Drivers of inflation-linked public debt: An empirical investigation

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Drivers of inflation-linked public debt: An empirical investigation

This paper empirically explores the drivers behind the cross-country heterogeneity in inflation-linked (IL) debt for advanced and emerging economies between 1995 and 2017. It finds that countries with more flexible exchange rate regimes and higher tax rates issue more of their public debt linked to inflation. There is some evidence that high inflation countries issue more IL debt, but no indication that country size, financial development, or institutional quality is significantly associated with the IL debt share. For IL debt over gross domestic product, however, institutional quality matters, but the exchange rate regime and inflation do not.

Keywords: Inflation-linked debt, public debt composition, institutional factors

JEL classification codes: F34; H63

I. INTRODUCTION

The relevance of inflation-linked (IL) debt in countries' public debt composition has increased substantially in recent years. Between 1995 and 2017, the average share of IL debt in public debt has increased by almost 9 times – from 1.2% to 10.7% – and the average share of IL debt to gross domestic product (GDP) has almost tripled – from 2% to 5.9%.

Nonetheless, the popularity of this type of debt is highly uneven across countries. On the one hand, in 2016, Chile issued almost half of its public debt in this manner, and Israel, Brazil, and the United Kingdom issued more than a quarter; on the other hand, countries such as the Czech Republic, India, Korea, and Japan issued 1% or less of their public debt linked to inflation.

Previous work on IL debt has studied its rationale vis-à-vis nominal debt from a normative perspective (Calvo 1978; Persson et al. 1987, 2006; Bohn 1988; Calvo and Guidotti 1990; Alfaro and Kanczuk 2010), its business cycle properties (Gomez-Gonzalez 2019) and its diversification ability (Swinkels 2012). However, less is known about the drivers of cross-country heterogeneity in countries' reliance on IL debt, which is therefore the focus of this study.

Part of the reason for this gap in the literature could be that IL debt is a relatively new asset for many countries. Of the 26 countries in the study's sample, half started their issuance in the 2000s, and Hungary, Japan, and Spain started only in the 2010s. Lack of available data could have prevented researchers from studying this topic.

To investigate the drivers of the cross-country heterogeneity in IL debt, this study builds on the literature examining the factors driving local currency (LC) debt issuance in emerging markets and the original sin problem, which refers to countries' inability to issue LC debt abroad (Eichengreen et al. 2002; Hausmann and Panizza 2003; Burger and Warnock 2006; Claessens et al. 2007; Ogrokhina and Rodriguez 2018; Engel and Park 2019).

As in the aforementioned research, this study uses data between 1995 and 2017 on IL debt, exchange rate (ER) regime, inflation-targeting (IT) regime, size, inflation, fiscal health, financial development, and institutional quality for 26 countries that issue IL debt.

Following Claessens et al. (2007), the study analyzes not only the share of IL debt in public debt, but also the depth of the markets for IL debt in the different countries, measured by the share of IL debt to their GDP.

First, the results regarding the share of IL debt in public debt are as follows. The ordinary least squares regression results show that countries with more volatile ER regimes issue more IL debt.

Going from a peg to a floating ER regime is associated with a share of IL debt between 6.5 and 8.5 percentage points (pp) higher. Additionally, more fiscally responsible countries, especially countries with higher tax rates, issue more of their debt linked to inflation.

Contrary to the literature on the original sin, this study finds no evidence of country size, measured as the logarithm of the nominal GDP, or financial development, measured as the ratio of credit to GDP, financial credit to GDP, and deposit money bank assets to GDP, having a significant association with the share of IL debt in public debt.

Moreover, this study's empirical investigations find some evidence of lagged inflation being positively related to IL debt, suggesting that high-inflation countries issue more of their debt linked to inflation.

Second, the results for the depth of IL debt markets, measured as IL debt to GDP, are similar but not identical to the ones for the composition of public debt. In terms of similarities, countries with higher tax rates have deeper IL debt markets and country size and financial development are unrelated to IL debt over GDP.

In terms of differences, the exchange rate regime and lagged inflation play no role in the depth of IL debt markets, but more politically unstable countries exhibit higher IL debt-to-GDP ratios.

The remainder of the paper is structured as follows. Section II reviews the relevant literature. Section III summarizes the statistics for the share of public debt indexed to inflation and the depth of IL debt markets around the world. Section IV describes the data set and the empirical methodology. Section V presents the main results of the empirical analysis. Section VI summarizes the results of robustness checks and alternative specifications. Lastly, Section VII concludes the paper.

II. LITERATURE REVIEW

This study is related to several strands of literature. First, it is related to the empirical research exploring the drivers behind the composition of public debt and public debt issued abroad, also known as international debt. This research has concentrated mostly on emerging economies and has focused almost exclusively on the LC versus foreign currency (FC) dichotomy. Within this literature, the phenomenon of the original sin, or emerging economies' inability to issue LC debt abroad, has received substantial attention. The seminal work of Eichengreen et al. (2002) and Hausmann and Panizza (2003) and the subsequent papers cited previously belong to this strand of research. This study builds on the methodology of these papers but studies IL debt and expands the sample to include not only emerging economies but also advanced economies.

Second, this paper is related to the literature on IL public debt. Following the seminal work of Calvo (1978), several normative papers, cited in the previous section, on monetary policy's time inconsistency have shown that countries lacking commitment have an incentive to erode the real value of debt by increasing inflation. Issuing indexed debt can restore time consistency and lower borrowing costs by acting as a commitment device. In contrast, this study is empirical and tests, among other things, this literature's predictions, using recent IL debt data for advanced and emerging economies.

Third, this study contributes to the literature on optimal fiscal policy by testing some of its key predictions, using recent data on IL debt. A key finding is that governments aim to smooth taxes over time (Barro 1979; Bohn 1990; Chari and Kehoe 1999; Angeletos 2002). Through the lens of this literature, countries facing more volatile exchange rates should issue more IL debt to move away from FC debt and avoid volatile repayments. This is indeed what this study's empirical evidence on IL debt shows.

Finally, this paper contributes to the literature on IL debt in advanced economies. Most other studies concentrate on the costs of issuing IL debt vis-à-vis nominal debt, with an emphasis on the United States and the United Kingdom (Barr and Campbell 1997; Dudley et al. 2009; Christensen and Gillan 2011, 2012; Fleckeinstein et al. 2014; D'Amico et al. 2018). Instead, this study concentrates on the cross-country heterogeneity in the share of IL debt issued by advanced economies and the depth of these markets.

III. DATA ON IL DEBT

This section provides an overview of the size of IL debt markets with respect to total public debt and GDP in each of a sample of 26 countries, of which 12 are advanced and 14 are emerging, between 1995 and 2017.

Table 1 lists the countries in the sample, providing broad and representative geographic coverage. The time span is also ample, covering more than 20 years, which, for 17 countries in the sample, includes the year they started issuing IL debt.

The sample of countries is smaller than those in the LC debt literature, for example, Hausmann and Panizza (2003) or Burger and Warnock (2006), because the number of countries that issue IL debt is much smaller than the number of countries issuing LC debt. Indeed, many of the countries missing in the sample do not issue this type of debt, for example, some Asian economies, such as Malaysia and Indonesia. The sample of advanced economies included in the analysis is similar to those of Ermolov (2018) and Fleckenstein (2013), two of the very few finance papers studying advanced economies' IL debt outside the United States and the United Kingdom. These advanced economies have the largest IL debt markets in the world.

Figure 1 plots the average share of IL debt and the average IL debt over GDP over time. The average share of IL debt over debt increased from 1.2% in 1995 to 13.5% in 2012, decreasing to 10.7% in 2017. All the decrease between 2012 and 2017 is due to the drop in Chile's outstanding IL debt. The share of IL debt over GDP increased from 2.0% to 5.9%.

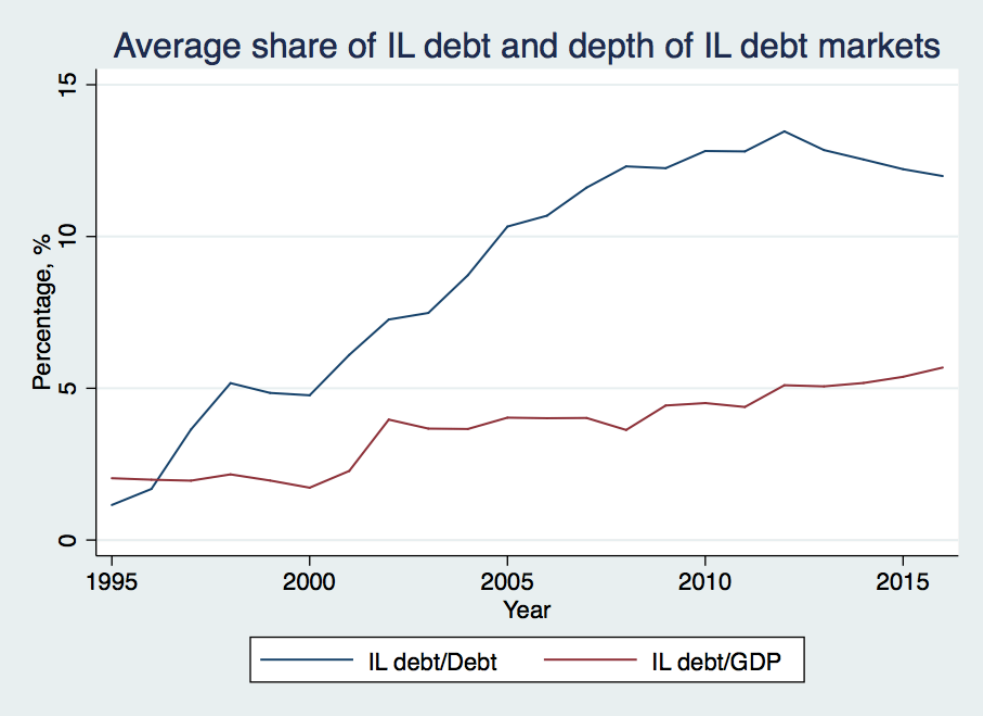

Figure 1: Average shares of IL debt to total debt and IL debt to GDP over time. Sources: See Table A.1. in Appendix A.

As Table 1 shows, between 1995 and 2017, governments issued, on average, almost 13% of their public debt linked to inflation, conditional on issuing this type of debt. Table 1 shows that these averages hide a substantial amount of heterogeneity. The second column in Table 1 shows that,

for example, Chile issued more than half, and Argentina, Israel, and the United Kingdom about a quarter, whereas India, Japan, and Korea issued about 1% or less.

Moreover, IL debt as a share of GDP was, on average, 5.3% in the same period, also conditional on positive issuance. The third column in Table 1 shows that countries such as Argentina, Italy, Israel, and the United Kingdom had the deepest markets, with shares of IL debt over GDP that were double the sample average.

All the countries except for five—that is, Argentina, the Czech Republic, India, Poland, and Thailand—increased their share of IL debt in public debt, as the fourth column shows. The Czech Republic and Thailand only issued IL debt between 1999 and 2001 and in 2011, respectively, and their share of IL debt to GDP shows a similar pattern. All the countries except for six—the five just mentioned and Israel—have deepened their IL debt markets, as the last column reports. Figures A.1 and A.2 in the Appendix show the time series of the ratio of IL debt over total debt and over the GDP by country.

The average increases in the share of IL debt in public debt and in GDP have been large. The former was almost 10 times; the latter was almost 20. Furthermore, as Figure 2 shows, the size of the overall world IL debt outstanding went from 40 billion US dollars in 1995 to more than 3.5 trillion US dollars in 2017.

The increasing relevance of this type of bonds in terms of public debt composition and the growing depth and size of these markets call for further research on this type of debt. The next section focuses on investigating the drivers behind the heterogeneity found in countries' reliance on this type of debt.

Country	IL debt/total debt (as a %)	IL debt/GDP (as a %)	ΔIL debt/debt	ΔIL debt/GDP
Argentina	26.5	13.2	0.4	0.1
Australia	7.3	1.0	2.2	3.0
Brazil	18.7	8.0	62.6	252
Canada	4.9	1.5	4.4	3.2
Chile	51.4	4.9	4.8	21.5
Colombia	21.1	5.6	2.6	11.7
Czech Republic	4.5	0.2	0	0
France	10.0	5.9	7.1	12.4
Germany	3.8	1.6	6.4	6.1
Hungary	3.8	2.1	10.9	14.7
India	0.04	0.03	0.1	0.1
Israel	24.7	19.1	1.1	0.6
Italy	7.8	10.7	12.7	17.0
Japan	1.0	1.9	3.0	3.0
Korea	1.2	0.4	2.4	3.6
Mexico	12.2	2.8	2.1	4.4
Peru	3.4	0.5	9.9	18
Poland	1.8	0.8	0.6	0.8
Russia	1.2	0.1	1.4	1.2
South Africa	15.6	5.2	46.9	66.2
Spain	3.1	2.3	2.9	3.4
Sweden	12.9	5.1	12.8	5.0
Thailand	1.5	0.3	0	0
Turkey	12.3	4.2	49.9	40.8
United Kingdom	23.7	13.2	2.0	3.3
United States	8.4	3.4	8.8	17.5
Average	12.9	5.3	9.9	19.6

Table 1: Average share of IL debt and IL debt over GDP between 1995 and 2017 (as a percentage), conditional on the country having IL debt outstanding that year. This table also

shows the increase (denoted by Δ) in the amount of IL debt issued and the share of IL debt to total debt (as the number of instances). Sources: See Table A.1 in Appendix A.

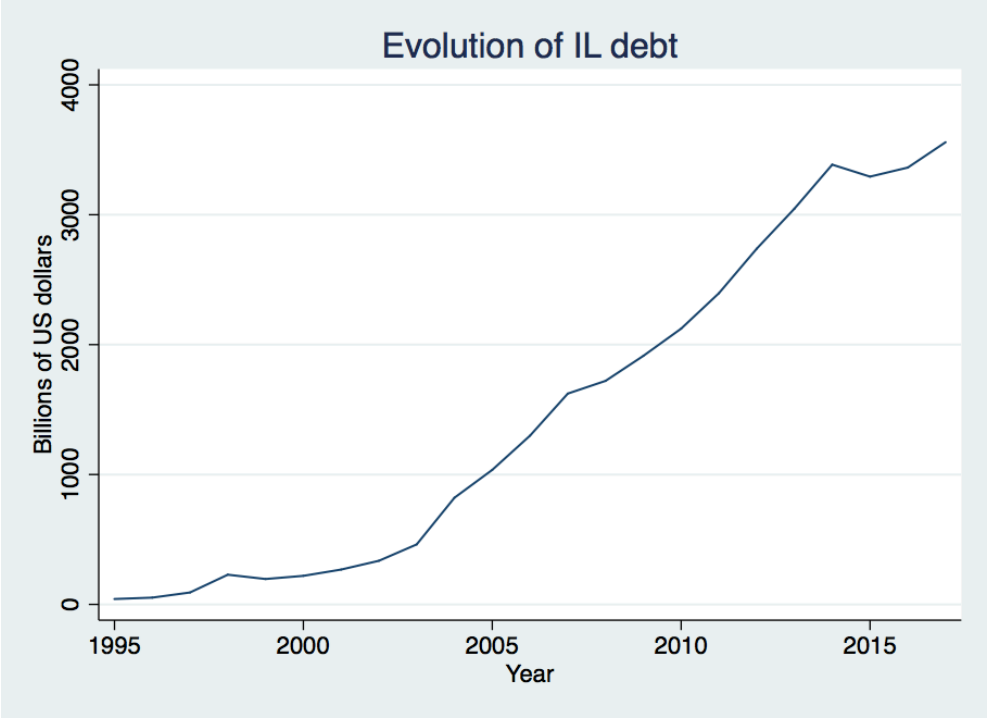

Figure 2: World IL debt outstanding in billions of US dollars. Sources: See Table A.1. in Appendix A.

IV. DATA AND METHODOLOGY

This section describes the variables included in the data set and the empirical methodology used in the analysis.

Following the earlier literature on LC debt and the original sin, the variables in the data set belong to seven categories: the ER regime, the IT regime, country size, inflation, fiscal health, financial development, and institutional quality. What follows describes in detail the variables for each category and their sources.

For the exchange rate regime, this study uses the de facto exchange rate classification of Ilzetzki et al. (2019), which updates Reinhart and Rogoff's (2004) classification and covers all the countries in the sample between 1995 and 2016. For each country and year, the classification provides a number between one and 15 for the fine measure, or between one and six for the coarse measure, where higher numbers refer to more flexible exchange rate regimes. For example, for the fine measure, a two is a peg and a 13 is a freely floating exchange rate regime. Another de facto exchange rate regime measure, used by Hausmann and Panizza (2003) and Claessens et al. (2007), is the Levy, Yeyati, and Sturzenegger's (2003) measure. Unfortunately, this classification ends in 2013 and its use would exclude a fair amount of IL debt data for many countries. Due to the data coverage limitation, the Ilzetzki et al. (2019) classification is favored.

For the IT regime, this study uses two dummy variables that take the value of one if the country is an inflation targeter in a given year, and zero otherwise. The IT start dates are obtained mainly from the International Monetary Fund.[1] Little and Romano (2010) report that Spain started targeting inflation in 1995, formally abandoning it after entering the euro area in 1999. Indeed, as Jahan explains in the International Monetary Fund's *F&D* article, although both the United States and the euro area have adopted elements of IT, they do not officially call themselves inflation targeters. For this reason, two dummy variables are used: the first includes the United States as an inflation targeter since 2012, when the 2% objective was made public, and the euro area since its inception in 1999; the other dummy does not include these countries as inflation targeters at all. The first dummy variable can be interpreted as indicating an implicit IT regime and the second as a formal IT regime.

[1] This information is from an *F&D* article by Sarwat Jahan, available at https://www.imf.org/external/pubs/ft/fandd/basics/pdf/jahpan-inflation-targeting.pdf

All previously mentioned studies on LC debt include the logarithm of the nominal GDP as a measure of country size in their specifications, because an influential and puzzling finding of the early original sin literature was the irrelevance of most of domestic institutional factors but the strong effect of country size in explaining the share of LC debt held abroad (Hausmann and Panizza 2003).

For inflation, this study uses the GDP deflator-based measure of inflation in order to include Argentina, since their CPI-based measure of inflation is unavailable. Following Claessens et al. (2007), to somewhat mitigate endogeneity concerns, the monetary freedom index from the Heritage Foundation is used as an alternative to inflation. This measure averages the inflation rate over the last three years and assesses the extent of price controls in a country. Based on its construction, *high* values of the index are associated with *low* levels of inflation over the last three years and a *low* incidence of price controls.

The tax burden and government spending indexes from the Heritage Foundation, available for the entire sample, are used for fiscal health variables. The tax burden index is calculated using the top marginal tax rate on individual and corporate income, as well as the total tax burden as a share of GDP. Based on the tax burden index construction, *higher* values are associated with *lower* marginal tax rates and tax burdens. The government spending index is calculated using government expenditures and transfer payments. Again, based on the government spending index construction, *higher* values are associated with *lower* government expenditures and transfers. As an alternative measure of fiscal health, the analysis also includes direct measures of tax revenues and government spending over GDP, from the World Bank World Development Indicators.

For financial development, the study uses the ratio of credit to GDP, of financial credit to GDP, and of deposit money banks' assets to GDP, obtained from the World Bank's Global Financial Development Database, available for the entire sample. Hausmann and Panizza (2003), Ogrokhina and Rodriguez (2018), and Engel and Park (2019) all include one of these measures in their specifications. Another commonly used measure of financial development is the broad multidimensional index-based measure of Svirydzenka (2016). Unfortunately, this variable ends in 2013 for all the countries in the sample and so, due to the data coverage limitation, the Global Financial Development Database variables are favored.

Finally, for institutional quality, following Engel and Park (2019), this analysis uses the World Bank's World Governance Indicators, which are publicly available for the entire sample. In particular, the study concentrates on political stability for the baseline specifications and uses government effectiveness and the rule of law for the robustness checks. Other popular institutional measures, such as those in the International Country Risk Guide, used by Ogrokhina and Rodriguez (2018), are not publicly available.

In terms of the empirical methodology, the analysis runs ordinary least squares regressions with all the observations in the sample, clustering standard errors at the country level, due to the presence of heroskedasticity and serial autocorrelation. The analyses of Hausmann and Panizza (2003) and Burger and Warnock (2006) involve cross-country regressions, ignoring time-series variation, which can be potentially informative; however, their samples are larger, with 91 and 49 countries, respectively. The smaller sample size in the current study, 26 countries, makes the examination move away from cross-country analysis, and the relatively small time-series variation within country moves the examination away from fixed-effects regression. Thus, ordinary least squares are used to exploit all the variation in the sample.

The baseline regression equation is the following:

$$IL\ debt_{it} = \alpha + \beta_1 ER\ regime_{it-1} + \beta_2 IT\ regime_{it-1} + \beta_3 Inflation_{it-1} +$$
$$\beta_4 Tax\ burden_{it-1} + \beta_5 Government\ spending_{it-1} + \beta_6 Size_{it} + \beta_7 Fincredit_{it}$$
$$+ \beta_8 Political\ stability_{it} + \beta_8 Trend_t + u_{it} \quad (1);$$

where IL debt denotes IL debt over total debt or IL debt over GDP, the tax burden and government spending are the corresponding Heritage Foundation indexes, country size is measured by the logarithm of the nominal GDP, *Fincredit* denotes financial credit over the GDP, *Trend* is a time trend, and *u* denotes the error term.

The first five variables, corresponding to the ER and IT regimes, inflation, and fiscal health, are lagged to partially mitigate endogeneity concerns. For example, public debt composition clearly influences a country's decision to float their currency. Also, the higher the share of IL debt in public debt, the higher the inflation rate needed to inflate away a country's real burden of its debt and the smaller the fiscal room countries have. For this reason and because lagging variables is an imperfect solution to the endogeneity problem, the analysis also conducts instrumental variable regressions as robustness.

Finally, Table A.2 in Appendix A reports the results of Choi (2001) unit root tests for panel data. The conclusion of these tests is that we cannot reject the presence of unit roots in several of the variables in the analysis. Hence, to avoid concerns about spurious correlation, equation (1) includes a time trend.

V. REGRESSION RESULTS

The estimation results for equation (1) with IL debt over total debt as the dependent variable are shown in Table 2. Columns (1) and (2) use the fine Ilzetzki et al. (2019) classification and columns (3) and (4) the coarse classification; columns (1) and (3) use the implicit IT regime definition, whereas columns (2) and (4) use the formal IT regime definition.

The main results are as follows. First, the positive and significant coefficient for the ER regime shows that countries with more flexible exchange rate arrangements issue more IL debt. The point estimates suggest that going from a peg (2 in the fine classification) to a flexible exchange rate (13 in that classification) is associated with a share of public debt linked to inflation between 6.6 and 8.6 pp higher, depending on whether the IT regime is defined formally or implicitly. The significance of the coarse classification is sensitive to the IT regime definition considered. When the formal IT regime is used, the effect of the ER regime becomes nonsignificant, as column (4) shows. However, when the implicit IT regime is used, the effect of the ER is positive and significant. Going from a peg (a value of one in the coarse classification) to a floating exchange rate (a value of three in that classification) is associated with a 4.9 pp higher share of IL debt in total public debt. This empirical finding is consistent with the principle of tax smoothing in the optimal fiscal policy literature (Barro 1979; Bohn 1990). Countries with more volatile exchange rates wish to move away from FC debt and to issue more IL debt, to avoid more volatile repayments. As the robustness section shows, the association between the ER and the IL debt over debt is present in most, but not all, specifications.

Second, regarding monetary policy arrangements, the coefficient on the IT regime is nonsignificant, when defined both implicitly and formally.

Third, the positive and significant coefficients for lagged inflation in three of the four specifications point to the fact that higher-inflation countries issue more IL debt. A one standard deviation increase in inflation, which corresponds to 13 pp, is associated with a share of IL debt 2.6 pp higher. Historically, many countries, such as Latin American economies and Israel, have seen in IL debt a way to encourage investment in high-inflation environments (United Nations Economic Commission for Latin America and the Caribbean 1993).

Besides, high inflation might be a symptom of poor monetary policy discipline: countries that lack monetary policy discipline are more likely to allow high inflation, in order to erode the real value of their public debt. In fact, IL debt is often interpreted in the literature as a commitment device for this type of countries (Calvo 1978; Persson, Persson, and Svensson 1987, 2006; Bohn 1988; Calvo and Guidotti 1990; Alfaro and Kanczuk 2010). The models of Jeanne (2005), Engel and Park (2019), and Du et al. (forthcoming) predict that less disciplined countries in terms of monetary policy issue more FC debt and less LC debt. Because IL debt cannot be deflated away, it is comparable to FC debt (Fleckenstein, Longstaff, and Lustig 2014; Sunder-Plassman 2018); hence, through the lens of the literature on lack of commitment, higher shares of IL debt are expected in countries with lower monetary policy credibility and higher inflation. Although the positive inflation coefficients in Table 2 are consistent with this interpretation, other explanations are also possible. For this reason, the next subsection explores other indicators of monetary policy discipline.

Fourth, country size, measured as the logarithm of the nominal GDP, is nonsignificant in all specifications, which runs counter to the findings for the share of LC issued abroad. Hence, there seem to be no mystery or puzzle, as in the early original sin literature (Eichengreen et al. 2002;

Hausmann and Panizza 2003). On the contrary, there is evidence that several domestic institutional factors are associated with the variation in IL debt over debt.

Fifth, the results for the fiscal indexes show that the tax burden is significant in all the specifications. Given the construction of the Heritage indexes, the negative coefficients imply that countries with higher tax rates (lower index values) issue more IL debt. For a sense of magnitude, a one standard deviation increase in the tax burden index is associated with a share of IL debt 6 pp higher. The government spending index is nonsignificant in all specifications. Taken together, these findings suggest that more fiscally responsible countries, especially countries with a higher taxation ability, issue more IL debt. This result is present in all specifications.

Finally, financial development and political stability are nonsignificant in all the specifications in Table 2. As the next section shows, these results are robust to using other commonly used proxies for both variables.

Next, this section explores the determinants of the depth of IL debt markets, by running the regressions in Table 2, but using IL debt over GDP as the dependent variable. Table 3 reports the results. The following reviews the findings in connection to those for public debt composition.

Similar to the results for IL debt over debt, this analysis finds that countries with higher tax rates (a lower index) have deeper IL debt markets. A one standard deviation increase in the tax burden index is associated with a share of IL debt over GDP almost 2 pp higher, which is arguably a sizable effect, given that the average share of IL debt over GDP is 5%. Moreover, the coefficients on the IT regime, the government spending index, country size, measured by the logarithm of the nominal GDP, and financial development, measured by the financial credit over GDP are all nonsignificant.

As far as the differences are concerned, importantly, the ER regime and lagged inflation do not play a role in the depth of IL debt markets. However, institutional quality does. More politically unstable countries have deeper IL debt markets. A decrease of a one standard deviation in political stability is associated with a depth of IL debt markets 2.5 pp higher.

VI. ROBUSTNESS

This section presents a number of robustness tests that complement the main results. The results of the robustness tests are shown in Tables 4 to 8.

A. Inflation and monetary policy discipline

The first robustness test is related to inflation. The previous results show evidence of a positive association between inflation and the share of IL debt and no association between inflation and the depth of IL debt markets. Because inflation is likely to be an endogenous variable, the Heritage Foundation monetary freedom index is used. The results are reported in columns (1) and (2) in Table 4. The conclusion is that IL debt is unrelated to inflation and the extent of price controls in a country. The monetary freedom coefficients are nonsignificant in both specifications. The coefficients on the ER regime, the tax burden index, and the political stability indicator remain significant and are in line with the previous findings.

High inflation can also be an indicator of poor monetary policy discipline. To explore further whether countries with poor monetary policy discipline issue more IL debt, the analysis runs equation (1) substituting lagged inflation with two other indirect measurements of monetary policy discipline: average inflation and the standard deviation of inflation, both calculated using

a three-year rolling window. The (unreported) results for the former are similar to the ones in specification (1) in Tables 2 and 3. The three-year average inflation is positively correlated with the share of IL debt and unrelated to the depth of IL debt markets. The results for the latter are in columns (3) and (4) in Table 4 and show no significant association between IL debt and the volatility of inflation. Thus, the results lend, if anything, weak support to the hypothesis that countries with less discipline in terms of monetary policy issue more IL debt. These indirect measures of monetary policy credibility also have a poor track record in explaining the share of LC debt in international debt (Hausmann and Panizza (2003) and Engel and Park (2019)).

B. Fiscal variables

The alternative variables used for fiscal health are fiscal revenues over GDP, government spending over GDP, and, as an inverse measure of fiscal health, government spending minus tax revenues. Table 5 reports the results.

Consistent with the previous results, specifications (1) and (2) show that more fiscally responsible countries issue a higher share of IL debt. A one standard deviation increase in tax revenues over GDP, which corresponds to 5.6 pp, is associated with a share of IL debt over debt 4.8 pp higher. Similarly, a one standard deviation decrease in government spending minus tax revenues, which corresponds to 4.6 pp, is associated with a share of IL debt over debt 4.1 pp higher. In these specifications, lagged inflation remains significant and positively associated with IL debt, but the effect of the ER regime disappears. As in the main specifications, when including tax revenues and government spending over GDP, only tax revenues are significant.

The results for IL debt over the GDP are the following. Specification (3) shows that a one standard deviation increase in tax revenues over GDP is associated with IL debt markets 1.9 pp

deeper. The negative and significant coefficient on political stability is robust to including these measures of fiscal health. However, as specification (4) shows, when including the government spending minus tax revenues measure, fiscal health becomes nonsignificant, and so does political stability.

A caveat to keep in mind is that these measures of fiscal health are more likely to be endogenous since they are not indexes but rather the raw macroeconomic data. For this reason, instrumental variable regressions are presented later.

C. Financial development

The results for financial development so far have been clear. The evidence points to financial credit over GDP having no association with IL debt, as a share of public debt and as a share of the GDP. Table 6 explores two other variables capturing financial development: the ratio of credit to GDP and deposit money bank assets as a share of GDP. The results are the same. Financial development does not have a significant relationship with the share of IL debt over debt nor the depth of IL debt markets. The remaining results are broadly in line with the main findings.

D. Institutional variables

In terms of institutional variables, Engel and Park (2019) specifications include government effectiveness, and Hausmann and Panizza (2003) and Burger and Warnock (2006) include a measure of the rule of law. Therefore, this subsection studies the robustness of the institutional

quality results to the inclusion of government effectiveness instead of political stability and the corresponding rule of law index from the World Bank WGI database. Table 7 shows the results.

Government stability and the rule of law do not have a significant effect on IL debt over debt, as specifications (1) and (2) show, but they do have a strong, negative effect on IL debt over GDP. Countries with more ineffective governments and a weaker rule of law have deeper IL debt markets. A one standard deviation increase in government effectiveness and the rule of law is associated with a share of IL over GDP 2.1 and 2.4 pp lower, respectively.

The inclusion of the government effectiveness and the rule of law indicators leave the significance and magnitude of the tax burden effect unchanged but dampens the effect of the ER regime. However, this last finding is sensitive to the variable employed for financial development. Although not reported in the tables, using credit over the GDP instead of financial credit over the GDP recovers the positive and significant coefficient for the ER regime.

E. Instrumental variables

The variables that raise the most endogeneity concerns in equation (1) are the ER regime, the IT regime, inflation, the tax burden index and the government spending index. Countries can directly choose or strongly influence these variables, and, undoubtedly, the degree of public debt indexation plays a role in these decisions. For example, countries with more of their public debt indexed to inflation require a higher inflation rate to erode the real value of their nominal debt. Relatedly, because inflation is costly, a higher degree of public debt indexation might force a country to be more fiscally responsible to repay its public debt if it chooses to keep inflation low.

This subsection aims to deal with these endogeneity concerns by employing instrumental variable regressions. In a nutshell, instruments are variables that influence IL debt only through their effect on the right-hand side variable that they are instrumenting. In a country-level analysis, finding good instruments for the endogenous variables highlighted is a challenge.

Following Claessens et al. (2007) and a somewhat common practice in the economics literature, two lags of the endogenous variables are used as instruments. For these to be valid instruments, they must satisfy two conditions. First, the lagged variables should have an effect on the instrumented variables (relevance condition). The first stage (unreported) shows that these instruments are relevant: the coefficients are all significantly different from zero. Furthermore, they are strong instruments since the F statistics are all larger than 10. Second, the lagged variables should be uncorrelated with the error term in the second stage equation (exclusion restriction), which is impossible to test. However, for it to be met, it is sufficient that the lagged variables influence IL debt only through their effect on the contemporaneous variables. For instance, the lagged ER regime affects IL debt only through the impact the former has on the contemporaneous ER regime, IT regime, inflation, and fiscal health variables. This is possible given the breadth of the instrumented variables, which cover monetary, fiscal, and exchange rate decisions.

The results of the second-stage regressions are in Table 8. The results are roughly in line with the ordinary least squares regressions presented so far —countries with floating currencies and more fiscally responsible issue more IL debt as a share of public debt. Additionally, more politically unstable countries have deeper IL debt markets, but fiscal responsibility does not affect the depth of IL debt markets.

If we believe that the lagged variables satisfy the exclusion restriction, then these coefficients have a causal interpretation. However, Angrist and Krueger (2001) warn that, in the presence of serial autocorrelation of the errors, using lagged variables as instruments is problematic. For this reason, the causal interpretation of these coefficients should be taken with a grain of salt.

VII. CONCLUSIONS

This study shows that IL debt is an increasingly relevant asset in advanced and emerging economies' public debt and that IL debt markets have become, between 1995 and 2017, progressively deeper. Importantly, the analysis demonstrates that governments' reliance on this type of asset and the depth of IL debt markets exhibit large cross-country variation.

Contrary to the early original sin literature, several domestic institutional characteristics play a role in the share of IL debt, both over total public debt and over GDP.

Consistent with the interpretation of IL debt as a commitment device, there is evidence of countries with higher inflation rates, higher three-year inflation rates, and greater political instability issuing more IL debt.

More flexible exchange rate regimes support substantially higher shares of IL debt: between 6.5 and 8.5 pp higher. Consistent with the principle of tax smoothing, more rigid exchange rate regimes incentivize governments to rely on FC debt. IL debt, being in LC, can help decrease governments' exposure to exchange rate risk, especially for those countries that still lack the institutional quality to issue non-indexed LC debt.

For countries wanting to issue more IL debt, the study's findings suggest additional policy prescriptions regarding fiscal health. Countries with higher tax rates, but not necessarily lower government spending, issue more IL debt.

The results presented in this paper point to a number of promising avenues for future research. A limitation of the study is that it is not causal. Most of the analysis is based on observed patterns and associations. Although the study presents instrumental variable regressions, further research with better instruments is necessary before claiming causality. Because the analysis is empirical, it is mostly descriptive and positive in nature. Exploring from a normative perspective the optimal share of IL debt and the optimal depth of IL debt markets is of practical relevance to public debt management. Furthermore, studying the pecking order between LC, IL, and FC debt will improve our understanding of IL debt.

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	IL debt/debt (1)	IL debt/debt (2)	IL debt/debt (3)	IL debt/debt (4)
Lagged variables				
ER regime, fine	0.780**	0.601**		
	(0.350)	(0.272)		
ER regime, coarse			2.429*	1.313
			(1.379)	(1.125)
IT regime, implicit	3.915		4.357	
	(4.103)		(4.103)	
IT regime, formal		2.964		4.903
		(3.800)		(3.836)
Inflation	0.181*	0.161*	0.176	0.189*
	(0.103)	(0.092)	(0.106)	(0.095)
Tax burden, inverse	-0.449***	-0.463***	-0.432***	-0.454***
	(0.139)	(0.138)	(0.145)	(0.137)
Government spending, inverse	0.125	0.126	0.143	0.141
	(0.155)	(0.152)	(0.154)	(0.153)
Contemporaneous variables				
Nominal GDP	-0.433	-0.291	-0.586	-0.012
	(1.474)	(1.893)	(1.479)	(1.928)
Financial credit, over GDP	-0.04	-0.037	-0.048	-0.044
	(0.035)	(0.034)	(0.034)	(0.034)
Political stability	-0.587	-0.621	-0.366	-0.539
	(3.565)	(3.649)	(3.564)	(3.674)
Trend	0.713**	0.740**	0.735**	0.723**
	(0.293)	(0.330)	(0.293)	(0.334)
Constant	-1393.311**	-1448.596**	-1435.589**	-1421.205**
	(555.787)	(620.030)	(552.218)	(625.697)
No. Observations	429	429	429	429
No. Countries	26	26	26	26

Table 2: Estimation results for regressions of the form of equation (1). In all specifications the dependent variable is IL debt over total debt. Significance levels: *p<0.1, **p<0.05, ***p<0.01.

	IL debt/GDP (1)	IL debt/GDP (2)	IL debt/GDP (3)	IL debt/GDP (4)
Lagged variables				
ER regime, fine	0.266	0.281		
	(0.227)	(0.177)		
ER regime, coarse			1.056	1.023
			(0.851)	(0.723)
IT regime, implicit	-0.243		-0.165	
	(2.707)		(2.767)	
IT regime, formal		-0.232		0.102
		(2.511)		(2.613)
Inflation	0.029	0.029	0.023	0.028
	(0.058)	(0.052)	(0.061)	(0.058)
Tax burden, inverse	-0.138*	-0.137*	-0.134*	-0.133*
	(0.077)	(0.073)	(0.078)	(0.072)
Government spending, inverse	-0.071	-0.071	-0.068	-0.068
	(0.055)	(0.054)	(0.053)	(0.053)
Contemporaneous variables				
Nominal GDP	-0.247	-0.265	-0.325	-0.282
	(0.714)	(0.881)	(0.713)	(0.927)
Financial credit, over GDP	0.007	0.007	0.005	0.005
	(0.016)	(0.016)	(0.015)	(0016)
Political stability	-2.814**	-2.812*	-2.762**	-2.774*
	(1.359)	(1.377)	(1.323)	(1.349)
Trend	0.203**	0.202**	0.212**	0.205**
	(0.098)	(0.095)	(0.095)	(0.097)
Constant	-386.797**	-384.543**	-402.180**	-390.769**
	(182.231)	(176.217)	(177.771)	(178.445)
No. Observations	434	434	434	434
No. Countries	26	26	26	26

Table 3: Estimation results for regressions of the form of equation (1). In all specifications the dependent variable is IL debt over GDP. Significance levels: *p<0.1, **p<0.05, ***p<0.01.

	IL debt/debt (1)	IL debt/GDP (2)	IL debt/debt (3)	IL debt/GDP (4)
Lagged variables				
ER regime, fine	0.818**	0.282	0.808**	0.274
	(0.339)	(0.217)	(0.347)	(0.223)
IT regime, implicit	1.829	-1.241	3.364	-0.008
	(4.597)	(3.211)	(3.895)	(2.189)
Monetary freedom index	0.04	0.067		
	(0.109)	(0.082)		
Tax burden, inverse	-0.449***	-0.131*	-0.466***	-0.142*
	(0.143)	(0.076)	(0.151)	(0.076)
Government spending, inverse	0.12	-0.077	0.134	-0.07
	(0.154)	(0.052)	(0.158)	(0.055)
Contemporaneous variables				
Std. deviation of inflation, 3-year rolling window			0.584	0.282
			(0.392)	(0.209)
Nominal GDP	-0.584	-0.288	-0.423	-0.204
	(1.543)	(0.705)	(1.449)	(0.664)
Financial credit, over GDP	-0.046	0.005	-0.046	0.007
	(0.037)	(0.016)	(0.036)	(0.15)
Political stability	-0.868	-3.014**	-0.449	-2.796*
	(3.496)	(1.286)	(3.667)	(1.381)
Trend	0.722**	0.210*	0.824**	0.214*
	(0.317)	(0.114)	(0.357)	(0.105)
Constant	-1407.670**	-404.729*	-1614.450**	-410.479**
	(604.394)	(216.621)	(683.829)	(199.213)
No. Observations	429	434	406	411
No. Countries	26	26	26	26

Table 4: Robustness results for inflation and standard deviation of inflation. The corresponding dependent variable is in the first row. Significance levels: *p<0.1, **p<0.05, ***p<0.01.

	IL debt/debt (1)	IL debt/debt (2)	IL debt/GDP (3)	IL debt/GDP (4)
Lagged variables				
ER regime, fine	0.468	0.422	0.023	-0.071
	(0.290)	(0.303)	(0.172)	(0.189)
IT regime, implicit	4.696	5.754	-0.667	1.511
	(5.210)	(5.192)	(2.731)	(2.838)
Inflation	0.448**	0.472**	0.083	0.136
	(0.187)	(0.199)	(0.081)	(0.104)
Tax revenues, over GDP	0.950**		0.389**	
	(0.371)		(0.150)	
Government spending, over GDP	-0.609		0.325	
	(0.999)		(0.302)	
Government spending minus tax revenues, over GDP		-0.883*		-0.25
		(0.457)		(0.172)
Contemporaneous variables				
Nominal GDP	1.352	1.179	0.717	0.325
	(1.576)	(1.447)	(0.781)	(0.885)
Financial credit, over GDP	-0.025	-0.018	0.001	0.016
	(0.028)	(0.033)	(0.014)	(0.021)
Political stability	-0.434	0.009	-2.414*	-1.501
	(3.378)	(2.820)	(1.336)	(0.093)
Trend	0.392	0.386	0.109	0.093
	(0.230)	(0.238)	(0.074)	(0.086)
Constant	-826.266*	-805.257*	-246.563*	-194.108
	(422.113)	(454.157)	(144.389)	(177.329)
No. Observations	405	405	410	410
No. Countries	26	26	26	26

Table 5: Robustness results for fiscal health. The corresponding dependent variable is in the first row. Significance levels: *p<0.1, **p<0.05, ***p<0.01.

	IL debt/debt (1)	IL debt/debt (2)	IL debt/GDP (3)	IL debt/GDP (4)
Lagged variables				
ER regime, fine	0.873**	0.807**	0.26	0.264
	(0.338)	(0.352)	(0.211)	(0.227)
IT regime, implicit	3.05	4.543	-0.073	-0.199
	(4.321)	(4008)	(2.709)	(2.583)
Inflation	0.19	0.198*	0.019	0.035
	(0.131)	(0.104)	(0.063)	(0.057)
Tax burden, inverse	-0.410***	-0.418***	-0.155*	-0.128
	(0.130)	(0.140)	(0.077)	(0.076)
Government spending, inverse	0.117	0.131	-0.066	-0.07
	(0.145)	(0.158)	(0.057)	(0.056)
Contemporaneous variables				
Nominal GDP	-0.827	-0.797	-0.101	-0.236
	(1.917)	(1.516)	(0.762)	(0.706)
Credit, over GDP	-0.014		-0.002	
	(0.044)		(0.018)	
Bank assets, over GDP		-0.029		0.009
		(0.045)		(0.020)
Political stability	-0.949	-0.728	-2.695*	-2.772*
	(3.354)	(3.518)	(1.399)	(1.367)
Trend	0.658**	0.660**	0.216**	0.221**
	(0.266)	(0.263)	(0.095)	(0.099)
Constant	-1276.999**	-1282.713**	-415.447**	-423.497**
	(497.841)	(493.338)	(177.723)	(184.656)
No. Observations	430	426	434	430
No. Countries	26	26	26	26

Table 6: Robustness results for financial development. The corresponding dependent variable is in the first row. Significance levels: *p<0.1, **p<0.05, ***p<0.01.

	IL debt/debt (1)	IL debt/debt (2)	IL debt/GDP (3)	IL debt/GDP (4)
Lagged variables				
ER regime, fine	0.581	0.582	0.347	0.337
	(0.502)	(0.515)	(0.210)	(0.216)
IT regime, implicit	3.677	3.5	-0.54	-0.321
	(4.012)	(3.986)	(2.153)	(2.297)
Inflation	0.27	0.258	-0.015	0.001
	(0.188)	(0.162)	(0.067)	(0.055)
Tax burden, inverse	-0.405**	-0.391**	-0.199**	-0.206**
	(0.152)	(0.149)	(0.084)	(0.080)
Government spending, inverse	0.177	0.166	-0.054	-0.044
	(0.166)	(0.150)	(0.051)	(0.051)
Contemporaneous variables				
Nominal GDP	-0.636	-0.681	-0.199	-0.168
	(1.686)	(1.791)	(0.838)	(0.877)
Financial credit, over GDP	-0.067	-0.061	0.014	0.008
	(0.054)	(0.043)	(0.020)	(0.018)
Government effectiveness		3.679		-2.733*
		(7.271)		(1.539)
Rule of law	3.488		-2.800*	
	(6.870)		(1.490)	
Trend	0.830**	0.826**	0.212*	0.223*
	(0.360)	(0.355)	(0.106)	(0.109)
Constant	-1627.598**	-1619.852**	-402.415*	-425.200**
	(690.697)	(679.120)	(198.744)	(201.082)
No. Observations	429	429	434	434
No. Countries	26	26	26	26

Table 7: Robustness results for institutional variables. The corresponding dependent variable is in the first row. Significance levels: *p<0.1, **p<0.05, ***p<0.01.

	IL debt/debt (1)	IL debt/GDP (2)
ER regime, fine	0.804**	0.298
	(0.351)	(0.226)
IT regime, implicit	6.361	-0.048
	(5.530)	(3.720)
Inflation	0.415	0.061
	(0.323)	(0.137)
Tax burden, inverse	-0.503***	-0.141
	(0.163)	(0.092)
Government spending, inverse	0.141	-0.077
	(0.173)	(0.061)
Nominal GDP	-0.037	-0.193
	(1.590)	(0.832)
Financial credit, over GDP	-0.046	0.005
	(0.035)	(0.014)
Political stability	-0.163	-2.679**
	(3.581)	(1.272)
Trend	0.762**	0.209*
	(0.345)	(0.111)
Constant	-1502.365**	-399.204**
	(657.765)	(203.553)
No. Observations	393	397
No. Countries	26	26

Table 8: Instrumental variable regressions. The corresponding dependent variable is in the first row. Significance levels: *p<0.1, **p<0.05, ***p<0.01.

APPENDIX

A.1. Appendix to Section III

IL debt	Source	Coverage
Argentina, Australia, Brazil, Canada, Germany, India, Israel, Mexico, Peru, Poland, South Africa, Spain, Thailand, United States	Bank of International Settlements (BIS)	1995-2017
Chile	BIS	2003-2016
Colombia	BIS	1996-2017
Czech Republic	BIS	1999-2017
France	Agence France Tresor	1999-2017
Hungary	BIS	1997-2017
Italy	Ministero dell 'Economia e delle Finanze	2003-2017
Japan	Ministry of Finance	2013-2017
Korea	BIS	2002-2017
Russia	BIS	2004-2017
Sweden	Swedish Debt Office	1995-2017
Turkey	BIS	2000-2017
United Kingdom	BIS	2004-2017

Table A.1. Data sources and coverage for IL debt

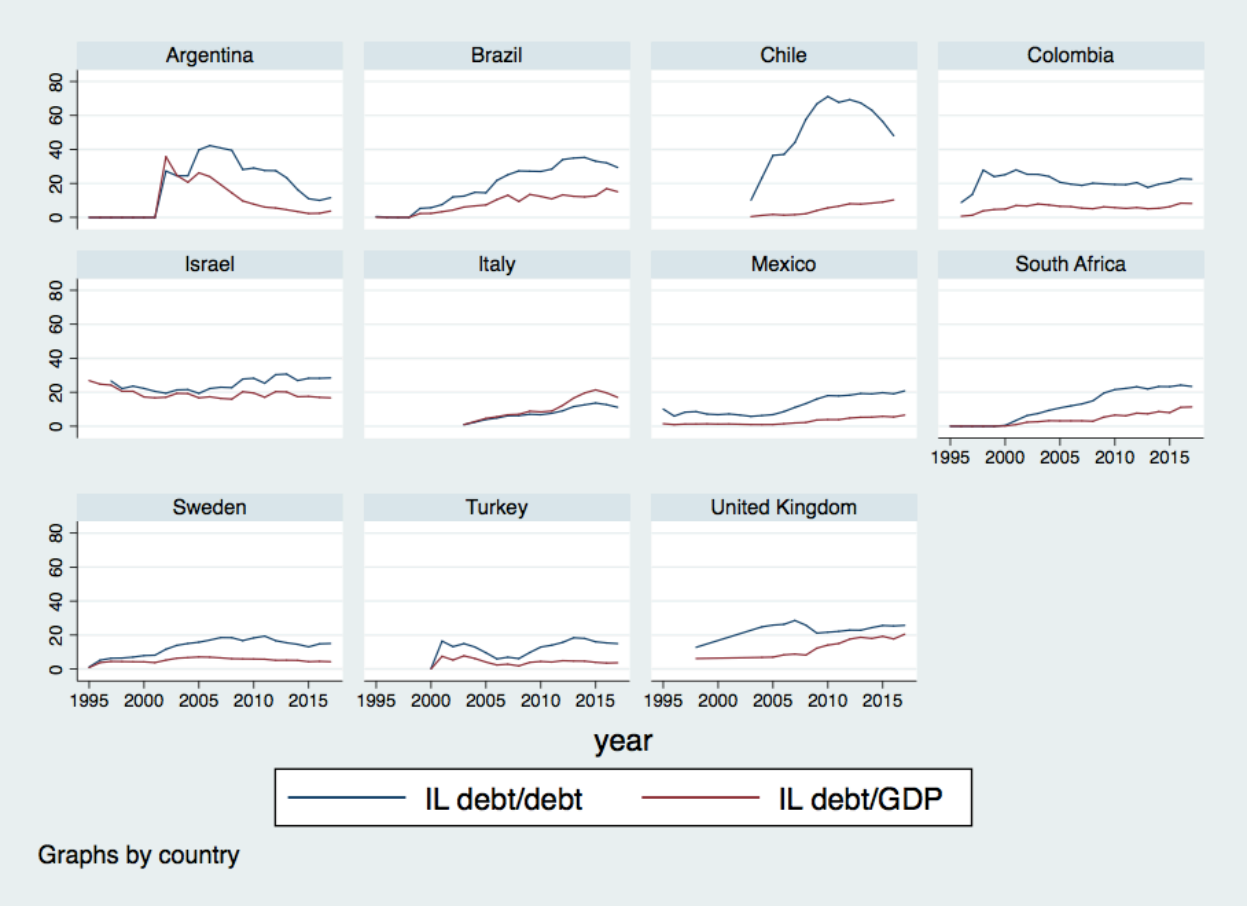

Figure A.1: IL debt as a share of total debt and GDP, by country between 1995-2017. Sources: See Table A.1.

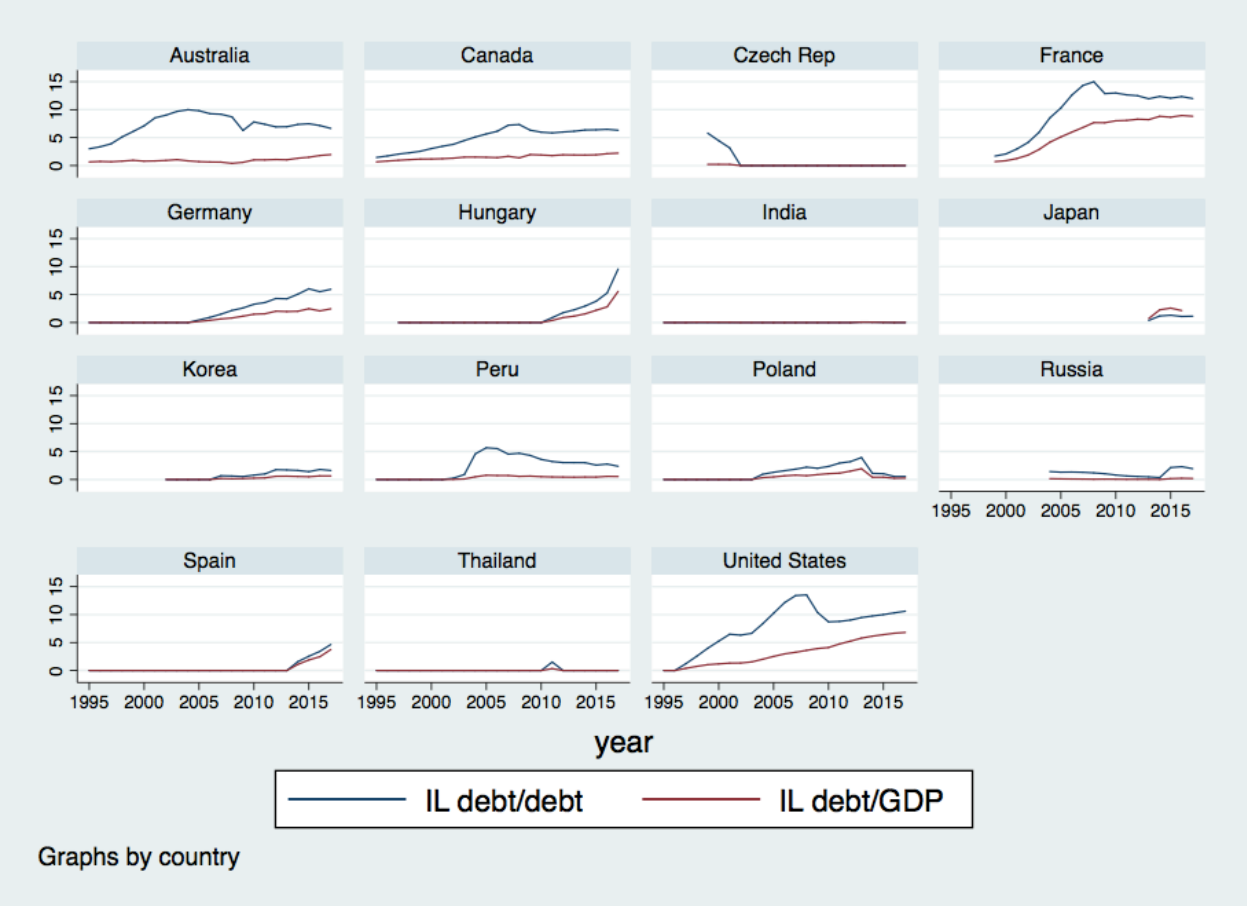

Figure A.2: IL debt as a share of total debt and GDP, by country between 1995-2017. Sources: See Table A.1.

Country	Starting date of IL debt issuance	Country	Starting date of IL debt issuance
Argentina	2002	Japan	2013 Also, 2004-2008
Australia	1985	Korea	2007
Brazil	1964	Mexico	1989
Canada	1991	Peru	2003
Chile	1956	Poland	2004
Colombia	1967	Russia	2004
Czech Republic	1999	South Africa	2000
France	1998	Spain	2014
Germany	2006	Sweden	1994
Hungary	2011	Thailand	2011
India	1998	Turkey	2000
Israel	1955	United Kingdom	1981
Italy	2003	United States	1997

Table A.2. Starting date of IL debt issuance, by country. Sources: for emerging markets Gomez-Gonzalez (2019) and the sources mentioned in Table A.13, Bank of International Settlements Table C2, Appendix A in Fleckenstein (2013), McCray (1997) for Australia, Thedeen (2004) for Sweden, Japan's Ministry of Finance and Lazard (2017) for Israel.

Variable	Inverse normal Z statistic	p-value
IL debt over debt	-0.296	0.384
IL debt over GDP	1.608	0.946
ER regime	-4.655	0.000
IT regime	-2.022	0.022
Inflation	-8.947	0.000
Tax burden	-2.403	0.008
Government spending	-1.985	0.024
Nominal GDP	3.557	1.000
Financial credit over GDP	1.064	0.856
Political stability	-2.408	0.008

Table A.3. Results of Choi (2001) unit root tests for panel data. The statistic used is the inverse normal Z statistic because Choi (2001)'s simulations suggest that this statistic offers the best trade-off between size and power. The number of lags used in the Augmented Dickey-Fuller equations is one. The null hypothesis is that all panels contain unit roots. The alternative hypothesis is that at least one panel is stationary