	-0.6658		0.0543	1.5814
CIV	Const	1.0498	7.1855	PHL	0.7548	3.9420
	REER	-0.2284	-6.7980		-0.2998	-7.2803
	Debt	0.1150	0.6408		0.4745	2.0096
	Debt2	-0.0261	-1.0257		-0.0824	-2.3000
GMB	Const	1.0573	7.8601	RWA	1.0616	10.3171
	REER	-0.2242	-7.6722		-0.2296	-10.9981
	Debt	0.1081	0.6511		0.0986	0.7730
	Debt2	-0.0188	-0.8093		-0.0228	-1.1836
GUY	Const	1.0625	10.9006	SEN	1.0714	5.2276
	REER	-0.2238	-9.3180		-0.2204	-5.1559
	Debt	0.1012	0.8472		0.0896	0.3535
	Debt2	-0.0199	-1.3189		-0.0242	-0.6354
HND	Const	0.7894	3.6278	TGO	1.0238	6.0151
	REER	-0.2820	-5.9546		-0.2302	-6.1475
	Debt	0.4365	1.6275		0.1488	0.7092
	Debt2	-0.0790	-1.9766		-0.0306	-1.0227

Notes: Const, REER, Debt, Debt2 correspond to the constant, the lagged real effective exchange rate, the external public debt-to-GDP ratio, and squared variable of Debt, respectively. The number of iterations is 10.

Table B.2: Shrinkage estimators country by country from Eq.5 – 1975-2017

Country	Variable	Parameters	T-Stat	Country	Parameters	T-Stat
BGD	Const	0.3970	63.0947	KEN	0.3979	63.2196
	REER	-0.1117	-14.1645		-0.0967	-11.4798
	Debt	0.0902	7.0061		0.0768	5.8770
	Debt2	-0.0164	-5.5121		-0.0196	-7.5582
BEN	Const	0.3969	63.3247	LSO	0.3980	63.0504
	REER	-0.1084	-14.7415		-0.0969	-10.8979
	Debt	0.0856	6.6278		0.0782	5.9492
	Debt2	-0.0165	-6.7820		-0.0170	-6.2051
BWA	Const	0.3976	63.1772	MDG	0.3983	63.2900
	REER	-0.0991	-12.4037		-0.0977	-11.8008
	Debt	0.0789	6.0699		0.0809	6.1693
	Debt2	-0.0163	-3.9223		-0.0175	-7.2687
BFA	Const	0.3980	63.2896	MLI	0.3970	63.0641
	REER	-0.0979	-12.3582		-0.1048	-12.2407
	Debt	0.0790	6.0997		0.0828	6.2723
	Debt2	-0.0187	-6.4056		-0.0147	-6.4494
BDI	Const	0.3983	63.5820	MRT	0.3976	63.0832
	REER	-0.0961	-13.9912		-0.0923	-10.4302
	Debt	0.0796	6.2465		0.0721	5.5045
	Debt2	-0.0157	-7.3977		-0.0145	-6.8573
CMR	Const	0.3972	63.5381	MUS	0.3974	63.7264
	REER	-0.1054	-15.3927		-0.1020	-17.4057
	Debt	0.0845	6.5519		0.0805	6.4854
	Debt2	-0.0158	-7.0163		-0.0185	-6.9827
CAF	Const	0.3986	63.4275	NPL	0.3976	63.7112
	REER	-0.0958	-12.0752		-0.1043	-20.7800
	Debt	0.0803	6.1259		0.0853	7.2289
	Debt2	-0.0172	-7.2307		-0.0180	-7.6533
TCD	Const	0.3981	63.2522	NER	0.3982	63.3821
	REER	-0.0981	-12.2116		-0.0915	-12.3278
	Debt	0.0794	6.0919		0.0731	5.7253
	Debt2	-0.0186	-6.8142		-0.0181	-6.9542
COG	Const	0.3967	63.0945	PAK	0.3973	63.0629
	REER	-0.1084	-12.5078		-0.0975	-10.8139
	Debt	0.0854	6.4042		0.0759	5.7274
	Debt2	-0.0138	-7.0196		-0.0161	-5.7555
CIV	Const	0.3974	63.1946	PHL	0.3975	63.3350
	REER	-0.1041	-12.0037		-0.1038	-13.2333
	Debt	0.0844	6.3469		0.0836	6.4133
	Debt2	-0.0153	-6.9750		-0.0176	-6.7905
GMB	Const	0.3979	63.1277	RWA	0.3983	63.7141
	REER	-0.0952	-10.8498		-0.0943	-13.9074
	Debt	0.0766	5.8130		0.0753	5.8844
	Debt2	-0.0153	-6.2750		-0.0178	-7.4694
GUY	Const	0.3969	63.1387	SEN	0.3980	63.2372
	REER	-0.1080	-12.6140		-0.0972	-11.5870
	Debt	0.0853	6.3860		0.0781	5.9504
	Debt2	-0.0131	-7.2859		-0.0170	-6.5296
HND	Const	0.3980	63.1177	TGO	0.3972	63.1672
	REER	-0.0996	-11.1349		-0.1046	-12.2306
	Debt	0.0814	6.1370		0.0838	6.3374
	Debt2	-0.0179	-6.9326		-0.0147	-6.7028

Notes: Const, REER, Debt, Debt2 correspond to the constant, the lagged real effective exchange rate, the external public debt-to-GDP ratio, and squared variable of Debt, respectively. The number of iterations is 12.

Table B.3: Sensitivity Robustness Checks - Shrinkage estimators country by country from Eq.5 – 1975-2017

Country	**Variable**	**Parameters**	**T-Stat**	**Threshold**	**Country**	**Parameters**	**T-Stat**	**Threshold**
BGD	Const	0.6078	3.9081		JAM	0.4870	2.5321	
	REER	-0.1905	-6.3610			-0.1587	-3.9398	
	Debt	0.2079	13.8078	17		0.2035	12.7676	16.82
	Debt2	-0.0367	-12.7265			-0.0361	-14.9294	
BEN	Const	0.5107	2.7277		LSO	0.1602	0.9483	
	REER	-0.1739	-4.4363			-0.0881	-2.5610	
	Debt	0.2092	14.4373	18.36		0.1989	12.6462	17.21
	Debt2	-0.0359	-14.5290			-0.0350	-13.1213	
BWA	Const	0.0593	0.3349		MLI	0.1950	1.3126	
	REER	-0.0652	-1.8118			-0.1112	-3.5679	
	Debt	0.1950	12.3103	14.77		0.2124	13.6713	27.26
	Debt2	-0.0362	-8.6787			-0.0321	-14.3450	
BFA	Const	0.2670	1.5237		MRT	-0.1108	-0.9944	
	REER	-0.1075	-3.0711			-0.0375	-1.6291	
	Debt	0.1956	12.8835	13.58		0.2028	12.9684	24.18
	Debt2	-0.0375	-12.9819			-0.0318	-15.3325	
CMR	Const	0.4251	2.2450		MUS	0.2814	1.6400	
	REER	-0.1545	-3.7777			-0.1102	-2.9414	
	Debt	0.2093	14.5637	21.32		0.1929	14.2415	12.38
	Debt2	-0.0342	-15.1113			-0.0383	-14.7374	
COG	Const	0.4031	1.9510		PAN	-0.0370	-0.3862	
	REER	-0.1642	-3.6765			-0.0419	-2.0410	
	Debt	0.2199	14.1213	35.06		0.1941	12.3391	15.45
	Debt2	-0.0309	-15.1800			-0.0355	-14.8663	
CIV	Const	0.3762	1.8693		PRY	0.3122	1.6365	
	REER	-0.1494	-3.3764			-0.1129	-2.7172	
	Debt	0.2142	13.7799	25.72		0.1913	11.5684	11.54

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Table B.3: (continued)

Country	Variable	Parameters	T-Stat	Threshold	Country	Parameters	T-Stat	Threshold
	Debt2	-0.0330	-15.0897			-0.0391	-10.7981	
DOM	Const	0.5003	2.4520		PHL	0.4541	2.2046	
	REER	-0.1553	-3.6068			-0.1573	-3.5915	
	Debt	0.1946	11.8466	11.11		0.2057	13.8479	16.34
	Debt2	-0.0404	-11.8148			-0.0368	-14.1167	
EGY	Const	0.3053	1.5160		SEN	0.1737	0.9925	
	REER	-0.1298	-2.9530			-0.0911	-2.4938	
	Debt	0.2084	12.6586	21.95		0.1985	12.8981	16.81
	Debt2	-0.0337	-11.1314			-0.0352	-13.8326	
SLV	Const	0.2739	1.6396		LKA	0.6497	3.3875	
	REER	-0.1220	-3.1988			-0.2010	-5.2091	
	Debt	0.2067	12.6097	18.03		0.2077	13.0853	15.41
	Debt2	-0.0357	-12.4228			-0.0380	-13.6361	
GAB	Const	0.1463	0.8653		THA	0.3177	1.9093	
	REER	-0.0917	-2.5699			-0.1071	-2.9480	
	Debt	0.2053	12.9872	21.02		0.1811	14.5317	8.51
	Debt2	-0.0337	-13.3815			-0.0423	-14.8707	
GTM	Const	0.3778	2.1573		TGO	0.2597	1.3403	
	REER	-0.1112	-3.0997			-0.1226	-2.8713	
	Debt	0.1744	11.8254	6.6		0.2117	13.7604	26.47
	Debt2	-0.0460	-13.0303			-0.0323	-14.8837	
HND	Const	0.4401	2.2917		TUN	-0.0514	-0.3541	
	REER	-0.1501	-3.7452			-0.0414	-1.3821	
	Debt	0.2031	12.9499	15.89		0.1956	12.4172	16.12
	Debt2	-0.0367	-14.0047			-0.0352	-14.5477	

Notes: Const, REER, Debt, Debt2 correspond to the constant, the lagged real effective exchange rate, the external public debt-to-GDP ratio, and squared variable of Debt, respectively. The number of iterations is 8.

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