Foreign currency denominated indebtedness and the fiscal multiplier

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Abstract

After presenting an empirical evidence of the negative impact of foreign denominated debt on the fiscal multiplier, this paper develops a two-country DSGE model with sticky prices, imperfect and incomplete international financial markets and a financial accelerator à la Bernanke et al. (1999). Following an increase in public spending, the real exchange rate depreciates. In the case where firms are indebted in foreign currency, the depreciation leads to an increase in the value of firms' debt ratios. The financing costs therefore increase, generating a decrease in the investment level. The positive impact of fiscal policy becomes thus weaker. In contrast, if firms are indebted in local currency, the depreciation amplifies the positive impact of fiscal policy. This result supports the increasing number of measures taken in EMEs to limit their level of indebtedness in foreign currency.

JEL Classification:...

Keywords: Fiscal multiplier; DSGE; Financial accelerator; Emerging countries

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1 Introduction

The empirical evidence shows that fiscal multipliers are smaller in Emerging Market Economies (EMEs) than in Advanced Economies (AEs) (Chian Koh, 2017; Ilzetzki et al., 2013; Hory, 2016). While fiscal multipliers are often found larger than one in AEs, they remain close to zero in EMEs; and this gap seems due to some specificities that differentiate EMEs from AEs.

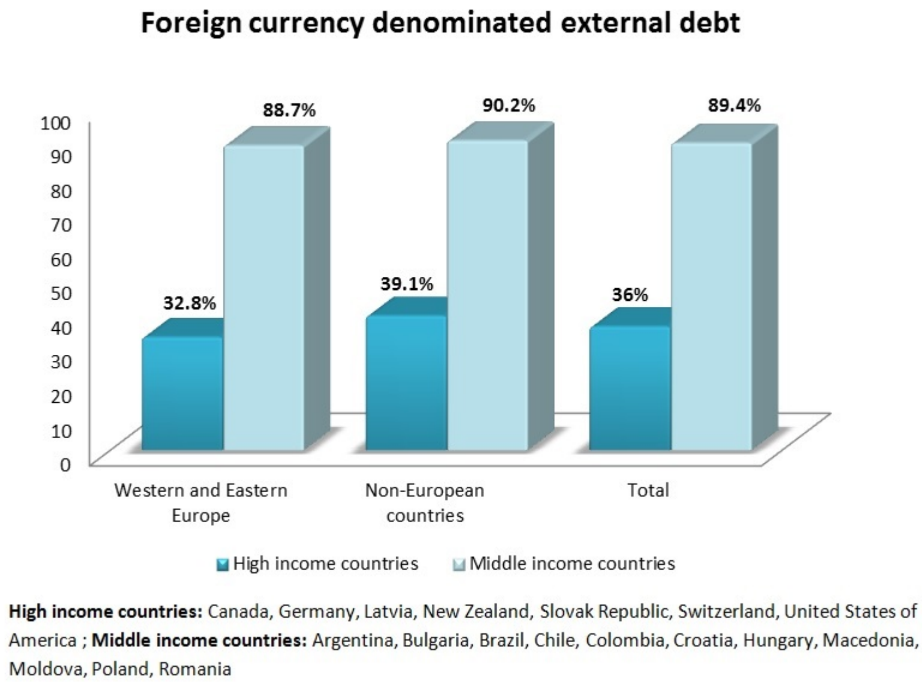
Among the determinants of the fiscal multiplier, the existing literature shows that, among others, fiscal multipliers are higher when public debt is low (Deák and Lenarcic, 2012; Cimadomo et al., 2010), during business cycle downturns (Baum et al., 2012; Corsetti et al., 2012) and/or when interest rates are relatively low (Nakamura and Steinsson, 2014; Woodford, 2011). However, this literature often considers the level of development as a determinant per se, without fully explaining why fiscal multipliers are so small in EMEs. Regarding the argument of public debt, for example, emerging countries often experiment lower public debt to GDP ratios than AEs, that should lead to higher fiscal multipliers.[1] Moreover, some features of EMEs are not analyzed in the existing literature. This is the case of the currency denomination of external debt. In fact, there is a large difference between AEs and EMEs: while the former are mainly indebted in local currency, the latter are largely indebted in foreign currency. As shown in Figure 1, the share of foreign currency denominated external debt is close to three times higher in EMEs than in AEs.

The impact of this feature on the efficiency of public spending has not been addressed in the literature, and this is what this paper aims to do. Especially, the goal of this paper is to analyze the effect of public spending, through the computation of fiscal multipliers, conditionally to the currency denomination of private debt, with a particular attention to firms' indebtedness. To this end, after presenting an empirical evidence of the negative impact of foreign currency denominated debt on the fiscal multiplier, we develop a theoretical framework that allows the impact of public spending to vary according to the currency denomination of external debt. We build a two-country Dynamic Stochastic General Equilibrium (DSGE) model that incorporates sticky prices, imperfect and incomplete international financial markets, a not-too-aggressive monetary policy and a financial accelerator mechanism à la Bernanke et al. (1999). Such an approach could provide a explanation, at least partial, of the small values of fiscal multipliers observed in EMEs.

On the one hand, being indebted in foreign currency makes firms vulnerable to exchange

[1] Considering a panel of 41 countries from Europe and Central Asia between 2000 and 2013, the average debt-to-GDP ratio is 54% for high income countries, and 34% for middle income countries (Historical Public Debt Database, International Monetary Fund).

Figure 1: Share of foreign currency denominated external debt



rate fluctuations. While an appreciation of the local currency leads to a decrease in the real value of their debt, a depreciation leads to an increase.

On the other hand, a change in fiscal policy generates exchange rate fluctuations. According to the traditional Mundell-Fleming-Dornbush model, the exchange rate is supposed to appreciate following an increase in public spending. However, many papers show the opposite: the exchange rate depreciates following an increase in public spending (Kim and Roubini, 2008; Betts and Devereux, 2000; Ravn et al., 2007; Kollmann, 2010; Corsetti et al., 2012; Bouakez and Eyquem, 2015).

The depreciation of the exchange rate following a positive public spending shock is due to the variation of the interest rate differential between two countries that, in case of imperfect financial markets, determines the real exchange rate variations. If the long run interest rate differential decreases, the real exchange rate decreases. This occurs when the long term real interest rate increases less than the country premium. This condition necessitates to have a monetary policy not-too-aggressive, that is a feature consistent with actual worldwide trends in monetary policy.

This paper therefore considers a theoretical framework similar to Bouakez and Eyquem (2015). In addition, we consider a two-country model, in order to introduce the particular features of EMEs with respect to AEs, coupled by the presence of a financial accelerator mechanism à la Bernanke et al. (1999), in order to account for the (large) vulnerability of firms to exchange rate fluctuations when they are indebted in foreign currency. The presence of the financial accelerator seems to better fit the data (Christensen and Dib, 2008) and especially accentuates the impact of the financing structure of firms on economic fluctuations.

In fact, firms finance their activity by accessing external financing both in local and foreign currency. More than the interest rate, they have to pay an external finance premium, due to informational imperfections, that increases with their capital to net worth ratio. Introducing a financial accelerator makes the financing structure of firms non-neutral: a variation in the indebtedness level of firms and/or a variation of their net worth lead to a change in the external finance premium that modifies financing costs and therefore affects investment, leading to economic fluctuations.

Especially, if an increase in public spending leads to a depreciation of the exchange rate, the firms that are indebted in foreign currency face an increase in the real value of their debt. The increase of the external finance premium leads to a decrease in investment, and therefore economic growth worsens. The efficiency of an increase in public spending could therefore be reduced in such a case.

To sum up, the contributions of this paper are twofold. Firstly, the paper provides an empirical evidence of the negative impact of foreign currency denominated external debt on the fiscal multiplier by using a Panel Conditionally Homogeneous VAR (Georgiadis, 2012). Secondly, the negative impact of foreign currency denominated debt is emphasized in a two-country DSGE model with sticky prices, imperfect and incomplete financial markets, a not-too-aggressive monetary policy and a financial accelerator mechanism.

The paper is organized as follows. Section 2 presents an empirical evidence of the negative impact of foreign currency denominated external debt on the multiplier. Sections 3, 4 and 5 respectively show the theoretical model, the calibration used and the results we obtain. Section 6 discusses alternative calibrations of the model. Finally Section 7 concludes.

2 Empirical evidence

In the literature, the impact of some determinants of the fiscal multiplier has been estimated, as for example the degree of openness or the level of public debt but, to the best of our knowledge, nothing is said about the importance of the currency denomination of private debt. This section therefore presents estimates of the impact of foreign currency denominated debt on the fiscal multiplier.

2.1 Empirical Specification

How does foreign currency denomination of indebtedness affect the impact of public spending on GDP? To address this question, fiscal multipliers have to be estimated conditionally to the currency denomination of debt. Nevertheless, this involves some technical difficulties.

First, some assumptions are necessary to identify exogenous shocks in public spending since measuring the impact of public spending on GDP leads to reverse causality issues.

Following Blanchard and Perotti (2002), we assume that the economic context can contemporaneously respond to government spending, but government spending are not contemporaneously affected by the economic context. Especially, it is assumed that a government takes at least one quarter to change its fiscal policy regarding economic context variations. This assumption reflects, among others, the implementation lag of fiscal policy. Therefore, we use a Panel Vector Autoregressive (PVAR) model with a Cholesky decomposition that allows to generate Orthogonalized Impulse Response Functions (OIRF), meaning that the shocks generated are identified.

Second, estimates have to be conditional to the currency denomination of indebtedness. Georgiadis (2012) provides a method which allows to estimate a dynamic, within a VAR, that can vary according to the level of a conditional variable. Using his Panel Conditionally Homogeneous VAR (PCH-VAR), the dynamic between public spending and GDP can be estimated conditionally to the currency denomination of external debt.

The following equation is estimated:[2]

$$X_{n,t} = \Sigma_{s=1}^{p} A_i(z_{n,t}) X_{n,t-s} + C_n + \varepsilon_{n,t} \tag{1}$$

with:

- $X_{n,t} = [G_{n,t}; Y_{n,t}]$, where G is the quarterly growth rate of public consumption, and Y is the quarterly growth rate of GDP;
- $z_{n,t}$ is a vector containing the conditioning variable: the share of external debt denominated in foreign currency;
- $C_{n,t}$ is a vector of country fixed effects;
- $\varepsilon_{n,t}$ is a vector of reduced form residuals with $var(\varepsilon_{n,t}) = \hat{\sigma}$.

[2] See Georgiadis (2012) for detailed explanations about the methodology, and Hory (2016) for an application of the PCH-VAR to the estimation of the fiscal multipliers.

2.2 Data

Data about currency denomination of private debt are not broadly available. This constrains to use data on currency denomination of total external debt, including both private and public debt; this is the first limitation of our estimations.

A sample of 7 countries[3] is considered , including both emerging and advanced economies, over the period 2005Q1-2013Q4, implying a total of 364 observations. Countries, as well as the time period, have been chosen conditionally to data availability.

Public consumption and GDP are taken from Eurostat, and the share of external debt denominated in foreign currency comes from the Quarterly External Debt Statistics database from the World Bank.

Public consumption and GDP are corrected for seasonality by using an X-11 process. They are introduced in growth rate in the regression because the series are non-stationary (the results of unit root tests are shown in Appendix, Table 2).

2.3 Empirical Results

Our results are presented in Figure 2 which shows the response of GDP to a one unit shock in public spending according to the share of external debt denominated in foreign currency.[4] The higher the share of external debt denominated in foreign currency is, the smaller the response of GDP to a public spending shock is. This result confirms that the currency denomination of external debt modifies the impact of public spending on GDP.

Generally, to measure the efficiency of fiscal policy, the fiscal multiplier is computed, that is the ratio of a change in output (ΔY) to a change in public spending (ΔG) (Spilimbergo et al., 2009). Here, the multiplier cannot be directly read on the IRF because the IRF in Figure 2 show the response of the GDP growth rate to a change in public spending growth rate, that is not the proper definition of the fiscal multiplier.

Hence, the fiscal multiplier at time t is computed as follows:[5]

$$\Lambda_t = \frac{\Delta Y_t}{\Delta G_t} = \frac{y_T}{g_T} irf_t \tag{2}$$

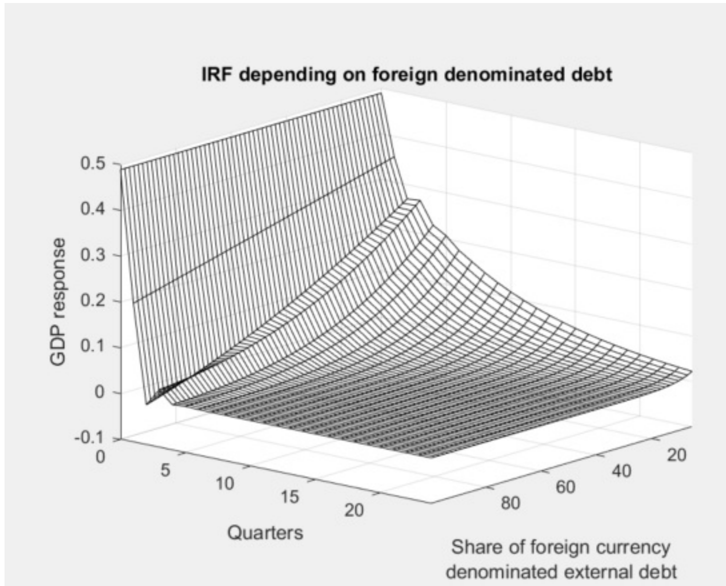
Where $\frac{y_T}{g_T}$ is the average ratio of public spending to GDP, and irf_t is the coefficient read on the IRF.

[3]Bulgaria, Croatia, Germany, Hungary, Slovak Republic, Switzerland and Turkey.

[4]The optimal lag-length is selected by minimizing the AIC criteria, which leads to introduce 2 lags, see Appendix, Table 3.

[5]See Hory (2016) for a demonstration.

Figure 2: GDP response to a one unit shock in public spending according to the share of external debt that is denominated in foreign currency



When the share of external debt denominated in foreign currency is less than 10%, the average fiscal multiplier is 1.75. However, it decreases when external debt increases. For share of external debt in foreign currency exceeding 90%, the average fiscal multiplier is about 1. Moreover, the fiscal multiplier becomes zero at the second period for countries highly indebted in foreign currency, rather than it remains positive during more than 10 periods for countries mainly indebted in local currency.

This result shows that the currency denomination of external debt is an important determinant of public spending efficiency since it affects the value of the fiscal multiplier. Especially, a large share of external debt denominated in foreign currency reduces the fiscal multiplier.

As no formalization have been found in the existing literature, the next Section of the paper develops a theoretical framework which allows the impact of public spending to vary according to the currency denomination of external debt.

3 The Model

In this section, a two-country DSGE model is developed. Two countries of equal size are considered: the Home bloc (H), and the Foreign one (F) that are populated by a continuum of identical households normalized to one. These households consume a composite good (C_t) including home ($C_{H,t}$) and foreign goods ($C_{F,t}$), and they also can buy home and foreign bonds ($B_{H,t}$ and $B_{F,t}$).

In each bloc, there are two types of firms: the wholesales and the retails.

The wholesale firms buy retail goods to turn it into capital, and they use capital to produce an homogeneous wholesale good. To finance their activity, they can borrow, both in local and foreign currencies, but they have to pay an external finance premium. This premium affects firms' solvency, thus modifying investment decisions and, in this way, producing economic fluctuations.

The retail sector is monopolistically competitive: retail firms purchase the wholesale goods, they differentiate them without any cost and then the retail goods are sold to the households.

3.1 Households

We consider an infinite horizon discrete time economy populated by a constant mass of agents whose size is normalized to one in each country. The representative household in the home country is characterized by the following preferences:

$$E_t \sum_{t=0}^{\infty} \beta^t U(C_t, L_t) \tag{3}$$

Where E_t indicates expectations at time t, $\beta \in (0,1)$ is the discount factor, C_t is the per capita consumption index, and L_t is the number of worked hours.

We assume that the utility function takes the following form:

$$U(C_t, L_t) = \frac{C_t^{1-\sigma_c}}{1-\sigma_c} - \frac{L_t^{1+\sigma_l}}{1+\sigma_l} \tag{4}$$

where $\sigma_c > 0$ is the inverse of the inter-temporal elasticity of substitution of consumption, and $\sigma_l > 0$ is the inter-temporal elasticity of substitution of labor.

The household faces the following budget constraint:

$$P_t C_t + B_{H,t} + S_t B_{F,t} + T_t = P_t W_t L_t + R_{n,t-1} B_{H,t-1} + \phi_{t-1}(d_{t-1}) S_t R^*_{n,t-1} B_{F,t-1} + \Gamma_t \tag{5}$$

where W_t is the wage rate in real terms, Γ_t are dividends received by the owners of firms, S_t is the nominal exchange rate expressed as domestic currency units needed to have one unit of foreign currency, $B_{H,t}$ and $B_{F,t}$ are risk-free one-period nominal bonds from the home and the foreign countries, T_t is a lump-sum tax levied on households, P_t is the Consumer Price

Index (CPI), $R_{n,t} = 1 + r_{n,t}$ and $R^*_{n,t} = 1 + r^*_{n,t}$ with $r_{n,t}$ and $r^*_{n,t}$ the domestic and foreign nominal interest rates.

The factor ϕ_t is a country premium received by the household who buys foreign bonds. It is an increasing function of the aggregate level of foreign debt d_t and it is defined as follows:

$$\phi_t(d_t) = exp\left(-\phi_d \frac{S_t B_{F,t}}{Y P_t}\right) \tag{6}$$

where $d_t = \frac{S_t B_{F,t}}{Y P_t}$ with $B_{F,t}$ being the total debt of country F, $\phi_d > 0$ is the country premium elasticity, .Finally, $\phi'(.) < 0$, namely it increases with the aggregate level of foreign debt $-B_{F,t}$ and at steady state, when the net foreign asset position is zero, $\phi(0) = 1$.

This function ensures the stationarity of the model (Schmitt-Grohé and Uribe, 2003), and the existence of a country risk premium reflects frictions in international capital markets, as the price to pay to access markets, agency costs or even the possibility of default. For analytical convenience, and without loss of generality, home households can hold foreign bonds, but foreign households cannot hold home bonds (Benigno and Thoenissen, 2008).

The representative households chooses C_t, L_t, $B_{H,t}$ and $B_{F,t}$ to maximize her utility subject to the budget constraint, leading to the following first order conditions:

1. Consumption and leisure are chosen in order to equalize the marginal rate of substitution between consumption and leisure to the real wage:

$$L_t^{\sigma_l} = W_t C_t^{-\sigma_c} \tag{7}$$

2. The Euler equation, representing household's taste for consumption smoothing:

$$R_{n,t} = \frac{1}{\beta} E_t \left[\frac{C_t^{-\sigma_c}}{C_{t+1}^{-\sigma_c}} \pi_{t+1} \right] \tag{8}$$

where $\pi_t = P_t / P_{t-1}$ is the inflation factor.

3. The arbitrage equation between national and foreign bonds:

$$E_t \left[\left(R_{n,t} - \phi_t \frac{rer_{t+1}}{rer_t} \frac{\pi_{t+1}}{\pi^*_{t+1}} R^*_{n,t} \right) \right] = 0 \tag{9}$$

where $\pi_{t+1} = P_{t+1}/P_t$ is the foreign inflation factor and $rer_t = \frac{S_t P^*_t}{P_t}$ is the real exchange rate. Finally, the standard transversality conditions must hold.

The per capita index of consumption, C_t, is an aggregate of consumption goods produced in the home country ($C_{H,t}$) and consumption goods produced in the foreign country ($C_{F,t}$).

It is defined as follows:

$$C_t = \left[w^{1/\mu} C_{H,t}^{(\mu-1)/\mu} + (1-w)^{1/\mu} C_{F,t}^{(\mu-1)/\mu}\right]^{\mu/(\mu-1)} \tag{10}$$

where $\mu > 0$ is the elasticity of substitution between home and foreign goods, and $w \in (0,1)$ captures the degree of home bias in the home bloc, $(1-w)$ can therefore be viewed as the trade openness degree.

Consumption in each bloc is defined by:

$$C_{H,t} = \left[\int_0^1 C_{H,t}(v)^{(\zeta-1)/\zeta} dv\right]^{\zeta/(\zeta-1)}; \quad C_{F,t} = \left[\int_0^1 C_{F,t}(v)^{(\zeta-1)/\zeta} dv\right]^{\zeta/(\zeta-1)} \tag{11}$$

where $\zeta > 0$ is the elasticity of substitution between the varieties v produced into each bloc.

The optimal intra-temporal allocations of consumption are:

$$C_{H,t}(v) = \left(\frac{P_{H,t}(v)}{P_{H,t}}\right)^{-\zeta} C_{H,t}; \quad C_{F,t}(v) = \left(\frac{P_{F,t}(v)}{P_{F,t}}\right)^{-\zeta} C_{F,t} \tag{12}$$

$$C_{H,t} = w\left(\frac{P_{H,t}}{P_t}\right)^{-\mu} C_t; \quad C_{F,t} = (1-w)\left(\frac{P_{F,t}}{P_t}\right)^{-\mu} C_t \tag{13}$$

The Consumer Price Index (CPI) associated with the index of consumption (10) is given by:

$$P_t = \left[w(P_{H,t})^{1-\mu} + (1-w)(P_{F,t})^{1-\mu}\right]^{1/(1-\mu)} \tag{14}$$

where the price sub-indexes associated with $C_{H,t}$ and $C_{F,t}$ are:

$$P_{H,t} = \left[\int_0^1 P_{H,t}(v)^{1-\zeta} dv\right]^{1/(1-\zeta)}; \quad P_{F,t} = \left[\int_0^1 P_{F,t}(v)^{1-\zeta} dv\right]^{1/(1-\zeta)} \tag{15}$$

3.2 The Exchange Rate

Since the Law of One Price (LOP) applies to differentiated goods

$$\frac{S_t P_{F,t}^*}{P_{F,t}} = \frac{S_t P_{H,t}^*}{P_{H,t}} = 1, \tag{16}$$

it is possible to rewrite the real exchange rate at time t as

$$rer_t = \frac{S_t P_t^*}{P_t} = \frac{\left[w^* + (1-w^*)\tau_t^{\mu^*-1}\right]^{1/(1-\mu^*)}}{\left[1 - w + w\tau_t^{\mu-1}\right]^{1/(1-\mu)}} \tag{17}$$

where $\tau = P_{F,t}/P_{H,t}$ represents the terms of trade (the domestic currency relative price of imports to exports).

Finally, using the household's first order condition (9), the (modified) Uncovered Interest rate Parity (UIP) condition is obtained:

$$E_t \frac{R_{n,t}}{\pi_{t+1}} = \phi_t E_t \frac{R^*_{n,t}}{\pi^*_{t+1}} \frac{rer_{t+1}}{rer_t} \tag{18}$$

It is different from the standard UIP because of the presence of the interest rate premium ϕ_t.

3.3 Firms

Both countries are populated by wholesale firms which buy the final good, both from H and from F, to convert it into new capital. Then they use capital to produce the wholesale good which is acquired and differentiated by monopolistically competitive firms, the retailers.

3.3.1 Wholesale Firms

Wholesale firms produce and sell an homogeneous good on a competitive market by using labor and capital. The production technology has constant returns to scale and is represented by a Cobb-Douglas function where technical progress is exogenous and captured by the factor A_t:

$$Y_t^W = A_t K_t^\alpha L_t^{1-\alpha} \tag{19}$$

where Y_t^W is the quantity of wholesale goods produced by a firm, K_t is the capital stock at the beginning of the period t, L_t is the labor demand function of the firm, and $0 < \alpha < 1$ measures the capital intensity.

To obtain capital, wholesale firms invest (I_t) by buying the final good sold by retailers and they use the existing capital to transform it into new capital (K_t). Wholesale firms have to support an internal adjustment cost of capital which is increasing and convex in I_t/K_t:

$$\Psi(I_t, K_t) = \frac{\Phi}{2}\left(\frac{I_t}{K_t} - \delta\right)^2 K_t \tag{20}$$

where $\delta \in (0,1)$ is the depreciation rate of capital, Φ is a positive parameter and I_t is a composite good from home and foreign retail firms constructed as follow:

$$I_t = \left[w_I^{1/\mu_I} I_{H,t}^{\frac{(\mu_I - 1)}{\mu_I}} + (1 - w_I)^{1/\mu_I} I_{F,t}^{\frac{(\mu_I - 1)}{\mu_I}} \right]^{\frac{\mu_I}{(\mu_I - 1)}} \tag{21}$$

where $w_I \in (0,1)$ measures the home bias of capital producers, and $\mu_I > 0$ the elasticity of substitution between home and foreign retail goods for capital producers. It is assumed that firms and households have the same preferences, meaning that $w = w_I$ and $\mu = \mu_I$. The price of I_t therefore corresponds to the CPI:

$$P_t = \left[w(P_{H,t})^{1-\mu} + (1 - w)(P_{F,t})^{1-\mu} \right]^{1/(1-\mu)} \tag{22}$$

The optimal intra-temporal demands for domestic and foreign inputs are:

$$I_{H,t} = w \left(\frac{P_{H,t}}{P_t} \right)^{-\mu} I_t; \quad I_{F,t} = (1 - w) \left(\frac{P_{F,t}}{P_t} \right)^{-\mu} I_t \tag{23}$$

Finally, the stock of capital evolves according to the following law:

$$K_{t+1} = I_t + (1 - \delta) K_t \tag{24}$$

Wholesale firms choose the level of investment, the quantity of labor and capital that maximize their profits. Let $P^W_{H,t}$ be the price of the wholesale goods at home, and $mc_t = \frac{P^W_{H,t}}{P_{H,t}}$ the marginal costs. The profit and the corresponding constraint of the representative wholesale firm can be written as follows:

$$\Pi^W_t = E_t \Sigma^{\infty}_{T=0} \beta^T_W \left[mc_{t+T} \frac{P_{H,t+T}}{P_{t+T}} A_{t+T} K^{\alpha}_{t+T} L^{1-\alpha}_{t+T} - W_{t+T} L_{t+T} - \frac{P_{t+T}}{P_{t+T}} I_{t+T} - \Psi(I_{t+T}, K_{t+T}) \right] \tag{25}$$

$$SC.\ K_{t+T+1} = I_{t+T} + (1 - \delta) K_{t+T} \tag{26}$$

By solving this problem we obtain the value of the average real wage in the home economy:

$$W_t = mc_t \frac{P_{H,t}}{P_t} (1 - \alpha) \frac{Y_t}{L_t} \tag{27}$$

the real price of capital, q_t:

$$q_t = 1 + \frac{\partial \Psi(I_t, K_t)}{\partial I_t} = 1 + \Phi \left(\frac{I_t}{K_t} - \delta \right) \tag{28}$$

and, finally, the real return on capital over the period t, R_t^k :

$$R_t^k = \left[\frac{\alpha mc_t \frac{P_{H,t}}{P_t} \frac{Y_t}{K_t} - \frac{\Phi}{2} \left[\delta^2 - \left(\frac{I_t}{K_t}^2 \right) \right] + (1-\delta) q_t}{q_{t-1}} \right] \tag{29}$$

where $R_t^k = 1 + r_t^k$, with r_t^k the real rate of return of capital.

The first part of (29) is the marginal productivity of capital $\left(mpc_t = \alpha mc_t \frac{P_{H,t}}{P_t} \frac{Y_t}{K_t} \right)$. Equation (29) means that each additional unit of capital yields $mc_t \frac{P_{H,t}}{P_t} \frac{Y_t}{K_t}$ to the firm, minus the cost due to the adjustment of capital. The equation also takes into account the fact that capital can also be resold at its depreciated value $(1-\delta)q_t$.

To finance their activity, wholesale firms borrow in local and foreign currency, and they have to support an external finance premium (Θ_t) defined by:

$$\Theta_t = \Theta \left(\frac{q_{t-1} K_t}{N_t} \right) \tag{30}$$

With $\Theta'(.) > 0$, $\Theta(1) = 1$ and $\Theta(\infty) = \infty$; N_t is the net worth of a wholesale firm, which will be defined below.

Wholesale firms borrow in home currency with proportion κ, and in foreign currency with proportion $(1-\kappa)$, with $\kappa \in [0,1]$. Therefore, home and foreign interest rates are combined to obtain the expected marginal cost of borrowing:

$$\begin{aligned} E_t \left(R_{t+1}^k \right) &= \Theta_{t+1} \left[\kappa E_t \left(\frac{R_{n,t}}{\pi_{t+1}} \right) + (1-\kappa) \phi_t(d_t) E_t \left(\frac{R_{n,t}^*}{\pi_{t+1}^*} \frac{rer_{t+1}}{rer_t} \right) \right] \\ &= \Theta_{t+1} \left[\kappa E_t \left(R_t \right) + (1-\kappa) \phi_t(d_t) E_t \left(R_t^* \frac{rer_{t+1}}{rer_t} \right) \right] \end{aligned} \tag{31}$$

with R_t and R_t^* the nominal exchange rates in the home and foreign economies. Equation (31) means that the real return of capital must be equal to the cost to acquire this capital. This cost is determined by the external finance premium, by the home interest rate in proportion κ, and by the foreign interest rate in proportion $1-\kappa$.

Wholesalers accumulate net worth according to the following dynamics:

$$N_{t+1} = \xi_e \left[R_t^k q_{t-1} K_t - \Theta_t \left[\kappa \frac{R_{n,t-1}}{\pi_t} + (1-\kappa) \phi_{t-1} \frac{R_{n,t-1}^*}{\pi_t^*} \frac{rer_t}{rer_{t-1}} \right] (q_{t-1} K_t - N_t) \right] \tag{32}$$

where $1-\xi_e$ is the probability for a firm to exit the market. The net worth is equal to the real return on capital held by the firm minus the financing cost of the acquired capital.

Equation (32) shows that firms are exposed to exchange rate fluctuations when they are indebted in foreign currency. For small values of κ, a decrease in the RER (an appreciation) inflates the firms net worth, and an increase in the RER (a depreciation) deflates their net worth.

Entrepreneurs that exit consume their remaining resources:

$$C_t^e = \frac{(1-\xi_e)}{\xi_e} N_t \tag{33}$$

As for households, the optimal consumption of exiting entrepreneurs is:

$$C_{H,t}^e = w\left(\frac{P_{H,t}}{P_t}\right)^{-\mu} C_t^e \ ; \quad C_{F,t}^e = (1-w)\left(\frac{P_{F,t}}{P_t}\right)^{-\mu} C_t^e \tag{34}$$

3.3.2 Retail Firms

Each retail firm uses the wholesale good Y^W to produce a differentiated good $Y(v)$. The output of each firm is:

$$Y_t(v) = Y_t^W(v) \tag{35}$$

Each retailer maximizes his profit facing the following demand function:

$$Y_t(v) = \left(\frac{P_{H,t}(v)}{P_{H,t}}\right)^{-\zeta} Y_t \tag{36}$$

Home retailers set the price of their goods as an optimal price $\widehat{P}_{H,t}(v)$ with a probability $1-\varrho_H$. If firms do not optimize the price at the period t, $P_{H,t}(v) = P_{H,t-1}(v)$. This assumption allows to introduce sticky prices following Calvo (1983).

The inter-temporal profit of a retail firm can be written as follows:

$$E_t \Sigma_{k=0}^{\infty} \varrho_H^k \frac{\lambda_{t+k}}{\lambda_t}\left[\widehat{P}_{H,t}(v)Y_{t+k}(v) - P_{H,t+k}mc_{t+k}Y_{t+k}(v)\right] \tag{37}$$

where $mc_{t+k} = \frac{P^W_{H,t+k}}{P_{H,t+k}}$ represents marginal costs, $\frac{\lambda_{t+k}}{\lambda_t} = \beta^k \frac{U_{C_{t+k}}}{U_{C_t}}$ is the discount factor for future (real) profits.

The first order condition related to the maximization of inter-temporal profit implies:

$$\widehat{P}_{H,t}(v) = \frac{\zeta}{\zeta-1} \frac{\Sigma_{k=0}^{\infty}(\varrho_H\beta)^k mc_{t+k} P_{H,t+k}^{\zeta+1} Y_{t+k}}{\Sigma_{k=0}^{\infty}(\varrho_H\beta)^k P_{H,t+k}^{\zeta} Y_{t+k}} \tag{38}$$

The price index is therefore given by the combination of revised (and optimally set) prices and non-revised prices:

$$P_{H,t} = \left[(1-\varrho_H)\widehat{P}_{H,t}^{(1-\zeta)} + \varrho_H (P_{H,t-1})^{1-\zeta}\right]^{\frac{1}{1-\zeta}} \tag{39}$$

Combining the log-linearization of Equations (38) and (39) leads to the following inflation dynamics, also called New-Keynesian Phillips curve:

$$\widehat{\pi}_{H,t} = \beta E_t \widehat{\pi}_{H,t+1} + \frac{(1-\varrho_H)(1-\beta\varrho_H)}{\varrho_H}\widehat{mc}_t \tag{40}$$

3.4 Fiscal Policy

Following, among others, Bouakez and Eyquem (2015), public spending is financed through lump-sum taxes:

$$P_t G_t = T_t \tag{41}$$

where G_t is the total amount of public spending. Note that public spending is aggregated as private demand.[6]

Public spending follows an autoregressive process of the type:

$$\widehat{G}_t = \rho_g \widehat{G}_{t-1} + \varepsilon_{g_t} \tag{42}$$

where $\widehat{G}_t = \frac{G_t - G}{G}$ is the log-deviation of G_t around the steady state, $\rho_g \in (0,1)$, and ε_t^g is a white noise.

3.5 Monetary Policy

The monetary authority sets the nominal interest rate according to the following Taylor rule with output growth y_t and consumer price index inflation (π) targets:

$$\widehat{R}_{n,t} = \rho \widehat{R}_{n,t-1} + (1-\rho)\left(\gamma_\pi E_t \widehat{\pi}_{t+1} + \gamma_y \widehat{Y}_t\right) \tag{43}$$

ρ is the coefficient of autocorrelation of nominal interest rate, γ_π is the weight given to inflation, and γ_y the weight for output.

[6] As for I and C^e, this assumption means that government has the same preferences than households. It ensures that the reactions of firms, households and the government act in the same way without affecting the results.

3.6 Market Clearing

The aggregated demand for the home economy is:

$$Y_t = w\left(\frac{P_{H,t}}{P_t}\right)^{-\mu}(C_t + C_t^e + I_t + G_t) + (1-w)\left(\frac{P_{H,t}^*}{P_t^*}\right)^{-\mu}(C_t^* + I_t^* + G_t^*) \tag{44}$$

The equilibrium between the current account and the financial account allows to define the trade balance (TB) as follows:

$$TB_t = P_{H,t}Y_t - P_tC_t - P_tC_t^e - P_tI_t - P_{H,t}G_t - P_t\Psi(I_t, K_t) \tag{45}$$

The home economy accumulates net foreign assets according to the following dynamics:

$$d_t = \phi_{t-1}d_{t-1}\frac{RER_t}{RER_{t-1}}\frac{R_{n,t-1}^*}{\pi_t^*} + \frac{P_{H,t}}{P_t}\frac{Y_t}{Y} - \frac{C_t}{Y} - \frac{C_t^e}{Y} - \frac{G_t}{Y} - \frac{I_t}{Y} - \Psi_(I_t, K_t) \tag{46}$$

The Walras' Law implies that the bond market equilibrium is reached when all the other markets are balanced.

4 Calibration

This section presents the calibration of the parameters of model and the steady state ratios. They are respectively shown in the Appendix, Tables 4 and 5. The values are selected from the existing literature, and alternative calibrations are tested, as presented in Section 6. Note that the parameters of the two countries are calibrated in the same way, excepted for monetary policy, fiscal policy, and the financial accelerator mechanism which is only introduced in the home economy in order to concentrate on the relevant mechanisms, without loss of generality.

4.1 Households

Following Bonam and Lukkezen (2014) or Elekdağ and Tchakarov (2007), the inverse of the inter-temporal elasticity of substitution (σ_c) is fixed at 2, and the inverse of the Frisch elasticity of labor supply (σ_l) at 1. As in most of the literature, the discount factor β is set at 0.99. The elasticity of substitution between varieties locally produced ζ is equal to 6, following Bouakez and Eyquem (2015) or Kitano et al. (2015). An alternative value of ζ is considered in Section 6.

Regarding the elasticity of substitution between home and foreign goods, μ, it is fixed at

1.5 as in Bouakez and Eyquem (2015), and the home bias (ω) is set at 0.75, which corresponds to a trade openness degree at 0.25, as for example in Kitano et al. (2015), Elekdağ and Tchakarov (2007) or Cook (2004).

Finally, the country premium elasticity ϕ_d is set at 0.0007 in line with Schmitt-Grohé and Uribe (2003) or Sangaré (2016). Alternative calibrations for this parameter are tested in Section 6.

4.2 Firms

Following Kitano et al. (2015), the capital intensity (α) is set at 0.35, which means a labor intensity ($1-\alpha$) at 0.65. The depreciation rate of capital δ is fixed at 0.025, which is in line with, among others, Christensen and Dib (2008). The adjustment cost function parameter Φ is equal to 6 following Chang and Fernández (2013). A sensitivity analysis is lead in Section 6.

Wholesale firms support an external finance premium which depends on the capital to net worth ratio with an elasticity of 0.042 (Christensen and Dib, 2008); a smaller value of this parameter is tested in Section 6 following Badarau and Levieuge (2011).

Wholesalers exit at the end of a period with probability $1-\xi_e$, with ξ_e equal to 0.985, in line with Levieuge (2009).

Regarding the price setting, the price rigidity parameter ϱ_H is fixed at 0.75, a widely used value in the literature (e.g. Bouakez and Eyquem (2015)). This correspond to a probability of 0.25 to set the price optimally.

4.3 Monetary and fiscal policies

Regarding the monetary policy, the temporal autocorrelation of nominal interest rate, ρ is commonly fixed at 0.85. Regarding the home economy, a not-too-aggressive monetary policy is considered: the weight for expected inflation, γ_π, is fixed at 1.1, and the weight for the output-gap, γ_y, is set to 0. In the foreign economy, the monetary authority is supposed to be more aggressive: $\gamma_\pi^* = 1.8$ and $\gamma_y^* = 0$.

As in Bouakez and Eyquem (2015), this configuration allows to obtain a decrease in the interest rate differential between H and F, that should lead to the depreciation of the real exchange rate, as found in empirical studies (e.g. Kim (2015)).

For the fiscal policy, the autocorrelation of public spending shocks ρ_g is set at 0.8 in line with most of the literature, and alternatives values are tested in Section 6.

5 The effects of public spending

In a closed-economy model, an increase in public spending acts as an increase in total demand, and the rise in total demand leads to an increase in firms' revenue. When firms' revenue rises, their net worth increases too. As a consequence, this decreases the external finance premium and thus the debt burden. The financing constraints of firms are therefore relaxed, boosting investment and economic activity.

However, in an open-economy model, we show that the currency composition of firms' indebtedness and the changes of the real exchange rate also interfere.

Following a positive public spending shock, it has been shown that the RER depreciates, allowed by a decrease in the interest rate differential between the two countries (see for example Kim (2015); Bouakez and Eyquem (2015); Kollmann (2010)). The central mechanism in our model is that a depreciation of the RER should lead to a decrease in the net worth of firms that are indebted in foreign currency. This rises the financing constraints, and the investment is reduced. Consequently, a high foreign currency denomination of external debt reduces the positive effect of public spending on economic growth.

On the contrary, if firms are indebted in local currency, the increase of the demand through the increase of public spending leads to a rise in firms' net worth. The financing constraints are reduced and the investment increases stimulating economic growth. The depreciation of the RER following the spending shock accentuates this positive effect by further increasing the demand since exports increase and imports reduce.

In sum, the currency denomination of external debt could modify the effect of public spending on economic activity by making firms vulnerable to exchange rate fluctuations.

Regarding our results more in details, Figure 3 shows the responses to an increase by 1% in public spending of output, consumption, investment, real exchange rate (RER), net worth, external finance premium (EPF). The red dotted line corresponds to a large share of debt denominated in foreign currency ($\kappa = 0.1$) and the blue line to the case $\kappa = 0.9$.

An increase in public spending leads to an increase in the real exchange rate, which is consistent with the results found by the existing literature (see for example Kim (2015); Bouakez and Eyquem (2015); Kollmann (2010)). As explained before, this depreciation has different effects depending on the currency denomination of external debt.

In the case firms are indebted in local currency at the 90% level ($\kappa = 0.9$), the rise of the RER after a public spending shock does not directly impact the firms' net worth. In that case, net worth and the cost to acquire capital are mostly determined by the local cost of borrowing (see equation 32). The depreciation of the RER has therefore more traditional effects:

the depreciation makes local goods more attractive than foreign ones, exports increase and imports decrease leading to an increase in firms' revenue. It follows a decrease in the EFP and thus a (large) increase in private investment. Consumption reduces because of the rise of tax, but the large increase of investment offset this fall in consumption, generating output growth.

In the case firms are indebted in foreign currency at the 90% level ($\kappa = 0.1$), following a public spending shock, the rise in the RER leads to a decline of net worth because of the increase in the borrowing cost.[7] In fact, the depreciation of the RER implies an increase in the real value of foreign currency denominated debt (negative wealth effect), that is equivalent to an increase in firm leverage. The EFP therefore rises, and investment decreases since the cost to acquire new capital increases.[8] In the standard case, a depreciation of the RER stimulates economic activity by increasing exports and reducing imports. However, here, this effect is partly offset by the reduction of private investment. A positive effect of public spending on output remains, but this effect is weak and especially smaller than in the case firms are indebted in local currency.

In order to measure the effect of public spending on output, we compute the fiscal multiplier that is the ratio of a change in output (ΔY) to a change in public spending (ΔG). Four types of multipliers can be computed (Spilimbergo et al., 2009):

- the impact multiplier, which measures the change in output at time t due to a change in public spending at the same time

$$\Lambda_t = \frac{\Delta Y_t}{\Delta G_t}$$

- the peak multiplier, defined as the largest impact of public spending on output over a period $[t; t+T]$

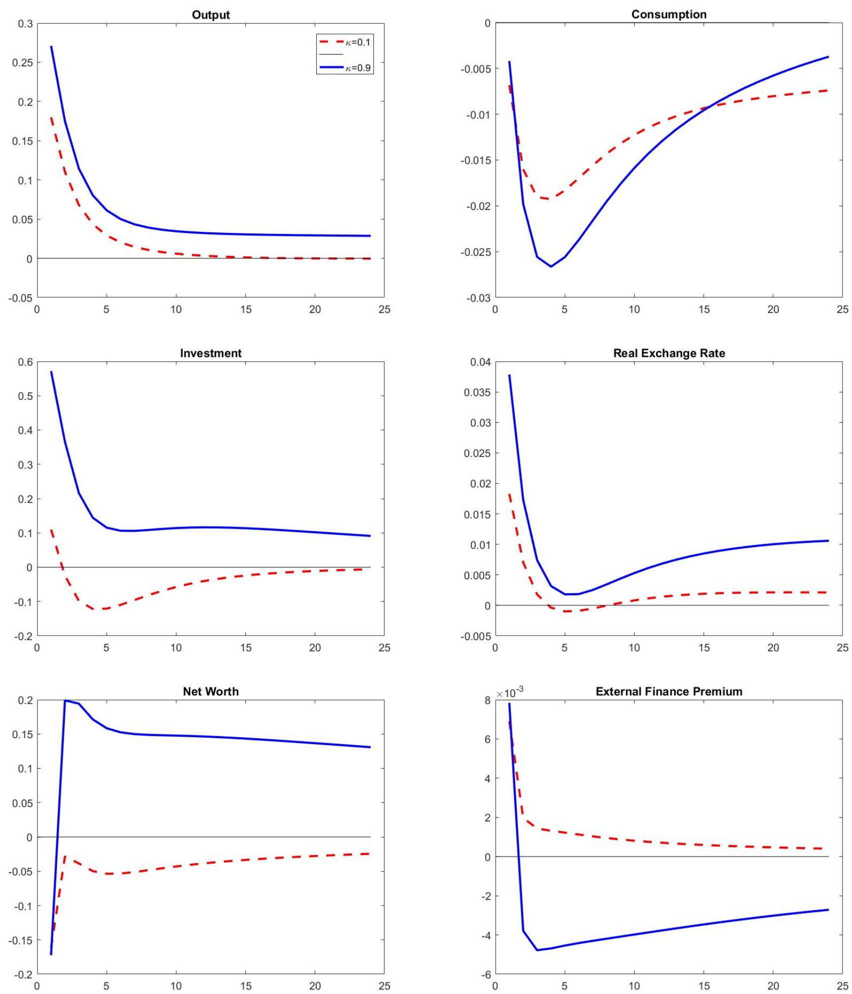
$$\Lambda_T^{max} = max_T \frac{\Delta Y_{t+T}}{\Delta G_t}$$

- the multiplier at some horizon T, measuring the change in output at time $t+T$ due to

[7]Following the log-linearized version of equation 32, the elasticity of net worth to the variation of the RER $\left(-\Theta(1-\kappa)\frac{R_n^*}{\pi}\left(\frac{K}{N}-1\right)\right)$ is negative for capital-to-net worth ratio larger than 1. Actually, it is always the case here since $\frac{K}{N} \leq 1$ would mean that firms do not borrow.

[8]The investment increases at the impact, but decreases from the second period, and the cumulative effect of public spending on investment is highly negative, around -1 since the 10th period. The positive response at the impact is justified by the initial increase of net export following the depreciation of the real exchange rate.

Figure 3: Effects of a 1% positive shock in public spending



a change in public spending at time t

$$\Lambda_T = \frac{\Delta Y_{t+T}}{\Delta G_t}$$

- the cumulative multiplier, which gives the cumulative change in output over a period $[t; t+T]$ due to the cumulative change in public spending over the same period;

$$\Lambda_{t+T} = \frac{\Sigma_{s=0}^{T} \Delta Y_{t+s}}{\Sigma_{s=0}^{T} \Delta G_{t+s}}$$

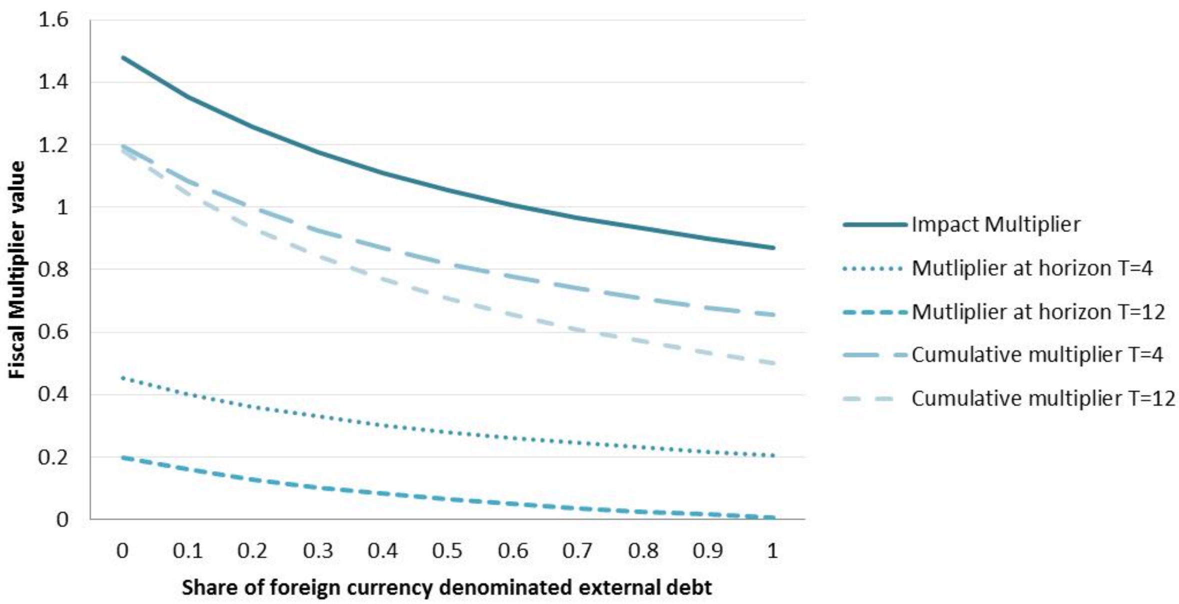
Note that, in our case, the impact multiplier coincides with the peak multiplier since the most important effect of public spending on GDP is observed at the impact.

Figure 4 shows the value of these multipliers as a function of the share of debt denominated in foreign currency (i.e. $(1-\kappa)$). The higher this share is, the smaller the multiplier is. This is true whatever the used definition of the multiplier.

When 90% of firms' indebtedness is denominated in local currency, the multiplier is around 1.4, rather than it is less than 0.9 when firms are indebted at the 90% level in foreign currency.

These results are consistent with the estimates presented in Section 2: countries with external debt mostly denominated in foreign currency have smaller multipliers than countries indebted in local currency.

Figure 4: Impact of a 1% increase in public spending on GDP according to the share of foreign currency denominated external debt



6 Sensitivity Analysis

6.1 Changing the parameters

In this Section, the sensitivity of the results to alternative calibrations of some parameters is tested. Especially, the fiscal multiplier is computed for different values of the autocorrelation of spending shocks parameter, the country risk premium elasticity, the capital adjustment cost parameter, the elasticity of external finance premium, and the elasticity of substitution between home goods.

Table 1 shows the value of the fiscal multiplier with alternative parameters and for different values of κ. Overall, the negative effect of foreign currency denomination of indebtedness on the fiscal multiplier remains whatever the calibration of the parameters, even if the magnitude of this effect changes.

Regarding the autocorrelation of spending shocks, the higher the coefficient is, the larger the multiplier is. The spread between the multiplier for $\kappa = 0.1$ and that for $\kappa = 0.9$ also slightly increases with the value of ρ_g. A higher autocorrelation in spending shocks means larger persistence of an increase in public spending. The consequences of an expansive fiscal policy are larger when the persistence degree is higher. Furthermore, for a given level of public spending shock autocorrelation, a high share of debt denominated in foreign currency reduces the fiscal multiplier; and for a given level of foreign currency denominated debt, the multiplier increases with the degree of public spending shock autocorrelation.

Considering the elasticity of the country risk premium, the spread between the multiplier for $\kappa = 0.1$ and that for $\kappa = 0.9$ does not significantly change according to the value of ϕ_d. The same observation can be made about the impact of a different elasticity of substitution between home goods. The calibration of these parameters does not really affects our results.

In contrast, changing the capital adjustment cost parameter implies relatively large changes in the multiplier values. A smaller adjustment cost implies both larger multipliers whatever the value of κ and a larger spread between the extreme cases $\kappa = 0.1$ and $\kappa = 0.9$. This result is consistent with the mechanism explained is the previous section: the negative effect of foreign currency denomination of debt occurs through the RER, the net worth and, by the way, through the investment level. The higher adjustment costs are, the less firms adjust their decisions, hence the observed change in investment is smaller. The responses of investment and output to fiscal policy are therefore reduced.

Regarding the elasticity of the external finance premium, a smaller elasticity leads to a smaller spread between the value of the multiplier when $\kappa = 0.1$ and $\kappa = 0.9$. Once again, this result seems consistent with results in Section 5 since a smaller elasticity of the EFP means that financing costs do not increase so much following a decrease in the net worth. Investment therefore declines less in the case θ is small than in the case θ is relatively higher.

Table 1: Sensitivity - **New Calibration With /0.2**

	κ=0.1	κ=0.5	κ=0.9	Spread
$\rho_g = 0.6$	0.83	0.92	1.09	0.26
$\boldsymbol{\rho_g = 0.8}$	**0.90**	**1.06**	**1.35**	**0.46**
$\rho_g = 0.9$	0.97	1.21	1.68	0.70
$\phi_d = 0.0001$	0.88	1.02	1.26	0.38
$\boldsymbol{\phi_d = 0.0007}$	**0.90**	**1.06**	**1.35**	**0.46**
$\phi_d = 0.001$	0.91	1.07	1.39	0.48
$\Phi = 3$	0.98	1.22	1.75	0.77
$\boldsymbol{\Phi = 6}$	**0.90**	**1.06**	**1.35**	**0.46**
$\Phi = 12$	0.86	0.97	1.14	0.28
$\theta = 0.025$	0.91	1.03	1.23	0.32
$\boldsymbol{\theta = 0.042}$	**0.90**	**1.06**	**1.35**	**0.46**
$\zeta = 1.1$	0.80	0.93	1.16	0.36
$\boldsymbol{\zeta = 6}$	**0.90**	**1.06**	**1.35**	**0.46**

6.2 What about the financial accelerator mechanism?

The model has been reformulated to eliminate the financial accelerator in order to test whether this mechanism actually affects the value of the multiplier. The model is exactly the same, but firms do not accumulate net worth anymore, and they do not have to support an external finance premium. The only "price to pay" to invest is the real interest rate.

Using the same calibration than the benchmark case, the values of the multiplier obtained are really different when the financial accelerator is eliminated from the model, and the impact of foreign currency denominated debt is significantly reduced. In fact, for a share of foreign currency denominated debt at the 90% level (i.e. $\kappa = 0.1$), the multiplier is around 0.9, and for a share of foreign currency denominated debt at the 10% level (i.e. $\kappa = 0.9$) the multiplier is 0.95. In both cases, the multiplier is below one, showing that the financial accelerator mechanism magnifies the effect of public spending, or at least, modifies the impact of public spending on economic growth. Without the financial accelerator, the fiscal multiplier remains below one whatever the value of κ. This is a common result in DSGE models. In fact, most of the DSGE models that generates fiscal multipliers larger than one consider non-ricardian households, which is not the case here. The introduction of the financial accelerator seems therefore sufficient to obtain results consistent with the keynesian theory.

The financial accelerator mechanism seems therefore important in the analysis of fiscal policy efficiency. *, especially since the effects of public spending could be underestimated if it is not introduced in DSGE model.*

7 Concluding Remarks

The empirical literature shows that fiscal multipliers in emerging market economies are smaller than those in advanced economies. While the existing literature often considers the level of development as a determinant of the fiscal multiplier, we argue that this gap can be due to specificities in EMEs. Especially, this paper considers the role of the currency denomination of private indebtedness, a feature that, to the best of our knowledge, has not been analyzed in the literature yet.

First, using a PCH-VAR, the negative impact of foreign currency denominated debt on the fiscal multiplier is underlined. Countries with a high share of external debt denominated in foreign currency have smaller multipliers than countries mainly indebted in local currency.

Second, this result is rationalized in a DSGE model with sticky prices, imperfect and incomplete international financial markets, a not-too-aggressive monetary policy and a financial accelerator à la Bernanke et al. (1999). In this framework, firms can borrow both in local and foreign currency, and their financial structure generates economic fluctuations, affecting the efficiency of fiscal policy.

We show that when firms are indebted in foreign currency, the increase in public spending generates a depreciation of the exchange rate, leading to a decrease in firms' net worth. The financing cost of investment therefore increases and this generates a decline in the investment level. The effect of public spending on growth remains positive but the decrease in investment weakens this impact. The fiscal multiplier falls below one, meaning that the increase in public spending leads to an increase in GDP less than proportional to the rise in public spending. At the contrary, when firms are indebted in local currency, the increase in public spending generates a depreciation of the exchange rate that stimulates the demand, therefore reducing the financing costs. Hence, investment increases, and the positive effect of an expansive fiscal policy is magnified. The fiscal multiplier is larger than one in that case, which is consistent with the traditional predictions of the Keynesian theory.

These results show that the currency denomination of indebtedness is an important determinant of the fiscal multiplier. The high share of debt denominated in foreign currency in

EMEs could be part of the features that makes fiscal multipliers so small in these countries. This statement outlines the need for reforms regarding the financial sector in emerging countries. While an increasing number of reforms have been implemented there,[9] fostering the use of local currency to finance economic activity seems still an important task for governments.

[9]According to the database of Cerutti et al. (2017), in 2000, only 6 EMEs and LICs countries had implemented some reforms to constrain foreign currency loans. In 2013, the same number of countries was three times higher.

Appendix

Table 2: Stationarity tests (p-values)

	No time trend				Time trend			
Variables in levels	IPS		Fisher		IPS		Fisher	
GDP	1.36	(0.91)	1.02	(0.85)	2.03	(0.98)	1.74	(0.96)
Public consumption	0.75	(0.77)	-0.09	(0.47)	2.01	(0.98)	1.92	(0.97)
Variables in first difference	IPS		Fisher		IPS		Fisher	
GDP	-12.88	(0.00)	-12.95	(0.00)	-15.43	(0.00)	-13.05	(0.00)
Public consumption	-14.4	(0.00)	-15.36	(0.00)	-11.44	(0.00)	-14.96	(0.00)

Table 3: Optimal lag length selection

lag	MMSC-AIC
1	4.29E-31
2	**1.12E-31**
3	7.63E-31
4	2.83E-30
5	3.79E-31
6	1.08E-30

The Steady State

Variable without time index denotes its steady state value.

Home Economy

$$C = \left[w^{1/\mu} C_H^{\mu-1/\mu} + (1-w)^{1/\mu} C_F^{\mu-1/\mu}\right]^{\mu/\mu-1} \tag{47}$$

$$C_H = w \left(\frac{P_H}{P}\right)^{-\mu} C \; ; \quad C_F = (1-w) \left(\frac{P_F}{P}\right)^{-\mu} C \tag{48}$$

$$P = \left[w P_H^{(1-\mu)} + (1-w) P_F^{1-\mu}\right]^{1/(1-\mu)} \tag{49}$$

$$RER = \frac{SP^*}{P} \tag{50}$$

$$\tau = \frac{P_F}{P_H} \tag{51}$$

$$I = \left[w^{1/\mu} I_H^{\frac{\mu-1}{\mu}} + (1-w)^{1/\mu} I_F^{\frac{\mu-1}{\mu}} \right]^{\frac{\mu}{1-\mu}} \tag{52}$$

$$I_H = w \left(\frac{P_H}{P} \right)^{-\mu} I \ ; \quad I_F = (1-w) \left(\frac{P_F}{P} \right)^{-\mu} I \tag{53}$$

$$I = \delta K \Leftrightarrow \frac{I}{K} = \delta \tag{54}$$

$$mc = \frac{P_H^W}{P_H} \tag{55}$$

$$\frac{WL}{Y} = mc \frac{P_H}{P} (1-\alpha) \tag{56}$$

$$q = 1 \tag{57}$$

$$\frac{Y}{K} = \frac{P}{\alpha mc P_H} \left[R^K - (1-\delta) \right] \tag{58}$$

$$\frac{I}{Y} = \frac{\alpha mc \delta}{R^K - (1-\delta)} \tag{59}$$

$$R_n = \frac{1}{\beta} \tag{60}$$

$$\Theta = \Theta \left(\frac{K}{N} \right) \tag{61}$$

$$R^k = \Theta \left(\kappa \frac{R_n}{\pi} + (1-\kappa) \frac{R_n^*}{\pi^*} \right) \tag{62}$$

$$C^e = \frac{(1-\xi_e)}{\xi_e} N \tag{63}$$

$$P_H = \widehat{P}_H = \frac{\zeta}{\zeta - 1} mc P_H \tag{64}$$

$$mc = \frac{P_H^W}{P_H} = 1 - \frac{1}{\zeta} \tag{65}$$

$$PG = T \tag{66}$$

Foreign Economy

$$C^* = \left[(1-w)^{1/\mu} {C_H^*}^{\mu-1/\mu} + w^{1/\mu} {C_F^*}^{\mu-1/\mu}\right]^{\mu/\mu-1} \tag{67}$$

$$P^* = \left[(1-w) {P_H^*}^{(1-\mu)} + w {P_F^*}^{1-\mu}\right]^{1/(1-\mu)} \tag{68}$$

$$I^* = \left[(1-w)^{1/\mu} {I_H^*}^{\frac{\mu-1}{\mu}} + w^{1/\mu} {I_F^*}^{\frac{\mu-1}{\mu}}\right]^{\frac{\mu}{1-\mu}} \tag{69}$$

$$I_H^* = (1-w)\left(\frac{P_H^*}{P^*}\right)^{-\mu} I^* \ ; \quad I_F^* = w\left(\frac{P_F^*}{P^*}\right)^{-\mu} I^* \tag{70}$$

$$I^* = \delta^* K^* \Leftrightarrow \frac{I^*}{K^*} = \delta^* \tag{71}$$

$$mc^* = \frac{{P_F^*}^W}{P_F^*} \tag{72}$$

$$\frac{W^* L^*}{Y^*} = mc^* \frac{P_F^*}{P^*}(1-\alpha^*)$$

$$q^* = 1 \tag{73}$$

$$\frac{Y^*}{K^*} = \frac{P^*}{\alpha^* {P_H^*}^W}\left({R^*}^K - (1-\delta^*)\right) \tag{74}$$

$$\frac{I^*}{Y^*} = \frac{\alpha mc^* \delta}{R^{K^*} - (1-\delta)} \tag{75}$$

$$R_n^* = \frac{1}{\beta} \tag{76}$$

$$R^{K^*} = \left(\frac{R_n^*}{\pi^*}\right) \tag{77}$$

$$P_F^* = \widehat{P}_F^* = \frac{\zeta^*}{\zeta^* - 1} mc^* P_F^*$$

$$mc^* = \frac{P_F^{W^*}}{P_F^*} = 1 - \frac{1}{\zeta^*} \tag{78}$$

Log-linearization

Home Economy

Demand

Total demand: (following Equation 44)

$$\begin{aligned}\widehat{Y}_t =&\mu(1-w)\left(\widehat{\tau}_t+\widehat{rer}_t\right)\\&+w\left(\frac{I}{Y}\widehat{I}_t+\frac{C^e}{Y}\widehat{C}^e_t+\frac{G}{Y}\widehat{G}_t+\frac{C}{Y}\widehat{C}_t\right)\\&+(1-w)\left(\frac{I^*}{Y^*}\widehat{I}^*_t+\frac{C^*}{Y^*}\widehat{C}^*_t+\frac{G^*}{Y^*}\widehat{G}^*_t\right)\end{aligned} \tag{79}$$

Households consumption: (Following Equation 8)

$$\widehat{C}_t = E_t\widehat{C}_{t+1}+\frac{1}{\sigma_c}\left(\widehat{\pi}_{t+1}-\widehat{R}_{n,t}\right) \tag{80}$$

Capital demand: (following Equation 29)

$$\widehat{R}^K_t = \left(1-\frac{1-\delta}{R^K}\right)\widehat{mpc}_t-\frac{\Phi\delta^2}{R^K}\widehat{K}_t+\frac{1-\delta}{R^K}\widehat{q}_t-\hat{q}_{t-1}$$

Expected cost of capital: (following Equation 31)

$$\begin{aligned}\widehat{R}^k_{t+1} =&\theta\left(\widehat{q}_t+\widehat{K}_{t+1}-\widehat{N}_{t+1}\right)+\Theta\left(\kappa\frac{R_n}{\pi R^k}\right)\left(\widehat{R}_{n,t}-\widehat{\pi}_{t+1}\right)\\&+\Theta\left(1-\kappa\right)\left(\frac{R^*_n}{R^k\pi^*}\right)\left(\widehat{R}^*_{n,t}-\widehat{\pi}^*_{t+1}+\widehat{rer}_{t+1}-\widehat{rer}_t\right)-\Theta\left(\phi_d\left(1-\kappa\right)\frac{R^*_n}{R^k\pi^*}\right)\widehat{d}_t\end{aligned} \tag{81}$$

Real price of capital: (following Equation 28)

$$\widehat{q}_t = \frac{\Phi\delta(\widehat{I}_t-\widehat{K}_t)}{q} \tag{82}$$

Consumption of exiting firms: (following Equation 33)

$$\widehat{C}^e_t = \widehat{N}_t \tag{83}$$

Supply

Marginal productivity of capital: (following Equation **??**)

$$\widehat{mpc}_t = \widehat{mc}_t + \widehat{Y}_t - \widehat{K}_t - \frac{(1-w)}{(2w-1)}\widehat{rer}_t \tag{84}$$

Inflation:

$$\widehat{\pi}_t = \widehat{\pi}_{H,t} + (1-w)\Delta\widehat{\tau}_t \tag{85}$$

Domestic inflation: (following Equation 40)

$$\widehat{\pi}_{H,t} = \beta E_t \widehat{\pi}_{H,t+1} + \frac{(1-\varrho_H)(1-\beta\varrho_H)}{\varrho_H}\widehat{mc}_t \tag{86}$$

Terms of trade and RER: (following Equation 17)

$$\widehat{rer}_t = (2w-1)\widehat{\tau}_t \tag{87}$$

Production function: (following Equation 19)

$$\widehat{Y}_t = \widehat{a}_t + \alpha\widehat{k}_t + (1-\alpha)\widehat{l}_t \tag{88}$$

Labor supply: (following Equation 7)

$$\widehat{L}_t = \frac{1}{\sigma_l}\left(\widehat{W}_t - \sigma_c\widehat{C}_t\right) \tag{89}$$

Wholesale marginal costs: (following Equation 27)

$$\widehat{W}_t = \widehat{mc}_t + \widehat{Y}_t - \widehat{L}_t - \frac{(1-w)}{(2w-1)}\widehat{rer}_t \tag{90}$$

Real Exchange Rate: (following Equation 18) :

$$\widehat{rer}_t = E_t\widehat{rer}_{t+1} + \widehat{R}^*_{n,t} - E_t\widehat{\pi}^*_{t+1} - \widehat{R}_{n,t} + E_t\widehat{\pi}_{t+1} - \phi_d\widehat{d}_t \tag{91}$$

State variables

Net foreign assets accumulation: (following Equation 46) [10]

$$\widehat{d}_t = \frac{1}{\beta}\widehat{d}_{t-1} - (1-w)\widehat{\tau}_t + \widehat{Y}_t - \frac{C}{Y}\widehat{C}_t - \frac{C^e}{Y}\widehat{C}^e_t - \frac{I}{Y}\widehat{I}_t - \frac{G}{Y}\widehat{G}_t \tag{92}$$

[10] Since d=0, $\widehat{d}_t$ denotes d_t/Y (e.g. Bouakez and Eyquem (2015))

Net worth accumulation: (following Equation 32)

$$\begin{aligned}\frac{\widehat{N}_t}{\xi_e} =& R^K \frac{K}{N} \widehat{R}^K_{t-1} + R^K \theta \left(1 - \frac{K}{N}\right) \left(\widehat{q}_{t-1} + \widehat{K}_t\right) + R^K \left(\theta \left(\frac{K}{N} - 1\right) + 1\right) \widehat{N}_{t-1} \\ &+ \Theta \left(1 - \kappa\right) \frac{R^*_n}{\pi^*} \left(\frac{K}{N} - 1\right) \left(\widehat{\pi}^*_t - \widehat{R}^*_{n,t-1} + \widehat{rer}_{t-1} - \widehat{rer}_t - \phi_d \widehat{d}_t\right) \\ &+ \Theta \kappa \frac{R_n}{\pi} \left(\frac{K}{N} - 1\right) \left(\widehat{\pi}_t - \widehat{R}_{n,t-1}\right)\end{aligned} \tag{93}$$

Capital accumulation: (following Equation 24)

$$\widehat{K}_{t+1} = \delta \widehat{I}_t + (1 - \delta) \widehat{K}_t \tag{94}$$

Monetary policy, fiscal policy and productivity shocks

Monetary policy:

$$\widehat{R}_{n,t} = \rho \widehat{R}_{n,t-1} + (1 - \rho) \left(\gamma_\pi E_t \widehat{\pi}_{t+1} + \gamma_y \widehat{Y}_t\right) \tag{95}$$

Fiscal policy:

$$\widehat{G}_t = \rho_g \widehat{G}_{t-1} + \varepsilon_{g_t} \tag{96}$$

Productivity:

$$\hat{a}_t = \rho_a \hat{a}_{t-1} + \varepsilon_{a_t} \tag{97}$$

7.0.1 Foreign Economy

Total demand:

$$\begin{aligned}\widehat{Y}^*_t =& \mu(1 - w) \left(\widehat{\tau}^*_t - \widehat{RER}_t\right) + w \left(\frac{C^*}{Y^*} \widehat{C}^*_t + \frac{I^*}{Y^*} \widehat{I}^*_t + \frac{G^*}{Y^*} \widehat{G}^*_t\right) \\ &+ (1 - w) \left(\frac{C}{Y} \widehat{C}_t + \frac{C^e}{Y} \widehat{C}^e_t + \frac{I}{Y} \widehat{I}_t + \frac{G}{Y} \widehat{G}_t\right)\end{aligned} \tag{98}$$

Households consumption:

$$\widehat{C}^*_t = E_t \widehat{C}^*_{t+1} + \frac{1}{\sigma_c} \left(E_t \widehat{\pi}^*_{t+1} - \widehat{R}^*_{n,t}\right) \tag{99}$$

Capital demand:

$$\widehat{R}^{K^*}_t = \left(1 - \frac{(1 - \delta^*)}{R^{K^*}}\right) \widehat{mpc}^* - \frac{\Phi {\delta^*}^2}{R^{K^*}} \widehat{K}^*_t + \frac{(1 - \delta^*)}{R^{K^*}} \widehat{q}^*_t - \widehat{q}^*_{t-1} \tag{100}$$

Expected cost of capital:

$$\widehat{R}_{t+1}^{K^*} = \widehat{R}_{n,t}^* - E_t\widehat{\pi}_{t+1}^* \tag{101}$$

Real price of capital:

$$\widehat{q}_t^* = \frac{\Phi\delta^*\left(\widehat{I}_t^* - \widehat{K}_t^*\right)}{q^*} \tag{102}$$

Marginal productivity of capital:

$$\widehat{mpc}_t^* = \widehat{mc}_t^* - (1-w)\widehat{\tau}_t^* + \widehat{Y}_t^* - \widehat{K}_t^* \tag{103}$$

Inflation:

$$\widehat{\pi}_t^* = \widehat{\pi}_{F,t}^* + (1-w)\Delta\widehat{\tau}_t^* \tag{104}$$

Domestic inflation

$$\widehat{\pi}_F^* = \beta^* E_t\widehat{\pi}_{F,t+1}^* + \frac{(1-\varrho_F^*)(1-\beta^*\varrho_F^*)}{\varrho_F^*}\widehat{mc}_t^* \tag{105}$$

RER:

$$\widehat{rer}_t^* = -\widehat{rer}_t \tag{106}$$

Terms of trade:

$$\widehat{\tau}_t^* = -\widehat{\tau}_t \tag{107}$$

Wholesale production:

$$\widehat{Y}_t^* = \hat{a}_t^* + \alpha\widehat{K}_t^* + (1-\alpha)\widehat{L}_t^* \tag{108}$$

Labor supply:

$$\widehat{L}_t^* = \frac{1}{\sigma_l^*}\left(\widehat{W}_t^* - \sigma_c^*\widehat{C}_t^*\right) \tag{109}$$

Wholesale marginal cost:

$$\widehat{W}^* = \widehat{mc}_t^* + \widehat{Y}_t^* - \widehat{L}_t^* - (1-w)\widehat{\tau}_t^* \tag{110}$$

Capital accumulation:

$$\widehat{K}_{t+1}^* = \delta^*\widehat{I}_t^* + (1-\delta^*)\widehat{K}_t^* \tag{111}$$

Monetary Policy:

$$\widehat{R}_{n,t}^* = \rho^*\widehat{R}_{n,t-1}^* + (1-\rho^*)\left(\gamma_\pi^* E_t\widehat{\pi^*}_{t+1} + \gamma_y^*\widehat{Y}_t^*\right) \tag{112}$$

Fiscal policy:

$$\widehat{G}_t^* = \rho_g^*\widehat{G^*}_{t-1} + \varepsilon_{gt}^* \tag{113}$$

Productivity:

$$\hat{a}_t^* = \rho_a^* \hat{a}_{t-1}^* + \varepsilon_{a_t}^* \tag{114}$$

Table 4: Parameters

Parameter	Definition	Value	Source
σ_c	Inverse of inter-temporal elasticity of substitution of consumption	2	Bonam and Lukkezen (2014)
σ_l	Inverse of Frisch elasticity of labor supply	1	Bonam and Lukkezen (2014)
β	Discount factor	0.99	
ϕ_d	Country premium elasticity	0.0007	Schmitt-Grohé and Uribe (2003)
ζ	Elasticity of substitution between varieties	6	Bouakez and Eyquem (2015) and Kitano et al. (2015)
α	Capital intensity	0.30	Kitano et al. (2015)
δ	Depreciation rate of capital	0.025	
μ	Elasticity of substitution across domestic and foreign goods	1.5	Bouakez and Eyquem (2015), Kitano et al. (2015)
ϱ_H	Prices rigidity parameter	0.75	
w	Home bias	0.72	Kitano et al. (2015)
Φ	Adjustment cost function parameter	6	Chang and Fernández (2013)
θ	Elasticity of extern financing premium to the capital-to-net wealth ratio	0.042	Christensen and Dib (2008)
ξ_e	Probability of firms to exit	0.985	Levieuge (2009)
γ_π	Weight of inflation for (home) monetary policy	1.1	
γ_y	Weight of output for (home) monetary authority	0	
γ_π^*	Weight of inflation for (foreign) monetary policy	1.8	
γ_y^*	Weight of output for (foreign) monetary authority	0	
ρ	Temporal autocorrelation of nominal interest rates	0.85	
ρ_g	Autocorrelation of public spending shocks	0.8	
ρ_a	Autocorrelation of productivity shocks	0.8	

Table 5: Steady states ratios - Calibration

Ratios	Value	Source
$\frac{K}{N}$	3	Badarau et al. (2014)
$\frac{I}{Y}$	0.18	Badarau et al. (2014)
$\frac{C}{Y}$	0.60	Badarau et al. (2014)
$\frac{C^e}{Y}$	0.02	Badarau et al. (2014)
$\frac{G}{Y}$	0.2	Badarau et al. (2014)

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