Inflation-linked public debt in emerging economies ☆

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Abstract

This study reports a set of stylized facts about inflation-linked (IL) public debt in emerging economies. On average, emerging economies issue 23% of their local currency (LC) public debt linked to inflation. IL debt issuance is countercyclical, increases in periods of nominal exchange rate depreciations, and substitutes foreign currency (FC) and non-indexed local currency debt. A two-sector small-open economy model of public debt composition can deliver the business-cycle properties of IL debt and shows that, during crises, amid nominal exchange rate depreciations, IL debt becomes cheaper to issue. The study finds evidence of IL rates decreasing in about half of the most recent crises in emerging economies. Finally, the study compares IL rates to FC and LC rates and concludes that, for some countries, IL rates are below LC rates, even after accounting for expected inflation.

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1. Introduction

Emerging economies issue a sizeable share of their public debt linked to inflation. Since 2004, in the study's sample, emerging economies have issued, on average, 23% of their local currency (LC) public debt linked to inflation and emerging economies' issuance of this type of debt has increased, on average, by five times since 1995.

Furthermore, for almost half the countries in the study's sample, inflation-linked (IL) rates are below LC rates, even after accounting for expected future inflation rates. For these countries, IL rates are between 1.2 and 5 percentage points lower than LC rates.

Despite the quantitative importance of this type of bond and the policy implications regarding IL rates in comparison to LC rates for some countries in the sample, relatively little is known about IL debt's business cycle properties. This paper aims to fill this gap.

The data shows evidence of the IL debt issuance being countercyclical, increasing when the domestic currency is weaker, and substituting FC debt and non-indexed LC debt issuance.

Previous work has studied IL debt vis-à-vis non-indexed LC debt (Bohn (1988), Bohn (1990), Calvo and Guidotti (1990), Diaz-Gimenez et al. (2008), Alfaro and Kanczuk (2010), Sunder-Plassmann (2017)). This study complements this literature by examining IL debt vis-à-vis FC debt and by offering a description of the IL debt issuance's business cycle properties.

To this end, the study presents a two-sector small-open economy model of public debt composition, where a government, who needs to finance an exogenous level of government spending, raises taxes, issues IL and FC debt in foreign debt markets, and commits to repay both types of securities.

The model abstracts from sovereign default because there is no evidence of differential sovereign risk associated to LC and FC debt (Du and Schreger (2016), Jeanneret and Souissi (2016)). The rationale for contemplating differential LC/FC sovereign risk in the first place is that, LC debt burden can be inflated-away, making outright default unnecessary for a country that wishes to renege on its debt. However, because IL debt is indexed, it cannot be inflated-away, implying that, from a sovereign risk perspective, it is like FC debt (Fleckenstein et al. (2014)).

Aside from outright default, underreporting inflation data defrauds holders of IL debt, whose returns fall short of protecting against actual realized inflation. With the exception of Argentina, the credibility of inflation statistics, for the countries in the study's sample, is not a source of concern[2] and, hence, the model abstracts from inflation statistics misreporting.

The key result of the model is that during an economic crisis, when the economy endures a nominal exchange rate depreciation, IL debt becomes cheaper to issue, making the government move away from FC debt and increase its IL debt issuance. The reason is that, if bad shocks are short-lived, a depreciation now implies an expected appreciation in the near future, low-

[2]See, for example, The Economist's argument to stop reporting official inflation statistics in 2014 (`https://www.economist.com/leaders/2014/06/20/dont-lie-to-me-argentina`).

ering foreign investors' required return to buy IL debt.

Under the purview of this model, the country substitutes FC debt for IL debt because the latter becomes cheaper to issue during crises. To explore whether the data supports this finding, the study examines the behavior of IL rates around recent crises in emerging economies and finds that, in approximately half of them, IL rates fell.

The rest of the paper is structured as follows. Section 2 presents the stylized facts about IL debt issuance for a sample of emerging economies. Section 3 lays out the baseline model. Section 4 presents the key result on the substitution of FC debt for IL debt. Section 5 explores IL rates during recent crises in emerging economies and investigates the role of expected inflation and expected exchange variations in explaining the positive FC-IL and LC-IL rate differentials. Section 6 concludes the study.

1.1. Literature Review

This study is related to several strands of the literature. First, it is related to the literature on IL public debt and the references cited in the previous subsection. These studies all examine IL public debt vis-à-vis non-indexed LC debt in an environment where the government lacks commitment. In such environment, the IL debt proves beneficial by acting as a commitment device for the government, lowering the cost of borrowing. The drawback of IL debt lies in the government's inability to introduce state-contingency through inflation.

Second, it is related to the vast literature on FC debt, which studies FC debt vis-à-vis LC debt. The 'original sin', or emerging economies' inability to borrow abroad in LC, gained considerable attention (Eichengreen et al.

(2005, 2007)). Recently, Du and Schreger (2016) notice an improvement in this situation and Du et al. (2016) find greater improvements in this situation for countries with high monetary policy credibility. From a normative perspective, Engel and Park (2017) and Ottonello and Perez (Forthcoming) examine the optimal composition of LC and FC debt in an environment with strategic default and/or strategic debasement through inflation. In this literature, FC debt acts as a commitment device for the government, lowering the cost of borrowing. The drawback of FC debt, like IL debt in the previous literature, lies in the government's inability to introduce state-contingency through inflation.

This study complements the two previous literatures by studying IL debt vis-à-vis FC debt and describing IL debt's business cycle properties.

Third, it is related to the literature on asset heterogeneity in public debt. In addition to the FC/LC debt dychotomy and the references mentioned above, the maturity composition of public debt obtained substantial attention (Arellano and Ramanarayanan (2012), Broner et al. (2013), Fernandez and Martin (2015), Aguiar et al. (2016), Bocola and Dovis (2016)). This study focuses on IL debt, relatively understudied in the literature on asset heterogeneity in public debt.

Finally, from the modeling standpoint, to study the business cycle properties of IL debt, the paper uses a standard real business-cycle model with two sectors of production similar to those in Mendoza (1995), Stockman and Tesar (1995), Corsetti et al. (2008), and Schmitt-Grohe and Uribe (2018) to name a few. The model in this study embeds a government, taxes, and two types of bonds and is able to study the cyclical behavior of bond rates.

2. Stylized Facts

This section compiles a set of stylized facts about IL debt issuance for a sample of emerging economies. Appendix A lists the countries in the sample and the data sources.

Fact 1: Emerging economies have issued, on average, 13% of their public debt linked to inflation between 2004 and 2016. This represents 23% of their LC debt.

Table 1 shows the share of IL debt over total debt (column 2) and the share of IL debt over LC debt (column 3) between 2004 and 2016. The last row shows the average IL debt issuance for the countries in the sample—13.3% of total public debt and 22.9% of LC debt.

The table shows substantial heterogeneity across countries. Five countries (i.e., Hungary, India, Peru, Poland, and Russia) issue less than 3% of their total debt linked to inflation, while the remaining countries in the sample, issue a more substantial share. Figures A.3 and A.4 in Appendix A plot the entire time-series of IL debt over total debt for the two groups of countries in the sample.

Columns 4 and 5 in table 1 show that, on average, IL debt has increased fivefold since 1995, while public debt has, on average, only tripled. All countries, except Argentina, India, Poland, and Turkey, have increased their IL debt issuance by more than their total public debt issuance.

Understanding the cross-section heterogeneity in table 1 or why some emerging economies (e.g., Czech Republic, Indonesia, Malaysia or Thailand) refrain from issuing this type of debt is outside the scope of this study[3].

Fact 2: IL rates are below FC and LC rates.

IL rates are below FC rates and LC rates for most of the economies in the sample and for most of the time period considered. See figures A.6 and A.7 in Appendix A for IL and FC rates and A.8 and A.9 in the same appendix for IL and LC rates. There are some exceptions, but most of the countries during most of the period under consideration exhibit a positive differential between the FC and the IL rates and between the LC and the IL rates.

Table 2 shows the average IL rate (column 2), FC rate (column 3), and LC rate (column 4). The last two rows report the cross-sectional average for each of these rates and show that, in the cross-section, IL rates are 1.7 percentage points lower than FC rates, when excluding Argentina's 2001 default, and 4.8 percentage points lower than LC rates.

The degree to which expected inflation rates and expected exchange rate variations can explain the differences in rates is explored in the last section of the paper.

The remaining facts refer to the business cycle properties of IL debt. For IL debt, I use issuance data between 1995 and 2016 deflated using the GDP deflator. The remaining variables of interest are the following: real GDP, FC and non-indexed LC debt deflated using the GDP deflator, the nominal exchange rate defined as units of LC to buy 1 US dollar, real effective

[3] Du et al. (2016) find that only countries with high monetary policy credibility can afford issuing LC debt instead of FC debt. Insofar IL debt resembles FC debt, the high IL debt economies should have low monetary policy credibility.

IL debt in emerging economies, 2004-2016				
Country	IL debt/debt	IL debt/LC debt	ΔILD	Δ Debt
Argentina	20.5%	52.2%	0.4	7.8
Brazil	18.1%	28.7%	6.7	3.5
Chile	48.1%	82.3%	22.0	5.7
Colombia	15.8%	25.5%	2.7	2.8
Hungary	2%	3.4%	6.7	1.1
India	0.1%	0.1%	0.5	2.1
Mexico	12.5%	14.5%	8	4.1
Peru	2.2%	11.0%	3.2	1.1
Poland	1.6%	2.4%	1.2	2.4
Russia	0.6%	1.7%	3.3	3
South Africa	14.5%	20.2%	4.4	4.4
Turkey	10.9%	16.0%	1.2	2.2
Average	13.3%	22.9%	5	3.3

Table 1: Average Inflation-Linked Public Debt (as % Total Public Debt and as % of Local Currency Public Debt) between 2004–2016. Averages are conditional on the country issuing this type of bond. Increases in IL debt issuance and total Public Debt issuance in number of times between 1995–2016. Sources: See Appendix A.

Interest rates on different debt instruments, 2002-2017			
Country	IL rate (r^{IL})	FC rate (r^{FC})	LC rate (r^{LC})
Argentina	10.1%	16.7%	23.3%
Brazil	6.3%	7.7%	13.9%
Chile	2.6%	4.9%	5.0%
Colombia	4.7%	6.7%	7.4%
Hungary	-	4.8%	6.5%
India	5.6%	3.4%	7.9%
Mexico	3.7%	5.7%	7.4%
Peru	6.3%	6.5%	6.2%
Poland	2.5%	4.5%	5.3%
Russia	2.9%	6.9%	7.8%
South Africa	2.4%	5.6%	9.1%
Turkey	2.5%	7.3%	20.2%
Average	4.6%	6.9%	9.4%
Excluding Argentina 2001Q4-2005Q2	4.6%	6.3%	9.4%

Table 2: Interest Rates on different Debt Instruments: IL, FC and LC debt.Time coverage depends on country and instrument. See Appendix A for time coverage and sources.

exchange rates (REER) defined as the real exchange rate against the basket of the country's trading partners, and the GDP deflator and the consumer price index (CPI) as measures of inflation. For data sources, see Appendix A.

Table A.12 in Appendix A shows the results of Im et al. (2003) unit root tests for panel data with heterogenous panels for the aforementioned variables. The conclusion of these tests is that we cannot reject the presence of unit roots in all panels for all variables. Hence, to make the series stationary, the stylized facts that follow use the first differences of log variables.

Stylized facts 3-6 refer to table 3, which reports fixed-effects regression coefficient estimates of β for regressions of the form:

$$\Delta ILD_{i,t} = \alpha_i + \beta \Delta x_{i,t} + \epsilon_{it} \tag{1}$$

where $\Delta ILD = ln(ILD_t) - ln(ILD_{t-1})$ denotes the log difference of IL debt issuance, $\Delta x = ln(x_t) - ln(x_{t-1})$ denotes the log differences of the different variables of interest in column 1 of table 3, and α_i denotes country fixed-effects.

The β coefficient in specification (1) states how much does ΔILD change, for a given country, as Δx varies over time. This is exactly the correlation of interest. The change in Δx across time can be due to common time shocks to all countries, since specification (1) omits time fixed-effects.

Table 3 reports the β coefficient estimates in the sample with (column 2) and without Argentina (column 3). The reason to study a subsample without Argentina is the lack of credibility of its official statics, which caused investors to move away from this country's IL debt[4], making IL debt issuance likely to be less related to the Argentinean business cycles. Furthermore, this lack of credibility might explain the substantial decline, since 2004, in the Argentinean share of public debt linked to inflation shown in table A.14 in Appendix A.

Fact 3: When excluding Argentina from the sample, IL debt issuance is countercylical.

The coefficient on real GDP in table (3) shows that a 1% increase in real GDP is associated with a 5.3% drop in the amount of IL debt issued, when Argentina is excluded from the sample.

By including Argentina in the sample, the p-value of the regression increases to 0.102, and hence barely non-significant at a 10% significance level. However, it is hardly surprising that including Argentina in the sample causes IL debt issuance to become unrelated to the country's real GDP, since Argentina's IL debt issuance was most likely related to the lack of demand from investors, due to official inflation underreporting.

Fact 4: IL debt issuance substitutes FC and non-indexed LC debt issuance.

A 1% drop in FC debt issuance increases IL debt issuance by 0.2% and a 1% drop in non-indexed LC debt issuance increases IL debt issuance by 0.4% (or 0.3% in the sample without Argentina).

The model in the next section focuses on the substitution of FC debt for IL debt, since it is one of the study's novel finding. Figure A.5 in Appendix

[4]The Financial Times reported in 2012 about this on "Argentina: inflation-linked peso bonds take a dive". Financial Times. July 16, 2012.

Estimates of β coefficient in fixed-effects regressions of the form $\Delta ILD_{i,t} = \alpha_i + \beta \Delta x_{i,t} + \epsilon_{it}$		
	All Sample	Excluding Argentina
GDP	-3.537	-5.331*
	(2.85)	(2.77)
FC debt	-0.220**	-0.19**
	(0.08)	(0.06)
Nominal debt	-0.406**	-0.291*
	(0.18)	(0.14)
Debt	-0.167	0.05
	(0.27)	(0.23)
Exchange rate	1.411*	1.664*
	(0.78)	(0.79)
REER	-2.026	-2.232
	(1.18)	(1.24)
GDP Deflator	2.883	3.722
	(2.05)	(2.07)
CPI	-	3.606*
		(1.96)

Table 3: Estimates of β coefficient in fixed-effects regressions of the form $\Delta ILD_{i,t} = \alpha_i + \beta \Delta x_{i,t} + \epsilon_{it}$. Robust standard errors are in parantheses. Significance levels: $^{*}p < 0.1, ^{**}p < 0.05, ^{***}p < 0.01$

A shows the shares of IL debt and FC debt (over total government debt) between 2004 and 2016 for Chile, Hungary, Mexico, and Peru. Chile in the first row is a particularly good example of the substitution of FC debt for IL debt.

Fact 5: Emerging economies increase IL debt issuance when the nominal exchange rate depreciates.

A 1% depreciation in the exchange rate increases IL debt issuance by 1.4% and 1.7% in the sample without Argentina. The behavior of the exchange rate is key to understand the substitution of FC debt for IL debt. The model in the next section makes this clear.

Fact 6: Emerging economies increase IL debt issuance when inflation is high.

The estimated coefficient for the CPI is evidence of this. Due to unavailability of Argentinean inflation data, the estimate is only reported for the sample without Argentina. A 1% increase in inflation is associated with a 3.6% increase in IL debt issuance.

This association could mask reverse-causality. When governments issue more of their debt linked to inflation, eroding the real value of the total debt stock requires a higher inflation rate. Thus, a non-independent Central Bank would let inflation increase as a response to the government's IL debt issuance. However, all countries in the study's sample have inflation-targeting (IT) Central Banks. See table A.13 in Appendix A for the dates of IT adoption.

Table 4 show the relationship between inflation and IL debt issuance for

Estimates of β coefficient in fixed-effects regressions of the form $\Delta ILD_{i,t} = \alpha_i + \beta \Delta x_{i,t} + \epsilon_{it}$		
	After IT adoption	After IT adoption excl. Argentina
GDP Deflator	-	3.415
	-	(1.93)
CPI	-	1.156
	-	(3.39)

Table 4: Estimates of β coefficient in fixed-effects regressions of the form $\Delta ILD_{i,t} = \alpha_i + \beta \Delta x_{i,t} + \epsilon_{it}$, including only IT years. Robust standard errors are in parantheses. Significance levels: $^{*}p < 0.1,^{**} p < 0.05,^{***} p < 0.01$

the subsample in which countries are inflation-targeters[5]. The point estimates remain positive, but lose significance.

Because the association between inflation and IL debt is absent for the IT years and all countries in the study's sample have IT Central Banks, the model in the next section concentrates on the previous stylized facts. Even if IT Central Banks had the incentive to miss their target and let inflation increase, this would be most relevant for the IL/LC dychotomy and less for the IL/FC dychotomy. Indeed, an increase in inflation would depreciate the currency, making both IL and FC debt comparable.

To sum-up, the next section studies facts 3-5 in a two-sector real business cycle model.

[5]Argentina became an IT officially in the beginning of 2017 and the study's sample covers only until 2016. Thus, when restricting the sample to countries being IT, Argentina is always excluded.

3. Model of Public Debt Composition

This section presents a small-open economy model of public debt composition, where a government raises taxes and issues IL and FC debt to finance an exogenous level of government spending.

3.1. Model Set-up: Domestic Economy

There are infinite periods and three goods: non-tradables, home- and foreign-produced tradables. The domestic economy is populated by a large number of risk-averse consumers, who supply sector-specific labor to domestic firms, and a government.

Let c_t denote consumption, $h_{N,t}$ labor in the non-tradable sector, and $h_{H,t}$ in the home-produced tradable sector. Household preferences are given by:

$$E_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{c_t^{1-\sigma}}{1-\sigma} - \frac{h_{N,t}^{1+\zeta}}{1+\zeta} - \frac{h_{H,t}^{1+\zeta}}{1+\zeta} \right] \tag{2}$$

where β is the domestic discount factor, which lies between 0 and 1 and c_t is a composite of tradable and non-tradable goods.

The constant elasticity of substitution (CES) consumption bundle c_t is defined by:

$$c_t = \left[(\omega_T)^{\frac{1}{\rho}} (c_{T,t})^{\frac{\rho-1}{\rho}} + (1-\omega_T)^{\frac{1}{\rho}} (c_{N,t})^{\frac{\rho-1}{\rho}} \right]^{\frac{\rho}{\rho-1}} \tag{3}$$

where $c_{N,t}$ is the consumption of non-tradable goods and $c_{T,t}$ is a composite of tradable goods given by

$$c_{T,t} = \left[(\omega_H)^{\frac{1}{\rho_T}} (c_{H,t})^{\frac{\rho_T-1}{\rho_T}} + (1-\omega_H)^{\frac{1}{\rho_T}} (c_{F,t})^{\frac{\rho_T-1}{\rho_T}} \right]^{\frac{\rho_T}{\rho_T-1}} \tag{4}$$

where $c_{H,t}$ is the consumption of home-tradable goods and $c_{F,t}$ is the consumption of foreign-tradable goods.

The corresponding idealized price indices equal:

$$P_t = \left[(\omega_T)(P_{T,t})^{1-\rho} + (1-\omega_T)(p_{N,t})^{1-\rho}\right]^{\frac{1}{1-\rho}} \tag{5}$$

$$P_{T,t} = \left[(\omega_H)(p_{H,t})^{1-\rho_T} + (1-\omega_H)(p_{F,t})^{1-\rho_T}\right]^{\frac{1}{1-\rho_T}} \tag{6}$$

The price of the foreign good abroad $p^{\star}_{F,t}$ is normalized to 1. Thus, the price of the foreign-tradable good $p_{F,t}$ equals the nominal exchange rate, e_t, defined as the amount of LC needed to purchase one unit of FC. Using this definition, a depreciation is an increase in e_t.

Households supply sector-specific labor, obtain an after-tax nominal wage of $(1-\tau_t)W_{j,t}$ from each sector $j = \{N, H\}$, and are prevented from making intertemporal choices. Instead, the government, who has access to international capital markets, makes transfers to them. The households' budget constraint in local currency is given by:

$$P_t C_t = (1-\tau_t)W_{j,t}h_{j,t} + T_t \ \ where \ \ j = \{N, H\} \tag{7}$$

where T_t are government's transfers to households.

Consumers' maximization of (2) subject to (7) gives rise to the following intratemporal optimality conditions:

$$c^{\sigma} h^{\zeta}_{N,t} = \frac{(1-\tau_t)W_{N,t}}{P_t} \tag{8}$$

$$c^{\sigma} h^{\zeta}_{H,t} = \frac{(1-\tau_t)W_{H,t}}{P_t} \tag{9}$$

which are the households' sector-specific labor supplies.

Households' utility maximization also implies the following demand functions for each type of good:

$$c_{T,t} = \omega_T (p_{T,t})^{-\rho} c_t \tag{10}$$

$$c_{N,t} = (1-\omega_T)(p_{N,t})^{-\rho} c_t \tag{11}$$

$$c_{H,t} = \omega_H (p_{H,t})^{-\rho_T} c_{T,t} \tag{12}$$

$$c_{F,t} = (1-\omega_H)(e_t)^{-\rho_T} c_{T,t} \tag{13}$$

The home-tradable and non-tradable sectors both feature perfectly competitive firms that maximize profits $\pi_{j,t} = p_{j,t} y_{j,t} - W_{j,t} h_{j,t}$ for each sector j. Production functions $y_{j,t}$ are given by:

$$y_{N,t} = A_{N,t} h_{N,t}^{\alpha_N} \tag{14}$$

$$y_{H,t} = A_{H,t} h_{H,t}^{\alpha_H} \tag{15}$$

where $A_{N,t}$ and $A_{H,t}$ are exogenous productivity processes and where the sector-specific labor intensities, α_N and α_H, can be different.

Profit maximization implies that nominal wages are equated to the value of marginal products:

$$W_{N,t} = p_{N,t} A_{N,t} \alpha_N h_{N,t}^{\alpha_N - 1} \tag{16}$$

$$W_{H,t} = p_{H,t} A_{H,t} \alpha_H h_{H,t}^{\alpha_H - 1} \tag{17}$$

The government is required to finance the purchase of non-tradable goods for government spending g_t by raising tax revenues on labor income and issuing a fixed quantity of public debt $\bar{d}$. Within its public debt issuance, the government can issue IL bonds (d_t^{IL}) or FC bonds (d_t^{FC}) to foreign investors. The gross rates of return are R_t^{IL} and R_t^{FC}, respectively.

The government transfers the government spending to households: $T_t = p_{N,t} g_t$ and is subject to the following budget constraint in local currency:

$$p_{N,t} g_t + R_{t-1}^{IL} P_t d_{t-1}^{IL} + R_{t-1}^{FC} e_t d_{t-1}^{FC} = \tau_t (W_{N,t} h_{N,t} + W_{H,t} h_{H,t}) + e_t d_t^{FC} + P_t d_t^{IL} \tag{18}$$

where expenses are on the left-hand side and revenues on the right-hand side. FC bonds are pre-multiplied by the exchange rate because the budget constraint is in local currency and IL bonds are pre-multiplied by the price level because they are effectively real securities. Alfaro and Kanczuk (2010), for example, introduce IL bonds in the budget constraints in the same way. The timing is such that, bond levels chosen today have the t, and not $t+1$ subscript.

The next subsection presents foreign investors utility maximization problem, which pins down bond rates, R_t^{IL} and R_t^{FC}, and provides empirical support for all bonds being held abroad.

3.2. Foreign Investors

Foreign investors are risk-neutral, buy both types of bonds, and have a discount factor $\beta^\star$ between 0 and 1. Their utility maximization problem is given by:

$$max \qquad E_0 \sum_{t=0}^{\infty} (\beta^\star)^t C_t^\star \tag{19}$$

$$\begin{aligned} s.t. \qquad & C_t^\star + d_t^{FC} + \frac{P_t d_t^{IL}}{e_t} \\ = \quad & \epsilon_t^\star + R_{t-1}^{IL} \frac{P_t d_{t-1}^{IL}}{e_t} + R_{t-1}^{FC} d_{t-1}^{FC} + \frac{\Psi}{2} \left(\frac{P_t d_t^{IL}}{e_t} \right)^2 \end{aligned} \tag{20}$$

where $C_t^\star$ is foreign consumption, R_{t-1}^{IL} and R_{t-1}^{FC} are the (gross) bond rates for $t-1$ bonds, and $\epsilon_t^\star$ is some endowment in foreign currency.

FC bonds pay in FC and, hence, enter the budget constraint directly. IL bonds are pre-multiplied by the domestic price level, P_t, to transform them into LC (Alfaro and Kanczuk (2010)) and then divided by the exchange rate e_t to convert them to FC.

Foreign investors are assumed to obtain a quadratic benefit of holding IL debt. The model is agnostic about the source of this benefit, but it allows the model to match,in steady state and for non-negative IL debt levels, $R_t^{IL} < R_t^{FC}$, reported in section 2, fact 2. This modeling strategy is similar to the one in Rabanal and Tuesta (2013), where a quadratic cost of holding FC debt for domestic households introduces a wedge between LC and FC rates [6].

Foreign investors' optimization gives rise to the following gross rates of return on FC and IL debt:

$$R_t^{FC} = \frac{1}{\beta^\star} \tag{21}$$

$$R_t^{IL} = \frac{1 - \psi \frac{P_t d_t^{IL}}{e_t}}{\beta^\star E_t \frac{\pi_{t+1}}{\Delta e_{t+1}}} \tag{22}$$

where $\pi_{t+1} = \frac{P_{t+1}}{P_t}$ and $\Delta e_{t+1} = \frac{e_{t+1}}{e_t}$.

The intuition for the expressions are as follow. The FC bond, absent default risk, is safe from the foreign investors' perspective and, thus, to break-even foreign investors only need to be promised the inverse of the discount factor. The IL bond becomes more attractive, requiring a lower rate of return, when investors expect inflation to increase, when investors expect a future appreciation, and when the *ad hoc* benefit of holding IL debt increases.

The model features all public debt held abroad. This is line with the tradition of studying external debt for emerging economies (Eaton and Gersovitz (1981), Aguiar and Gopinath (2006), Arellano (2008)). More importantly, it

[6] Alternatively, the model in this study could feature a cost of holding FC debt for foreign investors.

is consistent with the empirical evidence on FC and IL bond ownership. The majority of external debt is in FC (Du and Schreger (2016), Ottonello and Perez (Forthcoming)). There is also scattered evidence of foreign participation in IL debt markets. For example, 9% of 2016's Brazilian external debt is inflation-linked[7] and 25% of the Russian 2015 IL debt issuance was bought by foreign investors [8]. Thus, it is consistent with the investor base composition of FC and IL debt, that both bonds are priced by foreign investors.

3.3. Equilibrium

This subsection presents the model's equilibrium conditions. Market clearing in the public debt market and the non-tradable production sector, respectively, imply that:

$$d_t^{IL} + d_t^{FC} = \bar{d} \tag{23}$$

$$c_{N,t} + g_t = y_{N,t} \tag{24}$$

We define the value of exports, x_t, and the value of imports, m_t as:

$$x_t = p_{H,t}(y_{H,t} - c_{H,t}) \tag{25}$$

$$m_t = e_t c_{F,t} \tag{26}$$

[7] See the 2016 Annual Debt Report at (http://www.tesouro.fazenda.gov.br/documents/10180/269444/RAD_2016_ingles_EN.pdf/c3ae2138-7077-4c29-a383-3f3940f67311).

[8] See the Russian Ministry of Finance Report titled "A debut Issue of Sovereign Inflation-Indexed Bonds by the Russian Federation" at http://old.minfin.ru/common/upload/library/2015/09/main/OFZ-IN_case_study_ENG.pdf.

Finally, the economy's position with respect to the rest of the world is given by:

$$e_t d_t^{FC} + P_t d_t^{IL} - R_{t-1}^{FC} e_t d_{t-1}^{FC} - R_{t-1}^{IL} P_t d_{t-1}^{IL} = m_t - x_t \tag{27}$$

which states that trade deficits need to be financed by issuing external — FC and IL — debt.

The equilibrium is given by a set of 22 unknowns $\{c_t, c_{T,t}, c_{N,t}, c_{H,t}, c_{F,t}, h_{H,t}, h_{N,t}, W_{H,t}, W_{N,t}, y_{N,t}, y_{H,t}, P_t, P_{T,t}, p_{N,t}, p_{H,t}, e_t, d_t^{IL}, d_t^{FC}, R_t^{IL}, R_t^{FC}, x_t, m_t\}$ and given exogenous processes $\{g_t, \tau_t, A_{N,t}, A_{H,t}\}$. The equilibrium must satisfy households' intratemporal optimality conditions (8) and (9); the demand functions (10) to (13), the consumption and price indices definitions (3) to (6); firms' production functions and profit maximization conditions (14) to (17); the government's budget constraint (18); foreign investors' breakeven conditions (21) and (22); the definition for exports and imports (25) and (26); and markets clearing conditions (23), (24), and (27).

3.4. Model calibration

Table 5 reports the parameter values used. For the inverse elasticity of substitution, the model uses the standard value of $\sigma = 2$. Parameter $\zeta = 2$ delivers a Frisch elasticity of 0.5, consistent with microeconometric estimates (MaCurdy (1981), Altonji (1986), Chetty et al. (2011)). Most parameters in the consumption indices and the production functions are similar to those adopted by Schmitt-Grohe and Uribe (2018), who calibrate their model to 38 poor and emerging countries. One exception is the weight on home goods on the tradable consumption index, which they calibrate to match a 20% average export share in GDP in their sample. The average import and export share in

GDP in this study's sample is somewhat higher — about 30% and the weight on the home-tradable good reflects this. The foreign discount factor $\beta^{\star}$ is chosen to match the cross-sectional average FC rate in table (2) excluding Argentina's default. Finally, the parameter controlling the benefit of holding IL debt, ψ, is small but able to deliver the smaller cross-sectional average IL rate, as reported in table (2).

Parameter and symbol	Value	Reference
Inverse elasticity of substitution (σ)	2	Standard value
Inverse of Frisch elasticity (ζ)	2	Implies a Frisch elasticity $\frac{1}{\zeta} = 0.5$
Tradable weight in consumption index (ω_T)	0.5	Schmitt-Grohe and Uribe (2018)
Elasticity of substitution between c_T and c_N (ρ)	1	Schmitt-Grohe and Uribe (2018)
Weight on home good in tradable consumption (ω_H)	0.3	Matches average sample import share of GDP of 30%
Elasticity of substitution between c_H and c_F (ρ_T)	0.5	Schmitt-Grohe and Uribe (2018)
Labor share in non-tradable production (α_N)	0.75	Schmitt-Grohe and Uribe (2018)
Labor share in tradable production (α_H)	0.65	Schmitt-Grohe and Uribe (2018)
Foreign discount factor ($\beta^{\star}$)	0.94	Matches net rate of return $r^{FC} = 6.4\%$
Benefit of holding IL debt (ψ)	0.17	Small, but able to deliver $r^{IL} < r^{FC}$

Table 5: Parameter values

Table 6 compares key variables delivered by the model in steady state with the average emerging economy in the data. The model effectively replicates the debt over GDP, the share of debt linked to inflation, government spending over GDP, and tax revenues over GDP. The model also replicates the cross-sectional average of the IL rate, which equals 4.6% in the sample (table (2)) and 4.7% in the model's steady-state.

The next section uses this model to deliver stylized facts 3 to 5 in section 2.

Variable	Data	Model
Debt over GDP	45.1%	46.1%
IL debt over Debt	13.3%	15.9%
Government spending over GDP	15.5%	14.6%
Tax revenues over GDP	15.5%	17.6%
IL rate	4.6%	4.7%

Table 6: Comparison between the model ratios and IL bond rate and the data for the average emerging economy in the study's sample.

4. Results

4.1. Key result on FC and IL debt substitution

This subsection presents the model's response to a negative productivity shock in the non-tradable sector, $a_{N,t}$.

Figure 1 as well as figures B.11 and B.10 in Appendix B show the impulse response functions of the model to a negative productivity shock in the non-tradable sector with respect to the steady state, turning off all other shocks.

They show that, after a negative productivity shock in the non-tradable sector of 10%, the wage rate in this sector decreases by the same amount. The income effect of the lower wage dominates the substitution effect and labor supply in the non-tradable sector increases by 3%. The labor supply increase partly dampens the effect of the productivity shock on non-tradable output, which only falls by 5%.

For a given level of government spending, a drop in the non-tradable production, by market clearing condition (24), implies a drop in the non-tradable consumption. This causes the demand for the remaining goods to

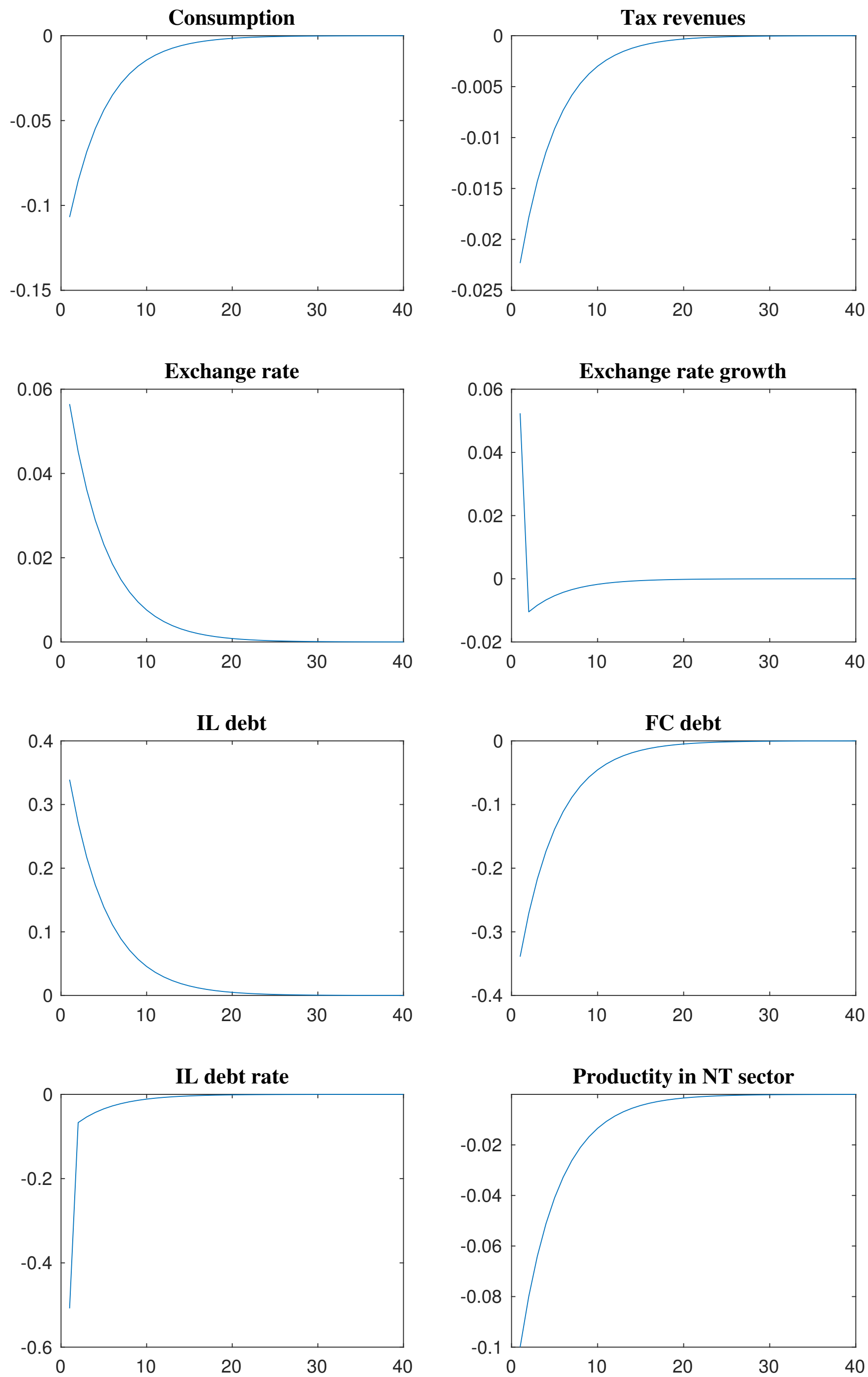

Figure 1: Model's response to a negative productivity shock in the non-tradable sector.

also fall, due to the complementarity between goods that demand equations (10)-(13) exhibit.

The drop in the demand for foreign goods, $c_{F,t}$, depreciates the exchange rate, as equation (13) shows. The depreciation of 6% implies that the domestic economy is only capable of financing smaller trade deficits (see equation (27)) — exports drop by 5% whereas imports only drop by 3%.

The drop in demand for home-tradable goods at home and abroad decreases their price, $p_{H,t}$, decreasing the value of the marginal product of labor in the home-tradable sector and, thus, decreasing the sector's wage. As before, the income effect of the lower wage dominates the substitution effect and labor supply in the home-tradable sector increases.

Tax revenues fall by 2% because the increases in the labor supply in both sectors are insufficient to compensate the larger sectoral wage falls.

The current exchange rate depreciation, jointly with the law of motion for the productivity shock, causes an expected future appreciation of the currency, $\Delta e_{t+1} = \frac{e_{t+1}}{e_t}$, which decreases the IL rate, as it is clear from equation (22). The fourth panel in figure 1 shows the future appreciation. The magnitude of the rate decrease is 50%, which, for the average economy, the model is calibrated to, implies a decrease in the IL rate from 4.7% to 2.4%. FC debt, on the contrary, still requires a 6.4% interest rate.

Finally, IL debt issuance increases by 35% and FC debt issuance decreases by 35%. For the average emerging economy, the model is calibrated to, this implies six percentage points increase in the IL debt issuance. This happens, in the model, because for the government's budget constraint (18) to balance in period $t+1$, a lower interest rate implies IL debt needs to increase. If public debt composition were chosen actively by the government, it would also choose to move towards IL debt because it becomes cheaper to borrow in this manner.

The total IL rate decrease is, partially, a result of the IL rate's dependance on the level of IL debt through the $1 - \psi\frac{P_t d_t}{e_t}$ term. The next subsection presents the IL rate decrease if $\psi = 0$.

4.2. IL rate dynamics if $\psi = 0$

When $\psi = 0$, foreign investors do not enjoy any benefit from holding IL debt versus FC debt. Because in steady state, $\pi_{t+1} = e_{t+1} = 1$, equations (21) and (22) imply that the (gross) interest rate for both bonds is the same and equal to $\frac{1}{\beta^\star}$. Hence, $\psi = 0$ precludes the model from delivering a steady-state interest rate differential between both bonds. It is still interesting to study the dynamics in this case for two reasons. First, it helps us understand the workings of the model and, second, it determines the magnitude of the interest rate fluctuations when the mechanical feedback between IL debt and IL rate is absent.

Figure (2) shows the response of the IL rate to a 10% negative productivity shock in the non-tradable sector, $a_{N,t}$ in the model with $\psi = 0$. The qualitative responses of the model are identical to the ones in the previous subsection but the IL rate drop is smaller. Indeed, the IL rate falls by 17%, which, for the average economy, the model is calibrated to, implies a drop from 6.4% to 5.3%. This is evidence that a large portion of the IL rate drop in the previous subsection is coming from the mechanical effect IL debt has on IL rates.

The model's key takeaway is that, during crises, borrowing in IL debt

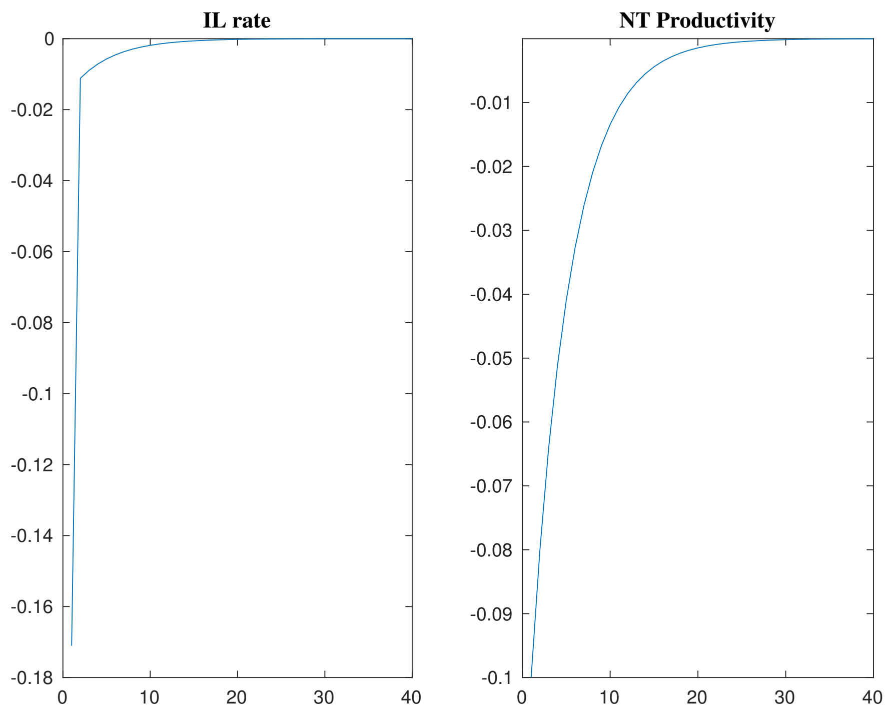

Figure 2: IL rate response to a negative productivity shock in the non-tradable sector when $\psi = 0$.

becomes cheaper because, for a short-lived recession, foreign investors expect a future appreciation. The next subsection evaluates the empirical support for the model's findings on IL rates during crises.

5. IL, FC, and LC rates

This section investigates whether, like the model predicts, IL rates fall during crises. Furthermore, it returns to the findings on IL, FC, and LC rates of fact 2 in section 2 and explores whether the rate differentials uncovered can be explained by expected infaltion rates and expected exchange rate variations.

5.1. IL rates during crises

In the study's sample, there are 11 crisis episodes, for which the IL rate is available. A crisis episode for a country is a year when its real GDP growth rate is negative. Out of these 11 episodes, 6 of them are accompanied by decreases in the IL rate and 5 are not. Table 7 lists each of the episodes and categorizes them as simultaneously exhibiting an IL rate decrease or not. Between parantheses are the magnitudes of the IL rate decrease in percentage terms.

A crisis episode in which the IL rate fails to drop is consistent with this study's model if the crisis is persistent. Indeed, if next period's exchange rate, e_{t+1}, is expected to fall further than in period t, then investors expect a future depreciation, Δe_{t+1} drops, and the IL rate increases. Studying the relationship between the behavior of IL rates and the crisis persistance is left for future work.

Crisis episodes and behavior of IL rates	
IL rate drop	IL rate increase
Argentina, 2014 (-44.1%) and 2016 (-73.5%)	Argentina, 2009 and 2012
Brazil, 2009 (-9.7%) and 2016 (-6.3%)	Brazil 2015
Chile 2009 (-8.6%)	Mexico 2009
Russia 2016 (-12.2%)	South Africa 2009

Table 7: Crisis episodes and behavior of IL rates

To sum-up, more than half of the crisis episodes simultaneously exhibit a decrease in the IL rate. However, the evidence is mixed. For 5 crises, IL rates failed to drop and it is unclear, at this point, that these were the most persistent crises. Exploring further the behavior of IL rates during crises is a possible topic for future research.

5.2. Role of expected inflation and expected exchange rate variations

Fact 2 in section 2 shows that, in the cross-section, $R_t^{FC} > R_t^{IL}$. Column 2 in table 8 reports the average FC-IL rate differential by country and, in the last row, shows that the differential is 0.9% on average, when excluding Argentina's default episode. Model equations (21) and (22) show that expected inflation and expected exchange rate variations can explain a positive FC-IL rate differential.

Fact 2 in section 2 also shows that, in the cross-section, $R_t^{LC} > R_t^{IL}$. Column 3 in table 8 reports the average LC-IL rate differential by country and, in the last row, shows that the differential is, on average, 4%. To complete the analysis, we need the theoretical expression for the LC rate.

To do this, from equation (20), the new budget constraint for foreign investors that can buy LC debt, d_t^{LC}, is given by:

$$C_t^\star + d_t^{FC} + \frac{P_t d_t^{IL}}{e_t} + \frac{d_t^{LC}}{e_t} = \epsilon_t^\star + R_{t-1}^{IL}\frac{P_t d_{t-1}^{IL}}{e_t} + R_{t-1}^{FC} d_{t-1}^{FC} + \frac{\Psi}{2}\left(\frac{P_t d_t^{IL}}{e_t}\right)^2 + R_{t-1}^{LC}\frac{d_{t-1}^{LC}}{e_t} \tag{28}$$

where d_t^{LC} is divided by the exchange rate, e_t, to transform the payment to FC.

Maximizing (19) subject to (28), instead of subject to (20), gives the following expression for the LC rate:

$$R_t^{LC} = \frac{1}{\beta^\star E_t \frac{1}{\Delta e_{t+1}}} \tag{29}$$

Equations (29) and (22) show that expected inflation can explain the positive LC-IL rate differential. Indeed, from equations (21), (22), and (29), the following rate differentials emerge:

$$r_t^{FC} - r_t^{IL} \approx E_t(\tilde{\pi}_{t+1}) - E_t(\Delta \tilde{e}_{t+1}) \tag{30}$$

$$r_t^{LC} - r_t^{IL} \approx E_t(\tilde{\pi}_{t+1}) \tag{31}$$

where r denote net rates of return for the different bonds — LC, IL, and FC — and the variables with tildes denote the net rate of inflation and net depreciation rate[9].

To account for these expectations, I use the averages of the 4-year ahead consensus forecasts of the inflation rate and the nominal exchange rate from FocusEconomics. See Appendix A for coverage and definitions.

[9] Note that foreign inflation cancels out in the calculation of the rate differentials. Intuitively, foreign inflation increases the interest foreign investors require on all bonds.

Longer-term forecasts, instead of one-year ahead forecasts, are necessary because the rates come from medium and long-term bonds. Unfortunately, long-term forecasts, especially for the nominal exchange rate, are not publicly available and, even within proprietary datasets, are hard to find for long horizons and with substantial historical coverage.

In the FocusEconomics data, the 4-year expected inflation rate is given in annual terms and the 4-year expected nominal exchange rate is given in units of LC needed to purchase 1 USD. Using the current level of the exchange, I can calculate the expected rate of depreciation over a 4-year interval. However, there is a time period mismatch between expected inflation rate and expected rate of depreciation. For this reason, I calculate annualized depreciation rates by dividing the total expected depreciation by 4, assuming, thus, that the total expected rate of depreciation is spread out smoothly over the 4-year period[10].

Using the 4-year ahead expected inflation rate and the imputed 4-year ahead depreciation rate, I recalculate the interest rate differentials in columns 2 and 3 adjusting the IL rates as follows:

$$r_{1,adj} = r_t^{IL} + E_t(\tilde{\pi}_{t+1}) - E_t(\Delta \tilde{e}_{t+1}) \tag{32}$$

$$r_{2,adj} = r_t^{IL} + E_t(\tilde{\pi}_{t+1}) \tag{33}$$

where the first expression is used to compare IL rates to FC rates and the second expression is used to compare IL rates to LC rates. The results are

[10] An alternative is to use the expected variation in the price index (e.g. CPI) over a 4-year window. However, to the best of my knowledge, expected price indices are not collected by Central Banks' surveys nor private companies.

in columns 4 and 5 of table 8.

Interest rate differentials, 2002-2017				
Country	$r^{FC} - r^{IL}$	$r^{LC} - r^{IL}$	$r^{FC} - r^{IL}_{1,adj}$	$r^{LC} - r^{IL}_{2,adj}$
Argentina	3.9%	13.3%	8.2%	5.0%
Brazil	-0.7%	5.6%	-1.2%	1.2%
Chile	1.9%	2.3%	-3.4%	-0.9%
Colombia	1.1%	3.2%	-0.4%	-1.0%
Hungary	-	-	-	-
India	-2.1%	2.4%	-7.7%	-3.1%
Mexico	1.3%	3.3%	-1.6%	-0.1%
Peru	-1.4%	-0.1%	-3.2%	-2.4%
Poland	1.5%	2.2%	-0.5%	-0.4%
Russia	1.1%	5.9%	-4.1%	1.5%
South Africa	2.7%	6.0%	-0.03%	1.9%
Turkey	2.6%	6.9%	-1.6%	1.2%
Average	1.4%	4.0%	-0.6%	-0.2%
Excluding Argentina 2001Q4-2005Q2	0.9%	4.0%	-1.2%	-0.2%

Table 8: Average Rate Differentials between FC debt and IL debt and LC debt and IL debt. Time coverage depends on country and instrument. See Appendix A for time coverage and sources.

Column 4 shows that, after including the expected inflation rate and the expected rate of depreciation, the FC-IL rate positive differential observed in column 2 reverses, implying that investors of IL debt require higher rates of return than merely the expected inflation and expected depreciation rate suggest.

Column 5 shows some cross-country heterogeneity. The positive LC-IL rate differential remains, even after including the expected inflation rate, for 5 of the 11 countries considered, implying that, for these countries, investors of LC debt require higher rates of return than the expected inflation would suggest. This is consistent with an inflation risk-premium, that is, investors requiring an additional premium to bear inflation risk (Bekaert and Wang (2010), Ermolov (2018)). For these countries, IL debt seems an attractive form of debt financing.

Understanding the drivers behind the rate differentials is outside the scope of this paper. Instead, the previous analysis takes the rate levels as given and explores the behavior of IL rates over the business cycle and how it affects emerging economies' public debt composition, in particular the substitution of FC debt for IL debt.

6. Conclusions

The study reports a set of stylized facts about recent emerging economies' IL public debt issuance. On average, emerging economies issue 13% of their public debt linked to inflation. This represents 23% of their LC public debt. The evidence on IL, FC, and LC rates, shows that, for half of the countries in the study's sample, IL rates are below LC rate, even after accounting for expected inflation rates. The paper also uncovers the following business-cycle properties of IL debt issuance — it is countercyclical, increases amid nominal exchange rate depreciations, and substitutes FC and non-indexed LC debt.

Subsequently, the study presents a two-sector small-open economy model of public debt composition that can deliver the business cycle properties of IL debt issuance. Moreover, the model shows that, during economic crises, when the economy endures a nominal exchange rate depreciation, IL debt becomes cheaper to issue. Finally, the study shows evidence of IL rates falling in about half of the recent crises in emerging economies.

This study has relevant policy implications. IL debt is an attractive instrument for some of the governments in the study's sample, since, for them, IL rates are, on average, below LC rates, even after accounting for expected inflation rates. Indeed, for these countries, IL rates are between 1.2 and 5 percentage points lower than LC rates. Moreover, the study's model shows that, IL debt can be a especially beneficial debt instrument to use during economic crises, as IL rates drop amid nominal exchange rate depreciations.

Exploring the cross-sectional variation in the amount of IL debt emerging economies issue, as well as why some economies (e.g. Czech Republic, Indonesia, Malaysia, and Thailand) avoid issuing this debt, is a promising avenue for future research. Studying further the behavior of IL rates during crises can help clarify when is IL debt a good debt instrument to finance government spending. Finally, exploring the negative FC-IL rate differential when accounting for expected inflation and expected exchange rate variations, as well as the cross-sectional variation in the LC-IL rate differential when accounting for expected inflation can shed light on the institutional determinants of IL debt being an attractive form of debt financing.

Appendix A. Appendix to the Empirical Evidence

Appendix A.1. Sample, sources, and coverage of key variables

Sample of countries and corresponding regions	
Region⋆	Countries in sample
Latin America	Argentina, Brazil, Chile, Colombia, Mexico, Peru
EMEA-UE	Hungary, Poland
EMEA-non UE	India, Russia, South Africa, Turkey

Table A.9: Sources and coverage for IL rates for all countries in sample. ⋆ Asian economies such as Indonesia, Malaysia or Thailand are not included in the study because they do not issue this type of public debt. The same happens with Czech Republic. See Table C2 in `https://www.bis.org/statistics/secstats.htm`.

1. **IL debt issuance:** Bank of International Settlements. Table C2. Link: `https://www.bis.org/statistics/secstats.htm`. Available at yearly frequency only, 1995-2016.
2. **Total government debt and local currency government debt:** Arslanalp and Tsuda (2014), 2004-2016.
3. **REER:** Darvas (2012), 1995-2016.
4. **All other macroaggregates:** World Development Indicators (WDI), 1995-2016.
5. **FC bond rate**: JP Morgan EMBI+, yield-to-maturity, 1995Q1-2017Q4.
6. **LC bond rate**: JP Morgan GBI-EM, yield-to-maturity. End date: 2017Q4. Starting dates: Argentina (2007Q3), Brazil (2002Q1), Chile (2002Q4), Colombia (2005Q1), Hungary (2001Q1), India (2000Q1),

Mexico (2002Q1), Peru (2006Q4), Poland (2001Q1), Russia (2005Q1), South Africa (2000Q1), Turkey (2000Q1).

7. **IL bond rate**:

IL bond rate: coverage and sources			
Country	Source	Bloomberg Ticker or Link	Coverage
Argentina	Barclays	BEMA8y Index	2003Q4-2017Q3
Brazil	Bloomberg	TRBRI15	2006Q1-2017Q3
Chile	Barclays	BEMC8y Index	2002Q3-2017Q3
Colombia	Barclays	BEMy8y Index	2003Q4-2017Q3
Hungary	-	-	-
India	S&P Index	`https://us.spindices.com/indices/fixed-income/sp-india-sovereign-inflation-linked-bond-index`	2013Q3-2017Q3
Mexico	Barclays	BEMM8y Index	2006Q1-2017Q3
Peru	S&P Index	`https://us.spindices.com/indices/fixed-income/sp-peru-sovereign-inflation-linked-bond-index`	2008Q2-2017Q3
Poland	Barclays	BEMv0y Index	2003Q3-2017Q3
Russia	Barclays	Brulcy Index	2015Q3-2017Q3
South Africa	Bloomberg	MLGSail	2004Q1-2017Q3
Turkey	Bloomberg	TRTKI5y	2013Q2-2017Q3

Table A.10: Sources and coverage for IL rates for all countries in sample.

Appendix A.2. Coverage and definitions of expectations data

1. **Expected exchange rate:** 4-year ahead expected nominal exchange rate, units of LC per USD. Eg. 2013 forecast of the nominal exchange rate in 2017. Source: FocusEconomics.
2. **Expected inflation rate:** 4-year ahead expected annual variation in the CPI. Source: FocusEconomics.

Coverage of expectations data	
Country	Coverage
Argentina	2003Q4-2017Q3
Brazil	2006Q1-2017Q3
Chile	2002Q3-2017Q3
Colombia	2003Q1-2017Q3
Hungary	-
India	2013Q3-2017Q3
Mexico	2006Q1-2017Q3
Peru	2008Q2-2017Q3
Poland	2006Q1-2017Q3
Russia	2015Q3-2017Q3
South Africa	2015Q2-2017Q3
Turkey	2013Q2-2017Q3

Table A.11: Coverage for expectations data for all countries in sample. If possible, coverage coincides with IL rates coverage. Coverage for expectations data for Poland and South Africa are shorter than for IL rates, due to data availability limitations at FocusEconomics.

Appendix A.3. Tables and graphs

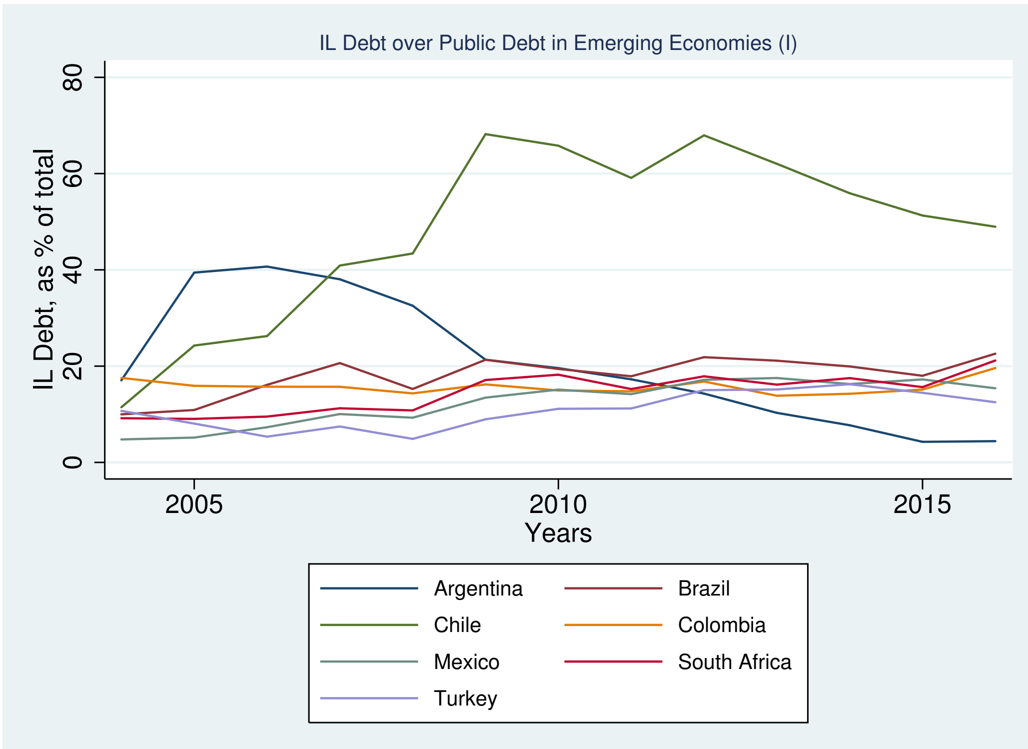

Figure A.3: Share of IL debt (as % of Total Public Debt) for Emerging Economies (I), by country. Data sources: see above.

Results of Stationarity Tests			
Variable	Number of lags (AIC)	W_t	p-value
ILD	0.58	1.654	0.951
GDP	0.25	8.909	1.000
FC Debt	0.33	2.504	0.994
Nominal Debt	0.08	4.910	1.000
Debt	0.33	6.127	1.000
Exchange rate	0.75	2.702	0.997
REER	0.50	-0.828	0.205
GDP Deflator	0.33	11.460	1.000
CPI	0.73	8.560	1.000

Table A.12: W_t is the statistic in Im et al. (2003) unit root tests for panel data with heterogenous panels. Im et al. (2003) does not require balanced panels. The null hypothesis, H_0, is that all panels contain unit roots. The alternative hypothesis, H_a, is that at least one panel is stationary. Number of lags are chosen using the Akaike information criterion (AIC). Using the bayesian information criterion (BIC) or Hannan-Quinn information criterion (HQIC), including a trend and/or subtracting the cross-sectional averages from the series to mitigate the impact of cross-sectional dependance leaves the conclusions of the tests above unchanged.

Dates of IL debt issuance start and IT adoption		
Country	IL debt issuance start	IT adoption date
Argentina	2002	2017
Brazil	1964	1999
Chile	1956	1999
Colombia	1967	1999
Hungary	2011	2001
India	1998	2015
Mexico	1989	2001
Peru	2003	2002
Poland	2004	1998
Russia	2004⋆	2015
South Africa	2000	2000
Turkey	2000⋆	2006

Table A.13: Dates of IL debt issuance start and IT adoption. Sources for IL debt issuance start: BIS Table C2. For Mexico IL debt start: Barclays (2004), p. 58. For Brazil, Chile and Colombia: Godoy et al. (2009). ⋆For Russia and Turkey, study's data starts in, respectively, 2004 and 2000 but previous years are missing (not zero). Sources for IT adoption date: Jahan (2012). For Argentina: slide 5 "Régimen de metas de inflación en Argentina" presentation from Banco Central de la República Argentina, September 2016 (`https://www.bcra.gob.ar/Pdfs/Prensa_comunicacion/Metas_de_inflacion26092016.PDF`). For India Reserve Bank of India press release mentioned in Bloomberg article "India keeps Rajan's inflation target as his term nears end", August 5, 2016. For Russia Korhonen and Nuutilainen (2017).

Increases in IL debt over time, 2004-2016	
Country	Δ (IL debt/debt)
Argentina	-12.6%
Brazil	12.6%
Chile	37.5%
Colombia	2%
Hungary	4%
India	-0.04%
Mexico	10.6%
Peru	2.1%
Poland	-0.3%
Russia	0.9%
South Africa	12.0%
Turkey	1.8%

Table A.14: Increases in IL debt over Total Public Debt between 2004 and 2016. Source: See above.

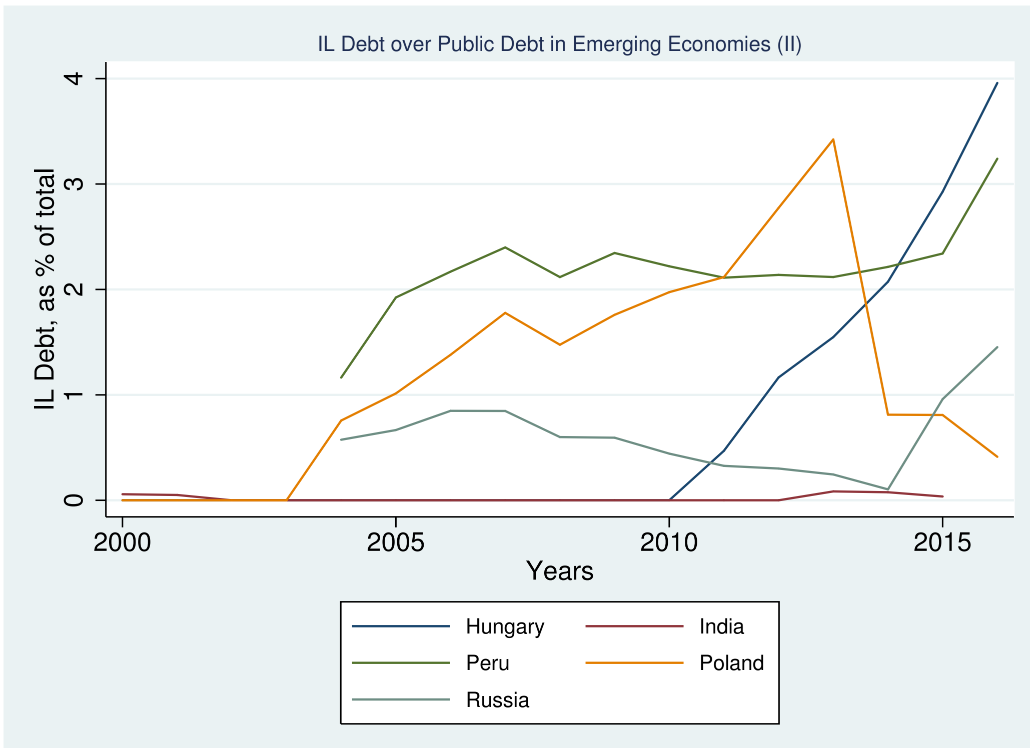

Figure A.4: Share of IL debt (as % of Total Public Debt) for Emerging Economies (II), by country. Data sources: see above.

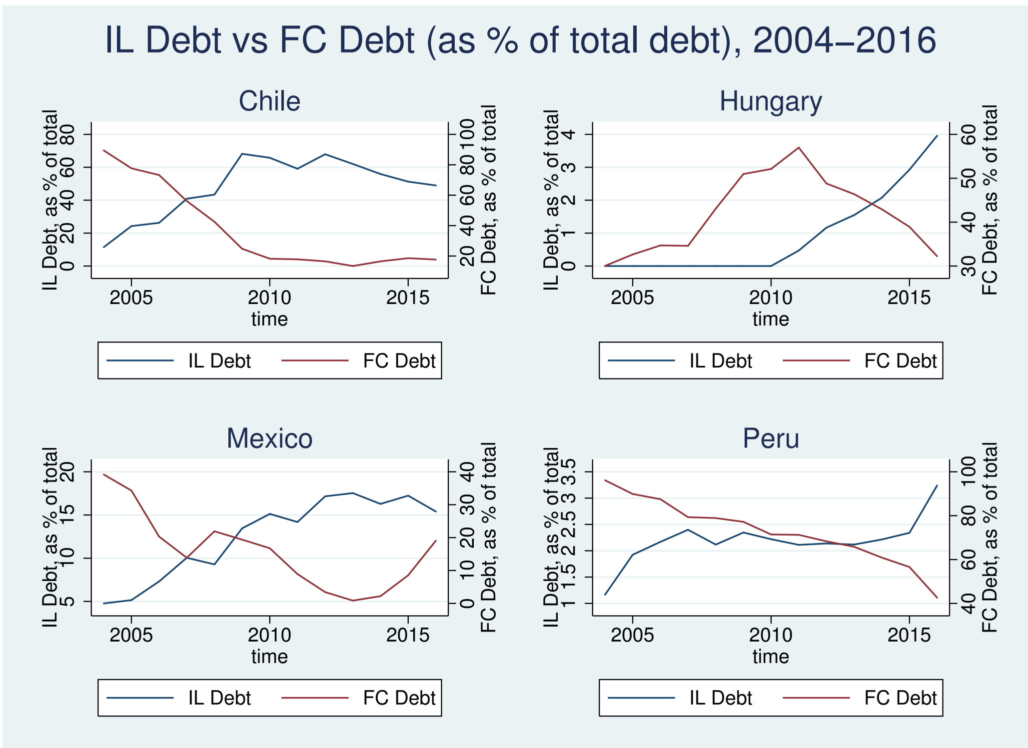

Figure A.5: Share of IL debt and FC debt (as % of Total Government Debt) for a selection of emerging economies. Data sources: see above.

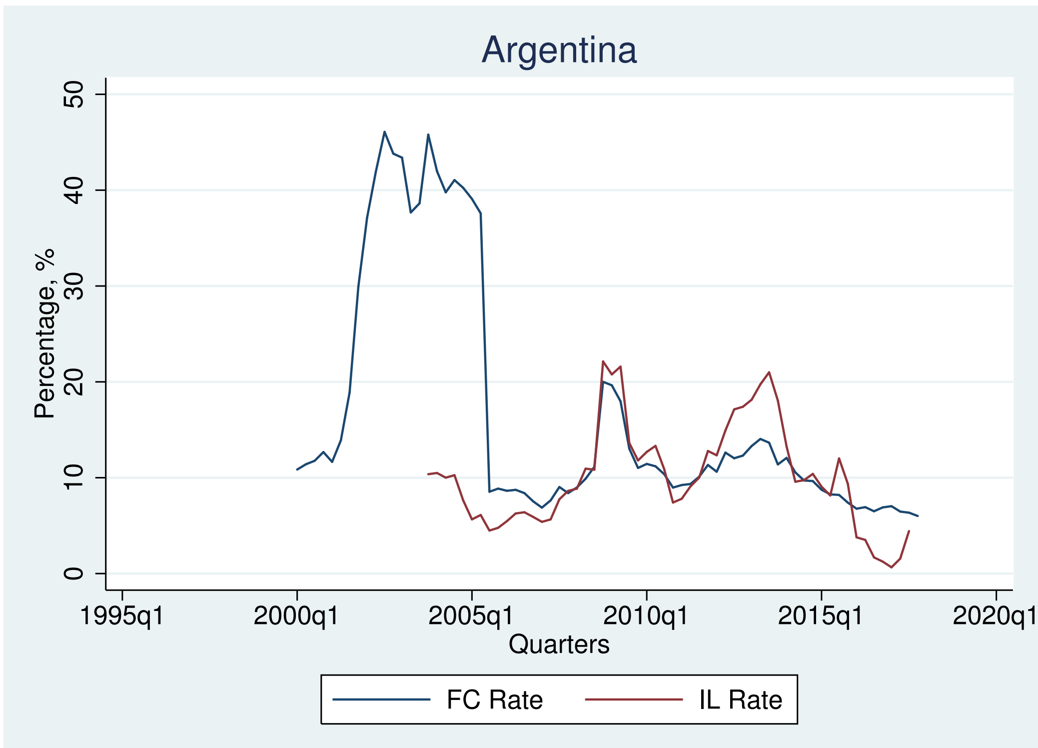

Figure A.6: Foreign currency (FC) and inflation-linked (IL) bond rates between 2002 and 2017 for Argentina. Data sources: see above.

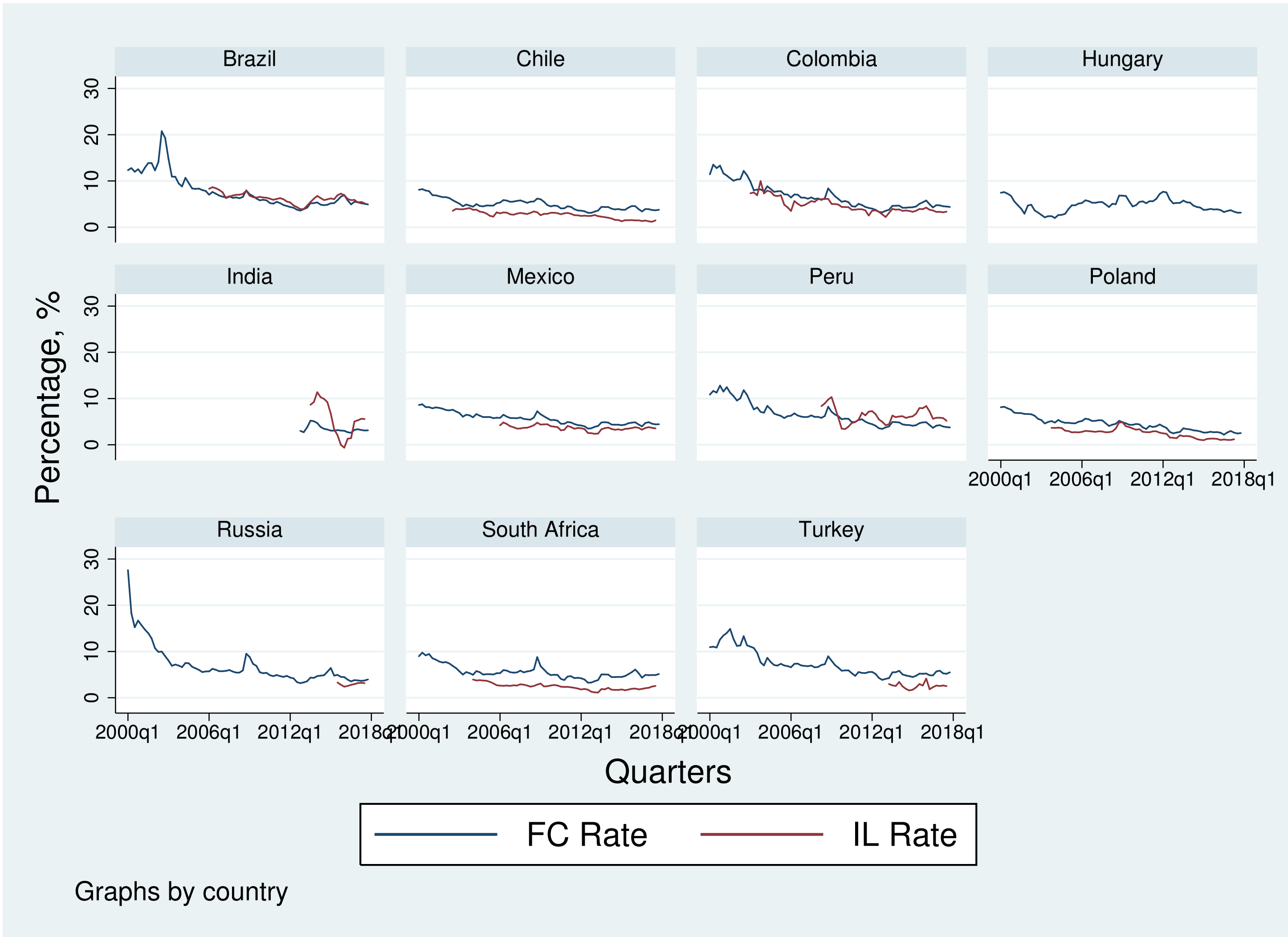

Figure A.7: Foreign currency (FC) and inflation-linked (IL) bond rates between 2002 and 2017. Sources: see above.

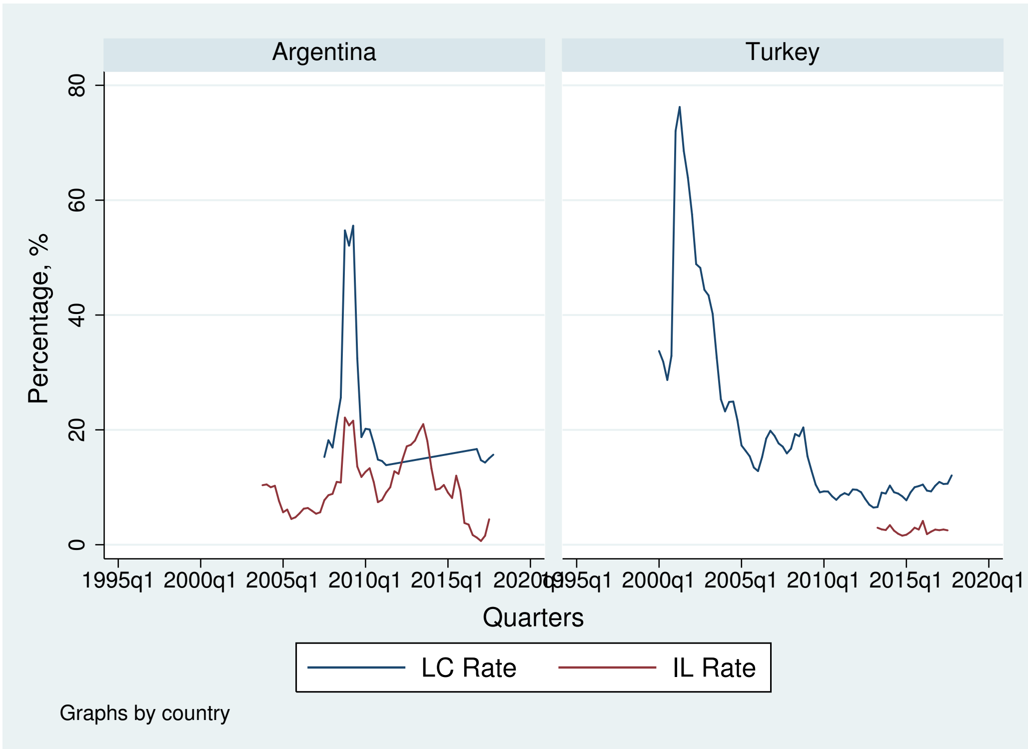

Figure A.8: Local currency (LC) and inflation-linked (IL) bond rates between 2002 and 2017 for Argentina and Turkey. Data sources: see above.

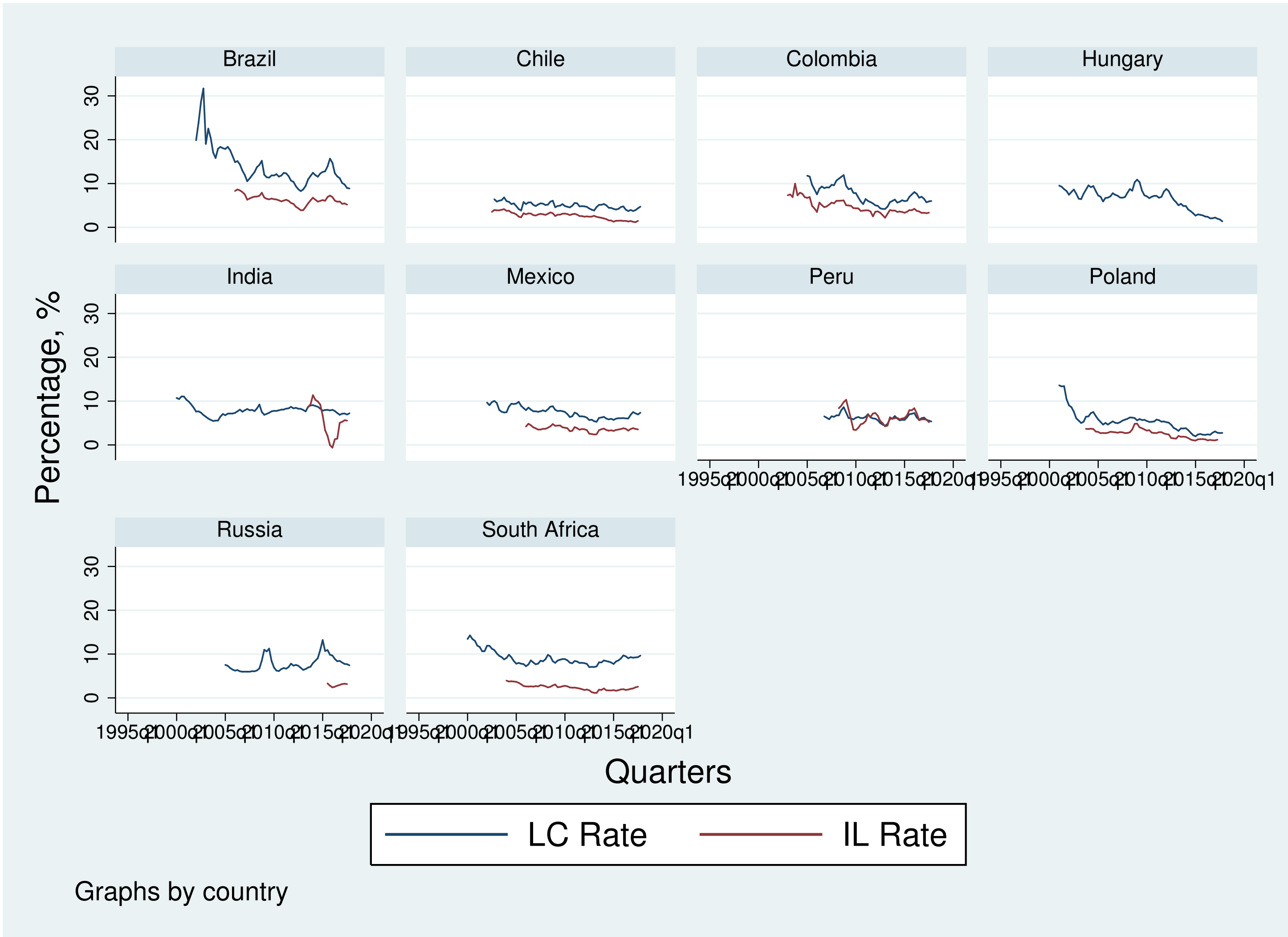

Figure A.9: Local currency (LC) and inflation-linked (IL) bond rates between 2002 and 2017. Sources: see above.

Appendix B. Appendix to the Model

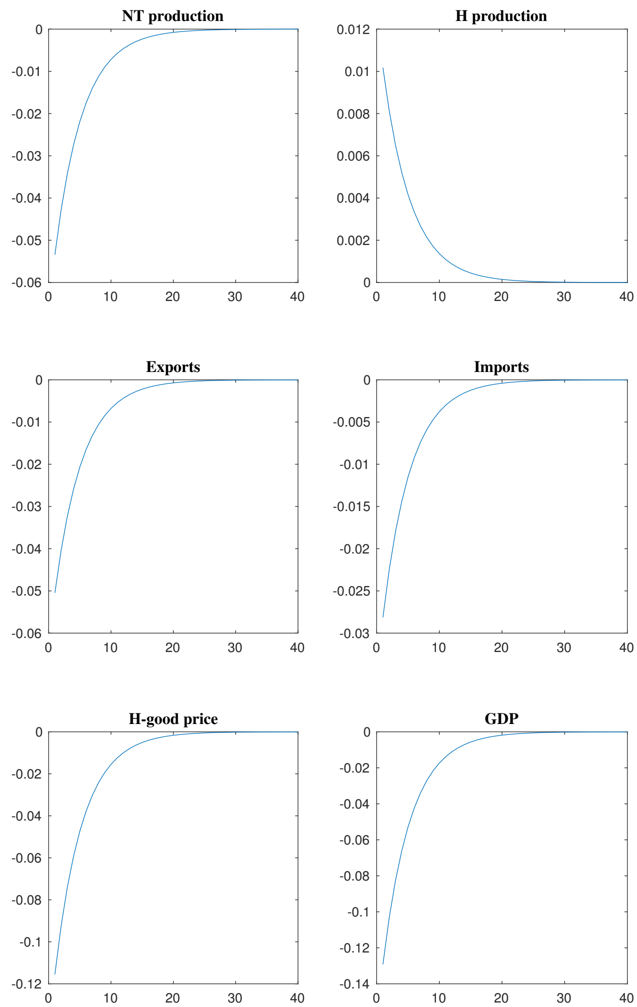

Figure B.10: Model's response to a negative productivity shock in the non-tradable sector.

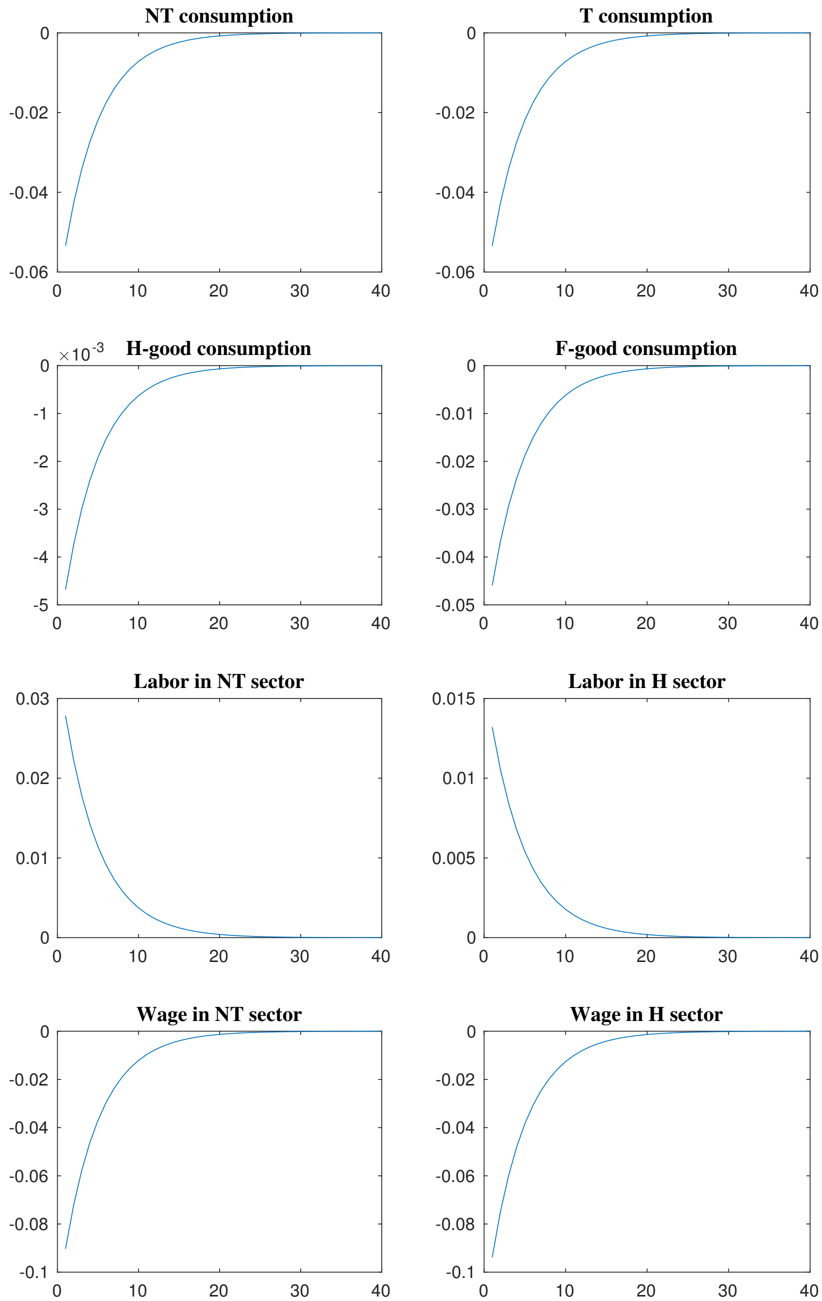

Figure B.11: Model's response to a negative productivity shock in the non-tradable sector.

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