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Local-currency debt and currency internationalization dynamics: A nonlinear framework

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Abstract

The aim of this article is to investigate the relationship between the exposition of emerging countries to original sin and the internationalization process of their currency in a nonlinear framework. For that purpose, we use a panel dataset of 12 emerging countries from 2005Q4 to 2018Q3, and we implement two complementary methodologies: a multiplicative interaction model and a dynamic panel threshold model. We investigate the impact of the measures of the currency internationalization process on the ability of emerging countries to issue debt in local currency. We show that the Economic size and the institutional quality of emerging countries, as well as the FX turnover of their currency, interact when explaining the share of local-currency external debt. Moreover, our results reveal the existence of thresholds beyond which there is a change in the evolution of original sin, notably for the economic size and the governance index of emerging countries.

Keywords Original sin · Currency internationalization · Nonlinear effects · Emerging markets

JEL Classification F31 · F32 · F33 · G15

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1 Introduction

The economic and financial integration of emerging economies over the past three decades, which is inherent to the process of globalization, has supported the dynamics of development and catch-up in these countries. This growing financial integration has also been accompanied by the process of internationalization of currencies, which have been attractive to international investors for the settlement of commercial transactions and the purchase of financial assets, notably bond securities. However, in the context of growing public debt in emerging countries following the COVID-19 crisis, some countries, such as Brazil in June 2020 and China in October 2020, have recently issued massive sovereign bonds in hard currency. The question of the currency in which the bonds are denominated is crucial for these countries because it impacts the structure of their debt—public or private—and is accompanied by a financial vulnerability that exposes them more severely to exogenous shocks. The purpose of this article is to precisely examine the link between the process of internationalization of emerging countries' currencies and their ability to take on debt in international markets in their own currency.

The process of currency internationalization refers to the progressive use by non-residents of a currency outside the issuer's borders for trade and financial transactions in international markets (Kenen, 2011). While the international monetary system is still dominated by a small number of hard currencies (the US dollar, the euro, sterling, and yen, among others), the latest IMF report on the composition of foreign exchange reserves (2020) seems to show that emerging currencies have played an increasingly important role in this system over the past decade. From a general perspective, the process of internationalization is supported by national authorities and liberalization reforms as supply factors. However, this process may also depend on markets as demand factors for trade and financial transactions. As this process for emerging currencies is not complete, it is necessary to think about the degree of achievement. The degree of internationalization is measured with respect to the three functions of an international currency established by Kenen (1983): store of value, medium of exchange, and unit of account. The indicators of this internationalization process[1] could be direct measures of the fulfillment of functions, such as the composition of international reserves, the use for foreign exchange interventions and transactions, and the denomination and payment of trade and financial operations. Alternatively, in a broader view, they can be drivers of the process as the economic size of the issuing country, its trade share, capital account openness, and financial depth.

Network effects as economies of scale are often mentioned as an acceleration vector in this process (Eichengreen, 2014; Frankel, 2011; Genberg, 2012; Park & Shin, 2012). Krugman (1984) indicated that the functions of an international currency are seldom separable and generate a self-reinforcing dynamic among them. In this way,

[1] Maziad et al. (2011); Frankel, (2011); Subramanian, (2011); Park and Shin, (2012); Gao and Yu, 2012); Ma and Villar, (2014); Eichengreen and Lombardi, (2017); Aizenman, (2015); Chinn and Ito, (2015); Lahet, (2017); Chey et al., (2019).

as internationalization progresses in one of the three functions, transaction costs are lower, and convertibility is higher, it becomes relevant to use the currency in other functions, reinforcing the use in the function that originally gave international status. The economic size of the issuing country is also a way to express network effects (Eichengreen, 2014; Lee, 2014; Engel & Park, 2018): the larger a country is, the more its currency is employed for several functions. Network effects could also lead to a phenomenon of inertia (Chitu et al., 2014; Frankel, 2011). After an acceleration phase in the process of internationalization, a currency can become and remain dominant in one or several functions (US dollars) even if other currencies emerge at an international level over time. This process is actually lengthy and progressive and comes in various degrees and dimensions with occasional phases of strong progression fulfilling the functions (Ma & Villar, 2014; Maziad et al., 2011).

The question of the currency structure of the debt for emerging countries is essential in understanding the risks to which they are exposed in the event of exogenous financial shocks. This will depend on the willingness of investors to lend to these countries in local currency. History has shown that emerging countries often have difficulty issuing local currency bonds on international markets, which is known in the literature as the original sin of emerging countries. This concept was first described in the late 1990s by Eichengreen and Hausmann (1999) and defined as the country's inability to issue debt in local currencies on international markets (Eichengreen et al., 2004, 2007).[2] From a sectoral perspective, original sin impacts the currency structure of both public and private sector debt. The exposure of emerging countries to the phenomenon of original sin is therefore reflected in the currency structure of their debt: the larger the share of hard currency debt in the balance sheets of domestic entities, the more the country appears to be vulnerable to original sin. The consequences for emerging market countries are manifold. In particular, when borrowers are exposed to original sin, they suffer from currency mismatches in their balance sheets. In the case of an exogenous shock leading to large currency depreciation, negative wealth effects increase the cost of financial crises for a country in times of economic contraction (Cespedes et al., 2004; Goldstein & Turner, 2004; Krugman, 1999; Snowden, 2006). These negative balance sheet effects tend to weaken the effectiveness of exchange rate adjustments intended to ease the effects of external shocks (Frankel, 2005). The inability of emerging countries to issue bonds in their own currency seems to be linked to various elements. The literature mentions the incompleteness of international financial markets (lack of hedging instruments against exchange rate risk and high transaction costs) as well as macroeconomic instability (debt sustainability, structural current account deficit, and high inflation) (Calvo & Guidotti, 1990; Eichengreen et al., 2007; Levy-Yeyati, 2006; Reinhart et al., 2003). An additional argument that may reinforce the dynamics of original sin concerns the weakness of institutions (the poor

[2] The authors also consider a domestic dimension of the original sin, which refers to the inability of countries to issue bonds on domestic markets, at fixed rates, and in the long term. We leave this dimension aside in this article.

rule of law or regulatory enforcement) (Eichengreen et al., 2002; Hausmann & Panizza, 2003). Some authors empirically prove that this institutional quality helps develop local currency issuance, whether for public (Claessens et al., 2007) or corporate securities (Kowalewski & Pisany, 2019). Still, others go further and have argued more recently that institutional quality can amplify the positive role of capital flows in emerging markets (Arya et al., 2019) and that foreign investors make their investment decisions on the basis of institutional pull factors that create a market-friendly environment (Osina, 2021).

In this context, the purpose of our article is to better understand how the dynamics of the internationalization process, which refers to the use of a currency by foreign investors, impact the structure of debt in emerging countries. Indeed, a currency that is internationalizing through network effects is thought to attract foreign investors, especially on the bonds issued by the borrowers, thus avoiding the formation of currency imbalances in the balance sheets. We attempt to investigate this complex mechanism here.

Currency internationalization and network effects have been extensively addressed in the literature for developed countries' currencies, such as Eichengreen and Flandreau (2008), Eichengreen (2014) and Eichengreen et al., (2014) who show that inertia and network effects, measured by economic size of the issuing country in particular, are determinants of the currency composition of central bank foreign reserves. But in itself, the internationalization of emerging currencies has not received as much attention in an empirical framework. In a previous paper (Lahet and Prat, 2021), we filled this gap and showed that measures of internationalization such as the economic size of the issuing country and FX turnover of the currency, as a measure of the means of payment function, but also institutional quality, are the major determinants of local currency external debt. This variable defined as the share of local currency external debt to the total external debt is a way to quantify the original sin phenomenon and is also a measure of the function store of value (Kenen, 1983; Krugman, 1984). Consequently, we supported the existence of network effects, both through economic size, as shown in the literature, but also between two functions of a currency. These network effects, which have been identified in a linear empirical framework, would, however, deserve to be further explored in a nonlinear empirical framework given the positive externalities they generate. Positive externalities, by definition, can indeed amplify the impact of some determinants. Previous studies have also shown nonlinear effects of the use of a currency in one of its functions (Lee, 2014 for the international reserve currency; Lai & Yu, 2015 for trade invoicing; He & Yu, 2016 for foreign exchange turnover). These analyses are based on steady-state equilibrium projections and predictions of the evolution of certain determinants (GDP share in world GDP, trade share in world trade, and financial depth), grounded on different empirical specifications (panel with GMM, OLS, and sometimes with the inclusion of the squared term of an explicative variable). However, the nonlinear aspects are only considered graphically (scatter plots that show convex relations) and not in a nonlinear econometric model. Their works lead to a broad/rough determination of a threshold point at which the dynamic evolution begins to accelerate. For example, Lee (2014) indicates that the renminbi,

the Chinese currency, could make up between 3 and 12% of foreign exchange reserves in 2035 once its GDP share in the world GDP is above 25%.[3]

Our approach goes further to understand how the dynamics of network effects impact original sin. Following these studies, we propose to adopt a nonlinear empirical framework to investigate the determinants of the function store of value (apprehended by the share of local currency external debt) and define the existence of a threshold at which currency internationalization accelerates the issuance of local currency debt and purchase by foreign investors.

Our article focuses on a panel of 12 emerging countries, and our database consists of quarterly data over the period between 2005Q4 and 2018Q3. We use two complementary empirical methodologies to shed light on the dynamics of the determinants of original sin linked to the internationalization process of emerging currencies. First, we explore a multiplicative interaction model to capture the behavior of the main determinants and their impact on the ability of emerging countries to issue debt in local currency. This empirical strategy allows us to focus on the interaction process of the main determinants and to estimate their conditional or marginal effects (following Alfaro et al., 2004; Brambor et al., 2006; Hainmueller et al., 2019; Tran et al., 2020). Second, we implement a dynamic panel threshold model to check for the existence of a threshold in the relationship currency internationalization–original sin following the approach of Kremer et al. (2013) and Baum et al. (2013) and as in Osei and Kim (2020). Our results of the multiplicative interaction analysis and the estimated marginal effects show nonlinear amplifying effects for the Economic size of emerging countries and the FX turnover of their currency, with a stronger impact on the original sin phenomenon as Economic size or the FX turnover increases. Moreover, the quality of institutions in emerging countries also plays an important role in this dynamic. Indeed, the impact of Economic size and FX turnover is actually stronger as institutional quality improves. When we explore threshold methodology, we find a nonlinear role for Economic size and the Governance index with an accelerating effect on the share of local currency external debt. Finally, the inertia phenomenon is a strong result regardless of the specification. This phenomenon reflects foreign investors' habits when buying bonds from year to year and that the difficulty for emerging countries is to issue in their own currency for the first time.

The contribution of our article to the literature is threefold. First, we implement two complementary methodologies–multiplicative interaction and dynamic panel threshold models–that, to the best of our knowledge, have never been adopted for the analysis of the currency internationalization process and the determinants of the function store of value. These approaches allow us to deepen our comprehension of the currency internationalization process—original sin relationship and emphasize its nonlinear nature. Second, we highlight three main determinants that crucially intervene in this dynamic of nonlinearities. Economic size and FX turnover, at the origin of network effects in the literature, and institutional quality, which the

[3] In 2019, the importance of the renminbi in the foreign exchange reserves is approximately 2%, and the GDP share is 17.4% in PPP terms. The GDP share is 15.9% for the US.

literature highlights for local currency securities issuance, are now identified as factors of nonlinearities. Third, our results can be expressed in terms of recommendations. It seems essential for emerging countries to improve their economic size and governance as they become financially integrated. Indeed, these determinants, as supply factors, are relevant to them for both issuing bonds in local currency and stimulating demand from foreign investors for these emerging market securities. As the quality of institutions amplifies the role of these main determinants, enhancing the regulatory quality and governance effectiveness is all the more important for attracting foreign lenders.

The remainder of the article is organized as follows. In Sect. 2, we present the data. In Sect. 3, we explain the empirical strategy. The results are analyzed in Sect. 4. Section 5 concludes the paper.

2 Data

The data set consists of a balanced panel of 12 emerging market countries that includes countries in Latin America, Asia, Turkey, and South Africa over the period from 2005Q4 to 2018Q3 (624 observations). The country coverage and time dimension choices are purely based on the availability of the data for external debt in local currency and FX turnover in the QEDS and the BIS databases, respectively. The countries under study are Argentina, Brazil, Chile, Colombia, Mexico, Peru, India, Indonesia, Thailand, South Korea, South Africa, and Turkey.

In the following, we describe the dependent variable, the measures of the internationalization process of a currency (both direct and indirect), and the control variables that are included in our model. The objective is to better understand the role of each variable and their interaction in the process of internationalization of currencies. We also aim to document the determinants at the origin of possible nonlinearities that shed light on the dynamics of the original sin issue for emerging countries. The descriptive statistics are presented in Table 6 of the Appendix.

We employ the local currency external debt, expressed as a share of total external debt (in %), as the dependent variable to proxy the original sin exposition of our countries. The data come from the QEDS database (Quarterly External Debt Statistic, IMF-World Bank, $Millions; from Datastream), and they represent the claims on a country (all sectors) that are held by nonresidents.[4] Because the value of these shares is restricted to between 0 and 1, we use the so-called Hausman transformation (Dinger, 2009; Frankel, 2011; Lee, 2014) when constructing the dependent variable. Indeed Y is expressed as $Y = \ln(\frac{share}{1-share})$. Consequently, the dependent variable can have values between $[-\infty, +\infty]$. The dependent variable can also be considered as an indicator of the function store of value of a currency (Kenen 1983; Krugman, 1984). A second measure of the dependent variable is the ratio of the local currency

[4] The IMF defines the gross external debt as the outstanding amount of liabilities that require payments of principal and/or interest by the debtor at some point in the future and that are owed to nonresidents by residents of an economy (IMF, 2014).

debt expressed as a percentage of total external debt (without the Hausman transformation), allowing us to perform robustness tests. An increase in the dependent variable, whatever its expression, indicates a decrease in original sin.

Among the explanatory factors of original sin, consistent with the existing literature on emerging market currency internationalization, we distinguish between direct and indirect measures or drivers of the internationalization process as in Lahet and Prat (2021).

We use the *FX turnover* from the BIS Triennial Central Bank Survey, the only widely available direct measure of the internationalization process. It is defined as the gross value of all new deals entered into during a given period and is measured in terms of the nominal or notional amount of the contracts (BIS, 2016). This value is expressed as the share of individual currencies in the total of FX transactions (in %). It reflects the use (sale/purchase) of a local currency by nonresidents as a vehicle currency on the FX market with respect to the function means of payment, even if it may also include transactions by national investors (Ehlers & Packer, 2013; Ma & Villar, 2014; Maziad et al., 2011). More precisely, FX turnover is a measure of market activity and the trading of FX instruments in spot and OTC derivatives markets (spot transactions, plus outright forward, FX swaps, currency swaps, and FX options). Among the currencies of emerging markets in our sample, the Mexican peso had an FX turnover of 3.83% in 2018 (Table 1). FX turnover increases are often very high over short periods; for example, for 2012Q4–2013Q1, the increases were 101% for the Mexican peso, 78% for the Turkish lira, 61% for the Brazilian real, and 54% for the South African rand. If a currency is increasingly used in FX transactions, it is more likely to be used in international debt markets due to network effects between the functions means of payment and store of value (Krugman, 1984). Consequently, the phenomenon of original sin will tend to decrease.

In keeping with the literature, we employ several indirect measures of the internationalization process that support the use of a currency in financial transactions. These drivers are, in fact, the economic fundamentals of a country. The following determinants are included in our model. We use the ratio nominal GDP/world GDP (expressed in %) as a proxy of the *Economic size* of the issuing country. We calculate the "world" GDP by adding nominal GDPs for a broad set of countries expressed in dollar terms for each period.[5] It is assumed that larger countries may attract foreign investors in commercial and financial transactions supporting the use of domestic currency and requiring confidence from investors in the country's currency. The size of the country is at the origin of the network effects. The larger a country is, the more its currency is used by investors for one

[5] The sample includes the largest advanced economies (in Europe: the Eurozone countries, the United Kingdom, Denmark and Sweden; in North America: the United States and Canada; and in Asia/Pacific: Japan, Australia and New-Zealand), the traditional set of emerging countries (in Latin America: Argentina, Brazil, Chile, Colombia, Mexico, Peru and Venezuela; and in Asia, the newly industrialized countries: China, India, Indonesia, Malaysia, the Philippines, Thailand, South Korea, Taiwan, Hong-Kong, and Singapore), and the largest CEEC (Poland, Hungary, the Czech Republic, Bulgaria and Romania), including Russia and Turkey. We add South Africa, and the sample also includes three major oil exporting countries for which data were available: Qatar, Kuwait and Saudi Arabia.

Table 1 FX turnover (percentage)

	Argentina	Brazil	Chile	Colombia	Mexico	Peru	India	Indonesia	Thailand	Korea, Rep	South Africa	Turkey
31/12/1998	0.279	0.448	0.159	0.000	0.916	0.000	0.175	0.139	0.286	0.301	0.805	0.000
31/12/2001	0.000	0.951	0.368	0.060	1.655	0.033	0.459	0.091	0.302	1.608	1.887	0.070
31/12/2005	0.071	0.532	0.242	0.071	2.213	0.026	0.648	0.215	0.400	2.283	1.447	0.211
31/12/2010	0.081	1.370	0.328	0.200	2.514	0.060	1.900	0.303	0.385	3.033	1.443	1.474
31/12/2013	0.056	2.209	0.594	0.218	5.054	0.120	1.970	0.338	0.638	2.397	2.229	2.638
30/09/2018	0.074	2.001	0.492	0.312	3.831	0.153	2.287	0.398	0.720	3.309	1.946	2.874

Source: Authors on BIS Statistics

function, leading to lower transaction costs and greater investor familiarity with the currency. This leads these investors to use the currency for other functions, such as buying local currency bonds. This is the main variable tested in this kind of literature. We measure the *Trade openness* of the issuing country as the ratio of exports of goods and services to GDP to express the strength of a country in international trade networks. A country that is economically open with a high ratio of exports to GDP and plays a major role in international trade will find it easier to issue bonds in its currency on international markets. The ratio claims on private sector/GDP (in %) expresses the *Financial depth* of a country, that is, the development of the banking sector and its ability to finance economic growth. A currency issued by a country with an efficient banking sector that intermediates capital flows is more prone to be used in bond transactions. Finally, we use the Chinn-Ito index, which measures a country's degree of *Capital account openness*. The capital account openness of a country is a factor that attracts foreign investors who could be more prone to include local currency bonds in their portfolios.

In addition to measures of currency internationalization, we include a *Governance* index that reflects the quality of institutions in the issuing country and that is mentioned as a determining factor of original sin in the literature. This index is the sum of two indicators. The first indicator is the regulatory quality, which reflects perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development. The second indicator is the rule of law, which expresses perceptions of the extent to which agents have confidence in and abide by the rules of society and, in particular, the quality of contract enforcement, property rights, the police, and the courts. By construction, the *Governance* index ranges from −5 (weak quality) to +5 (strong quality). Strong institutions may improve the development of the private sector and its funding by financial markets and pull foreign investors on local currency debt (Arya et al., 2019; Claessens et al., 2007; Eichengreen et al., 2002; Osina, 2021).

We then add variables to account for the external and domestic context. We control for the stability of the exchange rate by introducing the *Exchange rate (FX) volatility* of a country using the four -quarter moving standard deviation over the period (a higher variable means higher volatility). It allows us to account for the monetary stability of a country that is determinant to attracting investors to the country or the currency. FX volatility is also a way of controlling for the exchange rate regime. Low exchange rate volatility reflects a managed exchange rate regime that limits uncertainty and reduces foreign investors' exposure to currency risk. This encourages them to buy debt in local currency, thus lowering the original sin. The *VIX* index is also introduced as a measure of global uncertainty and investors' sentiment. Increasing financial stress does not favor debt issuing in emerging market currencies or purchases by foreign investors. Last, we control for the capacity or need for external financing of emerging economies by including the *Current account* balance (in % of GDP).

The data are obtained from Datastream, except for the *Chinn-Ito index*, which comes from Chinn and Ito's web database (KAOPEN). The *Governance* indicator is

obtained from the Worldwide Governance Indicator produced by the data catalog of the World Bank.[6]

3 Empirical strategy

To shed light on the dynamics of the determinants of original sin in relation to the internationalization process of emerging currencies, we implement two complementary empirical methodologies within a nonlinear framework. This analytical framework is justified because the shocks that have regularly hit advanced and emerging economies over the last twenty years have likely affected the dynamics of the emerging markets' development, their integration in the financial world, and the internationalization of these countries' currencies.

On the one hand, we use a multiplicative interaction model to capture the behavior of three major determinants of the original sin: (1) FX turnover, which is a measure of the degree of internationalization of a currency; (2) the economic size that supports the existence of network effects; and (3) the quality of the governance of the country, which may represent the willingness of the government to improve local currency financing. With this model, we seek to understand how these three factors interact according to their respective initial levels and their dynamics throughout the period. We anticipate that emerging countries will find it easier to issue bonds on the international financial markets in domestic currency; the higher the FX turnover is, the larger the size of the country and the higher the quality of the institutions will be (Lahet and Prat, 2021). As the dynamics of these variables cannot be fully understood simply by considering a linear regression model, a multiplicative interaction model seems more appropriate in this context. On the other hand, we introduce a dynamic panel threshold model to test for the existence of a threshold level for the three major determinants of original sin (as mentioned above, the FX turnover, the economic size, and the quality of the institutions) related to the process of internationalization of emerging currencies. For this purpose, our article was inspired by the methodology of Kremer et al. (2013), which estimates appropriate threshold values in a dynamic framework rather than arbitrarily imposing them.

We also run 2nd generation panel unit root tests (CIPS from Pesaran, 2007) to identify the stationary time series properties of our variables in the presence of cross-sectional dependency (Appendix Table 7).

We first perform a graphical analysis to justify the analytical framework. The preliminary evidence in scatter plots provides motivations to consider a nonlinear relationship between the dependent variable and some of its determinants (FX Turnover, Economic size, Governance), whether it be by comparing periods (Appendix Fig. 1) or quarters (Appendix Fig. 2).

[6] Dummies variables for the 2008 crisis and for region had been tested, but they are not significant and their inclusion does not improve the results. They are not presented in the results.

3.1 Multiplicative interaction baseline model

The first empirical methodology we implement consists of questioning the impact of the internationalization process of emerging currencies on the capacity of these countries to borrow on international financial markets in their own currency. Following Lahet and Prat (2021), the baseline equation of interest is given by:

$$y_{i,t} = \alpha_i + \phi_i y_{i,t-1} + \boldsymbol{\beta}_i^{'} \boldsymbol{x}_{i,t} + u_{i,t} \tag{1}$$

$$u_{i,t} = \boldsymbol{\gamma}_i^{'} \mathbf{f}_t + \varepsilon_{i,t} \tag{2}$$

where $\mathbf{f}_t$ is the unobserved common factor, $\gamma_i^{'}$ is the heterogeneous factor loading, α_i is the individual fixed effect and $\varepsilon_{i,t}$ is the iid idiosyncratic error term.

The heterogeneous coefficients are randomly distributed (Chudik and Pesaran 2015, assumption 4):

$$\boldsymbol{\beta}_i = \boldsymbol{\beta} + \boldsymbol{\upsilon}_i,\ \upsilon_i \sim \mathrm{IID}\left(0, \boldsymbol{\Omega}_v\right)$$

where $\boldsymbol{\Omega}_v$ is the matrix of variance–covariance.

Empirically, $y_{i,t}$ is our measure of local currency external debt, $y_{i,t-1}$ is the lagged dependent variable, and $x_{i,t}$ is a set of explanatory variables. Following the literature on currency internationalization and the determinants of original sin, our basic model includes measures of the internationalization process to take into account dynamic aspects related to network externalities as well as the lagged dependent variable to reflect inertial effects and some control variables.

Panel data analysis requires addressing two major econometric issues that consider macro panels[7] (Eberhardt, 2012): cross-sectional dependence and the heterogeneity of parameters (Pesaran & Smith, 1995; Pesaran et al., 1999). In particular, at the macro level, a contemporaneous correlation may reflect common factors that affect countries that are already deeply integrated in terms of trade and finance. In these cases, standard econometric methods lead to inconsistent estimations of coefficients and incorrect inferences (Kapetanios et al., 2011). Moreover, the hypothesis of parameter homogeneity across countries can also lead to inconsistent inferences and estimations of parameters if the degree of heterogeneity is high across countries (Pesaran & Smith, 1995; Pesaran et al., 1999). Finally, we must also address the well-known issue of endogeneity that comes from two sources: (1) the introduction in Eq. (1) of the lagged dependent variable as a measure of inertia (that likely causes the Nickell bias [Nickel, 1981]) and (2) the self-reinforcing dynamics between the dependent variable and some regressors related to the self-reinforcing functions of a currency.

[7] Macro panels are defined by a cross-sectional dimension that is equal to or smaller than the time dimension ($N \leq T$), in contrast to micro panels, whose structure is composed by a large number of individuals ($N > 100$) over a very short period of time ($T < 10$).

Recent academic literature provides different estimation techniques to account for these issues, especially the CCE-MG (common correlated effect—mean group) approach presented by Pesaran (2006) and developed in the context of nonstationary factors by Kapetanios et al. (2011) and Chudik et al. (2011) and the alternative estimator AMG (augmented mean group) introduced by Bond and Eberhardt (2009) and Eberhart and Teal (2010). However, these techniques do not consider dynamic panel data models, which are more appropriate for our purpose. Thus, we use the dynamic common correlated effect estimator (DCCEE) developed and recommended by Chudik and Pesaran (2015)[8] that consists of approximating the unobservable factors by adding the cross-sectional averages of the dependent and explanatory variables to the regression. In the case of the dynamic panel data model, the authors show that the estimator remains consistent if the $\sqrt[3]{T}$ cross-section means are added to the baseline equation.[9]

We control for the cross-sectional dependence between countries in our database (see, in particular, the Pesaran (2004) cross-sectional CD test and the p-value in our table results).

Next to our baseline scenario, we use a multiplicative interaction model modified from Eq. (1) to better understand the dynamics of the currency internationalization process and its impact on the ability of emerging countries to issue debt in their own currency. In particular, we focus on the interaction process of the three main determinants and how this process eases (or does not ease) the burden of original sin for emerging countries. To account for the possibility that the interaction effect may be due to some kind of nonlinearity, we consider in a first step introducing into the equation the squared terms of the FX turnover, the Economic size, and the quality of institutions index (Eq. (3)).

$$y_{i,t} = \alpha_i + \phi_i y_{i,t-1} + \boldsymbol{\beta}_i^{'} \boldsymbol{x}_{i,t} + \lambda_{1i} FXTURN_{i,t}{}^2 + \lambda_{2i} ECOSIZE_{i,t}{}^2 + \lambda_{3i} GOV_{i,t}{}^2 + u_{i,t} \tag{3}$$

$$u_{i,t} = \boldsymbol{\gamma}_i^{'} \mathbf{f}_t + \varepsilon_{i,t} \tag{4}$$

We expect the effect of the determinants on the dependent variable to accelerate over time, after the determinants have exceeded a certain level. For example, as in the seminal papers on the drivers of currency internationalization (previously mentioned), a larger economic size will have a greater impact on the debt issuing in local currencies above a certain size. Consequently, we rather expect a U-shaped relationship between the determinants and the original sin variable: they are supposed to be significant, with an expected positive sign for the squared terms. In a second step, we consider the interaction terms between these three variables (Eq. 5). The multiplicative interaction models are given by:

[8] The DCCE estimator of Chudik and Pesaran (2015) is implemented in STATA 14 by the command xtdcce2, as developed by Jan Ditzen (2018).

[9] Chudik and Pesaran (2015) also show that the CCE estimator still remains asymptotically valid, provided that the number of cross-sectional averages is as large as the unobserved common factors. For a discussion about the number of unobserved factors, see Stock and Watson (2002), Giannone et al. (2005), Bai and Ng (2007) and Stock and Watson (2005).

$$y_{i,t} = \alpha_i + \phi_i y_{i,t-1} + \boldsymbol{\beta}_i^{'} \boldsymbol{x}_{i,t} + \lambda_{4i} FXTURN_{i,t} \times ECOSIZE_{i,t} + \lambda_{5i} ECOSIZE_{i,t} \times GOV_{i,t} + \lambda_{6i} FXTURN_{i,t} \times GOV_{i,t} + u_{i,t} \quad (5)$$

$$u_{i,t} = \boldsymbol{\gamma}_i^{'} \mathbf{f}_t + \varepsilon_{i,t} \quad (6)$$

We want to ascertain whether a higher use by nonresidents of a currency issued by a large country has a significant moderating or amplifying impact on the share of local currency external debt. Then, with the interaction term including Governance with Economic size and FX turnover, we can examine whether a better governance indicator in a growing country (and in a country that issues a currency greatly used by nonresidents in FX transactions) has a significant impact on the local currency composition of the external debt. These two specifications offer a simple setup that allows the effects of explanatory factors to vary with the major determinants of the internationalization process of emerging currencies.

Several precautions are taken to correctly analyze the interaction terms (Eq. (5)). On the one hand, each variable is independently introduced in the model next to the interaction term to ensure that the interaction term is not a proxy for the three variables of interest (see in particular Alfaro et al. (2004) and Brambor et al. (2006)). On the other hand, the estimated coefficients for the three main determinants in Eq. (5) represent the partial effects of each of these variables on original sin for empirical scenarios in which the other variable (involved in the interaction) takes the value zero. This strong assumption appears unrealistic. Empirically, this implies that these coefficients should not be interpreted directly but rather that marginal or conditional effects should be considered (Brambor et al. (2006)). We follow Hainmueller et al. (2019) and consider that these estimated conditional effects may be nonlinear.[10]

3.2 The dynamic panel threshold methodology

We follow the approach of Kremer et al. (2013) and Baum et al. (2013) to implement a dynamic panel threshold model to test in another way for the existence of nonlinearities in the relationship between the internationalization of emerging market currencies and their ability to borrow in their domestic currencies on international financial markets.

This model derives from the panel threshold model of Hansen (1999) and the methodology proposed by Caner and Hansen (2004), who estimate dynamic linear models with endogenous regressors and exogenous threshold variables. The dynamic panel threshold model of the relationship between measures of original sin and determinants of internationalization of emerging currencies takes the following form:

[10] Indeed, there is no reason to consider a priori that the functional form of the interaction effects is linear. Hainmueller et al. (2019) proposed the Interflex STATA package to estimate the marginal effects by relaxing the linear interaction effect hypothesis. This command also ensures that there is sufficient common support in the data to calculate the conditional marginal effects.

$$y_{i,t} = \mu_i + \chi y_{i,t-1} + \alpha_i x_{i,t} + \beta_{1i} f_{i,t} I\left(q_{i,t} \leq \gamma\right) + \beta_{2i} f_{i,t} I\left(q_{i,t} > \gamma\right) + \varepsilon_{i,t} \quad (7)$$

where $y_{i,t}$ is the dependent variable of country i at time t, $y_{i,t-1}$ is the lagged dependent variable, μ_i are the country-specific fixed effects, $x_{i,t}$ is a k-dimensional vector of regime-independent control variables, and $f_{i,t}$ is a set of regime-dependent variables that are allowed to switch between regimes. The indicator function $I(.)$ takes the value of 1 if the argument in parentheses holds and 0 otherwise, with $q_{i,t}$ being the threshold variable and γ the threshold level. The error term ε_{it} is assumed to be independent and identically distributed (*iid*) with zero mean and a finite variance σ^2.

Finally, $\chi, \alpha_i, \beta_{1i}, \beta_{2i}$ and γ are the parameters to be estimated.

Following Kremer et al. (2013), forward orthogonal deviation transformation is considered to eliminate country fixed effects in the context of panel data. This first step, which consists of subtracting the average of all future available observations of a variable, ensures that the transformed error terms remain uncorrelated (Arellano & Bover, 1995) and that the estimates are consistent. In a second step, the procedure for estimating the coefficients of the dynamic panel model in Eq. (7) is performed sequentially (Caner & Hansen, 2004). First, we run a reduced-form regression of our endogenous variable,$y_{i,t-1}$, as a function of instruments $z_{i,t}$ to obtain the predicted values $\widehat{y}_{i,t-1}$.[11] To avoid overfitting of instrumented variables, we restrict the lag length to one for instruments of the lagged dependent variable. Second, we substitute the predicted value of $\widehat{y}_{i,t-1}$ in Eq. (7) and estimate the structural equation by least squares to obtain the threshold parameterγ. For a series of least squares estimations, the threshold values and the resulting sum of squared residuals $S(\gamma)$ are calculated. The estimation of the threshold parameter is selected as the one that minimizes the sum of squared residuals, i.e., $\widehat{\gamma} = argmin S_n(\gamma)$. The critical values for determining the 95% confidence interval of the threshold parameter based on Hansen (2000) and Caner and Hansen (2004) are given by $\Gamma = \{\gamma : LR(\gamma) \leq C\}$, where C is the 95% percentile of the asymptotic distribution of the likelihood ratio statistic $LR(\gamma)$. Third, once a significant threshold value $\widehat{\gamma}$ is determined, the sample can be divided into two subsamples based on the indicator functions $I\left(q_{i,t} \leq \widehat{\gamma}\right)$ and $I\left(q_{i,t} > \widehat{\gamma}\right)$. The two different slope parameters β_1 and β_2 are then estimated by GMM.[12]

We focus again on FX turnover, Economic size and Governance variables as regime-dependent variables or threshold variables. In particular, we consider the Economic size and the FX turnover as both regime-dependent and threshold variables as they are the main determinants at the origin of network effects. We expect that when the FX turnover (resp. Economic size) is beyond a threshold, an increase in FX turnover (resp. Economic size) has an even more positive impact on the local currency external debt. Because the FX turnover may increase in a very short time, it seems more relevant to consider it as a regime dependent variable. Moreover, the bigger the country, the higher the FX turnover of its currency. We expect that

[11] To account for the endogeneity issue stemming from the regressors, we implement panel Granger-causality tests, following Dumitrescu and Hurlin (2012). Results are presented in Appendix Table 10.

[12] The dynamic panel threshold model is implemented in STATA 16 by the command xtendothresdpd as developed by Ibrahima Amadou Diallo (2020).

when Economic size is beyond a threshold, an increase in FX turnover has a positive impact on the local currency external debt. Finally, the quality of institutions, which is a major determining factor of original sin in the literature and of capital inflows, is an element of economic framework that changes little over time. Thus, it is relevant to consider it as the threshold variable and not as a regime-dependent variable: we suppose that when Governance is greater than a level, an increase in FX turnover (resp. Economic size) has a positive impact on the local currency external debt.

In both steps, the dependent variable is the Hausman transformation of the local currency external debt as a share of total external debt. As robustness tests, we also test the ratio of the local currency external debt as a share of total external debt.

4 Results

4.1 Interaction analysis

We present the results of our multiplicative interaction approach in Table 2. As a reminder, the baseline model (without interactive terms) is presented in column (1). As expected, the main determinants of the local currency external debt are the lagged dependent variable, the FX turnover, the Economic size and the Financial depth. Among the control variables, the Current account and the VIX index are also significant with the expected sign.[13] Following the literature (Chitu et al., 2014; Frankel, 2011), the inertia phenomenon represented by the lagged dependent variable seems important for the ability of emerging countries to issue bonds in their own currency. In other words, it seems all the easier for emerging countries to issue local currency bonds and attract foreign investors if they have already issued this type of bond on the markets in the past. Moreover, the results confirm network externalities between the function means of payment (proxied by the FX turnover) and the function store of value (proxied by the dependent variable), with a positive and significant coefficient associated with the variable FX turnover. Economic size also plays an important role in the ability of emerging economies to issue debt in their own currency. These network effects allow wider use of the emerging currency at the international level (Eichengreen, 2014; Engel & Park, 2018; Frankel, 2011; Maziad et al., 2011).

Columns (2), (3), and (4) document our results obtained from estimating Eq. (3) using the square of our three main determinants. We find some support for a U-shaped relationship between Economic size and the original sin where both the variable and the squared term are significant (column 3). We estimate the tipping point at 0.40% (share of domestic GDP in global GDP), so that the share of local currency external debt tends to accelerate when Economic size exceeds this threshold. These results still highlight the importance of the country's economic size in reducing the original sin, as shown by Eichengreen et al. (2002) and Hausmann and Panizza (2003), but bring to the debate a new nonlinear dimension in the relationship

[13] The variables Capital account openness and FX volatility are not significant and are removed from the model as they remain insignificant for all other specifications. We no longer include them in the model.

Table 2 Interaction analysis results

Dependent variable: Local currency debt (expressed as a share of total external debt), Hausmann transformation							
Independent variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Lagged dependent variable	**0.535*****	**0.487*****	**0.460*****	**0.506*****	**0.317*****	**0.550****	**0.386*****
	5.07	*6.37*	*6.14*	*5.54*	*3.22*	*7.00*	*6.18*
Fx turnover	**1.371***	21.028	**1.831***	**1.246***	−9.727	1.003	0.760
	1.88	*1.50*	*1.67*	*1.74*	*−1.50*	*0.22*	*1.50*
Economic size	**1.365***	**1.306*****	**−20.277***	−1.564	**−3.026****	−1.895	−2.821
	1.72	*2.37*	*−1.83*	*−0.84*	*−2.04*	*−0.89*	*−1.13*
Trade openess	−0.024	**0.049****	−0.035	−0.042	0.011	−0.013	−0.000
	−1.58	*2.16*	*−0.84*	*−1.39*	*0.41*	*−1.26*	*−0.03*
Financial depth	**0.010****	**0.040****	**0.021****	**0.021*****	**0.042****	**0.026***	**0.030*****
	2.32	*2.19*	*3.14*	*3.43*	*2.15*	*1.72*	*3.05*
Capital account openess	−57.070						
	−0.89						
FX volatility	−0.106						
	−0.14						
Current account	**0.034****	−0.024	**0.030***	**0.034****	−0.012	0.036	0.002
	1.98	*−0.09*	*1.87*	*2.17*	*−0.65*	*1.41*	*0.15*
VIX	**−0.006*****	**−0.002***	**−0.003****	**−0.003****	**−0.003*****	**−0.007*****	**−0.002***
	−3.99	*−1.86*	*−2.36*	*−2.01*	*−2.40*	*−2.48*	*−1.79*
Governance	0.225	−0.162	0.245	**1.414***	−0.006	−0.612	−1.147
	1.53	*−0.42*	*0.69*	*1.82*	*−0.04*	*−0.64*	*−0.85*
Fx turnover^2		−128.37					
		−1.40					
Economic size^2			**25.247***				
			1.74				

Table 2 (continued)

Dependent variable: Local currency debt (expressed as a share of total external debt), Hausmann transformation							
Independent variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Governance^2				1.850			
				1.04			
Fxturnover*Economic size					**24.023***		
					1.54		
Fxturnover*Governance						**8.760****	
						1.98	
Economic size*Governance							**4.578***
							1.69
Country specific effects	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*
CD test statistics	*2.93*	*3.71*	*1.67*	*0.35*	*2.10*	*2.82*	*1.01*
p-value	*0.034*	*0.000*	*0.009*	*0.723*	*0.035*	*0.004*	*0.311*
Number of obs	588	588	576	588	576	576	576
R^2 adjusted	0.69	0.67	0.75	0.80	0.42	0.49	0.50
F-test	F(204,384) prob > F = 0.00	F(192,396) prob > F = 0.00	F(216,360) prob > F = 0.00	F(192,396) prob > F = 0.00	F(312,264) prob > F = 0.00	F(264,312) prob > F = 0.00	F(264,312) prob > F = 0.00

z-stats are in italics

*significant at 10%, **significant at 5%, ***significant at 1%

Countries included are Argentina, Brazil, Chile, Colombia, Mexico, Peru, India, Indonesia, Thailand, South Korea, South Africa, Turkey

Dynamic Common Correlated Effects with heterogenous coefficients. Constant not reported

Table 3 Marginal effects of interaction terms

	Marginal effects of interaction terms		
	(5)	**(6)**	**(7)**
Marginal effects of Fx turnover (a)			
Economic size Low (< 25th percentile)	0.779		
	[0.334–1.225]		
Economic size Medium (at 50th percentile)	0.323		
	[0.091–0.555]		
Economic size High (> 75th percentile)	0.371		
	[0.269–0.473]		
Marginal effects of Economic Size (b)			
Fx turnover Low (< 25th percentile)	0.856		
	[−0.469–2.182]		
Fx turnover Medium (at 50th percentile)	0.257		
	[−0.110–0.625]		
Fx turnover High (> 75th percentile)	0.415		
	[0.115–0.715]		
Marginal effects of Fx turnover (c)			
Governance Low (< 25th percentile)		0.221	
		[−0.068–0.511]	
Governance Medium (at 50th percentile)		0.258	
		[0.006–0.510]	
Governance High (> 75th percentile)		0.344	
		[0.061–0.628]	
Marginal effects of Economic size (d)			
Governance Low (< 25th percentile)			0.349
			[−0.221–0.920]
Governance Medium (at 50th percentile)			0.340
			[−0.030–0.710]
Governance High (> 75th percentile)			0.807
			[0.271–1.343]

The marginal effects are computed based on the results documented in specifications 5, 6 and 7 of Table 2

Between [], confidence interval of the estimated marginal effects

(a), (b), (c) and (d): see graphs of the marginal effects in Appendix Fig. 3

between economic determinants and the ability of countries to issue debt in local currency. Moreover, major determinants remain. Concerning the two other variables of interest, the results obtained do not allow us to conclude that there is a nonlinear relationship between FX turnover, on the one hand, and the governance index, on the other hand, with the dependent variable. Indeed, the squared terms are not significant (columns 2 and 4). Nevertheless, this does not change the results for the other variables in the model as in the baseline approach.

Table 4 Dynamic PTR methodology – baseline model

Dependent variable: Local currency debt expressed as a share of total external debt, with Hausmann transformation											
Threshold variables		(a)		(b)		(c)		(d)		(e)	
		FX turnover		Eco size		Eco size		Governance		Governance	
Estimated threshold		0.3117		0.3289		0.3289		−0.7262		−0.7262	
95% C.I		[0.2423–0.3378]		[0.3282–0.3370]		[0.3282–0.3370]		[−0.8632–2.2715]		[−0.8632– −0.5520]	
Regime-dependent variables	regime 1: q < γ	**Fx turnover**	**−0.3617***	**Eco size**	**−0.6149****	**Fx turnover**	**−0.7443*****	**Fx turnover**	**−0.3100****	**Eco size**	0.0260
			(0.213)		(0.306)		(0.216)		(0.148)		(0.0282)
	regime 2: q > γ	**Fx turnover**	−0.0186	**Eco size**	**0.1166*****	**Fx turnover**	−0.0150	**Fx turnover**	−0.0209	**Eco size**	**0.1023****
			(0.015)		(0.045)		(0.016)		(0.017)		(0.0480)
Regime-independent variables	Lagged dep. variable	**0.8678*****		**0.8590*****		**0.8754*****		**0.8843*****		**0.8820*****	
		(0.031)		(0.027)		(0.025)		(0.028)		(0.0297)	
	Fx turnover			−0.0168						−0.198	
				(0.014)						(0.0175)	
	Economic size	**0.0975****						**0.0961****			
		(0.045)						(0.045)			
	Trade openness	0.008		**0.009***		**0.006***		0.0069		0.007	
		(0.005)		(0.005)		(0.004)		(0.005)		(0.005)	
	Financial depth	0.000		0.001		0.000		0.000		0.0004	
		(0.001)		(0.001)		(0.001)		(0.001)		(0.001)	
	Capital account op	−0.0169		−0.045		−0.0292		−0.0103		−0.0277	
		(0.093)		(0.096)		(0.104)		(0.094)		(0.0952)	

Table 4 (continued)

Dependent variable: Local currency debt expressed as a share of total external debt, with Hausmann transformation						
Threshold variables		(a)	(b)	(c)	(d)	(e)
		FX turnover	Eco size	Eco size	Governance	Governance
	FX volatility	−0.0891	−0.0169	−0.1145	−0.0957	−0.0860
		(0.2148)	(0.226)	(0.239)	(0.191)	(0.1880)
	VIX	**−0.0033*****	**−0.0032*****	**−0.0033*****	**−0.0034*****	**−0.003*****
		(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
	Current account	0.0115	0.0121	0.0112	0.0108	0.0111
		(0.008)	(0.008)	(0.008)	(0.008)	(0.0089)
	Governance	0.0454	0.0709	0.0878		
		(0.078)	(0.073)	(0.061)		
Observations		612	612	612	612	612
N		12	12	12	12	12

Robust standard-error in parenthesis

***, **, * corresponds to statistical significance at 1%, 5% and 10% respectively

The results of the multiplicative interaction model estimates related to Eq. (5) are presented in columns 5–7 of Table 2. Interestingly, we observe that the coefficients of the interaction terms are all significant and might reveal some kind of nonlinearity in the effects of the internationalization process on original sin. This implies that the more internationalized the currency is, the higher the share of local currency external debt will be, with marginal effects differentiated according to the interaction variable examined.

Table 3 details the marginal effects of the interaction terms presented in columns (5–7) of Table 2. We first analyze the conditional effects of FX turnover on local currency external debt when the Economic size level is < 25th, set at the 50th, and > 75th percentiles of its distribution (column 5–specification a). This marginal effect is positive and significant at all the considered levels of the Economic size variable. Plotting this effect at all observed levels of Economic size confirms this positive impact (Case (a) in Fig. 3 in the appendix). Our findings reinforce the previous results of the baseline equation and the specifications with the squared variable (Table 2). Indeed, the observation of the estimated marginal effects, when the economic size increases, shows the existence of nonlinearity. The smaller the country is, the stronger the impact of FX turnover on the dependent variable is (marginal effect estimated at 0.779). More precisely, as the size of the country increases, for low Economic size values, the impact of FX turnover on debt issuance in the local currency tends to decrease (marginal effect estimated at 0.323). On the other hand, for large values, the impact of FX turnover is stronger. However, this is still lower than the estimated impact for small countries (marginal effect estimated at 0.371).

It is also interesting to estimate the conditional effects of Economic size as a function of FX turnover on the dependent variable (Column 5–specification b). Here, again, the marginal effects related to the interaction variable seem to be nonlinear (see Case (b) in Fig. 3 in appendix). The impact of country size on local currency debt issuance as a function of the levels of FX turnover is positive. However, for low values of FX turnover, this impact appears to be not significant. It becomes significant for high values of FX turnover. In other words, the stronger the impact of the size of the country on the issuance of local currency debt is, the higher the trading of the currency on exchange rate markets is. These results finally show the amplifying effect of Economic size—which, in the literature, is a variable at the origin of network effects (Eichengreen, 2014; Engel & Park, 2018; Frankel, 2011; Maziad et al., 2011)—in particular when associated with FX turnover, which is a determinant of original sin (Lahet and Prat, 2021). However, this amplifying effect is nonlinear, with a stronger impact on the original sin as economic size or FX turnover increases.

The last two results (Table 3, columns 6-7 and Cases (c) and (d)in Fig. 3 in appendix) show the impact of Economic size and FX turnover, conditioned to the quality of the country's institutions (Governance index), on local currency external debt. This effect is positive and nonlinear. In particular, it is significant for increasing values of Governance. In other words, the impact of the size of the country and FX turnover on the issuance of local currency debt is stronger as the quality of institutions improves for values of Governance above the median (> 50th percentile). This is consistent with the literature on the amplifying role of the Governance index (Arya et al., 2019).

All these results allow us to deepen our understanding of the link between the internationalization process and original sin by providing some evidence of the interaction dynamics between the three key variables in this process and their impact on local currency debt. In other words, the relationship between original sin and its determinants, particularly the indicators of internationalization, is complex, and evolves over time because it is shaped by network effects and by multifactor economic and institutional development dynamics.

Finally, the inertia phenomenon (proxied by the lagged dependent variable) is a strong result in the baseline analysis and the multiplicative interaction framework. This phenomenon reflects foreign investors' habits when buying bonds from year to year. Therefore, the most difficult step for these countries is to issue debt in local currency on international markets for the first time. This is part of the dynamics of the internationalization process of currencies.

Some robustness tests are presented in Table 8 in the appendix. The results confirm our previous findings of Table 2 and the major role of Economic size (see column 2).

4.2 The dynamic PTR regression

To further investigate the nonlinear analytical framework of original sin and its drivers, we implement a dynamic panel threshold model to test for the existence of a threshold level for the three major determinants of original sin related to the process of internationalization of emerging currencies (as mentioned above, the FX turnover, the economic size, and the quality of the institutions).

We successively retain as regime-dependent variables the two main determinants of original sin, which are also at the source of network effects (FX turnover and Economic size). The threshold variables are successively the FX turnover, the Economic size and the Governance index. The results are presented in Table 4.

Economic size again emerges as the key variable in this analysis of threshold effects both when it is regime-independent and regime-dependent. More precisely, in column (b), estimations tend to show that when Economic size is under the threshold (γ), an increase in Economic size has a negative impact (-0.6149) on the local currency external debt. However, when the Economic size is greater than γ, the impact becomes positive (0.1166). The threshold value is estimated at 0.3289%. We can return to the data set and check the recent position of countries with respect to this threshold. Only two countries in our sample, namely, Chile and Peru, are below the threshold. Consequently, the other countries fall within an improving dynamic of the original sin issue thanks to the growing weight of their economies. In column (e), we find that when institutional quality is above the threshold ($\gamma > -0.72$), an increase in economic size has a positive and significant impact (0.1023) on the dependent variable. This result is consistent with the literature on the importance for these countries to achieve good institutional quality to improve the attractiveness of financial securities denominated in local currency and convince investors to hold this type of debt (Claessens et al., 2007; Eichengreen et al., 2002; Hausmann & Panizza, 2003; Osina, 2021). Other estimates are less conclusive. In particular,

the impact of FX turnover appears negative and significant on the dependent variable when it is below the threshold, regardless of whether the threshold variable is FX turnover or Economic size (columns a and c). On the other hand, this impact becomes insignificant for FX turnover values higher than the estimated threshold, regardless of the threshold variable. This finding does not match the previous results. The same result appears when Governance is chosen as a threshold variable, but the estimates seem to show that the threshold value is not significant (column d). Inertia, regardless of the specifications, remains a major determinant, as in the multiplicative interaction analysis.

In conclusion, the threshold methodology confirms the nonlinear role of economic size and institutional quality in understanding the phenomenon linking the internationalization of emerging currencies to original sin. The use of emerging currencies by investors will therefore be favored if these countries attempt to implement reforms to improve institutional quality and become broadly integrated into large international networks (Ma & Villar, 2014; Maziad et al., 2011). The consequences are then beneficial for the currency structure of their debt by reducing the currency mismatches that are inherent in the original sin problem in their balance sheets.

4.3 Robustness tests

We run some robustness tests for the dynamic panel threshold methodology. The results are presented in Appendix Table 5. Following Baum et al. (2013) and Lay (2020), we apply one lag (column b') and four lags (column b'') to the variable Economic size to better capture the near contemporaneous effect, which could be interpreted as a stimulating effect of growing economic size on the dependent variable. We also consider in the last column another measure of the dependent variable, which is built as simply the ratio of the local currency external debt expressed as the share of the total external debt.

The results again confirm the role of the economic size of emerging countries in issuing bonds in international markets in their own currencies.

Moreover, we replace our *Governance* indicator with the *Doing Business Indicator* from the World Bank. We use in particular the *Protecting Minority Investors* topic which is the only one available for our sample, among those of interest for our research question (*registering property*, *protecting minority investors*, *enforcing contracts*, *resolving insolvency*). Results presented in appendix Table 9 confirm those in Table 4.

5 Conclusion

This article investigates the dynamics of the determinants of original sin in relation to the internationalization process of emerging currencies. We aim to understand how these factors interact according to their respective initial levels and their interlinkages throughout the period. These dynamics can be apprehended in a nonlinear analysis framework. For this purpose, we develop two different methodologies based on a multiplicative interaction model and a dynamic panel threshold regression.

Our empirical results confirm the existence of nonlinearity in the internationalization process–original sin relationship. These nonlinearities take the form of interactions

between Economic size, FX turnover and institutional quality, as well as threshold effects, especially concerning the Economic size. Our results support the fact that the weight of the country and the quality of the institutions, as supply factors, are determining drivers for these countries to issue bonds in their own currency. In addition, investor demand for these currencies comes into play, especially if the country has strong fundamentals. This shows the importance of emerging countries adopting strategies to promote economic growth and to attract foreign investors to domestic currencies and financial assets.

However, it is interesting to note that the marginal effects are all the more important in resolving the original sin when these countries are at an early but effective stage in internationalizing their currency. The improvement in the quality of institutions amplifies the conditional impact of the two main drivers of internationalization on original sin (Economic size and FX turnover). The evidence highlights the relevance for these economies to take care of the governance and quality of their institutions in the context of financial globalization.

Appendix

See Figs. 1, 2, 3,
Tables 5, 6, 7, 8, 9, 10.

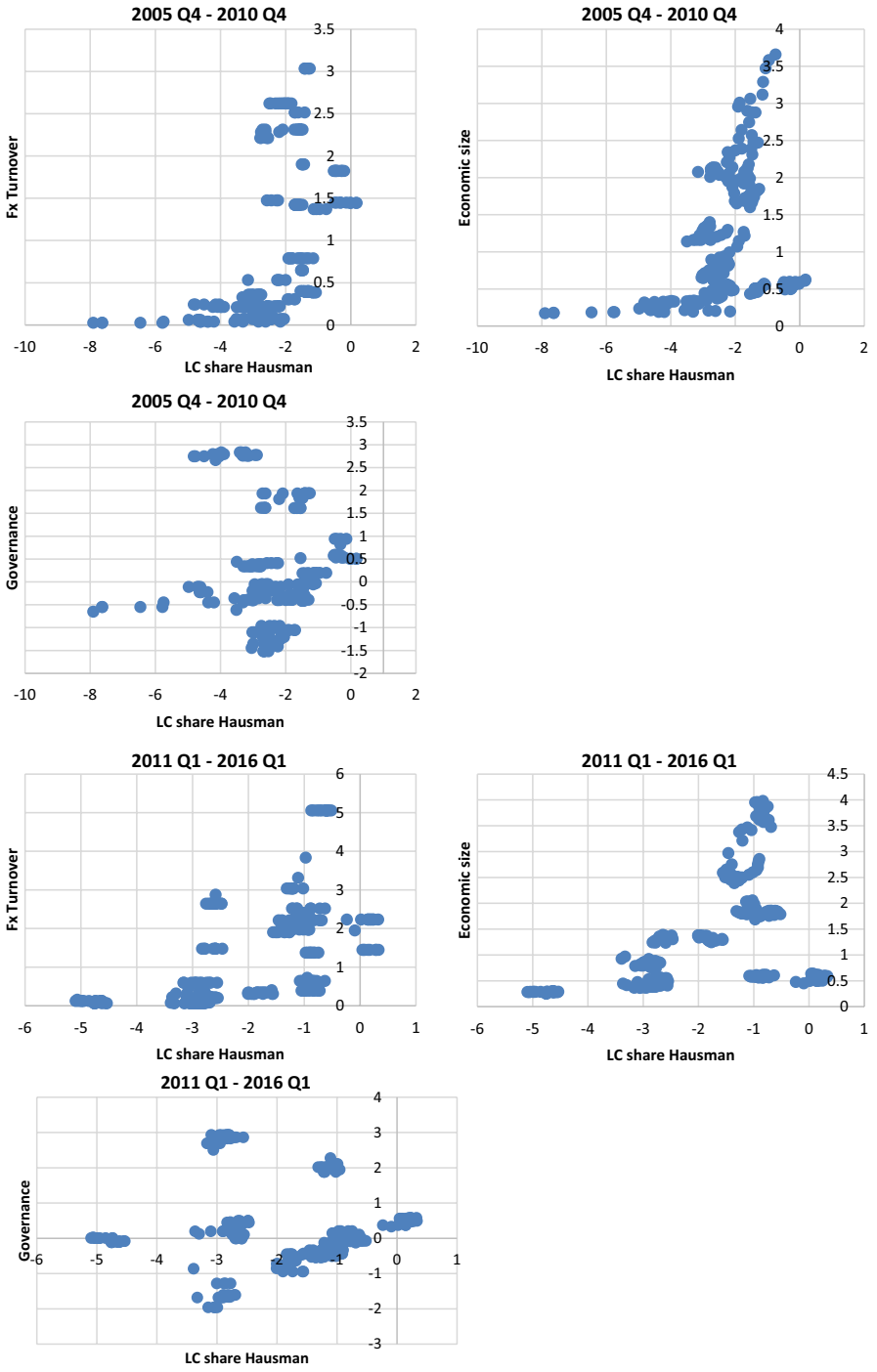


Fig. 1 Scatter plots with respect to someperiods

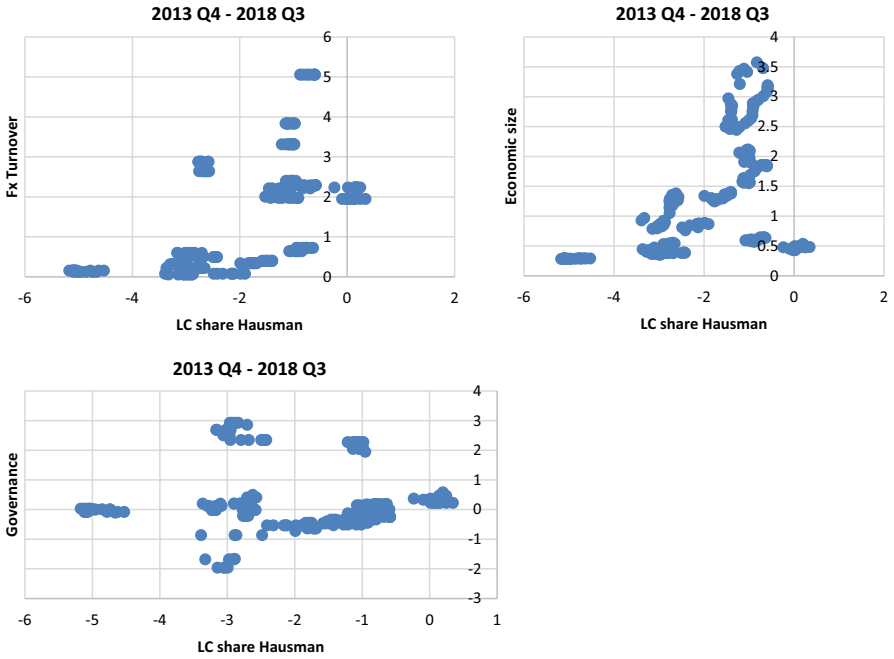


Fig. 1 (continued)

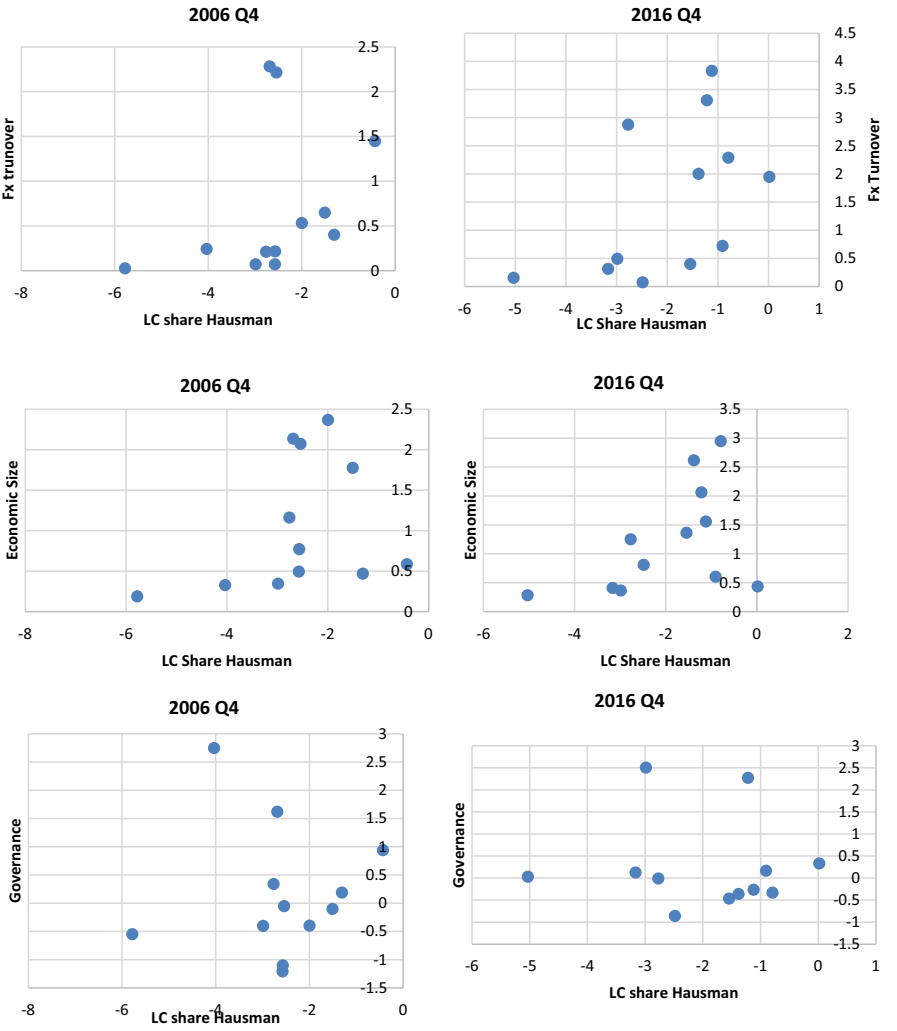
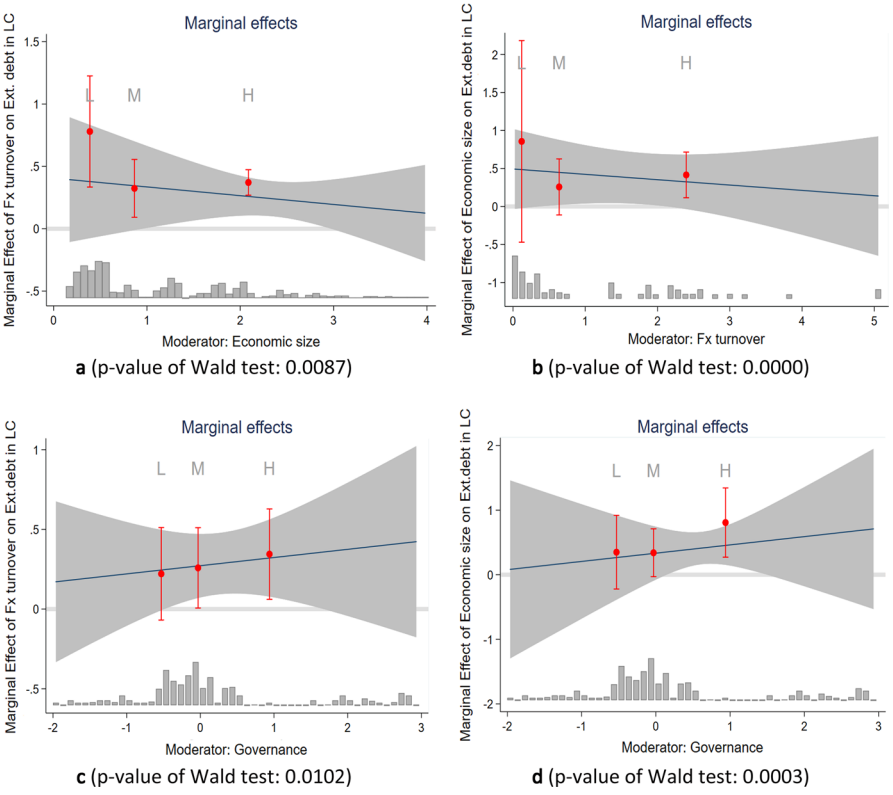


Fig. 2 Scatter plots with respect to some quarters



a (p-value of Wald test: 0.0087)

b (p-value of Wald test: 0.0000)

c (p-value of Wald test: 0.0102)

d (p-value of Wald test: 0.0003)

Fig. 3 Marginal effects of the interaction analysis

Table 5 Robustness tests

		(b')		(b'')		Ratio	
Threshold variables		Eco size		Eco size		Eco size	
Estimated threshold $\hat{\gamma}$ 95%C.I		0.3318		0.3275		1.8627	
		[0.3289–0.3318]		[0.3275–0.3282]		[1.8418–1.8994]	
Regime-dependent variables	Regime1:$q < \gamma$	**Eco size**	**−0.7145****	**Eco size**	**−0.8097****	**Eco size**	**0.0200*****
			(0.321)		(0.331)		(0.002)
	Regime2:$q > \gamma$	**Eco size**	**0.1059****	**Eco size**	**0.0918****	**Eco size**	**0.0137*****
			(0.047)		(0.042)		(0.003)
Regime-independent variables	Lagged dep.variable	**0.8544*****		**0.8318*****		**0.9059*****	
		(0.027)		(0.029)		(0.031)	
	FX turnover	−0.0184		−0.0112		**−0.005*****	
		(0.013)		(0.015)		(0.001)	
	Economic size						
	Trade openness	**0.009***		**0.009***		0.000	
		(0.005)		(0.004)		(0.000)	
	Financial depth	0.001		−0.0003		**0.0004*****	
		(0.001)		(0.001)		(0.000)	
	Capital account op	−0.039		−0.013		**0.0125***	
		(0.097)		(0.092)		(0.007)	
	FX volatility	−0.1121		−0.177		**−0.0322****	
		(0.210)		(0.211)		(0.016)	
	VIX	**−0.0032*****		**−0.0040*****		**−0.0002*****	

Table 5 (continued)

		(b')	(b'')	Ratio
Threshold variables		Eco size	Eco size	Eco size
		(0.001)	(0.001)	(0.000)
	Current account	**0.0132***	**0.01458***	**0.0006****
		(0.008)	(0.008)	(0.000)
	Governance	0.0839	0.0936	0.001
		(0.068)	(0.0695)	(0.004)
Observations		612	612	612
N		12	12	12

Case (b'): threshold variable and regime-dependent variable with one lag. Case (b''): threshold variable and regime-dependent variable with four lags

Ratio: the dependent variable is calculated as the ratio of local currency external debt expressed as a share of total external debt

Robust standard-error in parenthesis

***,**,*corresponds to statistical significance at 1%, 5% and 10% respectively

Table 6 Descriptive statistics

Variable	Obs	Min	Max	Mean	Std.Dev
LC external debt	624	−7.901	0.354	−2.060	1.310
FX turnover	624	0.026	5.053	1.197	1.178
Economic size	624	0.171	3.978	1.213	0.906
Trade openess	624	8.605	61.975	24.438	12.763
Financial depth	624	9.486	165.297	55.015	35.305
Cap.acc. Openess	624	0	1	0.468	0.286
Current acc. bal	624	−9.023	12.030	−1.151	3.438
Fx volatility	624	0.005	0.171	0.047	0.032
Governance	624	−1.960	2.930	0.208	1.090
VIX	624	9.51	44.14	24.438	12.763

Table 7 Stationarity Tests

	Pesaran (2007) Panel Unit Root test (CIPS)					
	With constant and no trend			With constant and trend		
Variable	Lags	zt-bar	*p* value	Lags	zt-bar	*p* value
Trade openess	0	4.468	1.000	0	4.526	1.000
	1	2.622	0.996	1	2.416	0.992
	2	2.567	0.995	2	2.507	0.994
	3	2.497	0.994	3	2.600	0.995
Current account balance	0	0.718	0.764	0	2.204	0.986
	1	−0.586	0.279	1	−0.434	0.332
	2	−1.063	0.144	2	−1.267	0.103
	3	−1.475	0.070	3	−1.661	0.048
Financial depth	0	−2.539	0.006	0	−0.715	0.237
	1	−1.270	0.102	1	0.612	0.730
	2	−0.904	0.183	2	1.419	0.922
	3	−0.126	0.450	3	2.636	0.996
FX volatility	0	−4.272	0.000	0	−3.244	0.001
	1	−3.989	0.000	1	−3.302	0.000
	2	−4.523	0.000	2	−3.739	0.000
	3	−3.458	0.000	3	−2.746	0.003
Economic size	0	5.052	1.000	0	6.142	1.000
	1	1.637	0.949	1	−0.198	0.421
	2	1.287	0.901	2	−0.615	0.269
	3	1.883	0.970	3	−0.041	0.484
Capital account openess	0	5.479	1.000	0	5.779	1.000
	1	5.585	1.000	1	6.228	1.000
	2	5.285	1.000	2	6.161	1.000
	3	4.814	1.000	3	5.562	1.000
FX turnover	0	−0.160	0.437	0	0.837	0.799
	1	−0.289	0.386	1	0.741	0.771

Table 7 (continued)

Variable		Pesaran (2007) Panel Unit Root test (CIPS)					
		With constant and no trend			With constant and trend		
		Lags	zt-bar	*p* value	Lags	zt-bar	*p* value
		2	−0.446	0.328	2	0.632	0.736
		3	−0.642	0.260	3	0.504	0.693
Gov		0	0.319	0.625	0	0.018	0.507
		1	2.085	0.981	1	1.979	0.976
		2	1.884	0.970	2	1.602	0.945
		3	1.569	0.942	3	0.821	0.794
Local currency external debt		0	−2.912	0.002	0	−3.562	0.000
		1	−1.957	0.025	1	−2.504	0.006
		2	−1.742	0.041	2	−2.232	0.013
		3	−1.355	0.088	3	−1.987	0.023
				t-Statistic			Prob.*
VIX	Augmented Dickey-Fuller test statistic			−3.388177**			0.0160
	Test critical values:						
	1% level			−3.565430			
	5% level			−2.919952			
	10% level			−2.597905			

H0 all series are non-stationary

*MacKinnon (1996) one-sided *p* values

Table 8 Robustness checks of the interaction analysis

Dependent variable: Local currency debt (expressed as a share of total external debt)					
Independent variables	(1)	(2)	(3)	(4)	(5)
Lagged dependent variable	**0.446*** **	**0.343** **	**0.413*** **	**0.391*** **	**0.459*** **
	4.46	*2.36*	*3.89*	*3.80*	*4.82*
Fx turnover	**0.065***	−0.024	−0.237	0.027	**0.101***
	1.61	*−0.41*	*−0.92*	*0.30*	*1.80*
Economic size	−0.069	**−2.021***		0.043	
	−0.56	*−1.61*		*0.65*	
Trade openess	−0.003	0.001	−0.001	−0.001	−0.000
	−0.73	*0.21*	*−0.61*	*−0.79*	*−0.41*
Financial depth	**0.002*** **	**0.002*** **	**0.001*** **	**0.001** **	**0.001*** **
	3.65	*3.83*	*3.77*	*2.49*	*3.70*
Capital account openess	327.65	−1006.47	0.004	**−0.042** **	**−0.023** **
	0.87	*−1.48*	*0.38*	*−2.12*	*−2.36*
FX volatility	−0.080	**−0.060***	−0.061	−0.076	**−0.093** **
	−1.36	*−1.62*	*−0.85*	*−1.14*	*−2.25*
Current account	0.000	−0.010	−0.001	0.000	−0.001
	0.26	*−0.49*	*−0.79*	*0.17*	*−0.64*
VIX	**0.000** **	0.000	**−0.0002***	**−0.0001***	0.000
	2.23	*0.09*	*−1.86*	*−1.78*	*0.14*
Governance	0.007		**0.035***		
	0.52		*1.82*		
FX turnover^2					
Economic size^2		**2.357***			
		1.76			
Governance^2					
FX turnover*Economic size			**0.494***		
			1.86		
Economic size*Governance				**0.087***	
				1.72	
FX turnover*Governance					**0.101*** **
					2.41
Country specific effects	*yes*	*yes*	*yes*	*yes*	*yes*
CD test statistics	*1.64*	*1.34*	*4.03*	*3.17*	*2.99*
p-value	*0.101*	*0.17*	*0.000*	*0.001*	*0.002*
Number of obs	588	576	564	564	564
R^2 adjusted	0.61	0.56	0.68	0.64	0.62
F-test	F(240,348) prob > F = 0.00	F(276,300) prob > F = 0.00	F(276,288) prob > F = 0.00	F(276,288) prob > F = 0.00	F(264,300) prob > F = 0.00

Countries included are Argentina, Brazil, Chile, Colombia, Mexico, Peru, India, Indonesia, Thailand, South Korea, South Africa, Turkey

Dynamic Common Correlated Effects with heterogenous coefficients. Constant not reported

z-stats are in italics

*Significant at 10%, ** significant at 5%, ***significant at 1%

Table 9 Robustness checks with *Doing Business Indicators*

Dependent variable: Local currency debt expressed as a share of total external debt, with Hausmann transformation											
Threshold variables		(a)		(b)		(c)		(d)		(e)	
		FX turnover		Eco size		Eco size		Doing business indicator		Doing business indicator	
Estimated threshold $\hat{\gamma}$		0.3117		0.3289		0.3289		55		55	
95% C.I		[0.2423—0.3277]		[0.3282—0.3370]		[0.3282—0.3370]		[55—55.85]		[55—55.85]	
Regime-dependent variables	regime 1: $q < \gamma$	**FX turnover**	**−0.3311****	**Eco size**	**−0.5311****	**FX turnover**	**−0.6225*****	**FX turnover**	**−0.1599*****	**Eco size**	0.0578
			(0.187)		(0.260)		(0.171)		(0.063)		(0.052)
	regime 2: $q > \gamma$	**FX turnover**	−0.0189	**Eco size**	**0.1424*****	**FX turnover**	−0.0184	**FX turnover**	−0.0146	**Eco size**	**0.1552****
			(0.015)		(0.049)		(0.016)		(0.021)		(0.0669)
Regime-independent variables	Lagged dep. variable	**0.8758*****		**0.8702*****		**0.8904*****		**0.8757*****		**0.8798*****	
		(0.028)		(0.022)		(0.020)		(0.022)		(0.0264)	
	FX turnover			−0.0179						**−0.036****	
				(0.013)						(0.0151)	
	Economic size	**0.1166*****						**0.100****			
		(0.043)						(0.045)			
	Trade openness	0.006		0.007		0.0033		0.0066		0.006	
		(0.005)		(0.005)		(0.004)		(0.005)		(0.005)	
	Financial depth	0.001		**0.001****		0.0012		0.000		−0.0001	
		(0.001)		(0.000)		(0.001)		(0.001)		(0.001)	
	Capital account op	0.0227		0.016		0.0451		−0.103		−0.0216	
		(0.084)		(0.085)		(0.098)		(0.113)		(0.0952)	

Table 9 (continued)

Dependent variable: Local currency debt expressed as a share of total external debt, with Hausmann transformation						
Threshold variables		(a)	(b)	(c)	(d)	(e)
		FX turnover	Eco size	Eco size	Doing business indicator	Doing business indicator
	FX volatility	−0.0904	−0.022	−0.1293	−0.106	−0.0654
		(0.215)	(0.230)	(0.248)	(0.233)	(0.189)
	VIX	**−0.0035*****	**−0.0035*****	**−0.0036*****	**−0.0039*****	**−0.0038*****
		(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
	Current account	0.0103	0.0103	0.0088	0.0109	0.0096
		(0.008)	(0.007)	(0.008)	(0.008)	(0.008)
	Doing business indic	**−0.002****	**−0.0036*****	−0.002		
		(0.001)	(0.001)	(0.001)		
Observations		612	612	612	612	612
N		12	12	12	12	12

Robust standard-error in parenthesis. ***, **, * corresponds to statistical significance at 1%, 5% and 10% respectively

Table 10 Panel Granger causality tests

FX turnover
Dumitrescu and Hurlin (2012) Granger non-causality test results:
Optimal number of lags (AIC): 15 (lags tested: 1 to 15)
W-bar = 33.7606
Z-bar = 11.8652 (p-value* = 0.1710, 95% critical value = 18.5158)
Z-bar tilde = 1.5404 (p-value* = 0.1720, 95% critical value = 2.9789)
H0: Local curr. debt does not Granger-cause FX turnover
H1: Local curr. debt does Granger-cause FX turnover for at least one panelvar (code)
*p-values computed using 1000 bootstrap replications
Economic size
Dumitrescu and Hurlin (2012) Granger non-causality test results:
Optimal number of lags (AIC): 15 (lags tested: 1 to 15)
W-bar = 45.1884
Z-bar = 19.0928 (p-value* = 0.1250, 95% critical value = 23.5396)
Z-bar tilde = 3.1037 (p-value* = 0.1250, 95% critical value = 4.0655)
H0: Local curr. debt does not Granger-cause Eco. Size
H1: Local curr. debt does Granger-cause Eco. size for at least one panelvar (code)
*p-values computed using 1000 bootstrap replications
Governance
Dumitrescu and Hurlin (2012) Granger non-causality test results:
Optimal number of lags (AIC): 15 (lags tested: 1 to 15)
W-bar = 20.9809
Z-bar = 3.7826 (p-value* = 0.6600, 95% critical value = 14.5336)
Z-bar tilde = -0.2078 (p-value* = 0.7990, 95% critical value = 2.1176)
H0: Local curr. debt does not Granger-cause Governance
H1: Local curr. debt does Granger-cause Governance for at least one panelvar (code)
*p-values computed using 1000 bootstrap replications
Trade openness
Dumitrescu and Hurlin (2012) Granger non-causality test results:
Optimal number of lags (AIC): 15 (lags tested: 1 to 15)
W-bar = 35.1158
Z-bar = 12.7223 (p-value* = 0.1170, 95% critical value = 17.0154)
Z-bar tilde = 1.7258 (p-value* = 0.1170, 95% critical value = 2.6544)
H0: Local curr. debt does not Granger-cause Trade open
H1: Local curr. debt does Granger-cause Trade open. for at least one panelvar (code)
*p-values computed using 1000 bootstrap replications
Financial depth
Dumitrescu and Hurlin (2012) Granger non-causality test results:
Optimal number of lags (AIC): 15 (lags tested: 1 to 15)

Table 10 (continued)

Financial depth
W-bar = 16.0954
Z-bar = 0.6928 (p-value* = 0.9420, 95% critical value = 14.4336)
Z-bar tilde = −0.8761 (p-value* = 0.2760, 95% critical value = 2.0959)
H0: Local curr. debt does not Granger-cause Fin. depth
H1: Local curr. debt does Granger-cause Fin. depth for at least one panelvar (code)
*p-values computed using 1000 bootstrap replications
FX volatility
Dumitrescu and Hurlin (2012) Granger non-causality test results:
Optimal number of lags (AIC): 15 (lags tested: 1 to 15)
W-bar = 26.3978
Z-bar = 7.2086 (p-value* = 0.2680, 95% critical value = 13.9420)
Z-bar tilde = 0.5332 (p-value* = 0.4810, 95% critical value = 1.9896)
H0: Local curr. debt does not Granger-cause vol. Fx
H1: Local curr. debt does Granger-cause vol. FX for at least one panelvar (code)
*p-values computed using 1000 bootstrap replications
Current account
Dumitrescu and Hurlin (2012) Granger non-causality test results:
Optimal number of lags (AIC): 15 (lags tested: 1 to 15)
W-bar = 32.3031
Z-bar = 10.9434 (p-value* = 0.2620, 95% critical value = 18.9354)
Z-bar tilde = 1.3410 (p-value* = 0.2630, 95% critical value = 3.0697)
H0: Local curr. debt does not Granger-cause Current acc
H1: Local curr. debt does Granger-cause Current acc. for at least one panelvar (code)
*p-values computed using 1000 bootstrap replications

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