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Abstract: As first argued in Sargent and Wallace (1981), under certain conditions a tighter monetary policy today might give rise to higher expected inflation if the public perceives that the worsened debt dynamics could end up in debt monetization. This channel is arguably stronger in countries featuring high debt and interest rates, along with weaker economic institutions. Brazil is a large emerging economy that fits the profile. Yet, using a high-frequency identification strategy, we show that higher interest rates lead to unequivocally lower inflation expectations (and local currency appreciation) around Brazil's Central Bank monetary policy meetings.

Keywords: monetary policy; inflation expectations; Brazil.

JEL Codes: E52, E31, E43.

Elusive Unpleasantness*

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Abstract

As first argued in Sargent and Wallace (1981), under certain conditions a tighter monetary policy today might give rise to higher expected inflation if the public perceives that the worsened debt dynamics could end up in debt monetization. This channel is arguably stronger in countries featuring high debt and interest rates, along with weaker economic institutions. Brazil is a large emerging economy that fits the profile. Yet, using a high-frequency identification strategy, we show that higher interest rates lead to unequivocally lower inflation expectations (and local currency appreciation) around Brazilâs Central Bank monetary policy meetings.

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1 Introduction

Ever since Sargent and Wallace (1981) classic unpleasant arithmetic paper, macroeconomists have considered the possibility of higher interest rates causing inflation to *increase*. The logic of the "tight money paradox" is straightforward: higher real rates put pressure on debt which elicits expectations of future monetization, hence defeating the purpose of bringing inflation expectations down.[1]

Whether the unpleasant arithmetic manifests itself in the real world is, however, an empirical issue. Do people expect increasing debt piles to be eventually monetizated? If so, is this channel strong enough to give rise to the tight money paradox? Although Sargent and Wallace's contribution is now forty years old, the question remains contemporary. For instance, some argue that monetary policy may have become less potent in developed countries as a result of the massive accumulation of debt in the wake of the COVID-19 pandemic.[2]

In spite of the recent concern with the monetary policy regime in advanced economies (as of March 2022 inflation has reached 8 percent in the U.S.), countries more prone to suffer from the unpleasant arithmetic are those featuring high debt levels, elevated interest rates and weak credibility. One particular country that fits the description is the Latin American giant, Brazil.

Brazil's economic history is been plagued by hyperinflation and sovereign defaults. From the 1980s until the mid-1990s, the country went through bouts of hyperinflation. In 1994, Brazil implemented a successful stabilization plan (the Real Plan), bringing inflation down to reasonable levels through an exchange rate peg. In 1999, following a sequence of international crises (Mexico, Asia, Russia), the currency came under a speculative attack and the government was forced to abandon the peg. It then opted for an inflation targeting cum floating exchange rate regime. Since then, the Central Bank has been building reputational capital but, until very recently, was not granted formal independence. More to the point, government finances have been on shaky grounds. The country has one of the largest public debts among emerging economies, and interest rates have been very high since the 1990s.[3]

[1] Analyses of the so-called "tight money paradox" can be found in Loyo (1999), Bhattacharya and Kudoh (2003), Sims (2011), Uribe (2016), Andolfatto (2021), Werning (2021) and Barthelemy, Mengus and Plantin (2021a).

[2] In a recent op-ed piece at the Wall Street Journal, Thomas Sargent and William Silber state that: "The lesson for the current situation is clear. Without decreasing the budget deficit, combating inflation with monetary policy is like entering a heavyweight championship competition with one hand tied behind your back." (Sargent and Silber, 2022). See also Barthelemy, Mengus and Plantin (2021b) for further discussion and references.

[3] See Ayres et al (2022) for a discussion on Brazil's recent monetary and fiscal history.

This is illustrated in Figure 1, which compares Brazil's debt-GDP ratio with that of a set of emerging countries during the last decade.[4]

If we are to find direct evidence of higher real interest rates stoking inflation based on the arguments by Sargent and Wallace, there should be no better place. Here we use daily data from Brazilian inflation-indexed bonds to measure inflation expectations and then go on to assess the impact of monetary surprises on the former. Two features render this strategy attractive: (i) the country possesses a liquid market for inflation-backed government bonds of different maturities, (ii) in the same vein as the FOMC, the policy rate is set by a Central Bank committee that meets at pre-scheduled dates. This allows us to use Rigobon (2003)'s strategy of identification through heteroskedasticity to obtain causal estimates of the effect of monetary surprises on inflation expectations.

Summing it up, we do not find support for tight money paradox in Brazil during the period between 2009 and 2020. In fact, the expectations channels works clearly to increase the impact of monetary policy on final inflation. Our estimated parameters indicate that a positive/negative real interest rate surprise causes inflation *expectations* to decline/increase by a non-trivial amount. This effect is statistically very well estimated and its economic magnitude is large.

We also test a different version of the tight money paradox that works through exchange rates. Specifically, some authors argue that tighter monetary policy would increase interest payments and hence the probability of default, causing capital to exit the country (Blanchard, 2005; Favero and Giavazzi, 2005). This in turn would put pressure on the local currency and the concomitant depreciation would end up fuelling inflation. Data from 2009 to 2020 does not support this reasoning. During this period, we find standard textbook effects of monetary policy on the exchange rate: a positive/negative real interest rate surprise is associated with an appreciation/depreciation of the local currency.

In conclusion, we do not find signs of the famous unpleasantness in the data. Even in a highly indebted country as Brazil, tight money leads to lower inflation expectations and an appreciation of the local currency.

[4] General government gross debt, percent of GDP. Data from the IMF's World Economic Outlook Database (2009-2019).

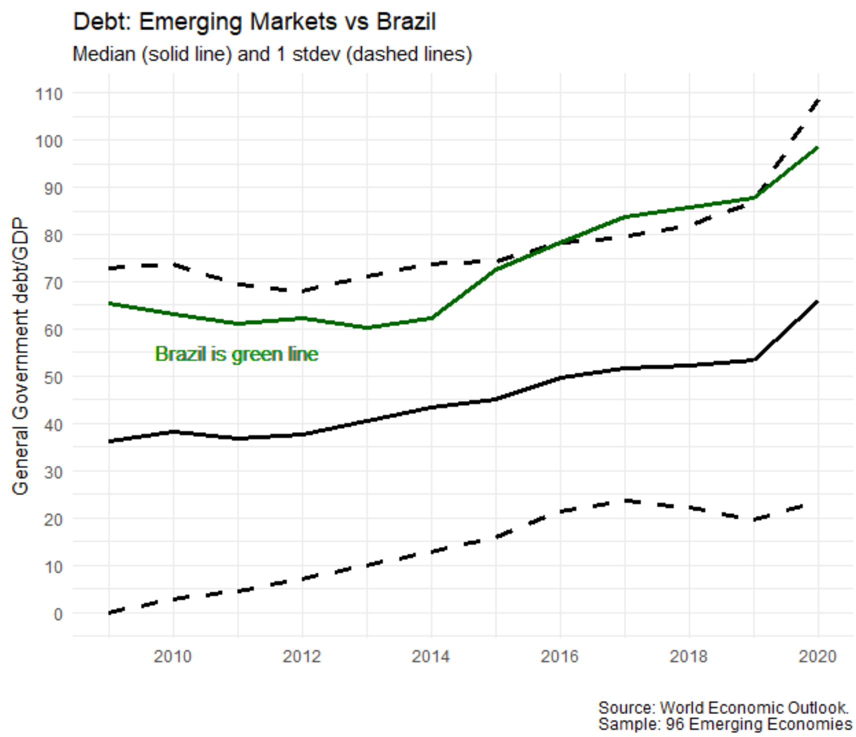

Figure 1: Debt/GDP in Emerging Economies

2 Data and empirical strategy

2.1 The identification strategy

Our goal is to estimate the effect of interest rates surprises (Δi) on inflation expectations ($\Delta \pi^e$). This is captured by the parameter β in equation (1) below. However, consistently estimating this effect is tricky. First, omitted variables might affect both interest rates and inflation expectations. Second, reverse causality may impart a positive bias on the OLS coefficient, as the Central Bank increases interest rates and bond holders demand higher nominal yields when they foresee higher inflation.

$$\Delta \pi_t^e = \alpha + \beta \Delta i_t + u_t \tag{1}$$

$$\Delta i_t = \gamma + \delta \Delta \pi_t^e + v_t \tag{2}$$

In the last equations, u_t and v_t are error terms with variances σ_{ut} and σ_{vt}, respectively. Our argument on reverse causality implies that $\delta > 0$.

To estimate consistently the effect of interest rate surprises on inflation expectations, we follow Rigobon (2003)'s approach of identification through heteroskedasticity. According to Rigobon and Sack (2004), identification is achieved if two conditions are satisfied: (i) the variance of interest rate shocks (v_t) is higher in the subsample of daily windows when the Central Bank's monetary policy committee meets to decide on the policy rate and (ii) no such difference in variances is present for shocks to inflation expectations (u_t).

In the same vein as the Fed's FOMC, in Brazil the monetary policy committee (Copom, in the Portuguese acronym) meets at pre-scheduled dates. Copom is composed of the Central Bank's president and board of directors, who discuss the state of the economy (present and future) and vote on how much the policy rate should be adjusted.

Let C represent the set of daily windows with Copom meetings, and N be the set of daily windows without Copom meetings. Define the variances of the shocks in equations (1) and (2) in these two subsamples as:

$$\sigma_{ut} = \begin{cases} \sigma_u^C & \text{, if } t \in C \\ \sigma_u^N & \text{, if } t \in N \end{cases} ; \qquad \sigma_{vt} = \begin{cases} \sigma_v^C & \text{, if } t \in C \\ \sigma_v^N & \text{, if } t \in N \end{cases}$$

Rigobon (2003) shows that, in the presence of heteroskedasticity as described in (3) and (4) below, the parameter β can be consistently estimated using a simple IV estimator.

$$\sigma_v^C > \sigma_v^N \tag{3}$$

$$\sigma_u^C = \sigma_u^N \tag{4}$$

Importantly, the instruments do not come from a quasi-natural experiment as in most empirical work in labor or development economics, but from a clever transformation of the variables at hand that allows us to exploit the heteroskedascity of shocks across sub-samples:

$$z_t^i = \begin{cases} \Delta i_t/\sqrt{T_C} & \text{, if } t \in C \\ -\Delta i_t/\sqrt{T_N} & \text{, if } t \in N \end{cases} ; \qquad z_t^\pi = \begin{cases} \Delta \pi_t^e/\sqrt{T_C} & \text{, if } t \in C \\ -\Delta \pi_t^e/\sqrt{T_N} & \text{, if } t \in N \end{cases}$$

where T_C is the size of the subsample in which Copom meetings occur, and T_N represents the number of observations in its complement.

Because the sizes of the subsamples are different, the explained variable is normalized as follows:

$$\Delta\widetilde{\pi}_t^e = \begin{cases} \Delta\pi_t^e/\sqrt{T_C} & \text{, if } t \in C \\ \Delta\pi_t^e/\sqrt{T_N} & \text{, if } t \in N \end{cases}$$

2.2 Data and test of the identification assumptions

Our sample consists of one day variations of the relevant variables for all the weeks in the period between September 2009 and December 2020. Since there is no futures market for the prime rate enabling us to calculate pure monetary policy surprises, we measure Δi using the inter-bank deposit rate. For robustness, we look at two different maturities: 360 days and 180 days.[5]

A Central Bank's meeting meeting occurs over a two-day period, with the final decision being announced on a Wednesday after markets close. Accordingly, the interest rate surprise (Δi) is the difference between i on its Thursday and its Wednesday value in every week within the sample. There is a total of 508 weeks/observations, out of which 80 feature meeting.[6]

Brazil features a private market for inflation-indexed bonds that allows us to tease out markets' inflation expectations without having to rely on survey information. Specifically, we calculate inflation expectations as the difference in yields between nominal and inflation-linked government bonds, for a given maturity.[7]

We compute $\Delta\pi_t^e$ in the same way as Δi_t, i.e., taking the difference between Thursday's and Wednesday's observations in each week. Using different bond maturities, we can create measures of $\Delta\pi_t^e$ for different time periods. Here, we look at changes in inflation expectations for 1, 2 and 3 years ahead.[8]

As mentioned in the Introduction, we also analyze the effect of monetary surprises on the exchange rate. In this case, we replace $\Delta\pi_t^e$ in the specification above by ΔE_t, which is the percentage change in the BRL/USD exchange rate between Wednesdays and Thursdays in the sample. In this case, a positive (negative) ΔE_t implies a depreciation (appreciation)

[5] Data can be downloaded from the Sao Paulo Stock Exchange webpage (BM&FBOVESPA, 2009-2021a,b).

[6] For most of the sample, meetings were held every 6 weeks.

[7] Arguably, our measure of inflation expectations (also known as break-even inflation) may capture other components, such as a premium for future inflation uncertainty. However, Central Bank of Brazil (2014) shows that, in the data, this variable captures mostly inflation expectations, especially for bonds of shorter duration.

[8] Daily data on government bond yields were downloaded from a Bloomberg terminal. See Bloomberg (2009-2021a,b,c) for non-inflation linked bond yields, and Bloomberg (2009-2021d,e,f) for inflation linked bond yields. Alternatively, the Brazilian Financial and Capital Markets Association (2009-2021a,b,c) provides free access to these series.

of the Brazilian Real against the U.S. Dollar.[9]

Simple variance tests allow us to verify if the identifying assumptions are borne out in our sample. According to expression (3), the variance of Δi_t should be higher in subset C as compared to subset N and, following (4), there should be no such difference in variances for $\Delta \pi_t^e$ and ΔE_t.

Table 1 shows, for each variable, the ratio between variances in set C and in set N, along with a 95% confidence interval. The message is clear: variances for Δi_t differ markedly across the subsamples. For $\Delta \pi_t^e$ and ΔE_t, though, we cannot reject the null of equal variances.[10] Hence the identifying conditions hold.

Table 1: Variance tests

		Ratio of variances	95% CI
Δi	Maturity 360d	1.773	$[1.29; 2.55]$
	Maturity 180d	3.059	$[2.22; 4.39]$
$\Delta \pi^e$	1 year	1.062	$[0.77; 1.53]$
	2 years	1.322	$[0.96; 1.90]$
	3 years	1.183	$[0.86; 1.70]$
ΔE		0.753	$[0.54; 1.08]$

Notes: This table displays tests of the identification assumptions based on Rigobon's (2003) methodology. Specifically, we check for differences in variances across set C (weeks with Copom meeting) and set N (weeks without Copom meeting), using daily data from the Brazilian market between September 2009 and December 2020. The middle column of the table shows the ratio between variances in set C and in set N. The last column presents the 95% confidence interval for this ratio. We show statistics for the change in nominal interest rates (Δi), the change in inflation expectations ($\Delta \pi^e$), and the percentage change in the BRL/USD exchange rate (ΔE). Δi is measured by changes in interbank deposit rate. We use two maturities: 360 and 180 days. Inflation expectations are measured taking the difference between inflation linked and non-inflation linked government bonds. In this case, we calculate the variance ratio for 1, 2 and 3-year maturities. For all variables, differences were computed between Wednesday's and Thursday's values in every week within our sample.

[9] Data were obtained at the Central Bank of Brazil webpage (SGS Banco Central do Brasil, 2009-2021).

[10] This follows because the confidence intervals for $\Delta \pi_t^e$ and ΔE_t contain 1, but the confidence intervals for Δi_t do not.

3 Results

3.1 Effect of monetary surprises on inflation expectations

We first report OLS estimates of equation (1), which illustrate the sources of endogeneity mentioned above when estimating the parameter β. Table 2 shows regression results for six different estimations, which combine our two measures of Δi (using 360- and 180-day maturities) and our three measures of $\Delta \pi^e$ (1, 2 and 3 years ahead).

Table 2: OLS estimates

	Dependent variable = $\Delta \pi^e$		
	1 year	2 years	3 years
Δi	0.070	0.003	-0.036
(360 d)	(0.024)	(0.022)	(0.022)
N	508	508	508
Δi	0.044	-0.059	-0.122
(180 d)	(0.056)	(0.027)	(0.027)
N	508	508	508

Notes: This table displays OLS regression results of changes in inflation expectations ($\Delta \pi^e$) against changes in nominal interest rates (Δi). We use daily data from Brazilian assets between September 2009 and December 2020. In the upper panel, Δi is measured using changes in 360-day interbank deposit rate between Wednesdays and Thursdays. In the lower panel, we use the same independent variable, but with a 180-day maturity. Inflation expectations are measured using the difference between inflation linked and non-inflation linked government bonds. $\Delta \pi^e$ is computed in the same way as Δi, as the difference between Wednesday's and Thursday's observations. We run regressions using 1, 2 and 3-year maturities, which are displayed in the three main columns of the table. Numbers in parentheses are standard errors.

Three of the six estimations yield positive coefficients. In particular, for the case with 360-day maturity and expectations for 1 year ahead, the coefficient is highly significant. This would be consistent with Sargent and Wallace's unpleasant dynamics (though a positive and significant β is not found for other specifications). However, as discussed in Section 2, these estimates are likely biased upwards because of reverse causality and omitted variables.

To address this issue, we estimate equation (1) using Rigobon (2003)'s IV approach, which explores differences in variances across Copom and non-Copom weeks. Results are in Table 3 (first three columns). Now our estimates are all negative and display very small standard-errors (all p-values are smaller than 1%). Interest rate surprises are associated with lower inflation expectations for all six combinations.

Table 3: IV estimates

	Dep. var. = $\Delta\pi^e$			Dep. var. = ΔE
	1 year	2 years	3 years	
Δi	-0.272	-0.355	-0.308	-1.700
(360 d)	(0.075)	(0.055)	(0.048)	(0.733)
N	508	508	508	508
Δi	-0.222	-0.375	-0.380	-2.681
(180 d)	(0.056)	(0.049)	(0.046)	(0.621)
N	508	508	508	508

Notes: This table displays regression results of changes in inflation expectations ($\Delta\pi^e$) against changes in nominal interest rates (Δi) using Rigobon's (2003) methodology of identification through heteroskedasticy. For that, we explore differences in variances between weeks with Copom meetings and weeks without Copom meetings. We use daily data from Brazilian assets between September 2009 and December 2020. In the upper panel, Δi is measured using changes in 360-day interbank deposit rate between Wednesdays and Thursdays. In the lower panel, we use the same independent variable, but with a 180-day maturity. Inflation expectations are measured using the difference between inflation linked and non-inflation linked government bonds. $\Delta\pi^e$ is computed in the same way as Δi, as the difference between Wednesday's and Thursday's observations. We run regressions using 1, 2 and 3-year maturities, which are displayed in the first three columns of the table. We also run the same regressions, but using the percentage change in the BRL/USD exchange rate (ΔE) as dependent variable (last column). Numbers in parentheses are standard errors.

In terms of magnitudes, taking the 1 year maturity as reference, a 50 basis point surprise in the interest rate leads to a reduction of almost 0.14 p.p. in expected inflation over the following year; and 0.18 p.p. for inflation two years ahead.[11] Since the Central Bank's target has been in the vicinity of 4% during the period under analysis, the magnitude of estimated effect is economically relevant.

3.2 Effect on the exchange rate

We now evaluate a version of the "tight money paradox" related to the exchange rate. In theory, an increase in interest rates could lead – contrary to suggested by a naive reading of

[11] These values are obtained by multiplying estimated coefficients in Table 3 by 0.50.

the UIP relationship – to a currency depreciation via higher probability of default. Results from the previous section indicate that even if this is true, it is certainly not enough to generate an increase in inflation expectations. A clogged monetary policy transmission channel (the exchange rate channel) could, nevertheless, still dampen the impact of interest rates on inflation expectations, reducing the power of monetary policy.

Regression outcomes with ΔE as the dependent variable suggest this not to be the case for the period under consideration. As shown in the last column of Table 3, a positive/negative monetary surprise leads to currency appreciation/depreciation: the sign of the coefficient is negative, although not as precisely estimated as in the previous regressions. Moreover, the effect is quantitatively meaningful. For instance, for the 360-day maturity, a 50 bps interest rate surprise is associated with a 0.86% appreciation of the Brazilian Real against the U.S. dollar.

4 Final remarks

The unpleasant arithmetic logic of Sargent and Wallace (1981) says that monetary policy can actually backfire if people perceive a tightening as unleashing bad debt dynamics that would eventually end in a sea of monetization. We do not find that in the data using Brazil – a highly indebted emerging economy – as a case study.

Crucially, that does not mean that monetary policy would not be more effective under a lower debt burden. We do not have this counterfactual and make no such a claim. Our findings are also not incompatible with high inflation rates being the result of fiscal profligacy (which is perhaps the most widely accepted explanation for the very high inflation rates in most of Latin America during the 1980s).

But if higher interest rates do not trigger higher inflation expectations in a highly indebted emerging economy as Brazil, slim are the hopes of finding the footprints of the unpleasant arithmetic anywhere else.

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