INTERNATIONAL MONETARY FUND

IMF Country Report No. 16/349

BRAZIL

SELECTED ISSUES

November 2016

This Selected Issues paper on Brazil was prepared by a staff team of the International Monetary Fund as background documentation for the periodic consultation with the member country. It is based on the information available at the time it was completed on October 14, 2016.

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International Monetary Fund
Washington, D.C.

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BRAZIL

SELECTED ISSUES

October 14, 2016

Approved By
Western Hemisphere Department

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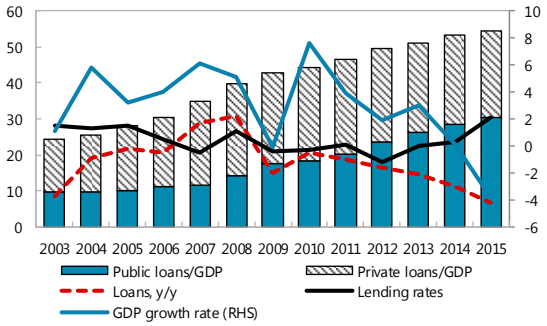
FINANCIAL AND BUSINESS CYCLES IN BRAZIL[1]

This paper assesses the importance of financial market developments for the business cycle in Brazil. The results underscore the importance of macro-financial linkages and highlight risks to the recovery going forward. They also show that offsetting the negative effects of a slowdown in private credit with an expansion in public credit can be costly, potentially leading to inefficiencies that are difficult to unwind.

A. Introduction

1. In the decade prior to the recent recession, Brazil enjoyed a period of rapid economic expansion and relatively easy financial conditions (Chart). With the exception of a short and shallow recession in 2009, annual GDP growth averaged 4.5 percent in the period from 2004 to 2013; the unemployment rate halved, the policy rate trended down, and lending rates fell by almost 10 percentage points. The perception of foreign investors was also favorable until 2014 making the price of foreign borrowing low. Credit expanded very rapidly, more than doubling as a share of GDP since 2004 (from 25 percent of GDP in 2004 to 55 percent at the end of 2015), with a particularly sharp rise in public sector credit following the global financial crisis.

Loans, GDP, Share And Y/Y Growth Rates



Source: Fund staff estimates.

2. While some of the rise in credit growth in Brazil can be attributed to financial deepening and rising income levels, it may have implications for economic activity going forward. Cross-country evidence suggests that periods of easy financial conditions can amplify economic fluctuations and possibly lead to adverse economic outcomes. For example, Jorda and others (2013) show that periods of strong credit growth are typically followed by periods of sluggish economic activity. Drehmann and others (2012) and Claessens and others (2011a) further show that the duration and amplitude of recessions and recoveries are influenced by the strength and intensity of financial cycles, with downturns being longer and deeper if accompanied by disruptions in financial and housing markets.

3. This paper assesses the importance of financial market developments for the business cycle in Brazil. To explore the nexus between the financial cycle and business cycle, cycles are estimated using a variety of commonly-used statistical methods and with a small, semi-structural model of the Brazilian economy. An advantage of using the model-based approach is that financial and business cycles can be jointly estimated, allowing information from all key economic relationships to be used in a consistent way. The model also allows a

[1] Prepared by Ivo Krznar (MCM) and Troy Matheson (WHD).

formal examination of linkages between financial and business cycles using impulse response functions and historical shock decompositions. The results underscore the importance of macro-financial linkages in Brazil and highlight the potential risks of a slow economic recovery going forward. We conclude with some policy implications.

B. Literature Review

4. While there is no consensus on the definition of the financial cycle, two main approaches to analyze short- and medium-term developments in financial markets have been used in the literature.

- **Financial/Credit cycles: medium-term concept.** One strand of the literature focuses on credit, credit-to-GDP and property prices either taken individually (see Aikman and others, 2013; Jorda and others, 2011, Dell'Arriccia and others, 2012 for studies focusing on credit only; and Claessens and others, 2011a, 2011b for studies focusing on credit and property prices) or combined (Drehmann and other, 2012).[2] Beyond credit and house prices, equity prices are found to behave differently from house prices and credit variables; they exhibit greater short-term volatility and are less clearly associated with financial crises (Claessens and others, 2011; Drehmann and other, 2012). The financial cycle is then defined either as an average of a cyclical component of the financial variables, most frequently real credit, credit-to-GDP or property prices, extracted using a univariate, statistical filter targeting a specific frequency. Alternatively, a financial cycle can be identified using turning-point analysis algorithms that that define downturn phases (from peak to trough) and upturn phases (from trough to the next peak). Most of the literature suggests that the financial cycles evolve at a relatively slow pace and capture medium-term developments in financial markets.[3]

- **Financial conditions index: short term concept.** Another strand of the literature combines a variety of financial variables into a financial conditions index (FCI) (see Ng, 2011; Hatzius and others 2010). These indexes can be thought of as capturing short-term developments in financial markets.

5. Financial sector developments are found to be an important source of macroeconomic fluctuations. Financial accelerator models highlight the role of credit and asset prices in shaping the business cycle (see, for example, Bernanke and Gertler, 1989, Bernanke, Gertler and Gilchrist, 1999, Kiyotaki and Moore, 1997). Models that highlight strategic complementarities between banks that generate a tendency for banks to collectively take on more risk suggest that small changes in fundamentals can generate large swings in credit. There

[2] Borio (2012) claims that combining credit and property prices is a useful way to characterize the financial cycle, because credit booms are often associated with housing bubbles, reinforcing risks to financial stability.

[3] For example, Drehmann and others (2012) find that the average length of financial cycle in advanced economies has been around 16 years and Claessens and others (2011a) find that financial cycles are longer, deeper and sharper than business cycles.

is a growing empirical literature documenting the importance of financial factors for business cycle fluctuations (Claessens and others, 2011a) and systemic crises (Dell'Arricia and others, 2012). Moreover, the financial cycle is closely associated with banking crises (Aikman and others, 2013), which tend to occur close to cyclical peaks and lead to severe recessions (Borio, 2012).

6. Understanding the role of the financial cycle is key for policy design. The financial cycle can help to identify risks of a financial crisis in the future. For example, Borio and Drehmann (2009) suggest that deviations of credit-to-GDP and asset prices from their trends are the best leading indicators of financial crises. Furthermore, the literature has shown that financial conditions indices are good leading indicators of growth.[4] As such, policymakers can use measures of the financial cycle to better identify risks of financial crisis, allowing them to build buffers during the financial booms that can be released during the downturns, thereby stabilizing the system.

C. Characterizing Brazilian Financial Cycles

7. To characterize the financial cycle in Brazil, two complementary approaches are used. Since time series of house price indices are too short and equity prices exhibit significant short-term volatility, the focus is on medium-term credit cycles only.[5] A broader range of financial variables that help to characterize the financial cycle at a higher frequency are summarized in a financial conditions index (FCI).

8. In addition to statistical measures of financial cycles, a semi-structural model of the Brazilian economy is used to jointly estimate financial and business cycles. When extracting a cycle, univariate statistical filters take into account only the data of the time series being filtered. One advantage of using a multivariate, model-based approach is that it allows information from all key economic relationships to be used in a consistent way to estimate cycles. Moreover, the model can be used to quantitatively assess the linkages between business and credit cycles and to project all variables of interest, including credit and GDP.

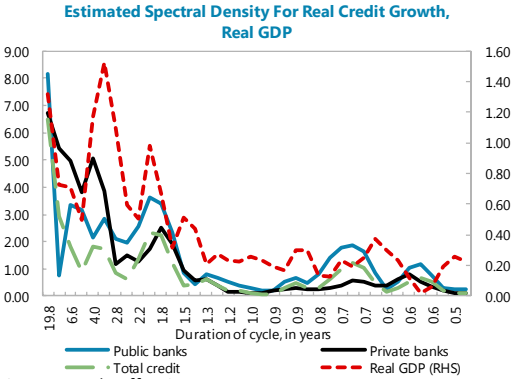
Statistical methods

9. A band-pass filter is used to isolate credit cycles at a medium-term frequency. The methodology employed in Borio and others (2012) is used; this involves employing the band-pass filter developed by Christiano and Fitzgerald (2003) to isolate a cycle in real credit and credit to GDP, defined as a deviation of the two series from their trends. Cycles are extracted under the assumption that financial cycles have much lower frequency (8 and 20 years) than

[4] See, for example, English and others (2005), Estrella and Trubin (2006), Hatzius and others (2010), Ng (2011).

[5] The OECD data on real house prices in Brazil start in 2008. Brazil's sale and lease price indices are also available since 2010 or 2012. While the central bank's residential real estate collateral value index is longer and available from 2001 only the HP trend component (calculated using a smoothing parameter of 3,600) is publicly available.

business cycles.[6] The estimated spectral densities of real credit growth justify setting a medium term frequency range to extract credit cycles (Chart).[7] The first peak in the density of real credit growth corresponds to a medium-term cycle with duration of around 20 years. The density also identifies a number of peaks at higher frequency, corresponding to short-term cycles with duration of less than 4 years. The data were filtered for each series and combined into the aggregate credit cycle, the financial cycle, by averaging the two filtered series.[8,9]



Source: Fund staff estimates.

10. Information in many financial variables was combined into a single indicator, an FCI, using principal component analysis (Table 1). The estimated spectral density also identified the importance of short-term developments for the overall variation in credit. To analyze the short-term financial market developments, an FCI is constructed. The following data are included to estimate the FCI: (i) risk measures (money market spread); (ii) collateral values (stock prices, house prices); (iii) quantities (total credit); and (iv) external financial conditions (EMBI, real exchange rate).[10] The FCI also includes interest rates.[11] The FCI is the first principal component of all the variables described above; it is essentially a weighted average the variables where the weights are derived so that the index explains the maximum amount of variation of all observed financial variables.[12] The weights (or "loadings") are displayed in Table 1.

[6] The choice of 20 years as an upper bound is a function of data availability that start in 1995 following the implementation of the "Plano Real" stabilization program.

[7] A spectral density shows contributions to the series' variance from cycles at different frequencies. When a specific frequency accounts for the spectrum more than others, it features a peak at that frequency—defining the period of the underlying cycle.

[8] Filtered series are additive as long as they are standardized.

[9] As a cross-check, HP filters were used as an alternative approach to isolating the trend component building on the BCBS's guidance for calculating credit gaps (one sided filter with the smoothing parameter lambda corresponding to cycles lasting 32 to 80 quarters). This led to broadly similar findings. Likewise, using the BIS broad definition of credit to non-financial sector, the filter identifies one more peak in the credit cycle in 2002 that can be explained by higher external borrowing by the corporate sector that ended following a sudden stop.

[10] CDS was not included as its dynamics are very similar to those of the EMBI but the data are only available from 2001.

[11] If the financial cycle is defined as fluctuations in perceptions and attitudes about financial risks (as in Ng, 2011), interest rates, which are predominantly driven by monetary policy, should not be included in the estimation of the FCI.

[12] To ensure stationarity, spreads were taken in levels, while collateral values, EMBI, interest rates, quantities are taken in y/y growth rates.

Table 1. Variables Included in the Estimation of Financial Conditions Index 1/

Variable	Loadings
EMBI, y/y	0.44
Money market spread	0.14
Lending rate, y/y	0.52
Selic, y/y	0.51
Total loans, y/y	-0.05
Real exchange rate	-0.14
Stock prices, y/y	-0.48

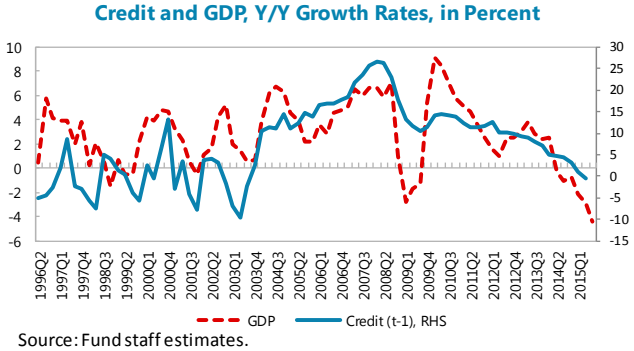
Source: Fund staff estimates.
1/ The financial conditions index explains 42 percent of the covariance between the variables included in the estimation

Quarterly projection model

11. A semi-structural model is used to estimate financial and business cycles and to model macro-financial linkages. The model is a variant of the models developed in Carabenciov and others (2008), and includes equations for output, inflation, interest rates, foreign demand, and the real exchange rate, among other key macroeconomic variables. Two versions of the model are developed: a version that includes total real credit and a version that includes real public and real private credit separately to account for differences in the behavior of private banks' and public banks' credit. The financial cycles in the model are defined as a credit cycle—the deviation of real credit from its trend estimated using the model—and the cycle in the FCI described above. Financial and business cycles are jointly estimated by specifying relationships between the cycles based on economic theory and empirical evidence, where the trend of each variable is endogenously determined. The models are estimated using Bayesian methods, with the sample beginning in 1999 and ending in 2015Q3. Appendices A and B provide more details on the model specifications and the parameter estimates.

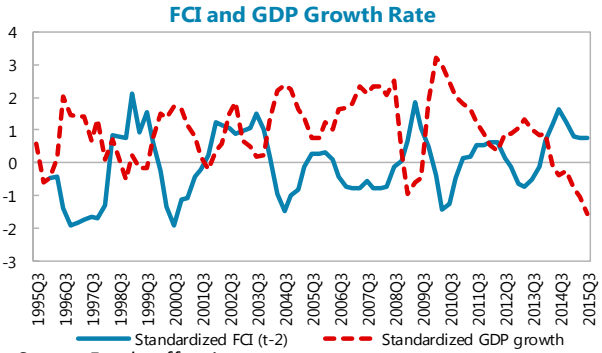
12. The models incorporate key assumptions about financial and business cycles:

- The credit cycle is positively correlated with the business cycle and lags it by one quarter (Chart). The lagging relationship is motivated by the observation the banks cannot immediate adjust their credit levels in response to demand shocks (for example, due to an inability to recall credit that has already been extended).



Source: Fund staff estimates.

- The FCI leads real GDP growth by two quarters and financial conditions ease with expectations of stronger growth (Chart).
- Autonomous shocks to credit (unrelated to demand developments) boost demand.
- An autonomous tightening of financial conditions (unrelated to demand developments) reduces demand.



Source: Fund staff estimates.

D. Results

Estimated cycles

13. Brazil is currently in a downturn phase of the credit cycle. The statistical filter and the model identify one medium-term financial cycle in total credit with the trough in 2004–05 and the peak in 2010–11.[13] Dynamics of public and private cycles are somewhat different, reflecting the countercyclical use of public banks over 2008–13.

14. The FCI shows four episodes of rapid tightening in financial conditions since 1996. The first period is characterized by a loss of foreign investors' confidence associated with spillovers from the Asian Crisis in the period from mid-1997 to mid-1999 and the second period relates to the 2002 sudden-stop episode. Financial conditions were relatively easy following the 2002 episode up until the global financial crisis, which, in Brazil, was mostly marked by tighter external conditions. The last period of tighter financial conditions started in 2013 and was initially sparked by heightened uncertainty about the future course of monetary policy in the U.S. (the so-called "taper tantrum"), and subsequently followed by adverse domestic developments that resulted in lower credit growth, higher interest rates and spreads, and a depreciation of real.

15. Panel 1 highlights a tight correlation between financial market developments and the business cycle. Both model-based and statistical-based estimates of financial and business cycles suggest that the financial cycle has both a longer duration and is of larger magnitude than the business cycle. The results also suggest that for every 1 percent increase in the output credit increases by around 3 to 5 percent, on average. Panel 1 also suggests that the business and the financial cycles move in tandem. Moreover, real GDP growth lags the financial conditions. Both facts suggest that financial sector developments are important for economic fluctuations in Brazil.

[13] It also appears that the medium term financial cycle in Brazil lags behind the financial cycles in the advanced economies (see Drehmann and other 2012 for financial cycles of other economies).

Macro-financial linkages: Impulse Response Functions

16. Impulse responses underline the importance of demand shocks for credit and financial conditions shocks for output. The estimated financial linkages between real credit for the aggregate and disaggregate models are displayed in Panel 2 and Panel 3. For comparison, simple bivariate VARs are also estimated over the same sample.[14] The impulse responses following 1 percent shocks to output, credit and financial conditions suggest the following:

- ***Credit responds more to output than output responds to credit.*** In the aggregate model, a 1 percent shock to output leads to an increase in credit of around 0.7 percent, while a 1 percent shock to credit leads around a 0.3 percent increase in output. Likewise, in the disaggregate model, the public and private credit responses to demand shocks are less than half the size of the demand responses to credit.

- ***The peak impact of output and credit shocks occurs around one year after the shock.*** While the peak impacts on output and credit following shocks occurs relatively quickly, the effects of the shocks are persistent; a 1 percent shock to output boosts credit for between 2 and 3 years, likewise for the impacts of credit shocks on output.

- ***Private credit is more responsive to output shocks than public credit.*** Private credit increases by 1 percent following a positive output shock, while public credit only increases by around 0.7 percent. This result is not surprising. Intuitively, the extension of credit by private banks is likely more driven by macroeconomic developments than that extended by public banks, who have adopted countercyclical policy measures in the past.

- ***Output responds strongly to shocks to financial conditions.*** While financial conditions loosen following a positive demand shock, the response is relatively small and short-lived. On the other hand, there is a significant reaction of output to shocks to financial conditions.

Macro-financial linkages: Historical Shock Decompositions Output

17. Historical decomposition of the output gap suggests that both short-term financial conditions shocks and medium-term credit shocks are important in explaining fluctuations in economic activity. The impacts of financial shocks on output since 1999 are displayed in Figure 4 and Figure 5:

- ***Private credit boosted output in the lead up to the global financial crisis and public credit boosted output following the crisis.*** Strong growth in private credit in over 2005 to 2008 acted to support output. When the crisis hit in late 2008, private credit growth began

[14] The bivariate VARs include real credit or the financial conditions index and the output gap; where possible, the shocks are identified in a recursive manner based on the same timing assumptions used in the structural models. In each specification, real credit and real GDP are de-trended using a standard HP filter (i.e., λ=1600). Median impulse responses are displayed along with the 10th and 90th percentiles obtained from bootstrapped distributions.

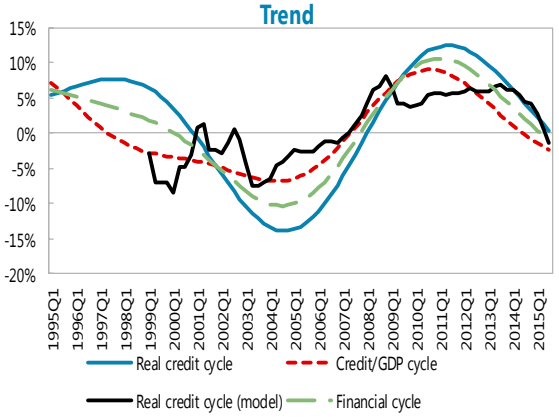
to slow as private banks acted to bolster their balance sheets. At the same time, public credit was expanded in an effort to support demand after the crisis, providing a boost to output over 2009–10. The impact of the slowdown in private credit growth can be seen in the drop in importance of private credit shocks towards the end of 2008. Likewise, public credit went from being broadly neutral for growth in the lead up the crisis to being strongly expansionary.

- ***Financial conditions played an important role both during the 2008/2009 and during the recovery period.*** Looser financial conditions were a key driver in the 2009 recovery of output. The positive impact of financial conditions lasted until 2013 when financial conditions tightened drastically following the taper tantrum and a rise in foreign funding costs.

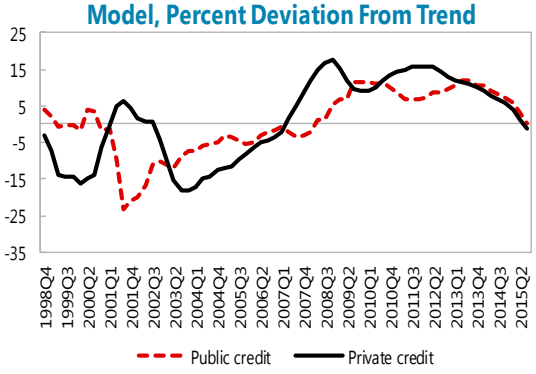
- ***More recently, public and private credit and financial conditions have begun to be a drag on output.*** In response to slowing demand, private credit began slowing before public credit. Estimates suggest both public and private credit have been a drag on output since early 2015 when a policy was adopted to limit the expansion of credit by public banks, largely due to fiscal efficiency considerations. Financial conditions also tightened in 2015, largely due to a rise in uncertainty related to the outlook for growth, inflation, and the public finances. A relatively large contribution of financial markets developments for economic fluctuations, at least in the recent period, reflect numerous macro-financial linkages as summarized in Table 2.

Figure 1. Financial Cycles, Business Cycle in Brazil

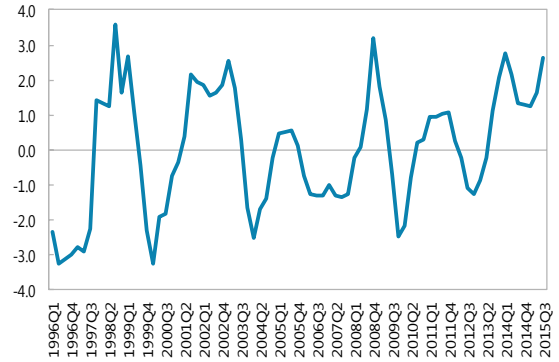
Medium-Term Credit Cycles, Percent From Trend



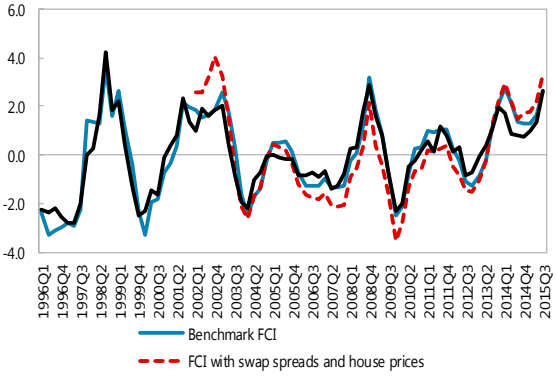
Estimated Credit Cycles, Dissagregate Model, Percent Deviation From Trend



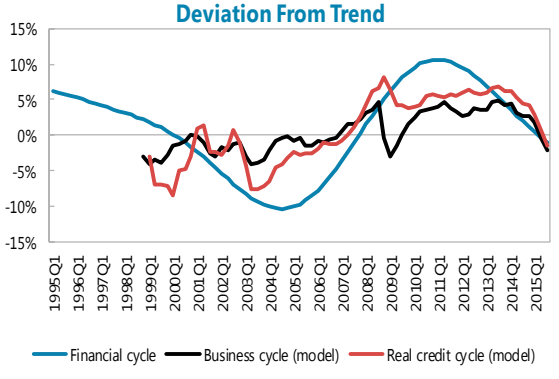
Financial Conditions Index



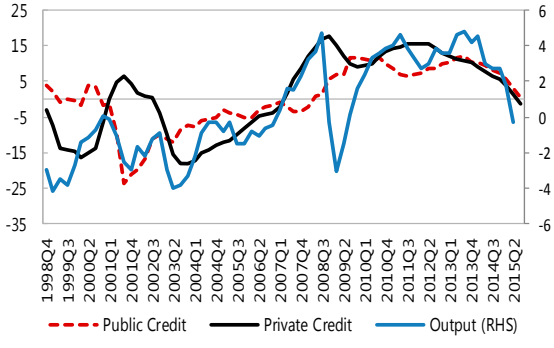
Financial Conditions Indices



Financial cycle and business cycle, Percent Deviation From Trend

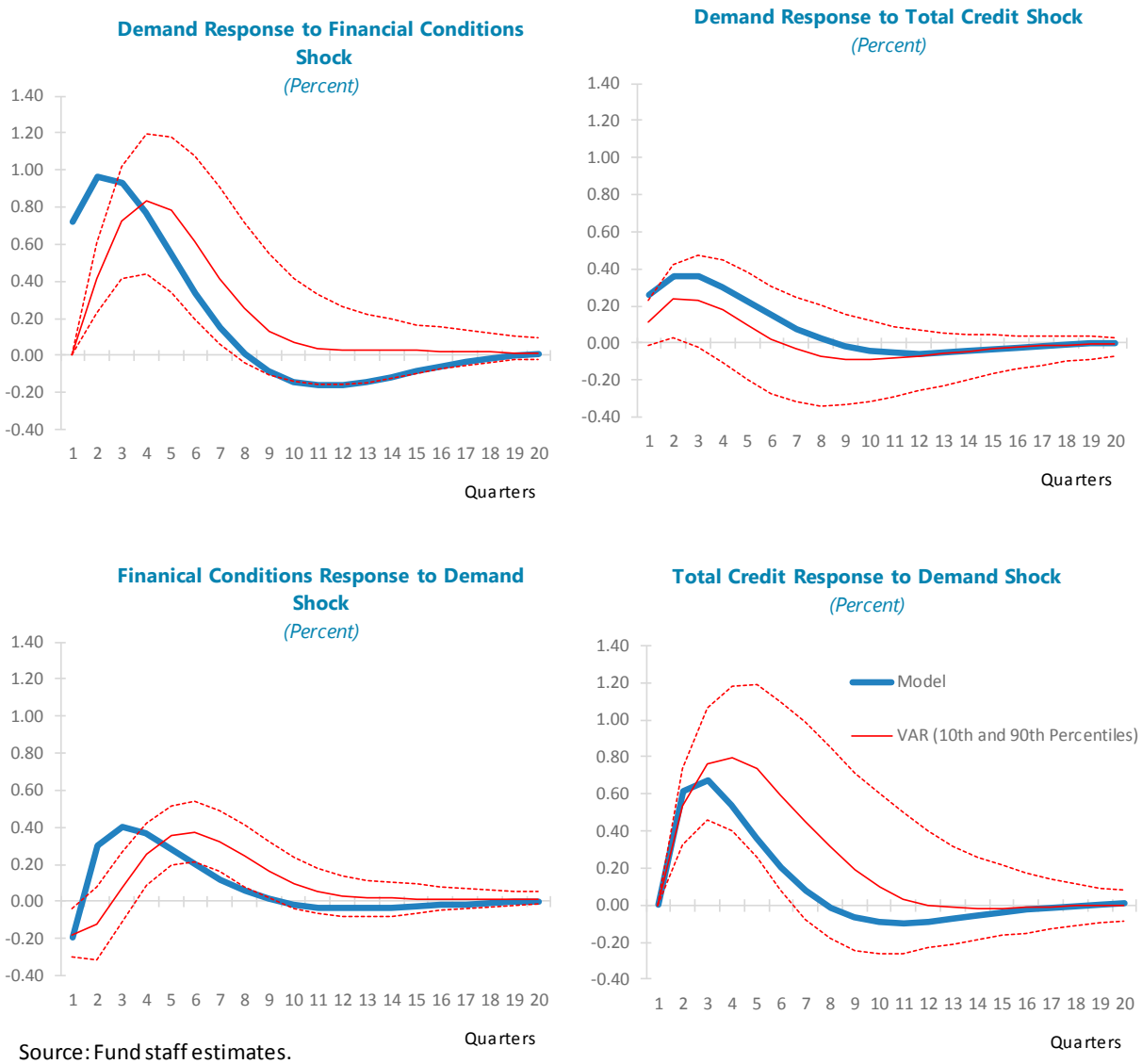


Estimated Cycles, Dissagregate Model, Percent Deviation From Trend



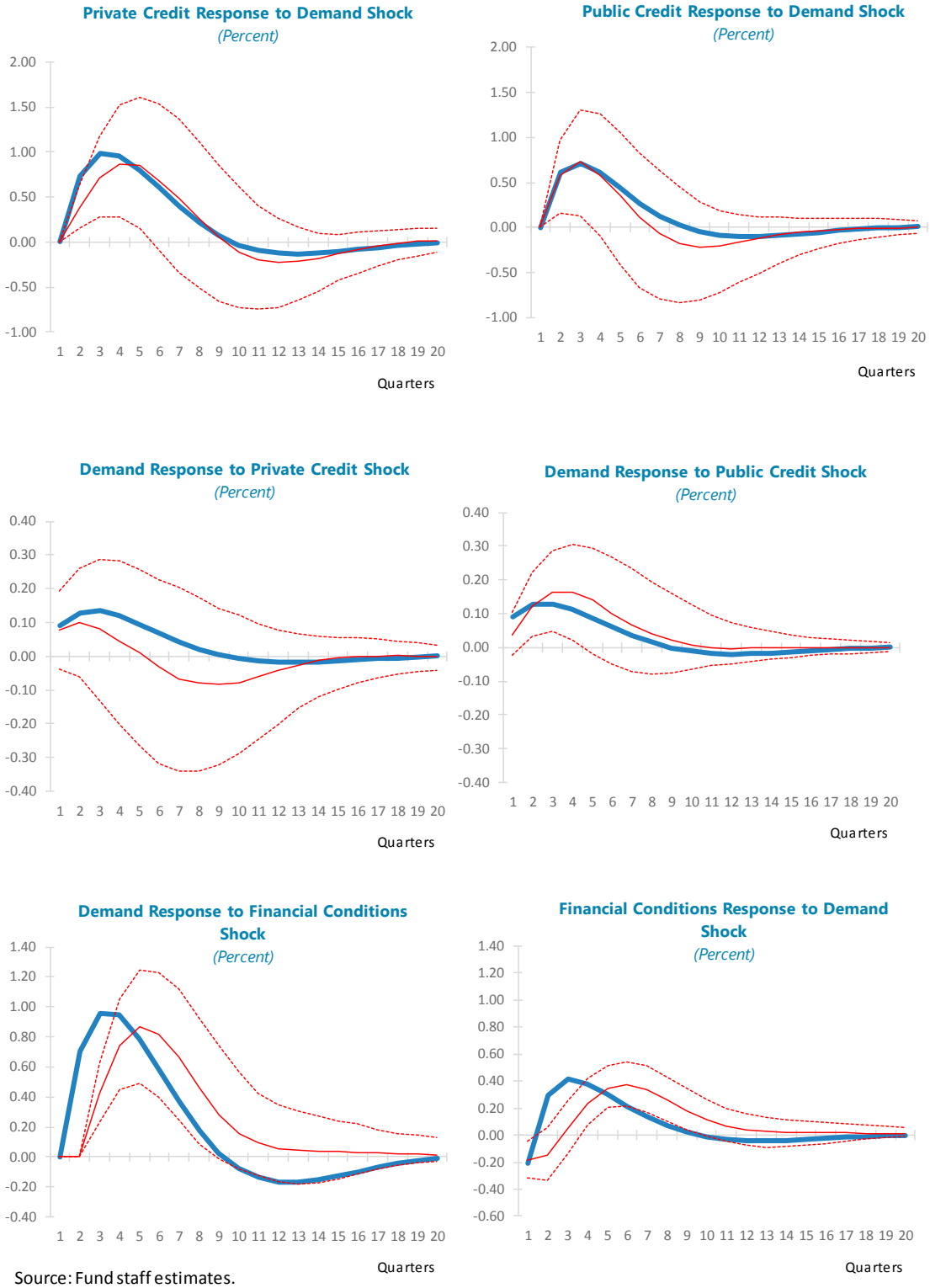
Source: Fund staff estimates.

Figure 2. Aggregate Model: Impulse Response Functions



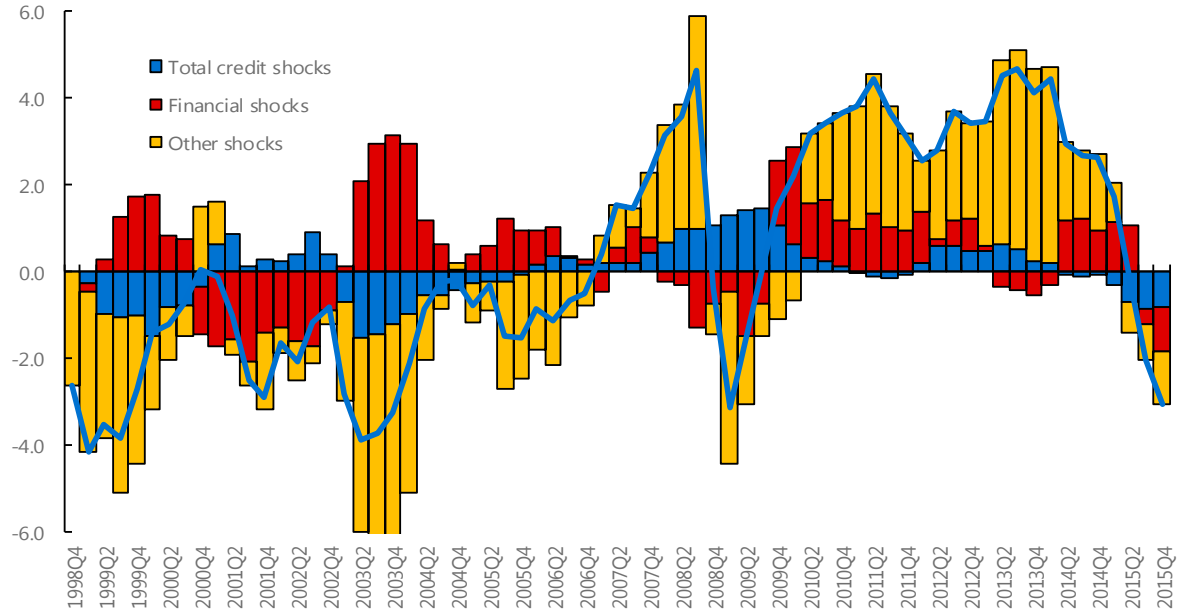
Source: Fund staff estimates.

Figure 3. Disaggregate Model: Impulse Response Functions



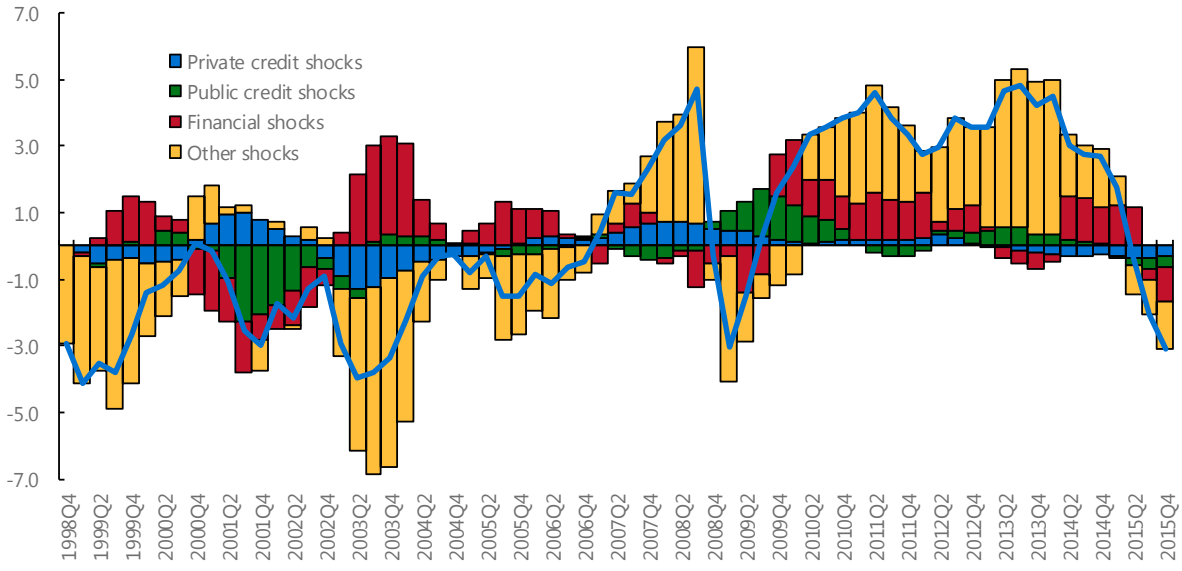
Source: Fund staff estimates.

Figure 4. Historical Shock Decomposition of Output Gap, Aggregate Model
(Percent deviation From Trend)



Source: Fund staff estimates.

Figure 5. Historical Shock Decomposition of Output Gap, Disaggregate Model
(Percent deviation From Trend)



Source: Fund staff estimates.

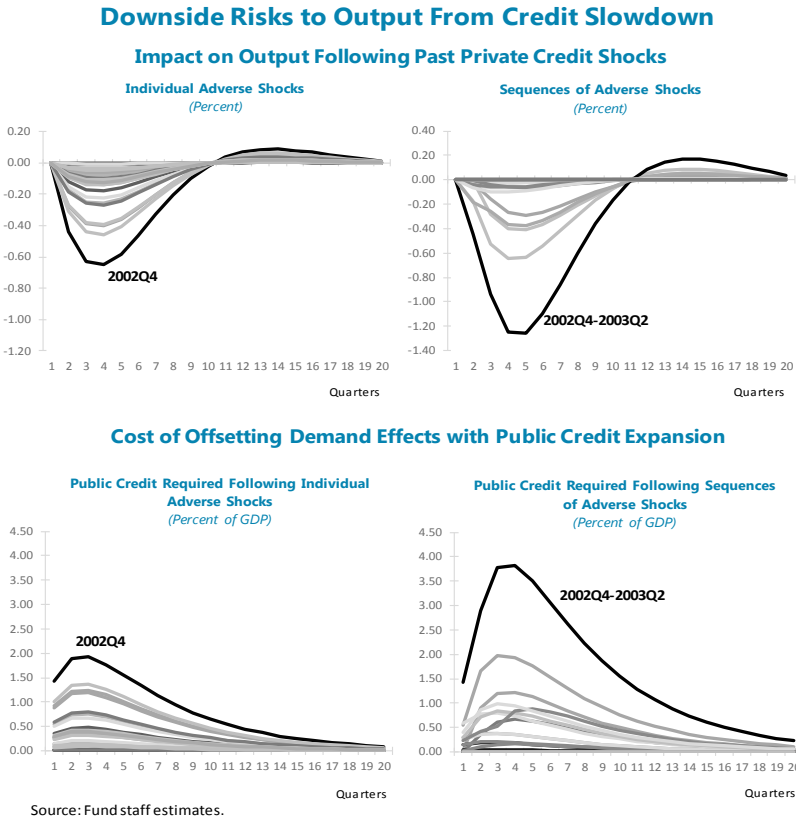
Table 2. Key Macro-Financial Linkages in Brazil

Macro Development	Direction of Link	Financial Sector/Balance Sheets	Short Description of the Link (With Direction of Link)
Uncertainties surrounding fiscal policy; higher government bond yields; sovereign downgrade	→	Overall banking sector	Higher funding costs; unrealized lossed on government bonds' holdings
	↔	Public banks	Lower funding opportunities from the government; slower expansion of balance sheet Lower dividends to Fazenda due to lower profits
	←	Central bank	Losses on reserves due to deprecitation of real Higher sovereing yields Risk of fiscal dominance
Monetary policy tightening	→	Households	Higher debt/interest burden
	→	Corporate sector	Higher debt/interest burden
	→	Overall banking sector	Higher funding costs; Higher lending rates; higher demand for LFs, LCIs, LCAs; lower demand for deposits (due to a cap)
	→	Mutual fund industry	Expansion of the industry: Substitution between lower yielding deposits for mutual fund shares
	↔	Public banks	Higher TJLP Directed credit diminish effectiveness of monetary policy
Recession; higher unemployment; weak investment and consumption; uncertain outlook	←	Households	Lower real wealth; lower consumption; lower confidence; higher interest rates
	←	Corporate sector	Lower profits, Lower investment, lower confidence; higher funding costs
	↔	Overall banking sector	Higher NPLs; losses on equity exposures Higher funding costs (lower liquidity); higher interest rates; Lower credit demand (due to higher unemployment; slower wage increases; higher interest rates; lower investment) Lower credit supply (tighter financial conditions)
Depreciation of BRL	→	Corporate sector	Higher debt/interest burden but mostly offset with hedging
	→	Overall banking sector	Higher funding costs but mostly offet with FX assets
Corruption probe	→	Corporate sector	Higher funding costs; lower profits; spilovers to suppliers
	→	Overall banking sector	Via deteriorating performance of Petrobras, contruction companies and their associated suppliers
Increase in taxes (over from 40 to 45; CSLL from 15 to 20)	←	Overall banking sector	Lower profits; higher interest rate; lower credit Higher DTAs, lower fiscal revenues
Precatorios	→	Public banks	Lower funding; higher funding costs
Judicial deposits by subnationals	→	Public banks	Lower funding; higher funding costs
Extension of tax exemption of LCI and LCA	→	Banks, mutual funds	Banks' funding more attractive, mutual funds' shares less attractive

Source: Fund staff estimates.

E. What are the Risks from a Credit Slowdown?

18. The disaggregate model is used to analyze potential downside risks from an autonomous slowdown in private credit. Banks could become more cautious and act to limit credit beyond what historical relationships between the credit cycle and the business cycle suggest. This may be of particularly concern during a downturn, when profitability and liquidity are under pressure, corporate vulnerabilities are rising, and buffers reach more critical levels. These effects may be further exacerbated in the current context as banks restructure their balance sheets during the transition towards meeting Basel III requirements over coming years.



Source: Fund staff estimates.

19. History suggests that credit slowdowns have had significant effects on demand. The top two panels of the text chart show the estimated effects of adverse shocks to private credit since 1999; the top left panel shows the impact on output of all past adverse private credit shocks and the top right panel shows the impact of past sequences of adverse shocks (i.e. all negative shocks that occurred, where negative shocks were followed by further negative shocks in subsequent quarters). The largest adverse shocks occurred during the slowdown in 2002–03, where large negative private credit shocks occurred in 3 consecutive quarters beginning in 2002Q4. Our estimates suggest that this adverse sequence of shocks acted to reduce output by around 1 percent after a year.

20. Offsetting the negative effects of a slowdown in private credit with an expansion in public credit can be costly. The effects of fully offsetting the output effects of adverse shocks to private credit with an expansion in public credit are displayed in the bottom 2 panels of the text chart. The estimates suggest that offsetting private credit slowdowns can be costly; for example, the output effects of the slowdown in private credit that began in 2002Q4 would have required a 4 percent of GDP expansion in public credit to offset.

F. Policy Implications

21. Rapid credit growth in the past points to vulnerabilities going forward. Statistical and semi-structural models show that the expansion of credit in the most recent cycle was both long in duration and large in magnitude. Moreover, Brazil is now in the downturn phase of the financial cycle. With cross-country evidence suggesting that periods of strong credit growth are typically followed by periods of sluggish growth, this may point to potential vulnerabilities for Brazil going forward.

22. A slowdown in credit could hurt growth. While our empirical results show that output has a stronger impact on credit than credit has on output, a sharp slowdown in credit could nevertheless be harmful to growth. Such a situation could be facilitated, for example, by a greater need to strengthen balance sheets as buffers reach more critical levels.

23. Offsetting a slowdown in private credit with an expansion in public-sector credit can be costly and lead to inefficiencies that are difficult to unwind. The active countercyclical role of public banks during the global financial crisis mitigated systemic risk, but also raised questions about the longer-term impact of public banks on the financial system as they are difficult to unwind; the evidence presented here suggests that reducing the size of public banks would entail a negative impact on output over time. Moreover, the rapid expansion of public banks since 2008 contributed to a deteriorating fiscal position and raising doubts about the credibility of the policy framework. Focusing public banks' activities on missing markets, such as providing guarantees for concessions, would improve the allocation of limited financing (see Coleman, Feler, 2015) and the effectiveness of monetary policy (see Bonomo, Martins, 2016). Similarly, reducing budget earmarking would release fiscal space and improve the allocation of limited fiscal resources.

Appendix I. Models and Parameters

A. Models

Aggregate Model

The model assumes that credit fluctuations are driven by the business cycle. In other words, a strong/weak economy leads to strong/weak credit:

$$c_t = \nu_1 c_{t-1} + \nu_2 y_{t-1} + \epsilon_t^c \quad (1)$$

where c_t is the real credit gap, y_t is the output gap, and ϵ_t^c is a shock to real credit. Thus, banks are assumed to set their desired levels of credit based on past levels of economic activity (demand). Because banks cannot immediately adjust credit levels (for example, due to an inability to recall credit that has already been extended), it is also assumed that credit levels are slow to adjust to output fluctuations, reflected in the term $\nu_1 c_{t-1}$.

Financial conditions, on the other hand, are set based on expectations of economic activity. If annual growth is expected to the strong in the near future, there will be a tendency for financial conditions to ease:

$$f_t = \chi_1 f_{t-1} - \chi_2 (y_{t+2} - y_{t-1}) + \epsilon_t^f \quad (2)$$

where f_t is the financial conditions index and ϵ_t^f is a shock to financial conditions.

We next establish a link between the credit cycle and demand. It is assumed that shocks to credit and financial conditions, ϵ_t^c and ϵ_t^f in equations 1 and 2 respectively, that are unrelated to past levels of output and inertia, reflect changes in the lending practices of banks and/or financing conditions that can directly affect output. In this simple model, the output gap is assumed to be related to a lead and lag of itself, the real interest rate gap, r_t, a foreign activity gap, y_t^* , and the effective exchange rate gap, z_t ,in addition to 'autonomous' financial shocks, i.e:

$$y_t = \rho_1 y_{t-1} + \rho_2 y_{t+1} - \rho_3 r_t + \rho_4 z_t + \rho_5 y_t^* + \rho_6 \epsilon_t^c - \rho_7 \epsilon_t^f + \varepsilon_t^y \quad (3)$$

where ε_t^y is an idiosyncratic demand shock. The first five terms in equation (3) are elements of a fairly standard new Keynesian IS cure, with output being positively related to lags and leads of itself, negatively related to the real interest rate, and positively related to a depreciated real exchange rate and the level of foreign demand. An autonomous expansion in credit is assumed to increase demand, while an autonomous tightening of the FCI is assumed to reduce output.

Disaggregate Model

The disaggregate model allows for differences in the behavior of public and private credit. The behavior of credit extended by public banks has differed from that private banks, thanks, in part, to public credit being used as a counter-cyclical policy instrument, particularly over the past several years. While equations (1) and (2) allow for macro-financial linkages between total real credit, financial conditions and real output, it is relatively straightforward to incorporate more disaggregate credit data. The following equations allow for differences in both the cyclical responses for public and private credit and differences in the way non-cyclical, autonomous credit shocks impact aggregate demand:

$$c_t^{pb} = \nu_1 c_{t-1}^{pb} + \nu_2 y_{t-1} + \epsilon_t^{c^{pb}} \quad (4)$$

$$c_t^{pr} = \tau_1 c_{t-1}^{pr} + \tau_2 y_{t-1} + \epsilon_t^{c^{pr}} \quad (5)$$

$$y_t = \rho_1 y_{t-1} + \rho_2 y_{t+1} - \rho_3 r_t + \rho_4 z_t + \rho_5 y_t^* + \rho_6 \epsilon_t^{c^{pr}} + \rho_6 \epsilon_t^{c^{pb}} - \rho_7 \epsilon_t^f + \varepsilon_t^y \quad (6)$$

where real total credit c_t in the aggregate model is replaced with separate equations for private and public credit, c_t^{pr} and c_t^{pb}, respectively, and aggregate demand is impacted by both private and public credit shocks.[1]

Aggregate Model Details[2]

Stochastic Processes and Definitions

- ***Output gap***

$$y_t = Y_t - \bar{Y}_t$$

where Y_t is the (log) level of real GDP and $\bar{Y}_t$ is potential output.

- ***Potential output***

$$\bar{Y}_t = \bar{Y}_{t-1} + \frac{1}{4} G_t + \varepsilon_t^{\bar{Y}}$$

[1] Note, for simplicity, the coefficient attached to public and private credit is the same.

[2] All shocks (denoted ε_t^x for variable x_t) are assumed to be independently and identically distributed white noise processes.

- ***Potential output growth***

$$G_t = \delta\, g + (1-\delta) G_{t-1} + \varepsilon_t^G$$

where g is steady state annual real GDP growth.

- ***Real credit gap***

$$c_t = C_t - \bar{C}_t$$

where C_t is the (log) level of real credit and $\bar{C}_t$ is trend real credit.

- ***Real credit trend***

$$\bar{C}_t = \bar{C}_{t-1} + \frac{1}{4} G_t^C + \varepsilon_t^{\bar{C}}$$

- ***Real credit trend growth***

$$G_t^C = \psi\, g^C + (1-\psi) G_{t-1}^C + \varepsilon_t^{G^C}$$

where g^C is steady state annual real credit growth.

- ***Inflation target***

$$\pi_t^* = \pi_{t-1}^* + \varepsilon_t^{\pi^*}$$

- ***Headline Inflation***

$$\pi_t = \alpha \pi_t^N + (1-\alpha)\pi_t^R$$

where π_t^N is non-regulated-price inflation and π_t^R is regulated-price inflation.

- ***Annual headline inflation***

$$\pi_t^4 = \frac{1}{4}(\pi_t + \pi_{t-1} + \pi_{t-2} + \pi_{t-3})$$

- ***Real interest rate gap***

$$r_t = rr_t - \overline{rr}_t$$

where rr_t is the real interest rate and $\overline{rr}_t$ is the trend real interest rate.

- ***Trend real interest rate***

$$\overline{rr}_t = \overline{rr}_{t-1} + \varepsilon_t^{\overline{rr}}$$

- ***Unemployment gap***

$$u_t = \overline{U}_t - U_t$$

where U_t is the unemployment rate and $\overline{U}_t$ is the NAIRU.

- ***NAIRU***

$$\overline{U}_t = \overline{U}_{t-1} + \varepsilon_t^{\overline{U}}$$

- ***Capacity utilization gap***

$$k_t = K_t - \overline{K}_t$$

where K_t is (log) capacity utilization and $\overline{K}_t$ is its trend.

- ***Trend capacity utilization***

$$\overline{K}_t = \overline{K}_{t-1} + \varepsilon^{\overline{k}}$$

- ***Real exchange rate gap***

$$z_t = Z_t - \bar{Z}_t$$

where Z_t is the (log) real effective exchange rate and $\bar{Z}_t$ is the trend real exchange rate.

- ***Trend real exchange rate***

$$\bar{Z}_t = \bar{Z}_{t-1} + \varepsilon^{\bar{Z}}$$

- ***Foreign output gap***

$$y_t^* = Y_t^* - \bar{Y}_t^*$$

where Y_t^* is the (log) level of U.S real GDP and $\bar{Y}_t^*$ is foreign potential output.

- ***Foreign potential output***

$$\bar{Y}_t^* - \bar{Y}_{t-1}^* = \bar{Y}_{t-1}^* - \bar{Y}_{t-2}^* + \varepsilon_t^{\bar{Y}^*}$$

Behavioral Equations

- ***IS Curve***

$$y_t = \rho_1 y_{t-1} + \rho_2 y_{t+1} - \rho_3 r_t + \rho_4 z_t + \rho_5 y_t^* + \rho_6 \epsilon_t^c - \rho_7 \epsilon_t^f + \varepsilon_t^y$$

- ***Phillips Curve (Non-Regulated-Price inflation)***

$$\pi_t^N = \gamma_1 \pi_{t-1}^4 + (1-\gamma_1)\pi_{t+1}^N + \gamma_2 Y_t + \gamma_3 \Delta z_t + \varepsilon_t^{\pi^N}$$

- ***Regulated-Price Inflation***

$$\pi_t^R = \omega \pi_t^* + (1-\omega)\pi_t^R + \varepsilon_t^R$$

- ***Policy Rule***

$$R_t = \xi_1 R_{t-1} + (1-\xi_1)(\bar{r}_t + \pi_{t+3}^4 + \xi_2(\pi_{t+3}^4 - \pi_{t+3}^*) + \xi_3 Y_t) + \varepsilon_t^R$$

- ***Real Interest Rate (Fisher Equation)***

$$rr_t = R_t - \pi_{t+1}$$

- ***Real Credit Gap***

$$c_t = \nu_1 c_{t-1} + \nu_2 y_{t-1} + \epsilon_t^c$$

where: $\epsilon_t^c = \nu_3 \epsilon_{t-1}^c + \varepsilon_t^c$

- ***Financial Conditions***

$$f_t = \chi_1 f_{t-1} - \chi_2(y_{t+2} - y_{t-1}) + \epsilon_t^f$$

where: $\epsilon_t^f = \chi_3 \epsilon_{t-1}^f + \varepsilon_t^f$

- ***Okun's Law***

$$u_t = \kappa_1 u_{t-1} + \kappa_2 y_t + \varepsilon_t^u$$

- ***Capacity Utilization Gap***

$$k_t = \phi_1 k_{t-1} + \phi_2 y_t + \varepsilon_t^k$$

- ***Foreign Output Gap***

$$y_t^* = \lambda y_{t-1}^* + \varepsilon_t^{Y^*}$$

- ***Real Exchange Rate Gap***

$$z_t = \mu z_{t-1} + \varepsilon_t^z$$

Disaggregate Model Details

The disaggregate model described above is same as the aggregate model except the real credit and output gaps are replaced with the expressions below. We denote x as representing either private credit or public credit, e.g. $\mathrm{C_t^x}$ for $\mathrm{x} = [\mathrm{pr}, \mathrm{pb}]$, where pr denotes private credit and pb denotes public credit.

- ***Real credit gap***

$$c_t^x = C_t^x - \bar{C}_t^{\,x}$$

where C_t^x is the (log) level of real credit and $\bar{C}_t^{\,x}$ is trend real credit.

- ***Real credit trend***

$$\bar{C}_t^{\,x} = \bar{C}_{t-1}^x + \frac{1}{4} G_t^{C^x} + \varepsilon_t^{\bar{C}^x}$$

- ***Real credit trend growth***

$$G_t^{C^x} = \psi\, g^{C^x} + (1-\psi) G_{t-1}^{C^x} + \varepsilon_t^{G^{C^x}}$$

where g^C is steady state annual real credit growth of both public and private credit.

- ***Real credit and output gaps***

$$c_t^{pb} = \nu_1 c_{t-1}^{pb} + \nu_2 y_{t-1} + \epsilon_t^{c^{pb}}$$

$$c_t^{pr} = \tau_1 c_{t-1}^{pr} + \tau_2 y_{t-1} + \epsilon_t^{c^{pr}}$$

where: $\epsilon_t^{c^{pb}} = \nu_3 \epsilon_{t-1}^{c^{pb}} + \varepsilon_t^{c^{pb}}$ and $\epsilon_t^{c^{pr}} = \tau_3 \epsilon_{t-1}^{c^{pr}} + \varepsilon_t^{c^{pr}}$

$$y_t = \rho_1 y_{t-1} + \rho_2 y_{t+1} - \rho_3 r_t + \rho_4 z_t + \rho_5 y_t^* + \rho_6 \epsilon_t^{c^{pr}} + \rho_6 \epsilon_t^{c^{pb}} - \rho_7 \epsilon_t^f + \varepsilon_t^y$$

where real total credit c_t in the aggregate model above is replaced with separate equations for private and public credit, c_t^{pr} and c_t^{pb} and ϵ_t^c is replaced with separate equations for $\epsilon_t^{c^{pr}}$ and $\epsilon_t^{c^{pb}}$.

B. Estimated Parameters

The models outlined in Appendix A are estimated using Bayesian estimation. The tables below display the calibrated parameters and the estimated parameters, along with the prior distributions used in posterior maximization. For more details on Bayesian estimation see Herbst and Schorfheide (2015).[3]

[3] Herbst, Edward, and Frank Schorfheide (2015), "Bayesian Estimation of DSGE Models", Unpublished Manuscript. http://sites.sas.upenn.edu/schorf/files/herbst_and_schorfheide_v5.pdf

Table A1. Calibrated Parameters

Calibrated Parameters*	
g	2.00
g^c	5.00
δ	0.05
ψ	0.05
$\sigma_{\varepsilon^{\bar{Y}}}$	0.11
$\sigma_{\varepsilon^{G}}$	0.24
$\sigma_{\varepsilon^{\pi^*}}$	1.42
$\sigma_{\varepsilon^{\overline{rr}}}$	0.48
$\sigma_{\varepsilon^{\bar{Z}}}$	3.99
$\sigma_{\varepsilon^{\overline{C^{pr}}}}$	0.61
$\sigma_{\varepsilon^{G}\,C^{pr}}$	1.26
$\sigma_{\varepsilon^{\overline{C^{pb}}}}$	0.92
$\sigma_{\varepsilon^{G}\,C^{pb}}$	1.74
$\sigma_{\varepsilon^{\bar{U}}}$	0.22
$\sigma_{\varepsilon^{\bar{K}}}$	0.25

*The shock standard deviations are calibrated based on trends extracted using a standard HP filter (i.e. with $\lambda = 1600$)

Source: Fund staff estimates.

Table A2. Estimated Parameters

	Prior Distributions	Aggregate		Disaggregate	
Estimated Parameters	F(mean,std)	Posterior	Std.	Posterior	Std.
γ_1	$\beta(0.2,0.5)$	0.40	0.04	0.41	0.03
γ_2	$\gamma(0.35,0.05)$	0.24	0.04	0.23	0.02
γ_3	$\gamma(0.1,0.025)$	0.08	0.02	0.08	0.02
ρ_1	$\beta(0.8,0.05)$	0.66	0.04	0.67	0.03
ρ_2	$\beta(0.1,0.025)$	0.07	0.02	0.07	0.01
ρ_3	$\gamma(0.35,0.05)$	0.29	0.04	0.29	0.02
ρ_4	$\gamma(0.05,0025)$	0.02	0.01	0.03	0.01
ρ_5	$\gamma(0.5,0.2)$	0.29	0.08	0.29	0.04
ρ_6	$\gamma(0.5,0.2)$	0.21	0.05	0.07	0.02
ρ_7	$\gamma(1,0.2)$	1.08	0.09	1.10	0.04
ξ_1	$\beta(0.8,0.025)$	0.76	0.02	0.77	0.02
ξ_2	$\gamma(1.5,0.05)$	1.51	0.05	1.51	0.04
ξ_3	$\gamma(0.2,0.025)$	0.20	0.03	0.20	0.02
ν_1	$\beta(0.5,0.1)$	0.43	0.07	0.67	0.04
ν_2	$\gamma(0.8,0.2)$	0.62	0.11	0.73	0.04
ν_3	$\beta(0.8,0.05)$	0.78	0.05	0.83	0.03
τ_1	$\beta(0.5,0.1)$	0.49	0.11	0.49	0.03
τ_2	$\gamma(0.8,0.2)$	0.00	0.00	0.61	0.05
τ_3	$\beta(0.8,0.05)$	0.83	0.06	0.80	0.03
ϕ_1	$\beta(0.5,0.1)$	0.26	0.05	0.26	0.03
ϕ_2	$\gamma(0.5,0.2)$	0.47	0.05	0.47	0.02
κ_1	$\beta(0.5,0.1)$	0.67	0.09	0.67	0.04
κ_2	$\gamma(0.5,0.2)$	0.18	0.03	0.18	0.02
χ_1	$\beta(0.5,0.1)$	0.40	0.06	0.41	0.04
χ_2	$\gamma(0.8,0.2)$	0.48	0.05	0.49	0.03
χ_3	$\beta(0.8,0.05)$	0.74	0.05	0.75	0.03
ω	$\beta(0.5,0.1)$	0.33	0.06	0.33	0.03
μ	$\beta(0.5,0.1)$	0.61	0.09	0.62	0.04
λ	$\beta(0.5,0.1)$	0.75	0.05	0.75	0.02
Shock Standard Deviations					
σ_{ε^y}	$\gamma^{-1}(1,\infty)$	1.09	0.04	1.13	0.02
$\sigma_{\varepsilon^{Cpr}}$	$\gamma^{-1}(1,\infty)$	1.27	0.06	1.57	0.04
$\sigma_{\varepsilon^{Cpb}}$	$\gamma^{-1}(1,\infty)$	0.00	0.00	2.73	0.04
$\sigma_{\varepsilon^{\pi^r}}$	$\gamma^{-1}(1,\infty)$	5.12	0.13	5.12	0.06
$\sigma_{\varepsilon^{\pi^n}}$	$\gamma^{-1}(1,\infty)$	2.72	0.09	2.74	0.05
σ_{ε^R}	$\gamma^{-1}(1,\infty)$	1.09	0.04	1.09	0.04
σ_{ε^z}	$\gamma^{-1}(1,\infty)$	4.34	0.11	4.46	0.04
σ_{ε^u}	$\gamma^{-1}(1,\infty)$	0.24	0.01	0.24	0.01
σ_{ε^k}	$\gamma^{-1}(1,\infty)$	0.36	0.02	0.36	0.02
$\sigma_{\varepsilon^{y^*}}$	$\gamma^{-1}(1,\infty)$	0.59	0.02	0.59	0.02
σ_{ε^f}	$\gamma^{-1}(1,\infty)$	0.53	0.02	0.51	0.02

Source: Fund staff estimates.

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CONSUMPTION IN BRAZIL: WHERE TO NEXT?[1]

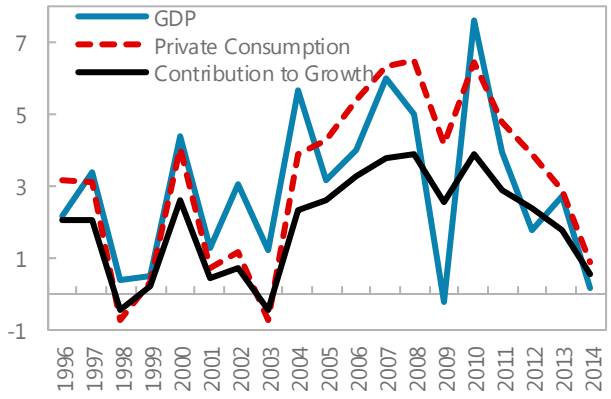
Private consumption has been a key driver of growth in Brazil for more than a decade. Over this time, Brazilian consumers have benefited from a favorable policy environment, a rapid phase of development—dramatically increasing economic, financial and social inclusion—and a supportive external environment. Meanwhile, infrastructure gaps have widened and investment and productivity levels have fallen behind. The consumption-led growth model now appears to have run its course. The prospect of a period of macroeconomic adjustment presents an opportunity to adjust policy settings to ensure stronger, more balanced and sustainable growth over the medium term.

A. Historical Developments

1. By the end of 2014, private consumption had been a key driver of growth for more than a decade. Consumption growth contracted briefly in 2003, but rebounded strongly, averaging more than 5 percent per year in real terms in the several years leading up to the global financial crisis—around 1 percent more than real GDP growth itself. Likewise, while slowing after the global financial crisis, consumption growth remained a key driver of activity, generally outpacing the other components of aggregate demand.

2. Strong consumption growth was supported by a range of favorable factors, including economic and social policies. The boost to the economy's productive capacity from higher levels of schooling and literacy in the 1990s began to pay dividends in the early 2000s as school-leavers entered the labor market, increasing productivity and income levels.[2] At the same time, social programs (notably, Bolsa Familia) and minimum wage policy provided a boost to incomes and increased financial inclusion for millions of Brazilians at the lowest income levels, increasing their purchasing power and access to financial services.[3] Widespread indexation to the minimum wage, including in the social safety net (e.g. the pension system and unemployment benefits), has also helped to support income levels and consumption. More recently, policies following the global financial crisis have been focused on

Figure 1. GDP and Consumption Growht
(In annual percent change, constant prices)



Source: IBGE.

[1] Prepared by Troy Matheson and Carlos Góes (WHD).

[2] For a detailed calculation of how the decrease in schooling inequality in Brazil helped decrease income inequality in the early 2000s, see Paes de Barros and others (2007).

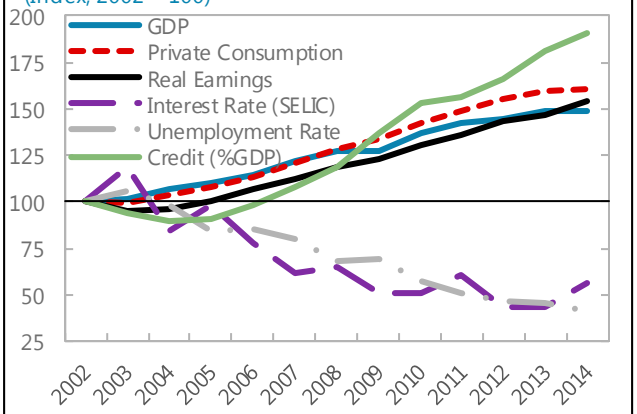
[3] In Brazil, the minimum wage has grown faster than productivity in real terms for many years. The minimum wage currently increases each year (*t*) based on real GDP growth from 2 years before (*t-2*) and inflation from the previous year (*t-1*).

stimulating household income and spending through various measures, including formal adoption of a minimum wage rule, income tax relief, subsidized lending for automobiles and other durable goods, and a rapid expansion of credit by public banks.

3. Strengthening of the policy framework improved country-risk perceptions and contributed to financial deepening and lower interest rates. Institutional changes including the fiscal responsibility law, the adoption of inflation targeting, and capital account liberalization helped to improve perceptions of risk related to Brazil at a time when global interest rates were trending down—fostering an increase in foreign investment. Both nominal and real interest rates fell dramatically between 2002 and 2014, bolstered by growing employment and financial innovation. Credit also rose very rapidly over this time, almost doubling as a share of GDP.

4. Is consumption-led growth sustainable going forward? Section B empirically assesses the determinants of private consumption in Brazil; the findings confirm that consumption has been a key factor driving growth over recent history and that income levels, real interest rates, credit, and confidence are key determinants of consumption. In Sections C and D, the prospects for future evolution of consumption are evaluated. Section E concludes with a summary of the findings and some policy conclusions.

Figure 2. Key Variables
(Index, 2002 = 100)



Source: Authors' calculations.

B. Closer Look at the Data: What Has Driven Consumption in Brazil?

Bivariate Granger Causality Tests

5. Granger Causality tests are a useful way to determine if one variable helps to predict another after controlling for autocorrelation (see Granger, 1969). As an initial step in the empirical analysis, bivariate Granger Causality is tested between real private consumption and a range of labor market and activity indicators using quarterly data ranging from 2004 to 2015. The results of the tests are displayed in Table 1 (see the Appendix more details on the data and testing methodology). In the table, the arrows reflect the direction of causality.

Table 1. Granger Causality 1/

	Consumption	Investment	GDP	Disposable Income	Income	Earnings	Employment	Unemp. Rate	Job Creation	Credit	Interest Rate	Confidence
Consumption		->	->				->		<-	->	<-	<->
Investment	<-		->		->		->		<-	->	<-	<-
GDP	<-	<-			->		<->		<-	->	<-	<-
Disposable Income					<-			<-		<-		
Income		<-	<-	->		<-	<-	<-	<-			
Average Earnings					->			<-			->	<->
Employment	<-	<-	<->		->				<-		<-	<-
Unemployment Rate				->	->	->			<-			
Job Creation	->	->	->		->		->	->		->	<-	<->
Credit	<-	<-	<-	->					<-		<-	
Interest Rate	->	->	->			<-	->		->	->		->
Confidence	<->	->	->			<->	->		<->		<-	

Source: Staff Estimates
1/ ->, <-, and <-> indicate causality directions that are statistically significant at the 10 percent level.

6. Private consumption has been a key driver of investment and GDP. Private consumption is found to have some ability to predict both investment and GDP over the sample, suggesting that investment and the other components of aggregate demand have generally responded to the behavior of consumption and not the other way around. Similarly, employment and credit are also found to be driven by the behavior of consumption. Net job creation, credit, real interest rates, and consumer confidence, on the other hand, appear to have some ability to predict the behavior of consumers, with the direction of causality running both to and from private consumption in the case of consumer confidence.

Vector-Error-Correction Models (VECMs)

7. A potential pitfall with using bivariate causality tests is that causal relationships may be missed if long-run relationships exist between two or more variables. In this section, real private consumption the determinants of consumptions are analyzed using VECMs. The basic Keynesian consumption function used here assumes a long-run, co-integrating relationship where real private consumption (c_t) is primarily determined by real disposable income (y_t):

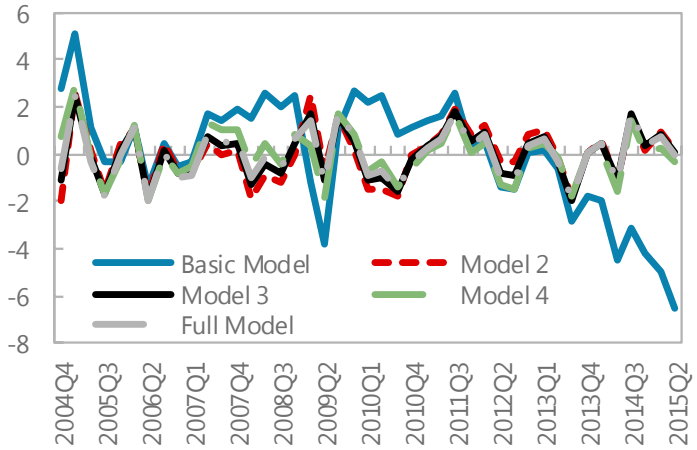
$$c_t = \beta_0 + \beta_1 y_t + \epsilon_t$$

where β_0 and β_1 are constants and the residual, ϵ_t, can be thought of as capturing additional factors that influence consumption and saving decisions other than the current level of disposable income. These factors could include real interest rates, uncertainty related to future income, and access to credit. Based on the analysis presented in section B, potential candidate variables for capturing these additional factors are the real interest rate (r_t), net job creation (jc_t) and consumer confidence (cc_t)—which both aim to reflect uncertainty about future income levels— and credit as a share of GDP (cr_t), which proxies for households' access to credit.

8. What do VECMs show? Four VECMs are estimated in addition to the basic model (see Table 2), where each model suggests there is single long-run relationship (cointegrating vector) between the included endogenous variables. The table includes the coefficients in the long-run relationships and the coefficients attached to the deviations from the long-run relationship in the

short-term dynamic equations (ECM). The ECM coefficients allow us to gauge the speed of adjustment of each variable to the long-run trend. The full model contains all the variables described above and has restrictions.[4] As can be seen in Figure 3 below, the basic model suggests very persistent consumption deviations from long run equilibrium and that allowing consumption to be determined by more factors than disposable income alone dramatically improves explanatory power. Overall, results suggest:

Figure 3. Private Consumption, Residual of Cointegration Equation (In percent deviation from long run equilibrium)



Source: Authors' calculations.

- ***Consumption responds strongly to changes in disposable income.*** The estimation results suggest a 1 percent increase in disposable income increases private consumption by around 1 percent, implying that consumption and saving shares of disposable income are constant in the long run.[5]

- ***More certainty about future income prospects and greater access to credit lead to higher consumption, while higher interest rates reduce consumption.*** Intuitively, the proxies for income prospects (net job creation and consumer confidence) and access to credit (credit to GDP) have positive coefficients and the coefficient attached to the real interest rate is negative in all specifications. It appears that the factors other than households' disposable income are also important determinants of consumption in the long run.

[4] Some of coefficients in the model that includes all variables (Model 4) are not statistically significant according to Chi-square tests. As such, the full model specification restricts the coefficient on credit and the ECM coefficients for all variables except consumption to be 0. The Chi-square test that the restrictions *do not* hold cannot be rejected, with a p-value of 0.52.

[5] Note: Because of methodological differences between private consumption in the national accounts and households' disposable income, the coefficient attached to disposable income cannot be interpreted as being the average propensity to consume.

Table 2. VECM Results

		Estimated Parmeters (standard errors in parentheses)						Cointegrating Vectors	
Model		c_t	y_t	r_t	jc_t	cc_t	cr_t	Trace (5%)	p-value
Basic	Long-run Equation	1 =	1.13					1	0.05
			(0.03)						
	ECM	0.11	0.26						
		(0.12)	(0.07)						
2	Long-run equation	1 =	0.98	-0.61	1.06			1	0.00
			(0.02)	(0.10)	(0.12)				
	ECM	-0.70	0.10	-0.04	0.63				
		-(0.22)	-(0.17)	-(0.12)	-(0.57)				
3	Long-run equation	1 =	1.00	-0.47	0.82	0.04		1	0.04
			(0.02)	(0.10)	(0.12)	(0.02)			
	ECM	-0.90	0.07	-0.22	0.48	0.19			
		(0.29)	(0.23)	(0.15)	(0.77)	(0.26)			
4	Long-run equation	1 =	0.96	-0.13	0.62	0.08	0.07	1	0.02
			(0.05)	(0.11)	(0.11)	(0.02)	(0.04)		
	ECM	-1.06	0.13	0.04	-0.11	0.89	0.92		
		(0.27)	(0.24)	(0.17)	(0.27)	(0.80)	(0.45)		
Full	Long-run equation	1 =	1.01	-0.37	0.75	0.05	0	1	0.02
			(0.02)	(0.10)	(0.12)	(0.02)	(0.00)		
	ECM	-1.20	0	0	0	0			
		(0.19)							

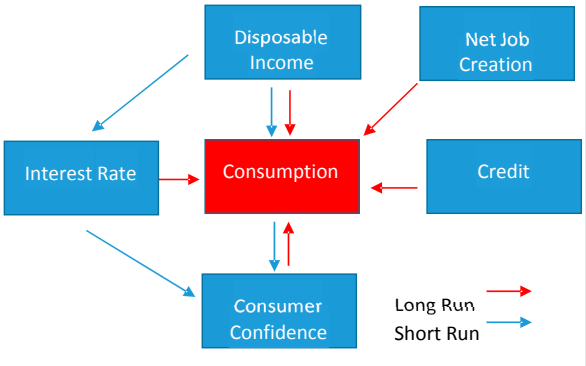
Source: Authors' estimates.

Note: All VECMs are estimated using the Johansen proceedure with the lag length of the VAR determined by the SBC.

- ***Consumption growth responds rapidly to changes in fundamentals.*** The ECM coefficient for consumption is close to one in all specifications with the exception of the basic model, suggesting consumption growth responds very rapidly to restore equilibrium. In contrast, as can be seen in the full model specification (and Model 4), the other variables do not significantly adjust to deviations from equilibrium.

9. What about Granger Causality? The existence of a single long-run relationship between consumption, disposable income, the real interest rate, net job creation, consumer confidence and credit implies there is Granger Causality among the variables. There are two types of causality that can be tested in the VECM framework, long-run causality and short-run causality. Long-run causality occurs when changes (or growth) of a variable reacts to restore equilibrium in the long-run relationship (empirically, a statistically significant ECM term

Figure 4: Granger Causality



Source: Staff Estimates

Note: Arrows reflect statistically significant causality at the 10 percent level

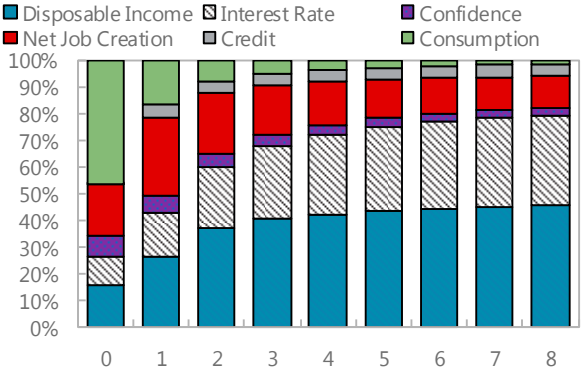
for that variable), and short-run causality occurs when changes (or growth) of one variable influences another (empirically, the statistical significance of the lags of one variable in another variable's equation in the VECM). A summary of the statistically significant causal relationships in the full model is displayed in figure 4. The full model specification suggests that long-run causality occurs only for consumption. That is, consumption is the only variable that adjusts directly to deviations from equilibrium. Tests of short-run causality also suggest that consumption growth is driven by disposable income growth and changes credit.

10. Impulse responses and variance decompositions highlight the importance of disposable income and interest rates as drivers of consumption.[6] The key findings from analyzing impulse response functions and variance decompositions are (see Figures 5 and 6):

- ***Disposable income and interest rates have large and persistent effects on consumption over time.*** Consumption rises significantly (by around 1½ percent) following a 1 percent increase in disposable income. Likewise, a 1 percent increase in the real interest prompts a reduction of consumption of around 2 percent. The other shocks act to boost consumption, but by a lesser extent. Forecast error variance decompositions (Figure 5) also show that disposable income and interest rates explain a significant proportion of consumption at longer horizons.[7]

- ***Consumption shocks are short lived.*** Exogenous shocks to consumption only have temporary effects on the level of consumption, lasting only about 1 or 2 quarters. Consumption is thus largely driven by other fundamentals (income and interest rates, etc.) and episodes of over/under consumption not justified by these factors are relatively short lived.

Figure 5. Explaining Consumption Changes at Different Horizons (In percent of forecast error explained by shocks)



Source: Authors' calculations.

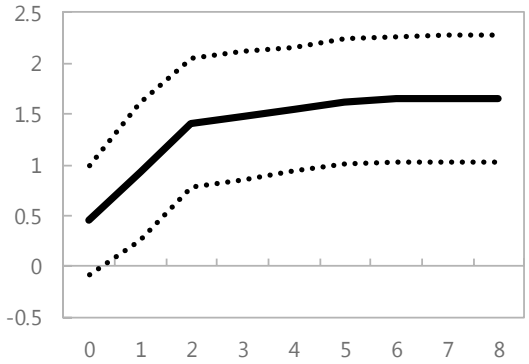
[6] The fully-specified VECM is identified with using a Cholesky decomposition, with consumption being the most endogenous variable. The causal ordering is: $y_t \rightarrow r_t \rightarrow cc_t \rightarrow jc_t \rightarrow cr_t \rightarrow c_t$. The results are robust to different orderings. Impulse responses show how each variable behaves to a shock. Variance decompositions show the amount of information each shock contributes to explaining each variable in the VECM at different forecast horizons.

[7] The decomposition shows the amount of information each shock contributes to explaining each variable in the VECM by determining how much of the forecast error variance of each of the variables can be explained by each of the exogenous shocks. Effectively, forecasts for each variable in the model at each point in time are uncertain due to developments in the (structural) shocks. Given the estimated parameters of the model, including the estimated shock variances, the forecast error variance for each variable can be computed at each horizon, allowing each forecast error variance to be attributed among the different structural shocks.

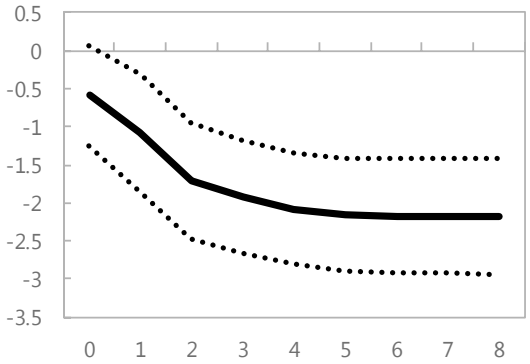
Figure 6. Consumption Responses to Shocks

(Percent response to a 1 percent shock in impulse variables at subsequent quarters after shock; dotted lines denote 90 percent confidence interval)

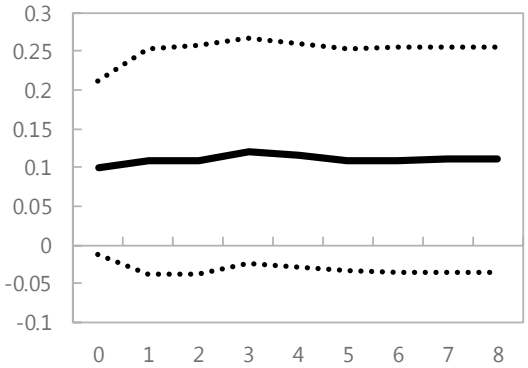
Disposable Income Shock



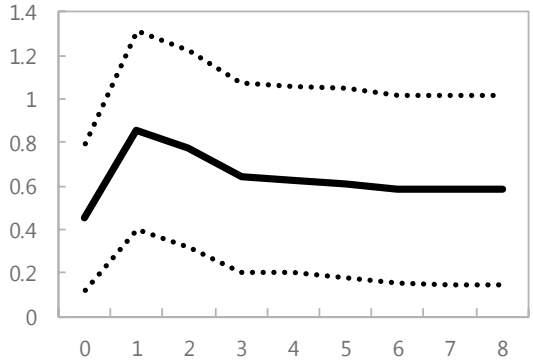
Interest Rate Shock



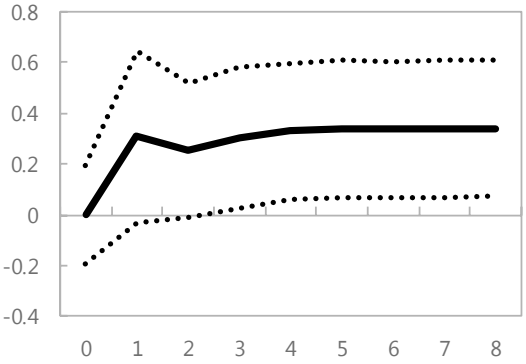
Confidence Shock



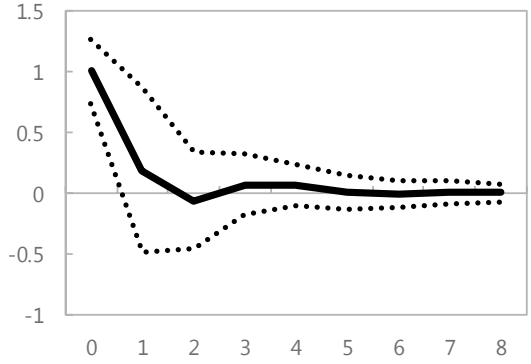
Net Job Creation Shock



Credit Shock



Consumption Shock



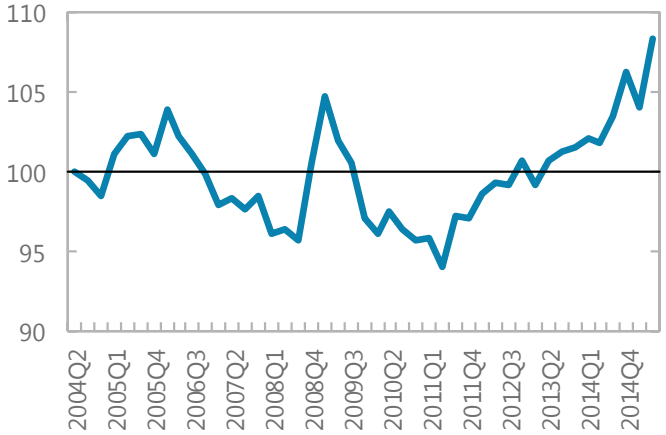
Source: Authors' calculations.

C. Where to Next for Consumption?

11. Consumption growth is likely to slow going forward. The favorable conditions that have driven strong consumption growth over the past 10 to 15 years look set to diminish.

- ***Income and the labor market:*** Disposable income growth has outstripped GDP growth over the past several years, leading to a situation in which labor has been gaining an increasing share of output—an unsustainable situation in the long run. After a prolonged period of declining unemployment and strong real wage growth that boosted disposable incomes across Brazil, employment and real wage growth look set to slow. Brazil's strong social safety net has come under stress as public finances have deteriorated. If they continue to be guided by their current formula, minimum wage increases may also hamper wage adjustment and employment growth going forward.

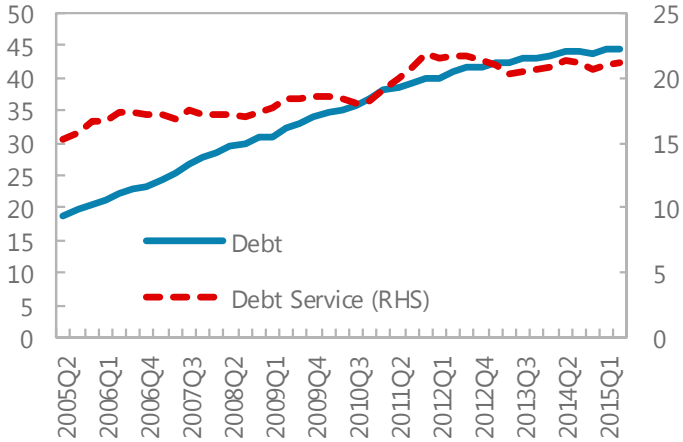
Figure 7. Disposable Income as a Percent of GDP
(Index, 2004Q2 = 100)



Sources: Authors' calculations with IBGE data.

- ***Real interest rates:*** Real interest rates have risen as the central bank has tightened monetary policy amid high regulated price inflation and a depreciating currency. Widespread indexation practices (price and wage) and price shocks could delay convergence of inflation to the center of the central bank's tolerance band and necessitate higher interest rates for longer. Moreover, over the longer-term, the boost to consumption from the drop in real interest rates facilitated by the adoption of inflation targeting, the strengthening of domestic fundamentals, and a generalized fall in global interest rates appears to have run its course. Central banks in advanced economies are also expected contribute to higher global interest rates over the foreseeable future as they gradually normalize their policy settings.

Figure 8. Household Debt
(In percent of disposible income)



Source: Brazilian Central Bank.

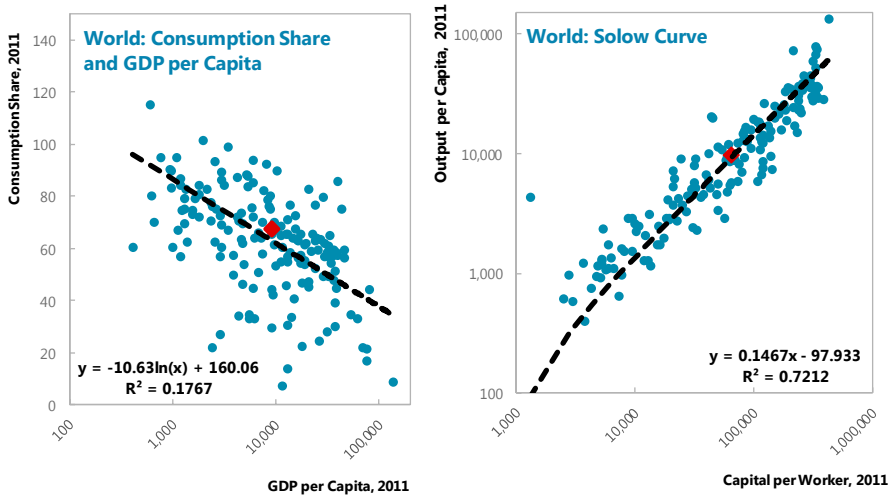
- ***Credit and debt:*** Credit growth has been slowing as the weakening labor market and high levels of debt and debt service have reduced consumers' demand for credit. At the same time, weak domestic demand and rising non-performing loans have led to a tightening of credit conditions on the supply side. A prolonged period of labor market weakness and high interest rates could prompt a sustained period of household deleveraging and hamper consumption growth. Likewise, the rapid rate of expansion in credit over the 10 years prior to the recession that resulted from financial deepening and formalization in the labor market looks set to slow.

- ***Uncertainty and Confidence:*** Consumer confidence is expected to remain at low levels as the result of the weakening labor market and persistently high inflation. At the same time, political uncertainty and uncertainty related to the Petrobras corruption probe looks set to continue in the near term, making households more cautious about their spending decisions and increasing saving.

D. Has Brazil's Growth Model Run its Course?

12. Consumption-led growth in Brazil has been evidenced in widening infrastructure gaps and relatively low levels of investment. Low levels of investment are associated with lower levels of capital per worker and lower levels of income per capita. There is also some evidence that lower levels of consumption are associated with lower levels of income per capita, with relatively few countries in the world having higher levels of consumption and higher levels of income. Brazil's heavy reliance on consumption as a source of growth over the past decade or so has contributed to a widening of infrastructure gaps that are hampering productivity and competiveness (see Garcia-Escribano and others, 2013).

Figure 9. Cross Section Relationships Between Consumption and Capital Stock and Income



Source: Penn World Tables.

13. Higher levels of income and growth can be achieved with more reliance on investment and less on consumption. Simple panel growth regressions (see table) suggest that a 1 percent rise investment as a share of GDP is associated with a 0.04 percent increase in per capita income growth. Moreover, while less significant (qualitatively and quantitatively), a decrease in consumption as a share of GDP by 1 percent is associated with 0.01 percent increase in per capita income growth. Overall, the results suggest a switch from a consumption-led model of growth toward an investment led model of growth with a 1 percent decline in the consumption share and a 1 percent increase in the investment share could boost growth in income per capita by 0.1 percent per year. While these estimated effects on income *growth* appear small at first sight, they are large in terms of their impact on income *levels* over time, consistent with the evidence in the figure above.

Table 3. Panel Regressions

	(1) OLS	(2) OLS	(3) GMM	(4) GMM	(5) GMM	(6) GMM
	Dependent Variable: Growth in GDP per Capita (PPP)					
Dependent Variable (t-1)	0.244***	0.223***	0.160***	0.141***	0.146***	0.137***
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
Dependent Variable (t-2)					-0.020*	-0.029***
					(0.011)	(0.011)
Change in Investment Share (t-1)	0.030**	0.031**	0.041***	0.039***	0.041***	0.040***
	(0.013)	(0.013)	(0.014)	(0.014)	(0.014)	(0.014)
Change in Consumption Share (t-1)	-0.007	-0.006	-0.010**	-0.008*	-0.011**	-0.009**
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Constant	1.679***	1.969***	1.861***	3.190***	1.982***	3.120***
	(0.071)	(0.455)	(0.068)	(0.774)	(0.071)	(0.762)
Country Fixed-Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed-Effects	No	Yes	No	Yes	No	Yes
Observations	7,942	7,942	7,774	7,774	7,607	7,607
R-squared	0.063	0.110				
Number of Countries	168	168	167	167	167	167
Sargand Statistic for Valid Instruments (p-value)			0.99	0.99	0.99	0.99

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Authors' estimates.

E. Policy Implications

14. The favorable factors that boosted consumption in the past look set to wane going forward. Over the early-to-mid 2000s, Brazil reaped the benefits of rapidly-rising incomes, real wages, employment, and productivity that resulted from structural and institutional reforms. This rapid phase of development also came against the backdrop of very favorable external conditions including a reduction in global interest rates. The structural boost consumption from these factors looks set to continue diminishing over the medium term. Moreover, in the short term, a number of cyclical factors look set to weigh on consumption, including labor market weakness (and slower income growth), higher real interest rates (domestic and international), and a potential re-evaluation

of appropriate levels of debt and debt service on the part of households and banks, that could prompt a period of deleveraging and slower credit growth.

15. Slowing consumption presents an excellent opportunity to foster alternative sources of growth—to both support growth in the near term and to make it stronger, more balanced, and sustainable over the long term. Key areas to address include:

a. ***Infrastructure bottlenecks:*** Expanding the scope and size of the infrastructure concessions program would not only boost investment growth in the near term, but also support stronger, more sustainable growth over the medium term. Factors impeding private sector involvement need to be addressed, including better matching of risk/reward tradeoffs for investors through the appropriate transfer of risks and program design.

b. ***Minimum wage and pension system:*** The minimum wage formula should better reflect productivity gains to promote employment over the long term (see Lipinsky and Góes, 2015). While the current formula boosts income and consumption levels of millions of Brazilians each year, it discourages saving, and is a key source of medium-term fiscal pressure by directly affecting the growth of pensions and other benefits. It also discourages investment and employment growth by depressing firms' profitability. Reforming the pension system through delinking it from the minimum wage and extending retirement ages would also encourage saving and provide funding for higher levels of investment.

c. ***Tax reform:*** Brazil's tax system is notoriously complex, and represents a large cost of doing business in Brazil. Simplification of the tax code would help to improve the overall business environment and foster investment. More generally, distortions in the system that promote consumption and discourage investment (and exports) should be evaluated and addressed to improve efficiency and more balanced growth in the long term.

Appendix I. Data and Methodology

Data

The data used in the empirical work are described below. All nominal variables are deflated with the extended national CPI, IPCA. Estimation is over a quarterly sample spanning 2004−15. Data used in section E come from the Penn World Tables (version 8.1).

Table A1. Description of Variables

Variable (x)	Details	Transform	Source
Consumption	Private consumption (GDP)	ln(x)*100	IGBE
Investment	Gross fixed capital formation (GDP)	ln(x)*100	IGBE
GDP	Gross domestic product	ln(x)*100	IGBE
Disposable income	Household disposible income	ln(x)*100	IGBE/BCB
Income	Income (employment times average real earnings)	ln(x)*100	IGBE
Average earnings	Real average earnings per worker	ln(x)*100	IGBE
Employment	Economically active employment	ln(x)*100	IGBE
Unemployment rate	Unemployment rate	x	IGBE
Job Creation	Net job creation (percent of working age population)	x	MTE/IGBE
Credit	Total credit (percent of GDP)	x	BCB
Interest rate	Real interest rate (SELIC minus ex-post IPCA inflation, yoy)	x	BCB
Confidence	Consumer confidence	ln(x)*100	Fecomercio

Granger Causality

All of the indicators considered are found to be non-stationary, I(1) processes, in pretesting.[1] Thus, the Toda and Yamamoto (1995) procedure is used.[2]

The Toda and Yamamoto (1995) procedure for testing for potential causal relationships between two variables, *x* and *y*, begins by estimating a vector-autoregression (VAR), i.e:

$$y_t = c_y + \sum_{i=1}^{p} \theta_i^{yy} y_{t-i} + \sum_{i=m+1}^{m+d} \theta_i^{yy} y_{t-i} + \sum_{i=1}^{p} \theta_i^{yx} x_{t-i} + \sum_{i=m+1}^{m+d} \theta_i^{yx} x_{t-i} + \varepsilon_y$$

$$x_t = c_x + \sum_{i=1}^{p} \theta_i^{xy} y_{t-i} + \sum_{i=m+1}^{m+d} \theta_i^{xy} y_{t-i} + \sum_{i=1}^{p} \theta_i^{xx} x_{t-i} + \sum_{i=m+1}^{m+d} \theta_i^{xx} x_{t-i} + \varepsilon_x$$

[1] Standard Augmented Dickey-Fuller tests were used to determine the order of integration of each series. The results of these tests are available on request.

[2] The lag length of each VAR, *p*, is determined using the Schwartz-Bayesian Criterion (SBC). As suggested by Toda and Yamamoto (1995), the null-hypothesis of no causality between *x* and *y* is tested using a Wald test with *p* degrees of freedom.

where the cs and θs are estimated parameters, εs are residuals, p is the lag length of the VAR, and d is the maximum order of integration of the two time series, y and x. Granger causality is then determined by the (joint) statistical significance of groups of parameters in the model. Specifically,

1. *x* Granger Causes *y* if $\theta_i^{yx} \neq 0$ for all $i = 1, \cdots p$ (denoted *x*->*y* in table 1);
2. *y* Granger Causes *x* if $\theta_i^{xy} \neq 0$ for all $i = 1, \cdots p$ (denoted *y*->x in table 1);
3. *x* and *y* Granger Cause each other if 1 and 2 are satisfied (denoted x<->y in table 1).

VECM Bootstrapping Algorithm

Standard errors were estimated from a bootstrapping procedure with 1,000 replications. The bootstrapping algorithm works as follows

- We ran the baseline model and collected residuals and fitted values for all endogenous variables.
- We then multiplied the reduced-form residuals by the inverse of the Cholesky lower triangular matrix in order to get the structural residuals while preserving the variance-covariance structure of the model.
- Afterwards, we re-sampled the structural residuals, thereby adding variability to the bootstrapping exercise, and transformed them back into reduced-form residuals, now re-sampled.
- We then created pseudo-series by adding the re-sampled residuals to the fitted values and ran a model that mirrors the baseline model (with the same Cholesky ordering), calculated the IRFs with the pseudo-series, and stored their values.
- After repeating this procedure 1,000 times, we calculated the second moment of the pseudo-IRFs, which represent the standard errors of our baseline IRFs.

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FISCAL CHALLENGES OF AN AGING POPULATION IN BRAZIL[1]

In recent decades, the elderly population has doubled in Brazil while pension and health related spending has increased in per capita terms and as a share of GDP. As the demographic profile changes, spending on health and pension will increase to unsustainable levels absent reforms to benefits. These reforms should start as soon as possible, so that they can be implemented gradually to ensure sustainability and population endorsement.

A. Overview

1. In recent decades, the elderly population has increased substantially in Brazil. Declining fertility rates and increasing life expectancy are important drivers of demographic changes in Brazil and Latin America, which have contributed to decreasing population growth and a growing share of elderly citizens in the total. Over the past half a century, fertility rate in Brazil and other middle-income countries has halved and is now in line with that of advanced economies (Figure 1). Annual population growth has thus declined dramatically. Meanwhile, thanks to income growth, redistribution policies, and health reforms, life expectancy has increased in Brazil, pushing up the dependency ratio. Population aged 65 and above constitutes now about 7½ percent of the total population, up by two percentage points from only a decade ago.

2. The demographic trends are set to continue, further increasing dependency ratios. Because of declining fertility, the population will start declining in absolute terms in Brazil by mid-century. According to the UN, by 2050 Brazil's old-age dependency ratio—the ratio of citizens aged 65 and above to the ratio of population aged 15 to 64—will reach close to 37 percent, and surpass that of more advanced economies by 2100. Brazil's statistical institute (IBGE) projects a similar trend, with old age dependency reaching 36 percent by 2050.[2]

3. An aging population will soon pose fiscal challenges in Brazil, much earlier than in 2050. Public age-related spending (on pensions and health) is projected to reach levels incompatible with fiscal sustainability already within the next decade. Pension and health expenditures represent half of total public spending in 2015 (16 percent of GDP) and, if the current generosity of benefits is left unaddressed, are projected to increase to 21 percent of GDP in 2025 and 40 percent of GDP by 2050 as the elderly share of population more than triples. However, unlike in other countries, where demographic disequilibria point to difficult times down the road, the Brazilian pension system is already in deficit, which is projected to reach 3.2 percent of GDP in 2016 (Tesouro Nacional, 2015).

[1] Prepared by Izabela Karpowicz and Carlos Mulas-Granados with support from Mauricio Soto and Kamil Dybczak.

[2] 2013 estimate.

4. Past reforms moderated pension deficits for a time, but urgent attention to ageing-related spending is needed once again. The 1998 pension reform had a limited impact on deficits, and in 2003 parametric changes were introduced in the mandatory public sector pension regime. In 2012, a defined contribution pillar for the public regime was established which reduced replacement rates for higher earners and enhanced progressivity and equity with respect to private pensions at a relatively low transition cost. The macroeconomic impact of the reform was estimated to be positive for Brazil, increasing private savings and labor supply, especially if financed through increased government savings (IMF, 2012). However, these reforms were insufficient, and will not contain the growth of pension spending ahead. In the area of health, limited consideration was given to efficiency and cost control until recently, although spending had increased massively over the last few decades to fill the gap in coverage and health outcomes with respect to advanced economies.

5. Several options for reform are explored in this paper.

- **Pensions.** A combination of reforms to reduce benefits eligibility are considered and have the potential of containing future deficits in the least distortionary way for labor incentives. Delaying retirement would ensure significant fiscal savings but is only a starting point. Changing the benefits indexation formula and removing existing payroll tax exemptions are also important measure and could be complemented by a benefit freeze to existing pensioners to frontload the savings.

- **Health.** Cost-containment in health is an unexplored area in Brazil. The experience of advanced economies provides insights on approaches to contain the growth of health spending. The effects of these reforms are difficult to quantify, however, and trends in longevity, evolving standards of care and the introduction of new technologies create new demands on health systems. This underscores the need to continuously refine approaches to achieve efficiency gains in the provision and utilization use of health services.

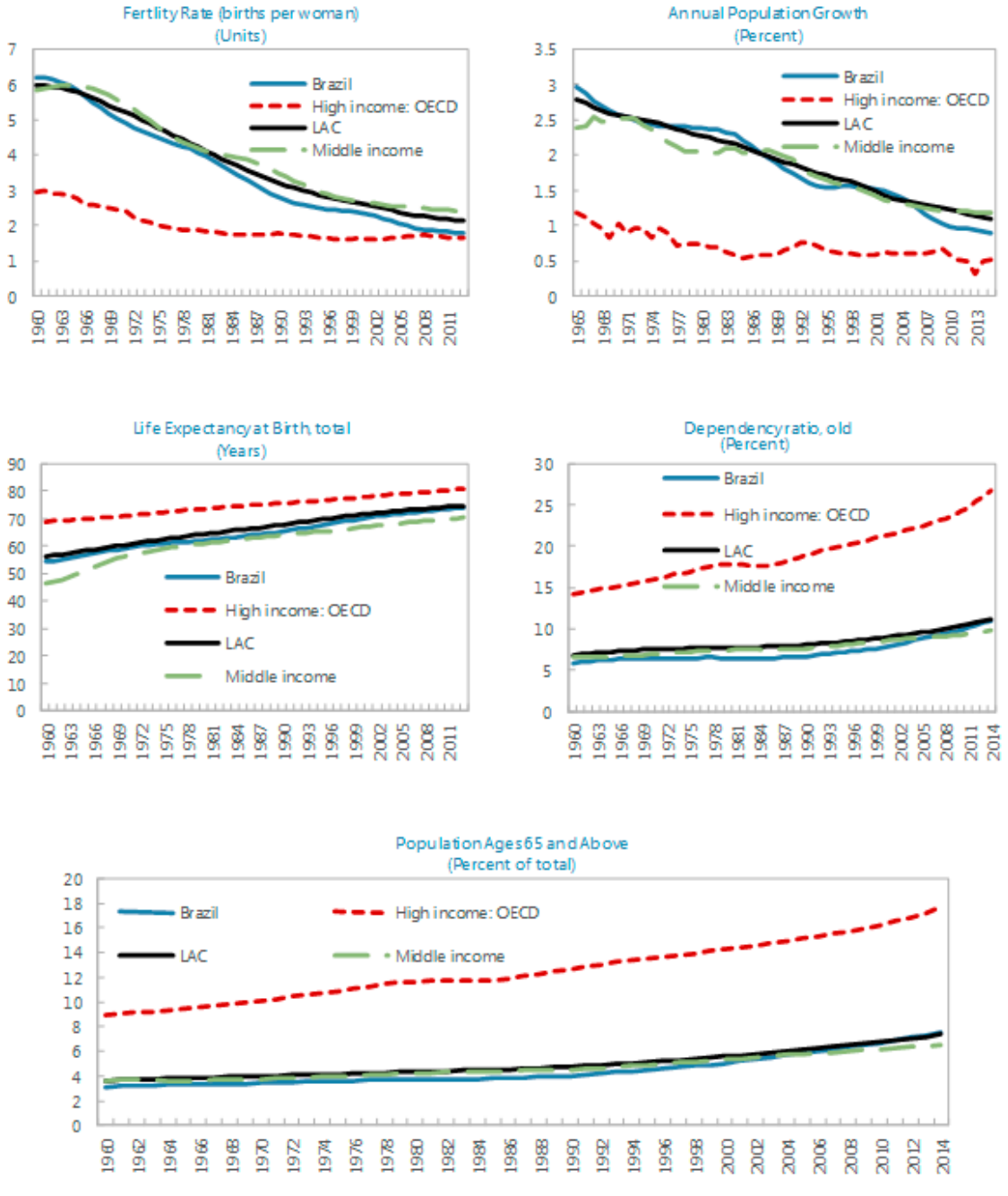
Reforms to age-related spending programs should start now so that they can be gradual.

B. Brazil's Pension and Health Systems

The Pension System

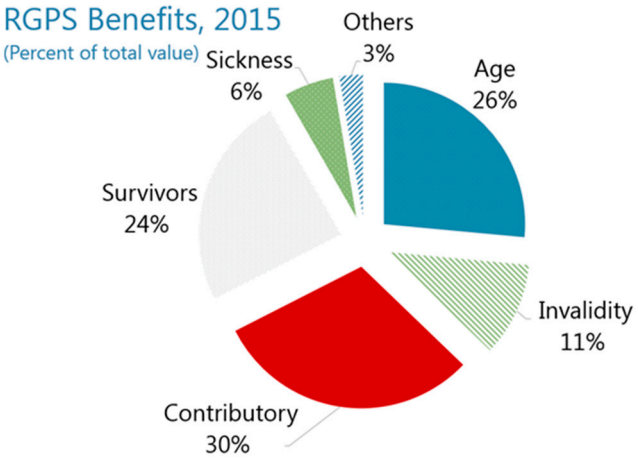
6. The Brazilian social security system offers a full menu of benefits, including old age, disability, and survivors' insurance, as well as early pensions. The institutions that offer retirement pensions also provide maternity benefits and worker's compensation, without requiring individuals to make separate contributions.

Figure 1. Demographic Indicators, 1960–2014



Source: World Development Indicators, The World Bank.

7. The core of Brazil's pension system consists of three main defined-benefit public schemes and a number of private, mostly voluntary, defined-contribution schemes.



- The mandatory system, known as *Regime Geral de Previdência Social* (RGPS), is a public system with 53 million contributors covering some 30 million beneficiaries in the private sector, and disburses 7.1 percent of GDP in pensions (2015 estimate). Benefits are financed from employee contributions (8–11 percent on wages), employers' contributions (20 percent), the COFINS tax and a profit tax—CSLL.[3] The RGPS receives regular transfers from the budget. Private sector employees can retire at age 65/60 (men/women) after 15 years of contribution ("Age"), or irrespective of the age with full contribution history—35/30 for men/women ("Contributory").[4] Old-age benefits are the largest expenditure within the RGPS (Age + Contributory in the figure), both by number of beneficiaries and total value of benefits, but survivor's and invalidity pensions are also important. There are 13 pension payments per year, which are indexed annually to inflation, except for those equal to one minimum wage (see below). There is another benefit within the RGPS called *Previdência Rural* (rural pension) for males/females aged 60/55 or older, who have completed at least 180 months of work in rural areas. The benefit is equal to the minimum wage (OECD, 2015). In 2015, about 9 million beneficiaries received a rural pension, representing approximately 31 percent of all recipients of pensions. The rural program represented 20 percent of the Government's pension expenditures or 1.7 percent of GDP in 2014.

- The *Regimes Próprios de Previdência Social* (RPPS) applies only to workers in the federal, state, and municipal governments: civil servants, the military, the judiciary, congressional staff, school teachers, and the police. It covers 1.5 million of beneficiaries, and disburses about 4 percent of GDP. Municipal, federal and state entities manage their own schemes for their employees, but are jointly coordinated by the Ministry of Pensions and Social Assistance. In general, these pension plans are financed on a pay-as-you-go basis with the employee paying a percentage of their salary.[5] At least 10 years of work within the government are required to qualify for a pension. The pension benefit formula takes into account the highest salaries from positions the member held for at least five years. To be entitled to a full public-sector pension benefit, the statutory retirement age is 60 for men and 55 for women (this applies to members who joined

[3] COFINS and CSLL are social security revenues. There are numerous exceptions to standard contribution rates which lower the effective rates.

[4] Contributions to pension plans are tax-deductible, up to certain limits, for both the employee and the employer. Pension benefits are taxed as ordinary income.

[5] The percentage varies depending on the public entity.

the system after the 1998 reform, while those who were already employed in the public sector in 1998 are subject to easier eligibility requirements—53 for men and 48 for women). Compared to the private-sector employees enrolled in RGPS, public-sector employees enrolled in RPPS receive higher pensions against lower contribution rates.

Table 1. Key Parameters of the Brazilian Pension System, 2015

Pension Parameter	Mandatory	
	Regime Geral (RGPS)	Regimes Próprios (RPPS) 1/
Coverage	Private sector	Civil servants
Funding	PAYG	MIXED
Pensionable age	65/60	60/55
Beneficiaries		
Millions	29.1	3.6
Benefit formula	Average of 80% of higher salaries	Average of 80% of higher salaries 2/
Average monthly benefit		
Thousands (R$)	1,159	1,342 (prov.)
Expenditure		
Billions	436	265
Percent of GDP	7.4	4.5
Indexation post-retirement	CPI	CPI 2/
Contributions		
Contributors (millions, R$)	53	6.5
Contribution rate	workers 8-11%, employers 20%	Min: workers 11%, employers 11-22%
Contributions (gross, millions)	350	116
Percent of GDP	5.9	2.0
Interest rate on contributions (monthly, Dec. 2015)		6%
Size of pension fund		
Billions	0.0	143
Percent of GDP	0.0	2.4

Sources: Tesouro, MPS, and IMF staff estimates.

1/ Workers in the federal, state, and municipal governments: civil servants, the military, the judiciary, congressional staff, school teachers, and the police.

2/ For workers joining the civil service after 2004.

- Pension-like assistance benefits are also available to those who do not qualify for a retirement benefit on the basis of the systems mentioned above. The *Benefício de Prestação Continuada* (BPC) was created to assist old-age people (65 years old and more, both male and female) or disabled people whose household income per capita is under one-quarter of the minimum wage (floor). They receive an amount equal to the minimum wage and their conditions are reviewed every two years. The operational side of the scheme is administered by the INSS (medical certification and means-test), but the responsibility for the benefit is given to the Ministry of Social Development and Fight Against Hunger (MDS). In 2015, nearly 1.8 million received a BPC, representing approximately 6 percent of all recipients of pensions. The BPC program represented 4 percent of the government's pension expenditures or 0.3 percent of GDP in 2014.

8. There are also voluntary private schemes. Under the *Regime de Previdência Complementar* (RPC), both occupational and personal pensions are provided on a voluntary basis. Two pension vehicles exist that can be used to finance private pension benefits. Closed private pension entities are non-profit organizations that can be established on a single-employer or multi-employer basis and by labor unions. In addition to the closed approach, which is predominantly chosen by large employers, authorized financial institutions provide complementary pension provision through open private pension systems.

9. The RGPS has complex redistributive effects. The redistribution is mainly achieved by exemptions from contributions and reduced contribution rates for low-wage earners and certain sectors. Moreover, by law, no pension can be lower than the minimum wage, which is also adjusted annually (it was R$880 in 2016). As of 2015, about 67 percent of individual benefits paid by the RGPS corresponded to 1 minimum pension and were thus indexed to minimum pension growth (Credit Suisse, 2016). However, redistribution is not necessarily progressive: the RGPS covers the more affluent share of the population, those who have been employed formally and have contributed to the system for at least 15 years. Moreover, as life expectancy of the better-off share population is higher, the NPV of benefits that accrues to them is also higher. Other features of the RGPS may also suffer from poor targeting, such as the non-contributory rural pensions for instance, but this area is outside of the scope of this study.

10. Past reforms have been insufficient to contain pension spending growth and have left unaddressed important challenges. Over the past two decades Brazil has made adjustments in some pension plans to reduce outlays. These adjustments included the 2003 reform of the RPPS for new entrants, the introduction of the *fator previdenciário* for the beneficiaries of the RGPS in 1999, and its subsequent replacement with a progressive 85/95 formula in 2015, and the tightening of the criteria for survivor benefits in 2015 (Box 1). Three major challenges remain, however:

- The average retirement age is low by international standards—54 in Brazil compared to 64 on average in the OECD (Queiroz and Figoli, 2010).
- Spending on pensions in percent of GDP is high relative to the share of elderly in the population (Figure 2 and Table 2).
- Benefits are growing faster than revenues, because of aging population, limited incremental gains from labor formalization, and the connection between the value of pensions and the minimum wage formula that pushes pension spending growth above GDP growth.
- The multiplicity of pension systems increases inequities and puts pressure on overall pension spending due to overlapping benefits.

Box 1. Recent Changes in Retirement Incentives

In 1999, a law introduced into the RGPS an actuarial coefficient called *fator previdenciário* (*fator*) whose use would be optional in the calculation of pensions in case of retirement on the basis of age, and mandatory in the calculation of benefits based on the retirement on the basis of length of contribution. The *fator* increases with the insured's contribution rate, contribution period, and age, and decreases with life expectancy. In the case of retirement on the basis of age, the benefit was equal to the average of the highest 80 percent monthly earnings multiplied by 70 percent plus 1 percentage point for each set of 12 months of contribution (capped at 100 percent) and multiplied by the *fator*—only if this factor was higher than 1.0. For the retirement on the basis of length of contribution, the benefit was the average of the highest 80 percent monthly earnings multiplied by the *fator*.[1]

$$f = \frac{Tc * t}{Le} * \frac{[1 + (Age + Tc * t)]}{100}$$

Where: f—fator; *Tc*—contribution time to retirement; t—contribution rate (0.3); Le—remaining life expectancy at retirement; and Age—age at the time of retirement.

The objective of this discount factor was to provide disincentives for early retirement and generate savings on pension benefits by offering higher pensions to new entrants with a longer contribution history and shorter residual life expectancy at retirement. Following a transition period in the 2000s, the discount factor contributed to lengthening of the contribution periods and increasing retirement age from 2009 on. It also generated lower pension benefits by about a third of what would have been paid out in the absence of this mechanism (Pereira, 2013).

In mid-2015, a new rule was introduced which would allow workers to retire with full benefits when the sum of age and contribution years was equal to 85/95, with a minimum of contribution of 30/35 years for women/men.[2] The use of *fator* became optional but workers who decided to retire with 30/35 years of contribution regardless of age would have their benefits curtailed by the application of the *fator*. These changes in rules were expected to postpone retirement but also to increase benefits in the period during which pensions were enjoyed, thus pushing up pension spending over the medium term.

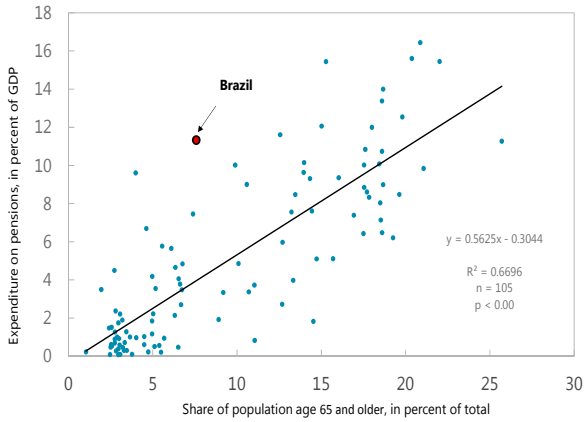
Nine months into the implementation of the 85/95 rule, there have been rapidly increasing retirement applications and widening spread between pension benefits based on length of contribution (mainly those of higher-income workers) and benefits based on age (those of informal and precarious workers with shorter contribution histories). However, early assessment of the effect of this change in the retirement incentives is affected by a strike of INSS employees in the second half of 2015, which contributed to a backlog of retirement applications, and possibly also by the start of public discussions about the needed reforms in the pension system—including the introduction of the minimum retirement age—which could have contributed to some advancement of retirement decisions.

[1] The minimum and maximum monthly earnings for benefit calculation purposes are the same as in retirement based on length of contribution. (OECD, 2015)

[2] This formula is to be adjusted every two years until it reaches 90/100 in 2026.

11. When benchmarked against other countries, the generosity of Brazil's pension system is evident. Total pension expenditure (public and private) is higher than in the advanced- and emerging-economy average, both as a share of GDP and per pensioner. When accounting for the demographic structure of the country, estimated spending on pensions in Brazil in 2015 was among the highest in a sample of about 100 countries (Figure 2 and Table 2).[6]

Figure 2. Pension Expenditure and Share of Elderly



Sources: World Development Indicators; and IMF Staff estimates.

12. Gross and net replacement rates are above the OECD average, for male as well as for female pensioners (at 70 and 76 percent of average wage for men respectively).[7] Pension contribution rates are extremely high and exacerbated by additional payroll levies, and contribute to high informality levels (contributors represent only 46 percent of working age population compared with 86 percent in advanced economies). Pension coverage, expressed as the share of pensioners to population aged 65 and older, is high at 93 percent, and close to advanced economies average, reflecting low effective retirement age for men and women and non-contributory pensions. The minimum retirement age with full contributory history in the mandatory public regime is 48 for women and 53 for men and the average retirement age in the RGPS is 58 for the "age" pensions and 55 for the "contributory"

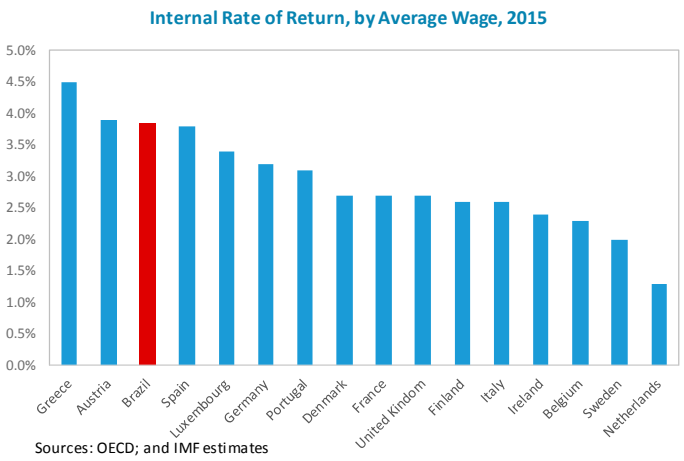
Table 2. Benchmarks of Key Indicators

Pension spending (percent of GDP)			
Brazil	11.3		
Advanced Average	8.7		
Emerging Average	5.0		
Developing Average	1.8		
Statutory retirement age - male		**Statutory retirement age - female**	
Brazil	65	Brazil	60
Advanced Average	64	Advanced Average	63
Emerging Average	61	Emerging Average	59
Developing Average	59	Developing Average	58
Old age dependency ratio (pop. 65+/pop. 15-64)		**Avg. spend. per pensioner (% GDP per pop. 15-64)**	
Brazil	12	Brazil	105%
Advanced Average	26	Advanced Average	32%
Emerging Average	11	Emerging Average	57%
Developing Average	6	Developing Average	85%
Contribution Rate, Pensions		**Coverage (Pensioners to pop. 65 and older)**	
Brazil	28%	Brazil	93%
Advanced Average	20%	Advanced Average	106%
Emerging Average	15%	Emerging Average	77%
Developing Average	13%	Developing Average	34%

[6] In Brazil, some of the pension system benefits have social assistance features which complicates the cross-country comparisons. Social benefits in other countries may be included in different expense category.

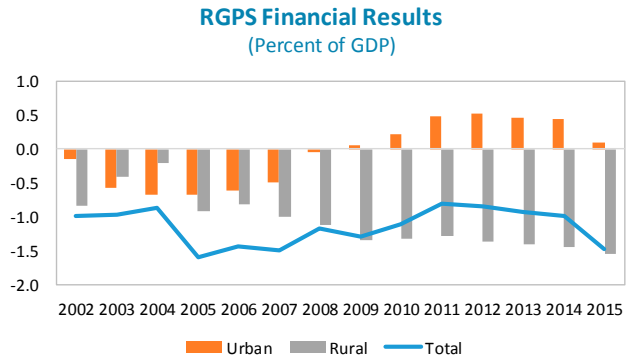
[7] The gross replacement rate is defined as gross pension entitlement divided by gross pre-retirement earnings. The net replacement rate is defined as the individual net pension entitlement divided by net pre-retirement earnings, taking into account personal income taxes and social security contributions paid by workers and pensioners. These indicators are measured in percentage of pre-retirement earnings by gender.

pensions against 64 for the OECD countries. The internal rate return, the difference between what an average retiree obtains (a person who enters the labor market at 25 years and retires at 65) from the pension system and what it contributes while working, is also high in international perspective.



Sources: OECD; and IMF estimates

13. The RGPS has been running deficits, mainly driven by rural pensions. Revenues of the RPGS pension system increased from 4.7 percent of GDP in 2003 to 6.1 percent in 2014. During the same period, expenditures increased from 6.2 to 7.5 percent of GDP as the number of pension recipients increased by 40 percent (Caetano, 2015). However, "urban" pension balances have been in positive territory in recent years and overall deficits were driven by limited contributions in the rural areas. In 2015, reflecting declining revenues due to the rising unemployment, the overall deficit in the RGPS reached 1.5 percent of GDP.[8] Growing deficits in the pension system require growing subsidies by the Treasury to finance the gap. According to authorities' projections, this imbalance will amount to 3.2 percent of GDP in 2016 (Tesouro Nacional, 2015).



Sources: MPS; and IMF Staff estimates.

The Health System

14. Brazil's Unified Health System (SUS) was established by the 1988 Constitution with the objective of providing universal health care in an equitable way and with continuity. The subsequent reforms revolutionized the health system by expanding hospital capacity, as well as enhancing primary care offered through outpatient structures. Moreover, the funding framework was also unified and health spending was financed through general revenues, social contributions and, for some time, the Contribuição Provisória sobre Movimentações Financeiras (CPMF).[9] Service provision was decentralized to municipalities, and physical access was equalized across regions. However, administration of such a complex, decentralized public-health system, in which a large

[8] A similar deficit was recorded in 2015 in the RPPS, where the number of beneficiaries is substantially lower, as contribution rates are extremely low.

[9] The federal health fund contributes to state and municipal funds which are also finances by subnational revenues (Couttolenc and Dmytraczenko, 2013).

share of services is contracted out to the private sector, together with many private insurance providers, has caused conflicts and coordination issues.

15. Over time, the financing mix has evolved. While states and municipalities must dedicate 15 and 12 percent of their budgets respectively to health since 2000, federal government contributes 6–7 percent of its gross revenue, and finances half of the total public spending on health. The share has, however, declined significantly reflecting decentralization of health provision over the past two decades. Financing of private provision shifted from more expensive fee-for-service arrangements to prospective payment mechanisms and results-based mechanisms for transfers from the federal government to municipalities.

16. Public spending on health increased in Brazil since the mid-nineties and is set to rise further in the near future. Since 1995, real growth of public outlays on health was 5 percent on average (against 4 percent in LAC) and reached 4.6 percent of GDP in 2013 (from 2.9 percent of GDP). Public health spending remained constant as a share of total government expenditure, and below that of LACs and OECD countries whose share in total reaches 30 percent (Figure 3). In 2012, a complementary law established that federal government spending on health should grow at least in line with previous year's nominal GDP. A constitutional amendment approved in 2015 set the minimum spending on health to at least 13.2 percent of net current revenues. This ratio is to increase until it reaches the 15 percent of net current revenue in 2019.[10] Tax expenditures, arising from the uncapped deductibility of health expenditures from personal and corporate taxes, was estimated at R$31.5 billion in 2015 (Receita Federal, 2016). Tax incentives have also stimulated acquisition of private health insurance plans whose incidence grew from 18 to 26 percent of population since 2000. (OECD, 2015b)

17. Private spending on health continued growing in parallel. One of the beliefs underlying the SUS reforms was that the role of private health care would decrease as a result of increased government spending and expansion of services. Contrary to expectations, private health care coverage continued to grow in real terms, but stabilized as a share of total health spending in recent years. The share of out-of-pocket expenditure constitutes over 30 percent of total expenditure, significantly higher than in OECD countries although in line with the LACs average (Figure 3).[11] At about 5 percent of GDP in 2013, private spending on health is almost proportional to government spending on health in Brazil, and represents a greater share of total spending compared to the average share in LACs.[12] Reflecting relatively high spending on private programs, total health

[10] A recent proposal to increase the share to 14.8 percent in 2017, followed by increases to 15.5, 16.2, 16.9, 17.6, 18.3, and 19.4 percent in 2023, is under discussion in the Senate.

[11] Out of pocket expenditure is any direct outlay by households, including gratuities and in-kind payments, to health practitioners and suppliers of pharmaceuticals, therapeutic appliances, and other goods and services whose primary intent is to contribute to the restoration or enhancement of the health status of individuals or population groups. Private health expenditure includes direct household (out-of-pocket) spending, private insurance, charitable donations, and direct service payments by private corporations.

[12] According to surveys, Brazilians rely on private provision for dental services.

expenditure in Brazil, at 9.7 percent of GDP, was above the LAC average, and more in line with the average share of spending in GDP in OECD countries.

18. Health outcomes of Brazilians have improved markedly over the past two and a half decades, contributing to higher life expectancy and lower child mortality. Brazil has near universal coverage of immunization and pre-natal care, as well as hospital deliveries. Studies have shown that mortality from avoidable diseases has declined over time thanks to improved health service delivery. Geographical disparities in health interventions of this type are limited (Gragnolati et al., 2013). Infant and under-five mortality rates have decreased to 20 and 23 per 1,000 births respectively, and maternal mortality is in line with upper middle-income country average. Life expectancy has improved overall, and has equalized across states over time, also reflecting increased income and control of tobacco use.

19. Brazil's healthcare system faces challenges common to developed countries. In emerging economies, life expectancy is lower and infant mortality higher than in advanced countries. At the same time, basic health coverage of the population tends to be lower and health outcomes are generally worse. The main objective tends to be expanding basic coverage and improving outcomes. In contrast, basic coverage in Brazil is universal and the pattern of diseases affecting the population in Brazil increasingly resembles problems of mature economies. Worsening demographic trends are rapidly complicating health spending sustainability. Specific healthcare challenges in Brazil are the following:

- Progress is still needed to improve the health status of large population segments and reduce regional disparities. To address these challenges, the government has introduced a program in 2013 (*Mais Médicos*) to hire doctors to work in poor areas plagued with medical staffing shortages.

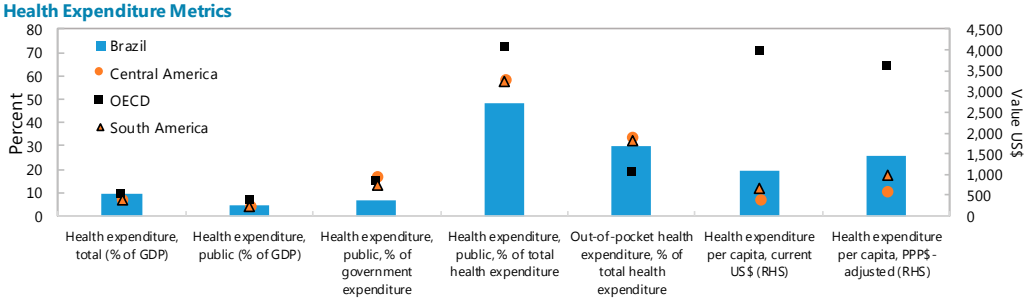
- Old health problems are lingering while new ones are manifesting as a result of urbanization and social and environmental change. For instance, diabetes prevalence in population ages 20 to 79 is at 8.7 percent in 2014 were closer to the advance (OECD) economies average, above that of middle-income countries and LAC.[13] Meanwhile, some old health issues persist, such as malaria and dengue fever.

- Dissatisfaction with the quality of service provision is high while per capita real funding for health care may be reduced in line with government efforts to combat the fiscal crisis.

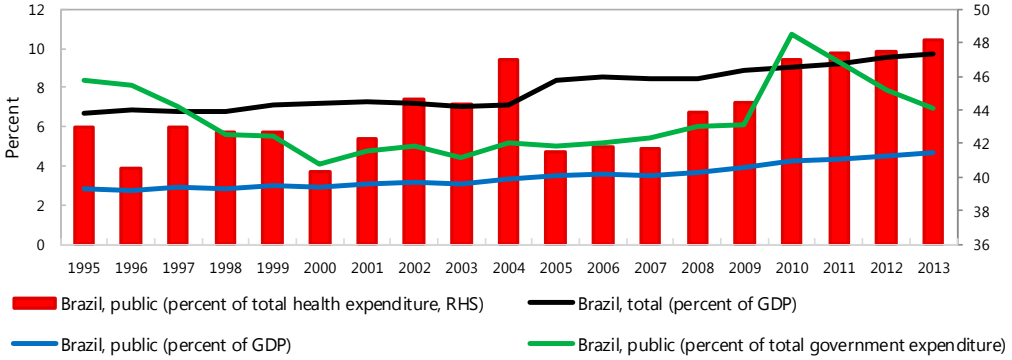
[13] Other non-communicable diseases, such as cardiovascular diseases, hypertension, obesity, and neuropsychiatric disorders account for the overwhelming majority of causes of death and their trend is worrisome. (Victoria et al., 2011 and Schmidt et al, 2011).

Figure 3. Health Expenditure, 2013

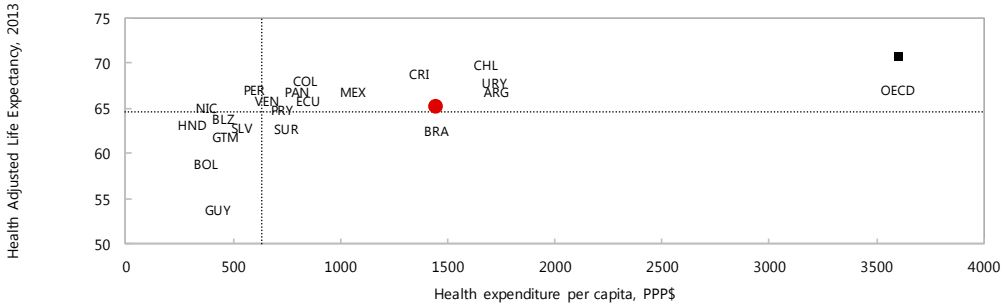
Health Expenditure Metrics



Health Expenditure Trends



Health Expenditure per Capita and Outcomes 1/



Sources: World Bank.

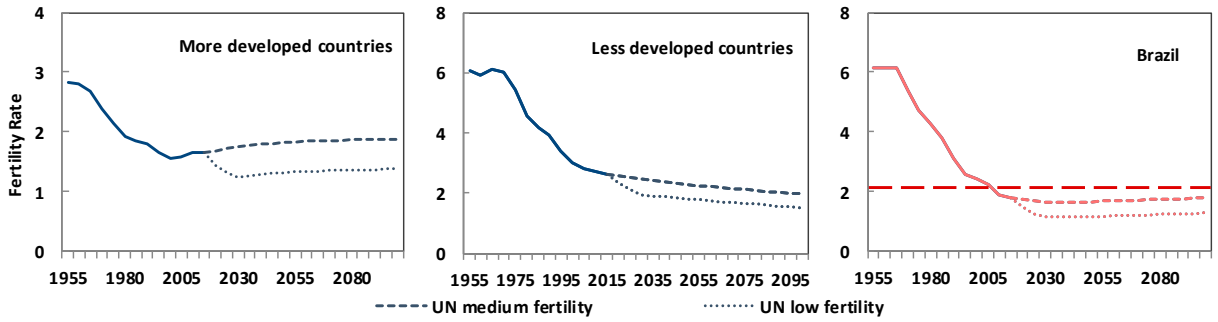
1/ The dashline is the average for Central America.

C. Challenges from Ageing Population

Demographic outlook

20. Brazil has one of the fastest aging populations in the world.[14] A continued but gradual decline in fertility rates is projected to take place in less developed countries, including in Brazil (Figure 4). Because these estimates are surrounded by considerable uncertainty, the UN illustrates two scenarios: the "medium fertility" projection assumes a continuous decline to about 2 children per woman by 2100 from 2.6 in 2015, while the "low fertility" scenario implies an immediate drop by about 0.5 children per women.

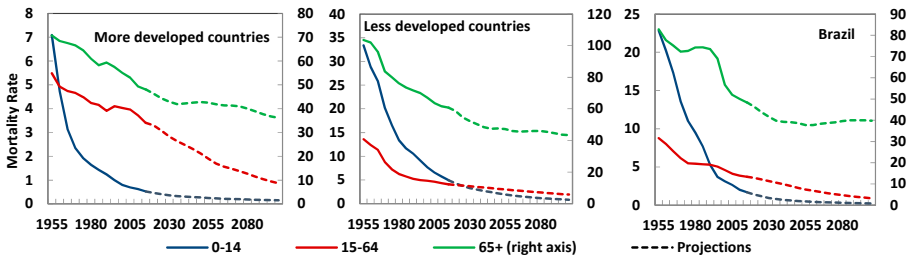
Figure 4. Projected Fertility Rates



Sources: UN; and IMF staff estimates.

21. The decreasing trend in fertility rates is coupled with increasing longevity. Whereas longevity improvement is expected to slow down in the more developed economies, for the less developed economies and Brazil the projections suggest continued improvements in longevity, as under-5 as well as old age mortality decrease reflecting increasing health care coverage (Figure 5). As the share of youth and working age population declines, old-age (above 65) population is expected to reach 40 percent as a share of people ages 15 to 64 by 2100 in Brazil.

Figure 5. Projected Mortality Rates



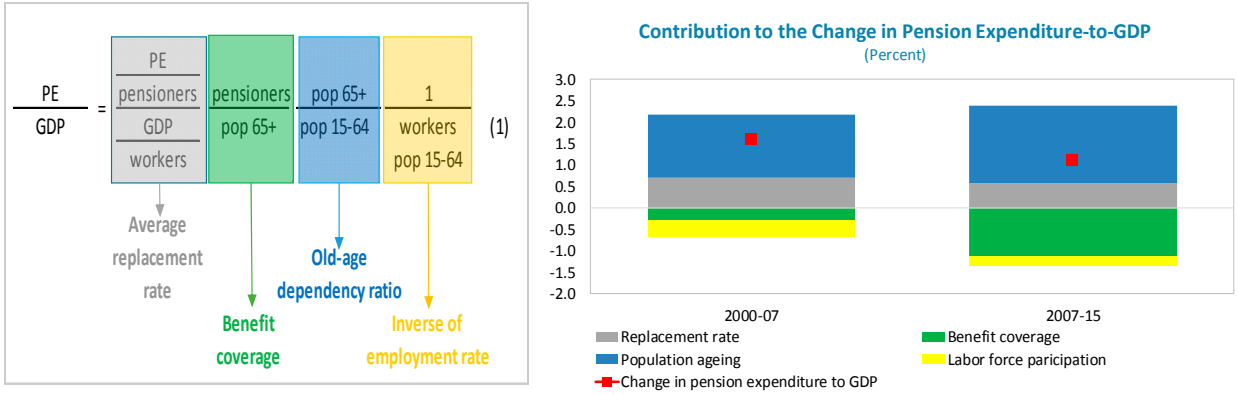
Sources: UN; and IMF staff estimates.

[14] Based on demographic projections by UN (*2015 Revision of the UN World Population Prospects*). The assumptions behind the projections of fertility and mortality rates, and migration are described in Clements et al (2015). In Figures 4 and 5, "more developed economies" are Australia, Canada, European countries Japan, New Zealand, and the United States, while "less developed countries" include the rest of the world.

Fiscal impact

22. Population ageing has been an important driver of pensions spending in Brazil, along with other determinants. The growth in pension expenditure as a share of GDP can be decomposed into four distinct contributions: the growth of average replacement rates, the increase in benefit coverage, the impact of demographic changes on the old-age dependency ratio, and the change of the inverse of employment rate. In Figure 6, the worsening age profile in Brazil and increasing replacement rates have affected pension expenditure growth over the past one and a half decade strongly. Higher replacement rates were the main driver of increasing pension spending in other emerging economies since the 1990s, but declining labor force and population aging have also played a role in emerging Europe (Clements et al., 2013). The *fator previdenciário (fator),* in effect since 1999, may have helped reduce the ratio of pensioners to the elderly population (i.e. the "benefit coverage", see Box 1).

Figure 6. Decomposition of Pension Expenditure



Sources: WDI, UN, OECD, INPS; and IMF staff estimates.

23. Health care expenditure also grows with the old-age dependency ratio albeit at a slower pace. On the demand side, the literature has identified raising income and aging population as the main drivers of public spending on health in advanced economies. Because elderly people consume more health care services than young people, increases in the share of elderly population increase health spending as a share of GDP. Other, non-demographic factors

Table 3. Determinants of Health Care Spending

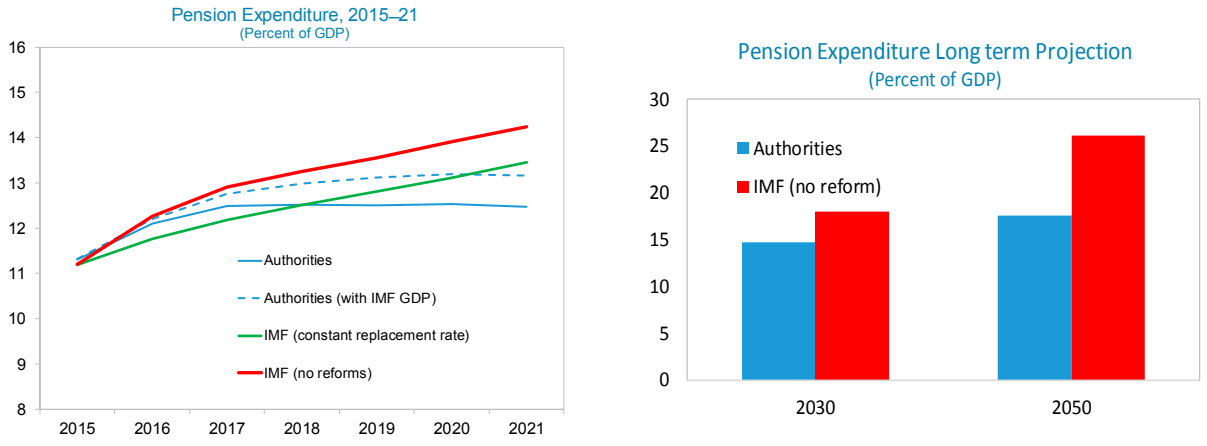
	(1) OLS Random Effects	(2) OLS Fixed Effects
	Dependent Variable: Health Care Expenditure to GDP	
Population over 65 years old as a share of total	0.329***	0.320***
	(0.037)	(0.061)
Natural log of GDP per Capita, PPP (Constant 2011 $)	0.200**	0.577**
	(0.084)	(0.223)
Constant	-1.242	-10.711**
	(2.045)	(5.426)
R-squared	0.116	0.123
Observations	3,909	3,909
Number of countries	210	210

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

including technological change, and the lower productivity of services relative to other sectors (the so-called Baumol effect) account for the remaining share.

24. Reflecting rapidly ageing population, Brazil's spending on pension and health is projected to reach unsustainable levels already in the next decade. In an inertial baseline projection without reforms, pension spending rises to almost 14 percent of GDP by 2021 (Figure 7), 17 percent of GDP by 2030, and 29 percent of GDP by 2050. This projection reflects the decline in real GDP over 2015-16, the rise in the real value of the minimum wage (affecting some 70 percent of pensioners), and uses the Treasury's projections of growth in the population of retirees, which is subject to larger-than-usual uncertainty because the new 85/95 rule introduced in mid-2015.[15] We also calculate a more optimistic forecast with average pensions growing with average wages (an underestimate by construction); the result is only slightly less worrisome (green line), and still well above official actuarial projections. Official projections (blue line) show very slow growth in pension spending over the next several years, which would be possible only if benefits are reduced significantly or if benefit coverage declines.

Figure 7. Pension Expenditure Projections, 2015–21
(Percent of GDP)



Sources: RGPS and RPPS actuarial reports; and IMF staff estimates.

[15] The Brazilian statistical institute (IBGE) projects that old-age dependency will reach 36 percent by 2050 from 11 percent today. The population of retirees is growing at about 3.6 percent a year. Given the rule for updating the minimum wage and its link to pension benefits, most retirees' benefits grow about as fast as nominal GDP; thus, the nominal growth in contribution revenue is barely enough to pay for the annual rise in the benefits of existing pensioners: little money is left over to finance the increase in the number of retirees.

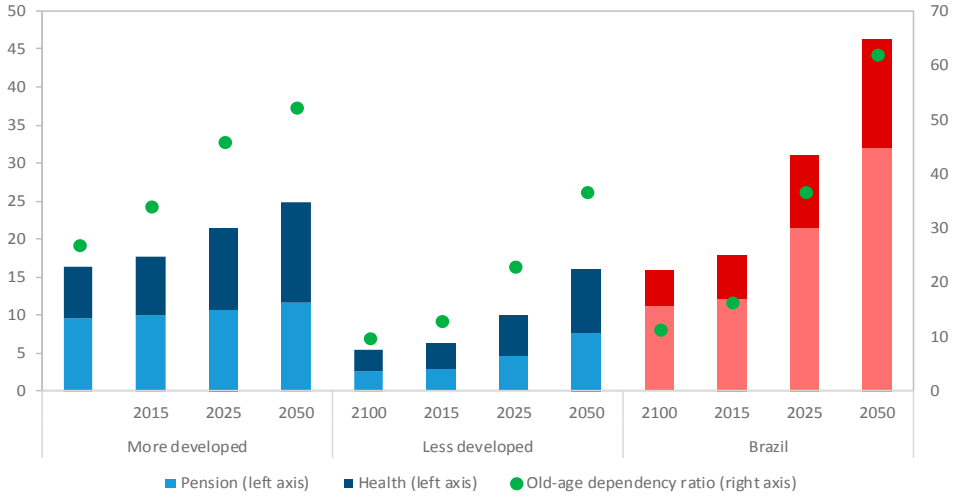
Box 2. Realism of Baseline Pension Expenditure Projections

A few characteristics of the Brazilian demographic profile and pension system are not fully captured in our baseline projections. We are projecting pension expenditures for the overall private and public systems aggregate. The growth in benefits is slightly overestimated because in the RPPS system virtually all pensions are above the minimum wage and are therefore adjusted upward in line with inflation—not in line with the growth of the minimum wage. On the other hand, however, civil servants retire earlier, particularly in the states where employment is disproportionally more concentrated in education and security services.

Another force not factored into our projections that may push expenditures up compared to the baseline is the higher participation of women in the labor force. Except for the very recent period, which witnessed a generalized decline in labor participation, female labor force participation has increased to over 60 percent of working age population in 2014 from 45 percent in the 1990. The share of female retirees in total has also increased to 56 percent (Informe de Previdência Social, 2014). Reflecting the current retirement rules which allow women to retire earlier, and given higher female longevity, pension expenditure can be expected to grow faster than under the baseline. Finally, our projections do not include possible effects of past reforms whose influence on spending may be delayed.

25. The pension and health spending long term trends are substantially worse in Brazil than in advanced and in other less developed economies.[16] Under unchanged policies (the "no reform" scenario), spending on pensions alone would reach 21.5 percent of GDP by 2050 in Brazil. Public spending on health would increase to 5.6 percent of GDP in 2025 (9.5 percent of GDP by 2050) from 4.6 percent of GDP in 2015 (Figure 8). The NPV of the funding gap of the social security system was estimated at 25 percent of GDP over the following two decades (IMF, 2012). However, since then, Brazil's potential growth was revised downward. This affects revenues adversely and contributes to an even larger funding gap.

Figure 8. Pension and Health Spending Under the Baseline Scenario
(Percent of GDP)



Sources: IMF Staff estimates.

[16] The demographic estimation uses baseline population projections by the UN under the "medium variant" scenario which employs probabilistic models to extract projectors of fertility and mortality rates for individual countries. Beyond 2065, pensions are projected to grow in line with demographic developments.

26. A sensitivity analysis is applied to study the effect of different aging scenarios on long-term pension and health spending and the effect of reforms. Health care spending is expressed as a product of the generosity of spending on young population, the inverse of the labor force participation rate for the young, and a function that depends on the old-age dependency ratio and the ratio of per capita health spending on old to the per capita health spending on the young.

$$\frac{HE}{GDP} = \frac{\frac{HE_{0-64}}{pop\ 0-64}}{\frac{GDP}{workers}} \frac{pop\ 0=64}{workers}\left(1+\alpha\frac{pop\ 65+}{pop\ 0-64}\right), \text{ where } \alpha = \frac{\frac{HE_{65+}}{pop\ 65+}}{\frac{HE_{0-64}}{pop\ 0-64}} \quad (2)$$

Holding everything else constant in (1) and (2), an increase in the share of population aged 65 and above translates in an increase in pension and health spending to GDP. In the short run, effects of different assumptions on growth should be small reflecting the fact that current pensions are determined by past growth/wage realizations. However, pension spending can diverge from the model outcome if pensions are indexed to minimum wage growth and minimum wages grow above productivity, as is the case in the "no reform" scenario in Brazil.[17]

27. The impact of lower fertility and higher longevity on spending on age-related programs could be significant. Compared to the baseline presented above, we also estimate two risk scenarios, to take into account potential shocks on fertility and longevity assumptions. For example, spending on pensions and health in Brazil would increase by 3 percentage points of GDP by 2050 (25 p.p. by 2100) under the "low fertility" scenario. Under the "longevity risk" scenario, assuming that mortality rates for age 65 and older decline 50 percent faster than in baseline, pension and health spending would be 1.6 p.p. of GDP higher by 2050 (4.8 p.p. higher by 2100).

D. Reform Options

28. Policies available to address fiscal pressures from pensions and health belong to two broad groups: policies affecting labor force participation, and policies directly affecting features of these spending programs. Broadly speaking, policies directed at pension and health programs aim at increasing financing of these programs and/or lowering generosity of benefits.

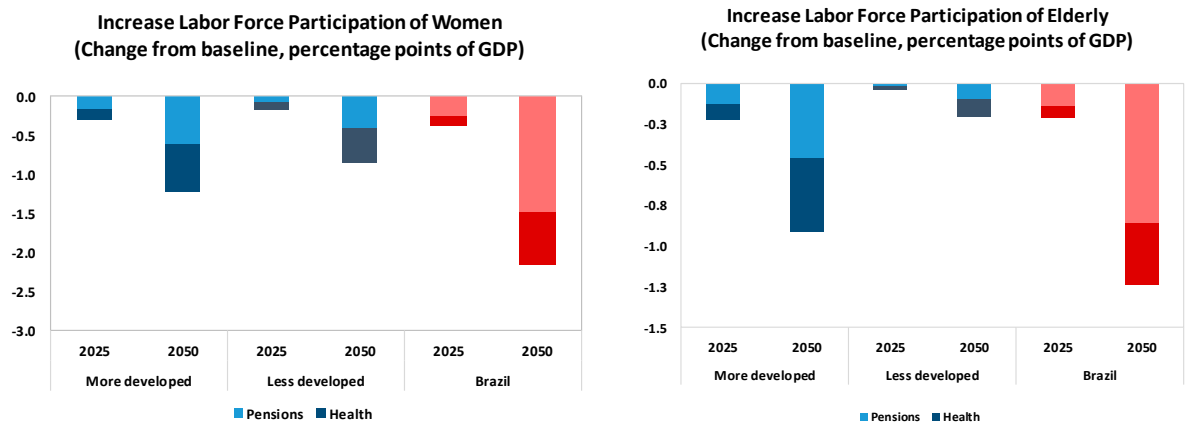
Labor market reforms

29. Policies that increase labor market participation for women and the elderly can partially offset the impact of aging. As in other Latin American developing countries, female labor market participation in Brazil is substantially lower than male participation by 20 percentage points, (65 as opposed to 85 percent of population age 15−64 in 2014). Absent a decline in average productivity per worker, halving the gap would boost GDP and increase financing for age-related spending, so that the ratio of such spending would fall by 2.2 percentage points of GDP by 2050. Brazil has low labor participation rates for population between 55 and 64 years old (56 percent in

[17] Second order interactions are not taken into account in the model.

2014 compared to the 81 percent for the age group between 25 and 54 years old).[18] While this gap is common in other Latin American countries, halving it would contribute to save 1.3 percentage points of GDP by 2050 (Figure 9).

Figure 9. Labor Market Policies



Sources: IMF Staff estimates.

Pension system reforms

30. While countries may opt for a variety of policies to reform their pension systems, generally efforts aim at containing eligibility, lowering replacement rates and increasing revenues. The combination of policies will depend on the country's objectives and reflect different social, political and economic preferences.

- **Containing eligibility**: raising retirement ages is an especially attractive option and helps complement efforts to boost the labor force participation of older workers.
- **Increasing revenues**: increasing taxes on pensions for upper income groups and/or increasing payroll contributions.
- **Reducing replacement rates:** the ratio of pensions to wages can be reduced by abandoning indexation to the minimum wage for instance, lengthening the period over which the pensionable wage is estimated, and/or modifying benefit formulas (accrual rates).

31. Brazil faces several policy alternatives to stabilize, and eventually reduce, pension deficits. With a deficit in the pension system equivalent to 1.5 percent of GDP in 2015 (and projected to reach 4.2 percent in 2025 in the authorities' scenario)[19], the minimum objective of any pension reform should be to stabilize the financing gap. By introducing reforms that prevent pension imbalances from growing, authorities can stabilize the amount of the subsidy that needs to

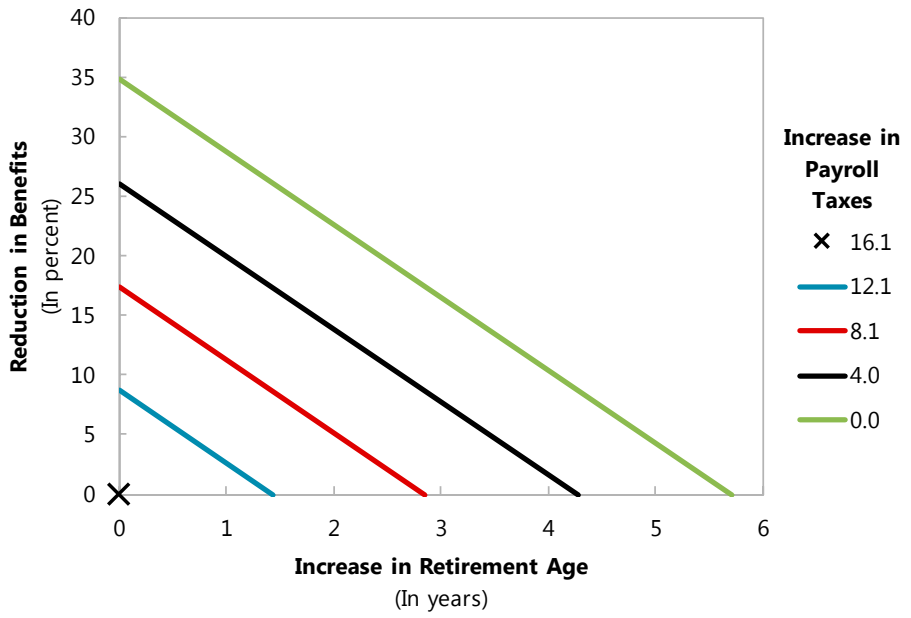
[18] ILO; based on Pesquisa Mensal de Emprego.

[19] Tesouro Nacional, 2015; includes RGPS and RPPS of the federal government.

be transferred every year from the federal budget to the social security system. This would be a major step forward in addressing fiscal sustainability problems in Brazil.[20]

32. Options to contain spending include some combinations of the three main policy instruments mentioned above (i.e. raising retirement age, increasing contributions and/or managing the generosity of benefits). These trade-offs are summarized in Figure 11. In Brazil's case, pension contributions are already high and need to be reduced over time to reduce market disincentives. To stabilize pension spending over 2015-30 it would be necessary, for instance, to reduce benefits by almost 35 percent or increase the retirement age by almost 6 years. A combination of options along the along the green line in Figure 10 would achieve the same result.[21]

Figure 10. Reform Options to Stabilize Pension Spending, 2015–30



Sources: IMF Staff estimates.

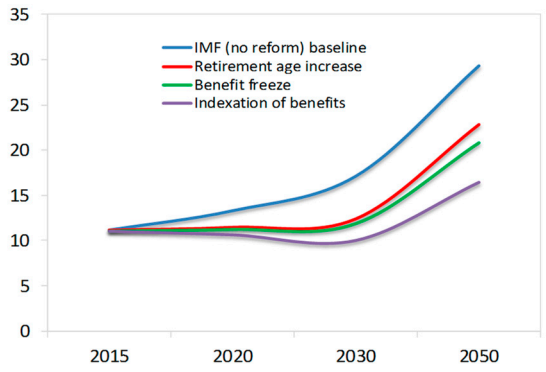
[20] Under the proposed constitutional amendment, capping nominal expenditures to GDP over the next 20 years, the objective is even tougher as it implies that federal social security spending must fit under the cap.

[21] There is a 6.5 percentage point increase in spending increase on pensions between 2015 and 2030 (from 12.2 to 18.7 percent of GDP). An across the board reduction in benefits of 35 percent (6.5/18.7), would bring spending down to 12.2 percent of GDP in 2030. To achieve the same result, retirement age would have to be increased by about 6 years: we estimate that in 2013, about 28 percent of the population age 60+ is aged 60-64. This means that an increase in the retirement age by 5 years would cut beneficiaries by about 28 percent. To achieve a 35 percent cut, pensionable age would have to increase by 5.7 instead of by 5 years. The third option is increasing revenue from contributions. We assume that in Brazil it is possible to raise about 0.4 percent of GDP per each contribution point (this is based on the wage-to-GDP ratio and might be optimistic). To achieve 6.5 percent of GDP in savings, it would be necessary to raise pension contributions by 16.2 (6.5/0.4) percentage points.

33. Gradually raising retirement ages is an attractive policy option for Brazil, but it is only a starting point. Increasing retirement age would also boost labor participation and growth, and avoid the need for larger cuts in benefits. It would also be desirable as retirement age in Brazil is comparatively low. Increasing the retirement age by 5 years over the next 5 years would generate savings in pension spending equivalent to 4.7 percentage points of GDP by 2030 compared to the "no reform" baseline. However, this overestimates the true contribution of the retirement age increase to savings inasmuch as the model assumes that pension payments remain unchanged (i.e. the replacement rate at retirement is constant), which is not the case when contributory history is longer. In the model, pension spending would be above the level in 2015 by about 1 percentage points of GDP (Figure 11).

34. Another source of pressure is the growth in the real benefits to existing pensioners. To solve this, it is necessary to remove the automatic link between pensions and the minimum wage (and/or to change the minimum wage formula). This would reduce pension expenditure by about 2.6 percentage point in 2030 (6.1 percentage points of GDP in 2050). But to frontload the rescue of the pension system by removing existing payroll tax exemptions would be advisable. A temporary freeze of nominal benefits (18 months, for instance, equivalent to a 10 percent cut in benefits) of existing pensioners could be considered as well, or at least a significant deceleration in their growth. An ambitious package would even create space for gradually lowering the currently high payroll contributions, with an overall neutral effect on spending over the long run. After 2050, the system would stabilize by linking the increase in the retirement age to gains in life expectancy.

Figure 11. Estimated Impact of Various Pension Reform Options
(Percent of GDP)



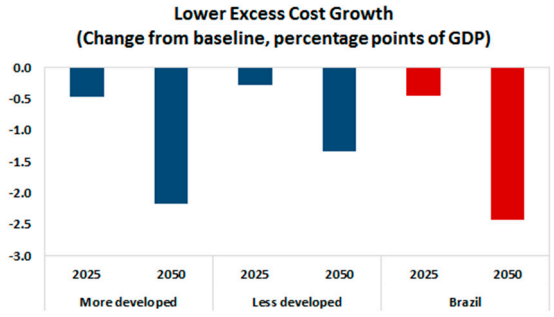
Expenditure Increase (2015–30) (Ppt. of GDP)	
Projected Spending Increase	**5.9**
Impact of Reforms	**-7.1**
Retirement Age Increase	-4.7
Indexation of Benefits	-2.6
Benefit Freeze	-0.8
Decrease in Social Contributions	1.0
Net Change	**-1.2**

Sources: IMF staff estimates.

Health system reforms

35. More limited funding does not need to jeopardize access to services or affect health outcomes given existing inefficiencies in the utilization of resources. Health-adjusted life expectancy of 65 years for Brazil is associated on average with higher public spending on health, both as a share of GDP and in per capita terms than elsewhere (Figure 3), suggesting there may be opportunities for achieving the same or higher outcomes while employing fewer resources, by aligning capacities to needs and reducing waste. Evidence of oversupply of technology in certain areas and underutilization of medical infrastructure, possibly resulting from attempts to equalize access to services across the country, have been documented in the literature (La Forgia and Couttolenc, 2008) and it is known that adoption of new technologies has not been subject to opportunity cost scrutiny so far.

Figure 12. Impact of Health Reforms



Sources: IMF staff estimates.

36. Going forward, options for cost-containment for Brazil can draw from the vast experience of advanced economies over the past few decades. A number of micro level reforms can improve health outcomes without increasing spending. Health technology assessment could support selection of new health care programs, drugs, and diagnostic equipment and tests.

Moreover, focus will shift to avoiding and curing chronic non-communicable diseases that become prevalent as population ages, and efforts will have to include education programs that induce healthy life style and prevention (Schmidt et al., 2011). Savings could be achieved in the future by abolishing tax-deductibility of private insurance contributions which have undermined funding for the SUS and on which patients still rely for expensive treatments not covered by private plans. Other areas for action could include: elaboration of clinical guidelines, reducing dependency on imported technologies, and renegotiating deals with pharmaceutical companies. Linking of health expenditure to government revenue and backward-looking line-item budgeting could be replaced with global budgets and activity-based payment mechanisms that improve transparency and efficiency. However, the financial impact of these reforms is difficult to quantify.

E. Concluding Comments

37. Brazil's population is aging rapidly and fiscal pressures are set to rise over time absent reforms to benefits. The demographic profile of the country and the already generous benefits system will put the finances under considerable strain over the next decades. As the dependency ratio climbs up, spending on pensions and health could surpass 31 percent of GDP by 2050, everything else held constant. Although labor market reforms can provide some temporary respite, reforms directly addressing high replacement rates cannot be avoided.

38. The growth of the publicly provided health care system will be difficult to sustain. Health care reform will have to contain growth of budgets without adversely effecting health outcomes by ensuring marginal expenditure is closely linked to incremental health benefits. While this is easier said than done, experience of advanced economies in health care cost containment offers important lessons for Brazil. The recently approved health expenditure rule which sets a floor on public spending on healthcare does little to ensure efficient utilization of resources. More remains to be done to reduce reliance on more expensive hospital treatments, by strengthening outpatient care and regional networks, and to reduce spending on pharmaceuticals, by promoting use of generic drug and developing clinical guidelines for the choice of cost-effective drugs and treatments. (OECD, 2015b)

39. Pensions reform options include some ideas already under discussion it the Brazil's government. Raising retirement age is currently debated in public and included in the government's agenda, while other needed reforms have been understood for a long time in Brazil. Although the deteriorating demographic profile will not affect public finances in the short-run, other features of the system, notably the link of pensions to the minimum wage and the latter's indexation rule, are driving pension spending up. To galvanize political support and foster social acceptance reforms should be equitable and mindful of the poor, but also gradual. To be gradual, reforms should start now.

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STRETCHING THE LIMITS: THE EVOLUTION OF SUBNATIONAL PUBLIC FINANCES IN BRAZIL[1]

This annex documents the ongoing subnational fiscal crisis in Brazil. It looks at the evolution of subnational public finances since 2003, and provides evidence that while present stresses have a strong cyclical component arising from the recession, in some states current liquidity problems are symptomatic of deeper structural problems jeopardizing medium-term sustainability. In particular, during the past decade personnel costs followed a steep upward trend in many states, and revealed themselves to be unsustainable during the sharp deterioration of growth and revenues in 2015–16. Going forward, the federal governments and subnational entities need to collaborate and undertake a comprehensive reform of personnel and age-related social expenditures, together with a reform of the ICMS tax, to put subnational public finances in order.

A. Overview

1. A fiscal crisis has gripped the lower levels of government in Brazil. The press has been reporting frequently on the difficult liquidity situation of many states, which are being severely affected by the decline in the ICMS, the subnational sales tax, while some states are also facing declining oil royalties. Real revenue growth has been negative in most states since the beginning of 2015, while real personnel expenditures and retirement benefits have continued rising. States have coped with this situation in different ways: 20 states have increased their rates of indirect taxes (ICMS and ITCMD), most have reduced discretionary spending, and some state governments have, reportedly, been postponing payments and expenditures and adopting "securitization" to raise money.[2]

2. Facing rigid personnel spending obligations, the majority of states have cut their investment expenditures undermining future growth prospects. In 2015, 15 out of 27 states breached the limit of personnel expenditures to current net revenues established by the Fiscal Responsibility Law, the rest were approaching that limit, and 2 states had already exceeded the alert limit for debt (Rio de Janeiro and Minas Gerais).[3] Constrained by declining revenues, mandatory spending and the prohibition imposed by the federal government in 2015 to take on new credit loans, states have slashed investment, by more than half compared to the previous period, thus affecting their capacity to contribute to the economic recovery.

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[1] Prepared by Izabela Karpowicz and Carlos Mulas-Granados.

[2] Payment deferrals processed have increased by 37 percent between 2015 and 2016. Acknowledged expenditures from previous exercises (known as *Despesas de Exercicios Anteriores)* have increased 44 percent between 2015 and 2016. For more details, see Vescovi (2016).

[3] The alert limit for personnel expenditures is set at 44 percent of net current revenues (and the maximum at 49 percent). The alert limit for state debt is set at 180 percent of net current revenues (and the maximum at 200 percent). See World Bank (2016) for other indicators of subnational fiscal distress.

B. Structure and Evolution of Subnational Budgets

3. Brazil is one of the most decentralized countries in the world. In Brazil there are 27 states and over 5,500 municipalities, which, after transfers, represent more than 40 percent of total budgetary resources collected in the country (Fardoust and Ravishankar, 2013). In areas such as health and education, the federal government and the states have overlapping responsibilities. In other areas, such as social spending for instance, the responsibility lies at the federal level almost exclusively, while the states administer almost 80 percent of spending on security.

4. In Brazil state governments rely on own revenues more than on federal transfers, while municipalities rely more on transfers from upper levels of government. States' own revenues include the ICMS, the motor vehicle property tax (IPVA) and a tax on inheritance and donations. The ICMS resembles an origin-based VAT, levied on transaction in goods, communication, and transport services. It is collected and administered by states, who share with the Federal Senate the responsibility of setting norms and rates. This has led over time to excessive dispersion of effective tax rates and the introduction of incentives to attract investors, which has narrowed the tax base and fueled fiscal wars. According to the World Bank (2013), the ICMS is the main revenue source of the Brazilian fiscal system and thus the largest subnational own-revenue source, but its relative importance has declined. Proponents of an ICMS reform seek the unification of the ICMS interstate tax rate and the institution of special funds to compensate "reform losers," and help states to boost infrastructure investment.[4]

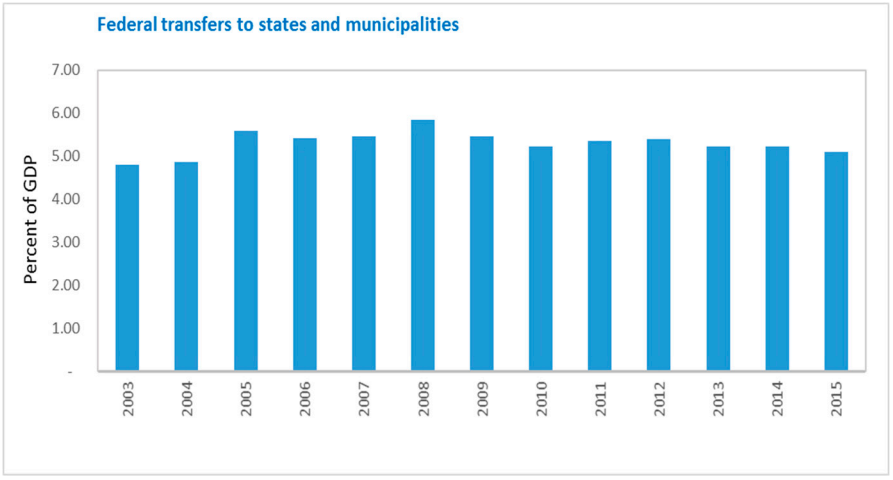
5. The states enjoy unconditional transfers from the federal government through the State Participation Fund (FPE) and receive also a share of royalties from oil and mining. The FPE is funded through 21.5 percent of total revenue collections from two federal taxes, the Income Tax (IRPF and IRPJ) and the Tax on Industrialized Products (IPI). The role of this fund was equalizing in nature when the fixed coefficients were calibrated in 1989 to benefit mostly the less developed states in the North, Northeast, and Center-West. Significant changes in regional development in the past two decades made the coefficients obsolete. However, with the approval of a new law in 2013 (no. 143/2013), the equalizing role has resumed. The FPE is now distributed according to two criteria foreseen in the law. The application of each depends on a reference value. This reference value is the amount received by each state in the previous year corrected by inflation and 75 percent of Gross National Product growth. Up to this value, the amount is distributed according to the previous fixed coefficients. What exceeds the reference value is distributed according to a new criterion. This new criterion considers population (50 percent) and inverse of per capita income (50 percent). The distribution of resources from petroleum suffers from a different kind of asymmetry, as some of these transfers are highly concentrated in the producing states of Rio de Janeiro and Espírito Santo (Bevilaqua, 2002; World Bank, 2013). The dependence on transfers from federal government thus varied dramatically from one state to another. Outside of the revenue-sharing framework, funds are

[4] The Revenue Compensation Fund (FCR—*Fundo de Compensação de Receitas*) would compensate the states for the losses incurred with the reduction in the interstate tax rate, while the Regional Development Fund (FDR—*Fundo de Desenvolvimento Regional*) would receive federal budgetary resources and proceeds from federal debt issuances to be distributed among states according to their share of population in total and the inverse of GDP per capita.

transferred to the states through the so-called convenios for the financing of investments, education, and regional development among others. These are negotiated grants funded through the Federal Budget (Rodden, 2003). Overall, transfers from the federal government to subnational entities has remained slightly above 5 percent of GDP during the last decade, but it has declined in recent years (Figure 1).

Figure 1. Transfers from the Federal Government to States and Municipalities, 2003–15

(Percent of GDP)

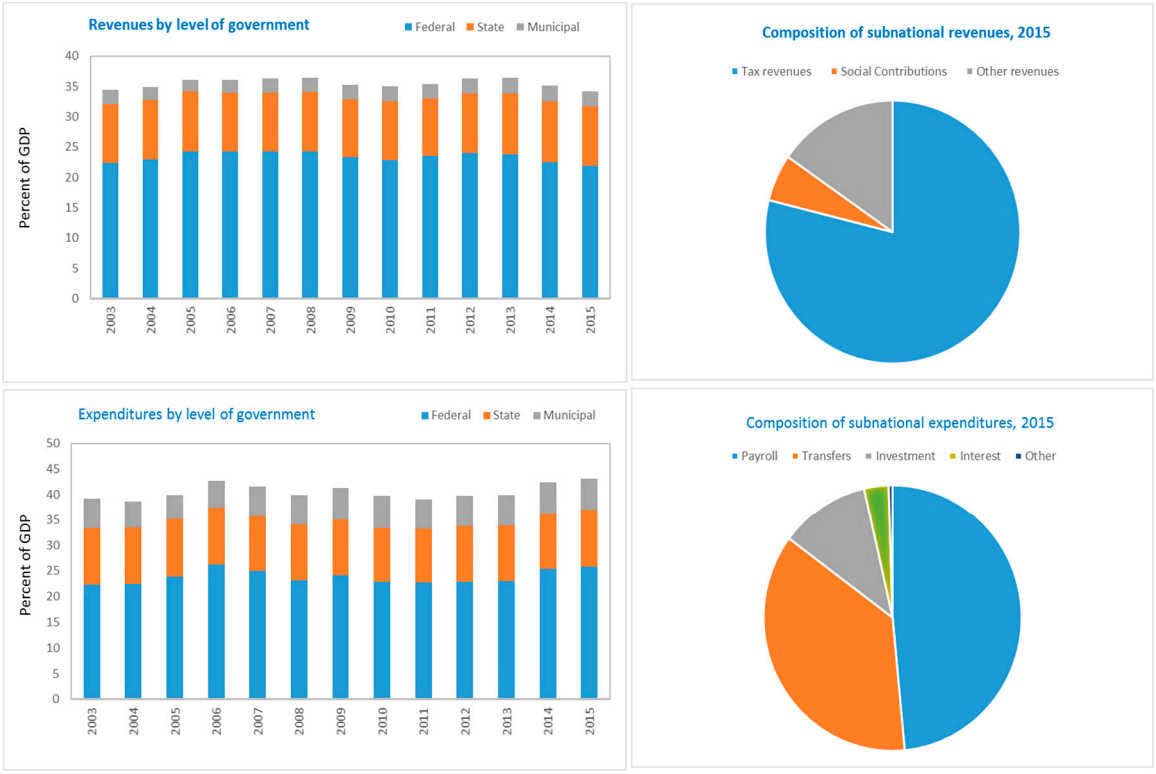


Sources: World Bank database; based on SICONFI, Treasury, Ministry of Finance.

6. Subnational spending has increased gradually, but its composition has shifted in favor of personnel spending over the years. Subnational expenditures increased to 17.2 percent of GDP in 2015, from 16.5 in 2003 but social transfers and payroll have been an increasing share of public spending, representing 6.3 and 8.4 percent of GDP in 2015 respectively (up from 5.1 and 8.1 in 2003). An important asymmetry is that although states can increase the payroll by hiring and raising salaries when circumstances are favorable, they have limited ability to reduce or even contain personnel costs; and the share of spending on personnel in total revenues increased already following the 1994 real stabilization plan (Rodden, 2003; Bevilaqua, 2002).[5] Other categories of subnational spending have been less important, with interest payments representing 0.5 and public investment 2 percent of GDP respectively. Subnational total revenues also grew over this period to represent 12.3 percent of GDP in 2015, up from 12 in 2003. Taxes were the major source of public revenues at 9.7 percent of GDP in 2015 (up from 9 in 2003), with social security contributions and other revenues representing only 2.6 percent of GDP (Figure 2). (These trends correspond to the aggregate of all subnational governments, and understates the adverse developments in some states, as will be discussed below).

[5] According to the 1988 Constitution, states cannot dismiss civil servants or decrease their wages in nominal terms.

Figure 2. Composition of Revenues and Expenditures by Government Level, 2003–15
(Percent of GDP)



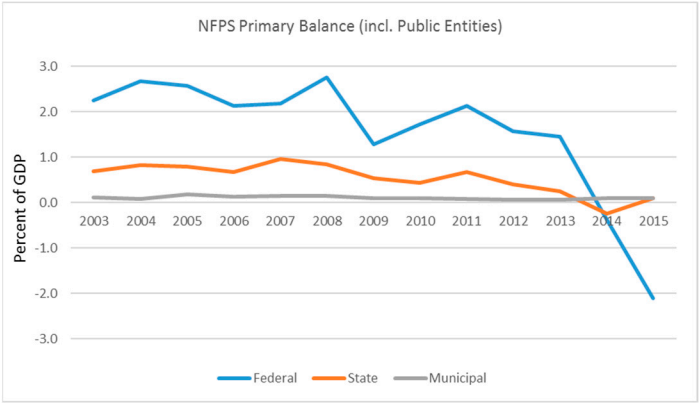
Sources: World Bank database; based on SICONFI, Treasury, Ministry of Finance.

7. Subnational finances have been deteriorating over the past few years. During 2003–11, state and municipal public finances generated a joint primary surplus of about 0.3–0.5 percent of GDP per year, reversing the deterioration of the 1980s and 1990s. However, some vulnerabilities had been building as cyclical revenue strength fostered real spending growth. The situation started worsening visibly in 2012 and turned alarming with the abrupt real contraction of activity in 2015. Because states rely on revenue sources that are very sensitive to the economic cycle, but face rigid mandatory expenditures, their primary balance became negative both in 2014 and 2015 (Figure 3). Some states had difficulties servicing their debt and even paying their payrolls on time.

8. Looking ahead, given population aging trends and current indexation rules, pensions will be a permanent source of spending pressure absent reforms. As with the federal government, the spending of the states on retirement benefits is growing and becoming increasingly unsustainable in the medium and long term. For example, out of 27 states, only Acre, Amapá, Rondônia, Roraima and Tocantins still registered a financial surplus in their social security systems at the end of 2015. On the other hand, São Paulo registered the largest negative result (-R$14.3 billion), followed by Rio Grande do Sul (-R$8.0 billion) and Minas Gerais (-R$7.1 billion). To attempt balancing the accounts in the future, some states are introducing the complementary social security systems in the mold of the Federal Public Worker Complementary Social Security

Foundation (Funpresp).[6] But more reforms are needed, especially with respect to special retirement plans granted to police officers, physicians and teachers, who can retire very early.

Figure 3. Primary Balance of the Non-Financial Public Sector, 2003–15
(Percent of GDP)



Source: Fund staff estimates; based on Ministry of Finance.

C. Structure and Evolution of Subnational Public Debt

9. Past subnational fiscal crises have resulted in bailouts by the federal government and a tightening of monitoring. Most states were affected by fiscal mismanagement in three notable episodes: in 1989, in 1993 and 1997.[7] The size of these refinancing operations (through Federal loans) ranged between R$10 and R$90 billion, and in some cases these bailouts spilled over to public banks. All three crisis episodes where characterized by high personnel expenditures and unsustainable borrowing. The conditionality attached to the restructuring in 1997 succeeded in addressing the fiscal imbalances, which remained unresolved during the first two restructuring episodes of 1989 and 1993. The 1997 bailout included elements of debt forgiveness, interest subsidy, restructuring of maturities, and divestiture of state assets (Cordes et al., 2015; Bevilaqua, 2002). Since 2001, the country's FRL gives the federal government significant control over the states, including the right to regularly supervise debt levels and personnel expenditures. The federal government must approve every new credit line, and guarantees all outstanding debt denominated in U.S. dollars. The FRL introduced a limit on the ratio of subnational net debt to net current revenues (NCR) at 200 percent, and a limit of 11.5 percent on debt service to NCR.[8]

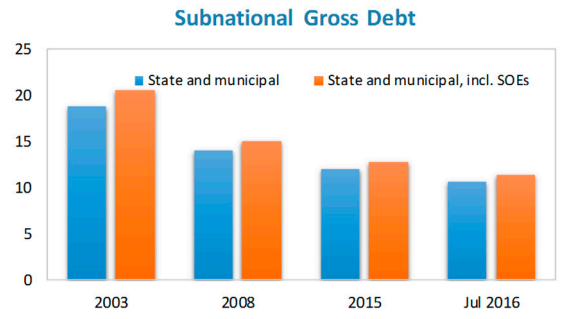
[6] For example, in the case of São Paulo, a complementary social security system for public workers was introduced in 2011 with the aim of guaranteeing financial equilibrium in the long term for the entire state social security system. Similarly, in 2013, Rio de Janeiro launched a complementary social security institution.

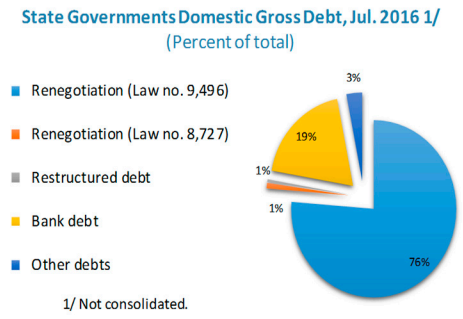
[7] The 1989 and 1993 debt crisis were due to growing vertical fiscal imbalances that have reduced subnational fiscal control incentives, and the macroeconomic adjustment, which resulted in a real output contraction and lower inflation.

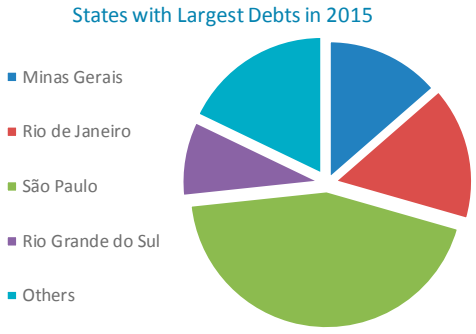
[8] Net current revenue is equal to current revenue minus transfers to municipalities. The limit on new borrowing is 16 percent of NCR and the limit on concession of guarantees is 22 percent of NCR.

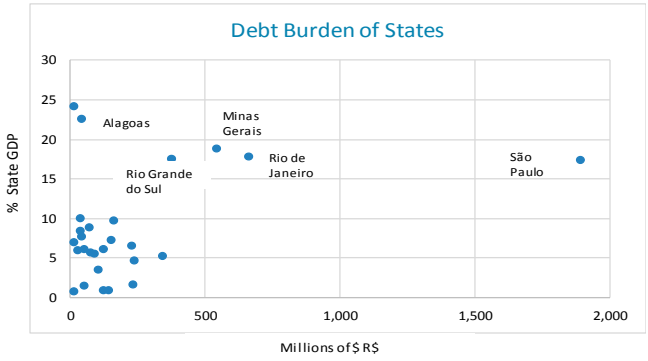
10. Total gross debt of states and municipalities has declined during the past decade. At end- 2015, nonconsolidated subnational net debt amounted to about 13 percent of GDP, down from over 18 percent of GDP in 2003, of which 78 percent was owed to the federal government. Net debt has been on a similar declining trend as subnational assets, consisting mainly of bank deposits and taxes collected but not transferred, have been constant over time at about 10 percent of subnational gross debt. By virtue of past subnational bailouts, the federal government assumed the majority of subnational debt to national and international creditors and became the subnational governments' main creditor.[9] The composition of gross debt is, however, uneven across regions: while the overwhelming majority of debt in the South and Southeastern states is owed to the federal government, Northeastern and Midwestern states also have a large share of bank and external debt (Figure 4).

Figure 4. Level and Composition of Subnational Debt, 2003–15
(Percent of GDP)









Sources: Central Bank of Brazil and Fund staff estimates.

11. Nearly 90 percent of the debts of states and municipalities is concentrated in just ten entities. The state of São Paulo accounts for over 30 percent of the total subnational debt stock. In addition, the states of Minas Gerais, Rio de Janeiro, and Rio Grande do Sul are large contributors to

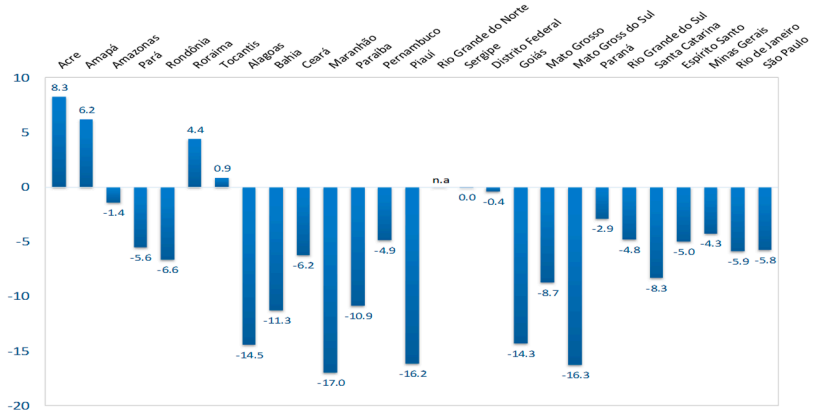
[9] For example, 90.7 percent, or R$199.3 billion (US$52.4 billion) of the state of São Paulo's debt in 2014 was owed to the federal government (Fitch Ratings).

total debt. Municipal debt is also highly concentrated within the five cities with largest populations. The largest and most populated states are also those with the highest debt burden as a share of state GDP, together with another group including the poorer states of the North and the North-East, such as Acre and Alagoas.

12. As a share of own (local) nominal GDP, the debt of states and municipalities declined until 2010, remained stable from 2011 to 2013, and rose during 2014–15. The largest decline in the debt-to-GDP ratio was registered in the northeastern state of Maranhão, followed by Piaui, Mato Grosso do Sul, Alagoas and Rio Grande do Sul (Figure 5). Since 2014, the subnational debt has, however, started to grow fast, primarily on account of an expansion in bank and external borrowing, induced in part by the slowdown in economic activity. Real growth of debt to domestic banks has been about 3 percent in annual terms over the past three years, but remains contained overall, below 2 percent of GDP in 2015.

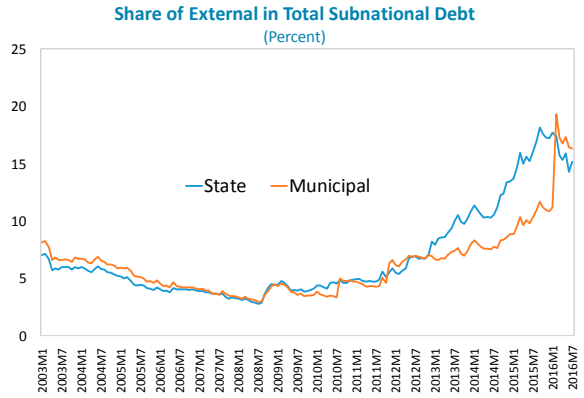
13. The share of external debt in total state debt has been growing since 2009, increasing the states' vulnerability to external shocks. In 2012, the federal government allowed 21 states to borrow an additional R$58 billion (14 percent of outstanding debt with the federal government) to make up for lower transfers caused by the economic slowdown and central government tax cuts. The total net debt of the states in 2015 was equivalent to 14 percent of GDP, 15 percent of which was foreign debt (Figure 6). In some states external debt was used to repay part of the debt owed to the federal government that bore higher interest rates. Yet, some 40 percent of the increase in external debt of states since 2009 was due to the depreciation of the real. Given that the vast majority of subnational governments does not earn revenues in foreign currency, the increase in foreign debt will put further pressure on servicing costs ahead, including for states with comfortable prudential ratios.

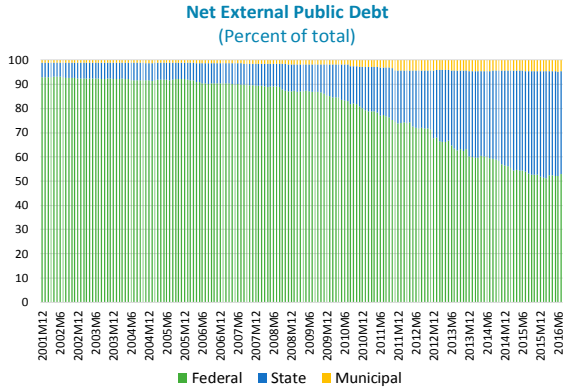
Figure 5. Change in Consolidated Net Debt, 2004–15
(Percent of subnational GDP)



Source: Ministry of Finance.

Figure 6. Subnational External Debt, 2003–15

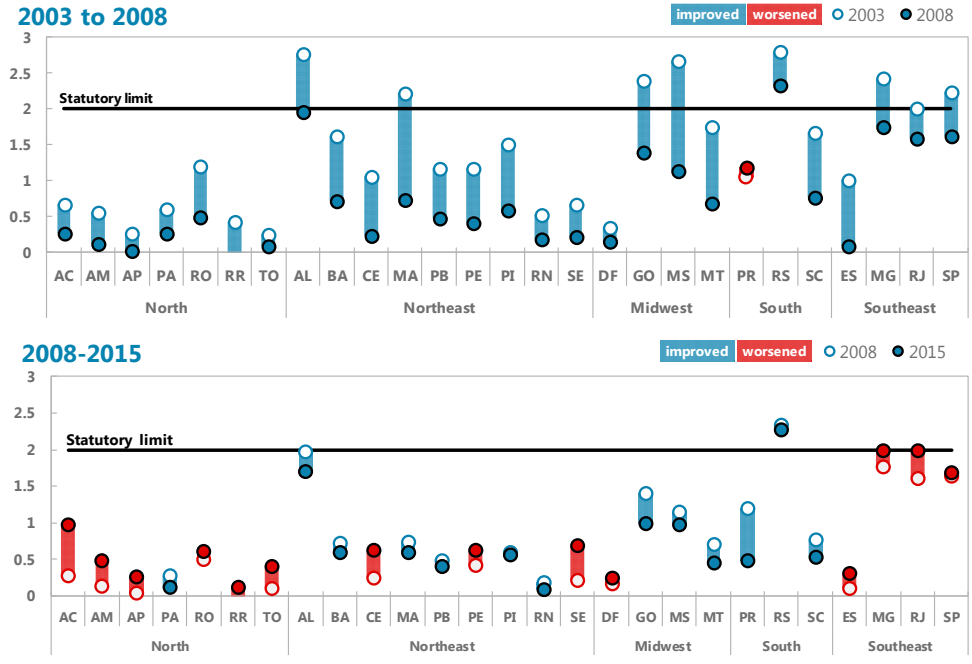




Source: Banco Central do Brasil.

14. Adherence to the fiscal rule continued to weaken. Between 2003 and 2015, net debt in percent of net current revenues declined across subnational entities and was below the FRL limit except for Rio Grande do Sul. In 2015, this indicator has shown a worsening trend in all states, and approached fast the prudential limit in the large states of the Southeast region that depend more on own taxes. In 2016, Rio Grande do Sul and Rio de Janeiro had already breached the limit (with a debt above 200 percent of net revenues).

Figure 7. Net Debt to Net Current Revenue Ratio, 2003–15



Source: Ministry of Finance.

15. The federal government approved in 2016 a short-term plan to restructure state debt. On September 2016, the Ministry of Finance sent to Congress a proposal to extend maturities of regional government debt with the National Treasury for 20 years and with BNDES for 10 years. According to that plan, states would be given a grace period of 6 months during the second half of 2016, and debt-repayment would resume in 2017. The budgetary impact for the federal government would be R$20 billion in 2016, and R$15 billion in 2017 and 2018 respectively. The government's proposal requires that States wanting to benefit from this debt rescheduling take a series of fiscal adjustment measures and accept to apply a spending cap for 24 months.[10] While this debt rescheduling would alleviate fiscal tensions in most states, it will not be sufficient for those states which are nearly insolvent like Rio de Janeiro. Final legislative approval of the negotiated solution was still pending as of the writing of this document, with delays arising from disagreements over the type of adjustment measures and spending limits that should be required of states; but the grace period in the servicing of debt is being observed.

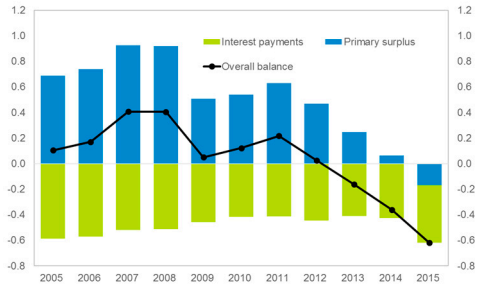
D. Recent Developments and Immediate Challenges in the Most Indebted Entities

16. The decline in the consolidated primary surplus of subnational entities since 2012 is mainly due to the weak fiscal performance of the 10 largest debtors (D-10).[11] Five large entities alone (São Paulo state, the municipality of São Paulo, Rio de Janeiro, Minas Gerais, and Rio Grande do Sul) account for 82 percent of total indebtedness. Together with the states of Paraná, Goiás, Bahia, Pernambuco and Santa Catarina, they constitute 91 percent of total subnational public debt. The average above-the-line primary balance of the ten most indebted states (D-10) has declined from 0.9 percent of GDP in 2008 to -0.15 percent of GDP in 2015 (Figure 8). From 2005, growing primary surpluses were used to repay debt, bringing down interest payments on debt close to zero by 2009. But since 2011, primary surpluses disappeared and indebtedness started to increase again. Interest payments of D-10 surpassed the primary balance, with the overall deficit becoming strongly negative (-0.5 percent of Brazil's GDP in 2015).

[10] The proposal, which was negotiated with state governors, was a solution to an unusual episode. In the second quarter of 2016, pressed for cash, 14 states asked the Supreme Court to order the federal government to use simple interest (as opposed to compound interest) in re-calculating states' liabilities to the central government. The federal government opposed this interpretation of the law (which, applied retroactively, would reduce outstanding states' debt to the federal government by 90 percent). The Supreme Court gave two months (expiring in September) to all the parties involved to work out an agreement or risk an unfavorable ruling. The 14 states have withdrawn their request for a ruling on simple vs. compound interest.

[11] See Brazil Economics Digest (Credit Suisse, May 19th, 2015).

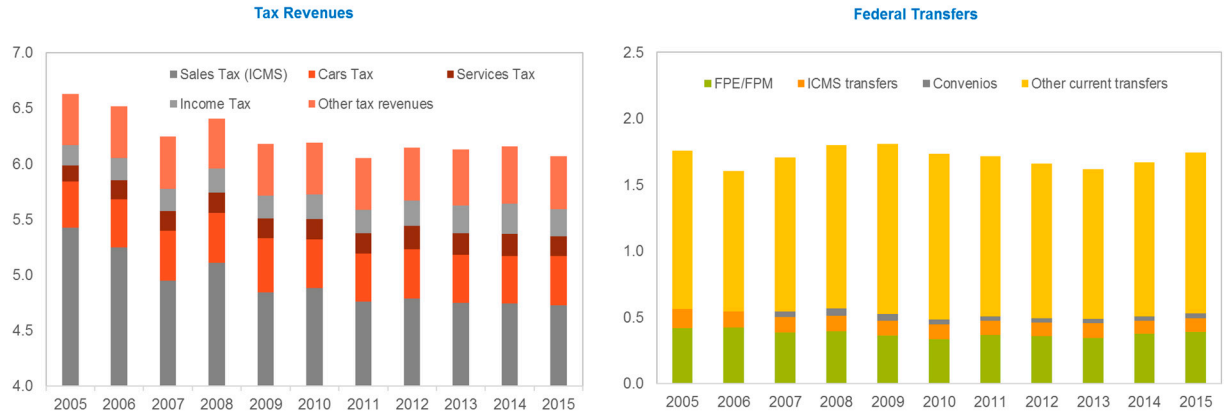
Figure 8. Budget Balance of D-10 States, 2005–15



Sources: Fund staff estimates and based on SICONFI, Ministry of Finance.

17. The ten largest debtors have been deeply affected by the decline in tax revenue, especially from ICMS.[12] Between 2005 and 2015, ICMS tax collection declined considerably in D-10 states, from 5.4 percent of GDP to 4.6 percent. Part of this decline was due to competition between states to attract investments, and more recently to the impact of the economic crisis (Figure 9). In contrast, current transfers from the federal government declined more slowly over the period, reaching about 1.7 percent of GDP in 2015. Most affected were states like Maranhão that are highly dependent on federal transfers. Other states with greater fiscal autonomy, such as Santa Catarina and Parana, have experienced lower downward pressure. In addition to the decrease in ICMS tax collection and the overall effect of the recession, the state of Rio de Janeiro suffered the fall in royalties associated to the extraordinary retrenchment in activity from Petrobras.

Figure 9. Revenue and Transfers of D-10 States, 2005–15
(Percent of GDP)

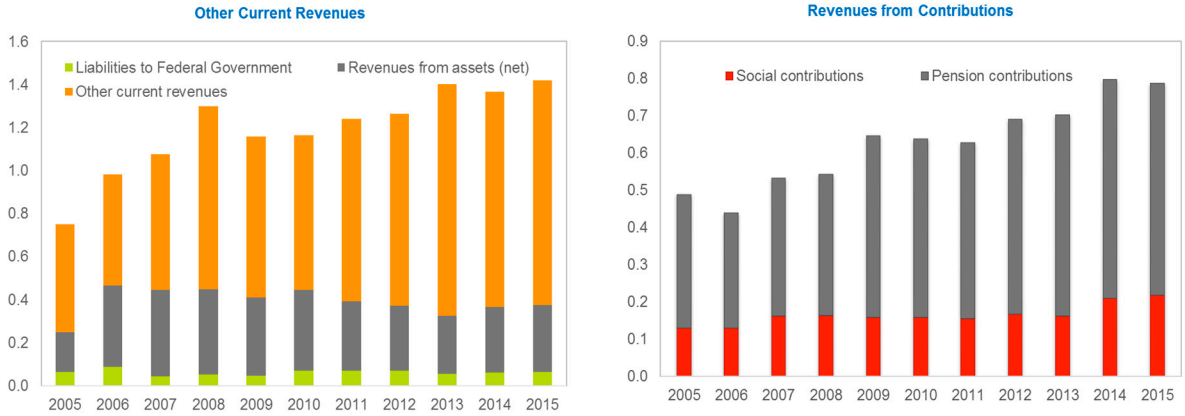


Sources: Fund staff estimates; based on SICONFI, Ministry of Finance.

[12] Almost 60 percent of revenues in the ten major debtor states come from taxes, while the other 40 percent correspond to voluntary or mandatory transfers from the federal government (constitutional mandates), social security contributions, and other current revenues (from service supplies, tax liabilities and tax debt renegotiations). Out of total tax revenues, 75 percent comes from the sales tax ICMS, and the rest from other local taxes. The most important federal transfers are those coming from revenue sharing mechanisms (taxes collected at the federal level, but shared by the three levels of government). Examples of these transfers are funds for education (Fundeb), revenues from oil and mining royalties, and fuel taxes (Cide).

18. Total consolidated primary revenues of D-10 states nonetheless were supported over 2005–15 by other revenue sources, most recently including one-offs. The decline in tax revenues (driven by weak ICMS tax collections) was compatible with stable primary revenues in the ten most indebted states thanks to two additional sources of growing revenues, which almost doubled. First, the increase in other current revenues from 0.75 to 1.6 percent of GDP between 2005 and 2015 was significant, and included revenues from fines, other indemnities and refunds, and judicial deposits in those states that resorted to these unconventional, one-off operations. In addition, the increase in revenues from social (and pension) contributions was also important and grew from 0.5 to 0.8 of GDP during the same period (Figure 10).

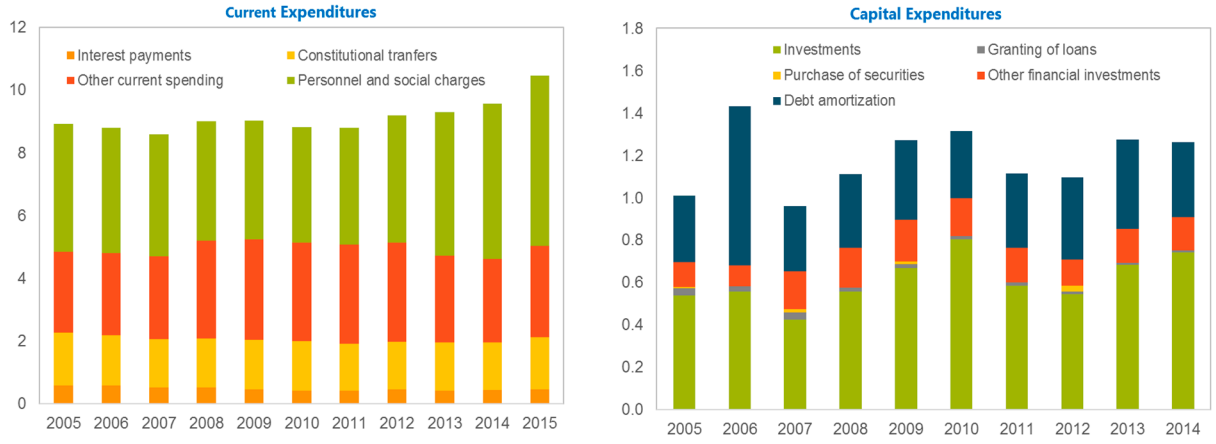
Figure 10. Other Revenues of D-10 States, 2005–15
(Percent of GDP)



Sources: Fund staff estimates; based on SICONFI, Ministry of Finance.

19. Widening primary deficits in D-10 States are largely a consequence of the increase in expenditures on employee compensation. A significant part of the primary expenditures of the largest debtors remained stable as a percentage of GDP from 2005 to 2015. The exception was the increase in personnel expenditures that matched the increase in social security contributions. The wage bill declined from 4 percent of GDP in 2005 to 3.7 percent of GDP in 2011. Since 2012, these expenditures experienced a sharp increase, reaching 5.1 percent of GDP in 2015 (Figure 11). In contrast, the evolution of public investment was volatile during the same period.

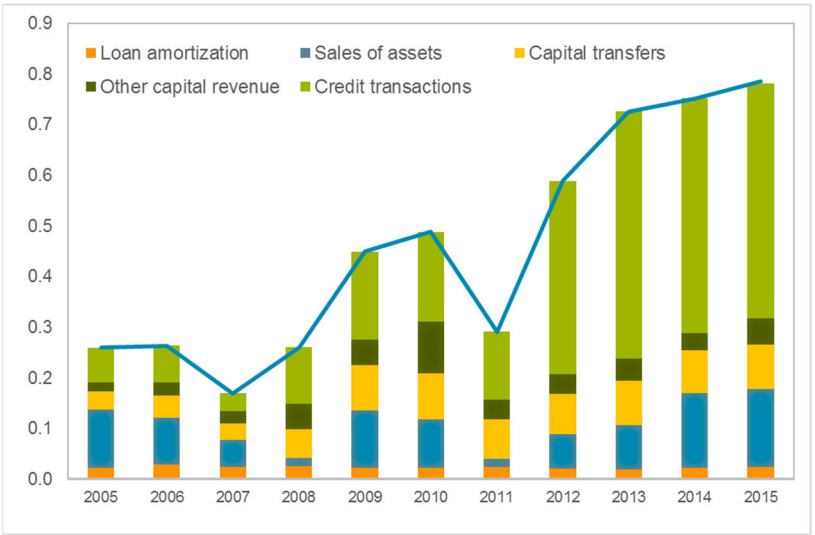
Figure 11. Current and Capital Expenditures of D-10 States, 2005–15
(Percent of GDP)



Sources: Fund staff estimates, and based on SICONFI, Ministry of Finance.

20. The increase in personnel expenditures in D-10 States was financed indirectly by borrowing. In 2011, the government stimulus policy allowed BNDES to finance certain subnational investment initiatives. Thus, credit transactions went up from 0.13 percent of GDP in 2011 to 0.81 percent of GDP in 2015 (Figure 12). These new resources freed up fiscal space, which was allocated to other current expenditures, in particular on personnel. The rise in personnel expenditures has increased the rigidity of the states' budgets, worsening prospects for balancing budgets beyond 2015. In 2015, the Ministry of Finance limited strictly new credit operations by regions and municipalities, with the purpose on ending this practice. Subnational entities had to then look for funds elsewhere (e.g. judicial deposits) or accumulate arrears on their wage bill payments.

Figure 12. Current and Capital Expenditures of D-10 States, 2005–15
(Percent of GDP)



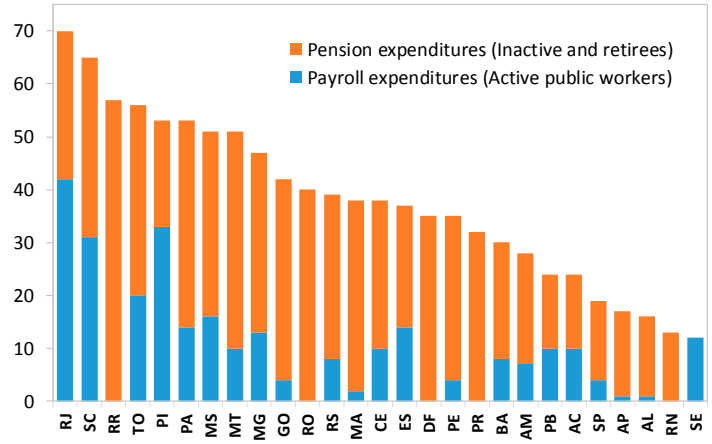
Sources: Fund staff estimates, and based on SICONFI, Ministry of Finance.

E. Concluding Thoughts

21. Much as the federal government, during the recession Brazilian subnational entities have been experiencing financial difficulties attributable to the general economic slowdown and budget rigidities. On the side of revenue collections, most states have been adversely affected by the decline in ICMS collection, but disproportionally more so those enjoying greater revenue autonomy. The contraction in revenue has mainly come from the slowdown in growth, possible compliance issues, as well as a decline in commodity prices affecting states highly dependent on these industries. Expenditure rigidities have become more binding in those states and municipalities that have rapidly increased wages and public employment in recent years (Rio Grande do Sul, Santa Catarina, São Paulo City, Bahia and Minas Gerais), planting seeds for a more difficult adjustment ahead. A rising share of external (foreign currency denominated) debt has pushed the interest burden up.

22. The adjustment in the near future will have to address the structural sources or revenue inefficiencies, and, most importantly, contain the structural growth of spending on wages and pensions. A reform of the ICMS reducing dispersion in tax rates across states, has the potential to unleash greater integration and to lower tax competition, while improving the business environment. While the crisis has not bottomed out, going forward the recovery of revenues will be uneven, with those states betting their future on commodity exports, such as Minas Gerais, needing a greater permanent adjustment than those penalized merely by the cycle (São Paulo). Most importantly, the resolution of the subnational fiscal crisis depends on structural expenditure rationalization that goes beyond the ten largest debtors and affect all states. In order to generate greater space for much needed investment, structural fiscal reforms need to address the pressures from unsustainable personnel and pension costs, which have increased 50 percent on average in the 27 states (up to 70 percent in Rio de Janeiro) between 2009 and 2015 (Figure 13).[13]

Figure 13. Real Growth of Payroll and Pension Expenditures in States, 2009–15
(Percent increase)



Source: Tesouro, Boletim das Finanças Públicas dos Entes Subnacionais (May 2016).

[13] As a share of current revenues, the wage bill exceeded the 46.55 percent limit under the FRL in 15 states in 2015.

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EFFECTIVENESS OF INTERVENTION IN BRAZIL[1]

A. Introduction

1. Unconventional monetary policies in advanced economies and volatile capital flows in and out of emerging markets have brought foreign exchange intervention (FXI) back to the forefront of the policy debate. Following the global financial crisis, policymakers argued that unconventional policies in developed economies were causing lending booms in developing economies and threatened their competitiveness.[2] More recently, net capital flows to emerging markets have slowed and turned negative in some instances amid uncertainty about the pace of policy tightening in major advanced economies (IMF, 2016). While flexible exchange rate regimes have facilitated more orderly currency adjustments than during past slowdowns, intervention has been an important part of the policy response, aimed at smoothing the adjustment, avoiding disorderly market conditions or defending against a perceived overshooting.

2. The effectiveness of sterilized FXI in moving exchange rates has long been under debate. Sterilized intervention should affect neither prices nor interest rates but could drive exchange rates through signaling (Mussa, 1981; Vitale, 1999) and coordination (Taylor, 1995; Taylor and Sarno, 2001) channels as well as when frictions cause agents not to be indifferent between holding assets denominated in different currencies (Branson and Henderson, 1985; Kumhoff, 2010; Gabaix and Maggiori, 2015). Economic theory would thus suggest FXI to be less effective in instances where reserve currency assets are perfect, or at least near-perfect, substitutes for domestic assets. The reason is that sterilized changes in reserves will be offset by an equal and opposite flow of private money. By contrast, in a country with imperfect asset substitutability the offsetting flow may only partially take place or not at all, thus rendering FXI more effective. In countries in which capital mobility is restricted, in turn, FXI could be effective even in the absence of imperfect substitutability (Bayoumi and Saborowski, 2014; Bayoumi et al, 2015).

3. The earlier empirical literature on the effectiveness of spot intervention focused on developed economies (Dominguez and Frankel, 1993; Humpage, 1999) and provided only limited evidence in favor of a potential relationship between FXI and the exchange rate in all but the very short term (or when interventions were coordinated between major central banks).[3] The findings of more recent cross country studies (Adler et al 2015; Blanchard et al 2015; Fratzscher et al, 2015) that include a large number of emerging economies, in turn, are more supportive of such a link. Similarly, several recent studies of emerging economies confirm that spot FXI may not only impact the exchange rate but also its volatility (Scalia, 2008; Broto, 2013; Fry and

[1] Prepared by Christian Saborowski.

[2] See http://www.bbc.com/news/business-11424864.

[3] For a comprehensive survey of this literature see Sarno and Taylor (2001), Neely (2005) and Menkhoff (2013).

Wanaguru, 2013). Nevertheless, it appears that these findings cannot be generalized to all countries and sample periods. (Disyatat and Galati, 2007; Broto, 2013; Catalan-Herrera, 2016).

4. A less well researched question regards the effectiveness of FXI in derivatives markets. In the 1990s, several Latin American countries (e.g., Brazil, Chile, Mexico and Peru) intervened in foreign exchange markets by issuing debt denominated in, or indexed to, foreign currencies. Since then, intervention in markets for swaps, options and forwards has become part of the policy toolkit in a number of countries amid the development of increasingly liquid markets (e.g. in Brazil, Colombia, India, Indonesia, Mexico, South Africa and Thailand).[4] The relatively scarce empirical literature on the topic finds that derivatives based intervention, similar to spot intervention, can indeed be effective. It includes Kohlscheen and Andrade (2014) who find that auctions of Brazilian non-deliverable FX futures settled in local currency had a significant effect on intra-day exchange rate changes. Chamon et al (2015) show that a program of pre-announced interventions using the same instruments was effective although it appeared not to affect exchange rate volatility. Relatedly, Keefe and Rengifo (2015) show in an event study that FX options based intervention conducted by the Central Bank of Colombia was effective in reducing daily exchange rate volatility. While the literature on derivatives based intervention thus finds evidence supporting the effectiveness of such policies, to our knowledge, there is no study that directly compares the effectiveness of spot and non-spot FXI.

5. In this paper, we aim to fill this gap by investigating the effectiveness of spot and non-spot FXI in a common empirical framework. In particular, we compare the Brazilian Central Bank's (BCB) FXI in spot markets to its intervention using non-deliverable futures contracts (commonly referred to as FX swaps and Reverse FX swaps). The particular context in Brazil is crucial in allowing a comparison of the two modes of intervention: the Brazilian authorities have used futures based interventions over a long period of time and, importantly, often alongside intervention in spot markets. This variation in the choice of FXI instrument should minimize the learning bias in our data that may arise when agents adapt their actions to the prevailing mode of intervention. In addition, the BCB provides detailed data not only on both modes of intervention but also on instruments that are key to identifying distinct reaction functions for each policy. Finally, the non-deliverable futures contracts the BCB employs settle in local currency and thus offer an interesting opportunity to determine whether the effectiveness of this mode of FXI may be conditional on the absence of convertibility risk.

6. The empirical approach we take in this paper is straightforward. We estimate instrumental variables regressions using daily data to explain changes in the R$-US$ exchange rate as well as its implied volatility. The baseline sample period of 2008−13 reflects data availability, but we also experiment with samples starting as early as 2002 by limiting the set of instruments included in the baseline specification. Our explanatory variables of interest are spot intervention—in billions of U.S. dollars—and futures intervention—in billions of U.S. dollar

[4] See BIS Quarterly Reviews of December 2010, March 2011, and December 2013.

equivalent of notional principal—defined such that positive values imply that the BCB takes a long dollar position. We control for the presence of conditional heteroscedasticity in the data using the continuously updated GMM estimator (CUE, Hansen et al, 1996).

7. The analysis finds strong evidence in favor of a significant link between intervention through both spot and derivatives markets and changes in the real/dollar exchange rate. Both spot intervention and futures intervention enter the regression significantly and with the expected signs. What is more, the impact of $1 billion in net spot market intervention changes the real/dollar exchange rate by about 1 percent and is statistically indistinguishable from the 0.7 percent change achieved through auctions of non-deliverable futures worth US$1 billion in notional principal. This main result of our paper survives a battery of robustness checks including extending the length of the sample period and using alternative estimation methods. In addition, we find that the same result holds when using the change in the implied exchange rate volatility as the dependent variable. Once again, both modes of intervention are statistically significant and enter the regression with the expected coefficient sign. The results imply that US$1 billion in spot dollar sales (or a comparable amount of futures intervention) reduces volatility by some 2.5 percent. We also distinguish interventions in which the BCB takes a short dollar position from those in which it takes a long dollar position. The findings provide tentative evidence suggesting that auctions of futures in which the BCB takes a long dollar position are less effective in depreciating the exchange rate than spot dollar purchases. Finally, there is evidence suggesting that futures intervention is ineffective in the presence of non-negligible convertibility risk, in line with the contingent local currency claim character of the underlying instrument.

8. The analysis also detects significant differences in the reaction function estimates of the two instruments. The BCB appears to use spot FXI, more so than futures based intervention, in reaction to daily movements in the exchange rate and to resist capital flow pressures. Conversely, it is more likely to use futures based intervention to smooth trend movements in the exchange rate and to react to changes in risk aversion in global financial markets. Finally, we also find that spot rather than derivatives based intervention tends to be used to offset the exchange rate effects of tighter/looser monetary policy.

9. Our results contribute to the scarce literature on derivatives based intervention in at least two important ways. First, to our knowledge this is the first study analyzing empirically the relative effectiveness of spot and derivatives based intervention in a common framework. By providing evidence suggesting that intervention in derivatives markets can be no less effective than intervention in spot markets, it highlights the advantages of a broader policy toolkit. Second, our study allows comparing central bank reaction functions for spot and derivatives based intervention, allowing us to understand which factors incentivize FXI more generally and one mode of intervention versus the other.

10. The remainder of this paper is organized as follows: Section II briefly discusses the data and the features of Brazilian foreign exchange interventions, before laying out our empirical specification. Section III outlines the results of the empirical analysis, and Section IV concludes.

B. Context and Empirical Specification

FX Intervention in Brazil

11. Since the adoption of its floating exchange rate regime in January 1999, the BCB has intervened frequently in foreign exchange markets, including through the use of derivatives instruments. Brazil's derivatives markets have developed to rank among the largest in the world amid demand for hedging instruments to cover interest and exchange rate risk given Brazil's history of high inflation, devaluations and high nominal interest rates. Trading volumes in Brazil's derivatives markets are around four times larger than those in its spot market for foreign exchange (Kang and Saborowski, 2014); relatedly, it appears that derivatives markets lead the spot market in price discovery (Garcia et al, 2014).[5] Importantly, the Brazilian exchange regime prohibits financial instruments traded in Brazilian markets from settling in foreign currency with a few exceptions.[6] As a result, policymakers can make use of a highly liquid market for FX derivatives that settle in local currency.

12. The derivatives instruments most frequently used by policymakers are the so-called Brazilian FX Swaps and Reverse FX Swaps.[7] The instruments were first used in March 2002 and soon replaced dollar linked treasury notes as the preferred mode of non-spot intervention (Bevilaqua and Azevedo, 2005). Formally, Brazilian FX swap contracts are structured such that, at maturity, the BCB pays its counterparts the observed exchange rate variation against the dollar plus the ex-ante Cupom Cambial and receives the ex-ante SELIC rate in return.[8] In other words, it makes a positive return if the observed exchange rate depreciation falls short of initial expectations and makes a loss otherwise. By offering a quantity of FX swaps, the BCB thus takes a short dollar position in the markets and expands the availability of hedge to investors with open *real* positions,

[5] Access to Brazil's spot market is restricted to chartered banks, laws preclude trading the real offshore, and domestic bank accounts denominated in foreign currency are forbidden by law.

[6] Brazilian law (Decree-Law No. 857) states that every contract, security, document or obligation, in order to be fulfilled in Brazil, can't stipulate payment in gold or foreign currency, or, in any form, restrict or refuse fulfillment in the Brazilian currency. The exceptions to that law are: currency exchange operations, import/export contracts, export financing (when a Brazilian bank buys, paying in reais, in advance, the amount of foreign currency to be received by an exporter in an export operation) or loans or any obligations in which the creditor or debtor is domiciled outside Brazil.

[7] Brazilian FX Swaps and Reverse FX Swaps are typically auctioned. The BCB announces detailed information prior to each auction, such as the exact time of the auction, the maximum quantity of contracts that the BCB offers, and the maturity. Bidders are allowed to place up to five bids, specifying the quantity and price quotation for the bids. However, every bid-winner pays the same SELIC rate and receives the same cupom cambial and exchange rate variation. The BCB has its discretion to accept any volume of contracts up to the maximum that is on offer.

[8] The Selic rate is the BCB overnight rate; the Cupom Cambial is a highly liquid instrument that serves as the onshore dollar interest rate and is priced in basis points equal to the spread between the overnight interbank deposit rate and the expected exchange rate variation.

potentially bidding down the forward exchange rate.[9] The Brazilian Reverse FX swap is structured in the same way except that the BCB takes the long dollar position.

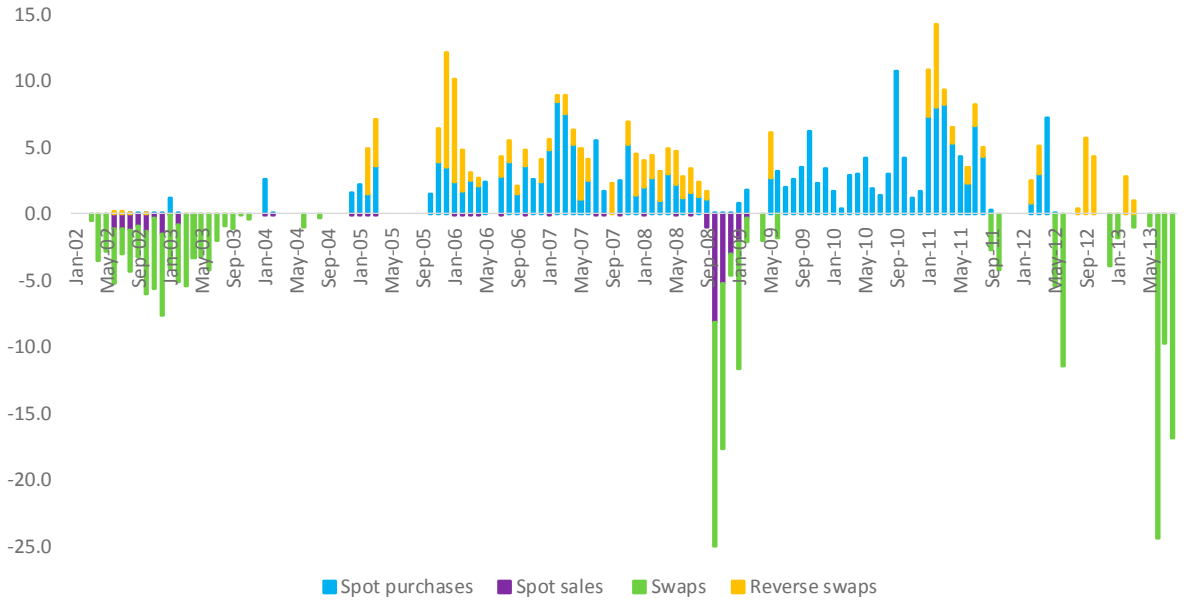
13. The discussion highlights that the name Brazilian FX swap is somewhat misleading since the instruments are more similar to non-deliverable futures; unlike conventional cross-currency swaps, they do not involve an exchange of notional principal; the crucial difference to conventional non-deliverable futures is that they settle in local currency.[10] One major advantage of intervening via these instruments is thus that the operation does not directly impact the BCB's stock of foreign exchange reserves. From the BCB's counterparts' perspective, however, the fact that the instrument settles in local currency represents a risk to the extent that immediate conversion to hard currency at maturity is less than certain. As a result, using auctions of FX swaps in place of spot dollar sales is likely to be ineffective if convertibility risk is non-negligible. The reason is that investors are unlikely to purchase the derivative contract if they cannot be sure that its proceeds can be converted back into dollars at maturity as needed (Kang and Saborowski, 2014). In what follows we frequently refer to FX swaps and Reverse FX swaps as futures based intervention for simplicity.

14. For the purpose of comparing the effectiveness of the two modes of intervention empirically, two conditions are key: first, developments triggering spot intervention as opposed to futures intervention need to be sufficiently distinct in order to allow for identification when included jointly in a regression; second, the two modes of intervention need to have been used during broadly the same time period in order to minimize the possibility that agents adapt their actions to the prevailing mode of intervention Figure 1 illustrates that these conditions are generally in place in our sample. The chart shows, for instance, that the BCB used both spot purchases and auctions of Reverse FX swaps during the period of 2005–11, presumably to tame appreciation pressures and accumulate reserves; in turn, both spot sales of dollars and auctions of FX swaps were used to stabilize markets during the crisis episodes of 2002–03 and 2008–09. Only during the market turmoil following the taper tantrum in May 2013 did the central bank use FX swaps alone.

[9] In addition, the instruments not only transmit price signals but also fill a market gap as futures contracts tend to have shorter maturities and OTC markets offering derivative products with longer maturities are not sufficiently liquid (Kang and Saborowski, 2014).

[10] Another frequently used instrument is the Brazilian FX repo which is akin to a conventional FX swap, resembling a dollar credit line. It has traditionally been used to provide FX liquidity to the market during periods of seasonal shortages.

Figure 1. Spot and Brazilian (Reverse) Futures Based Intervention in Billions of US$ or Notional Principal Equivalent



Source: Central Bank of Brazil and authors' calculations.
Notes: The chart shows the evolution of spot and futures based FX intervention. The variables shown are Spot market purchases (Spot purchases), spot market sales (Spot sales), Short-dollar futures intervention (Swaps) and Long-dollar futures intervention (Reverse swaps) in billions of U.S. dollars and aggregated at monthly frequency. The futures based intervention variables exclude auctions for roll-over.

Data and Empirical Approach

15. The sample period used for our baseline regression ranges from September 3, 2008 to August 21, 2013. The beginning of the period is determined by data availability. The end point is chosen to be one day before the announcement of the central bank's 2013–14 intervention program. We exclude this most recent episode because the heavy interventions conducted at the time were largely pre-announced months in advance (with rollover rates as the only discretionary factor). Including the episode would have required a distinct empirical approach compared to the one taken in this paper as auctions were likely priced in at the time they occurred (Chamon et al, 2015).

16. We estimate different variants of a standard intervention model:

$$\Delta y_t = \alpha_i + \sum_{i=1}^{p} \phi_i \Delta y_{t-i} + \sum_{i=0}^{q} \delta_i SWI_{t-i} + \sum_{i=0}^{l} \beta_i SPI_{t-i} + X_t'\gamma + \varepsilon_t \quad (1)$$

$$INT_t = Z_t'\theta + X_t'\varphi + u_t \quad (2)$$

where Δy_t is the dependent variable defined as the daily percentage change in the nominal R$/US$ exchange rate in the first set of regressions and as and the daily percentage change in the implied

R$/US$ volatility in the second set of regressions. The exchange rate is defined in units of local currency such that higher values imply a depreciation of the *real* and rising volatility respectively. The specification includes lagged values of the dependent variable, a measure of futures intervention, SWI_{t-i}, a measure of spot intervention, SPI_{t-i}, and a vector of control variables, including year dummies, X_t. All of these variables are defined in Table A1 in Appendix I.

17. For the remainder of the paper, spot intervention is defined as spot dollar purchases minus spot dollar sales in billions of U.S. dollars. The BCB publishes data on spot sales and purchases at a daily frequency since May 2009 and at a monthly frequency since 2000. In order to allow extending our daily sample back to include earlier episodes of heavy interventions, we construct an estimate of both variables based on daily data the BCB publishes under the heading "Factors conditioning the Monetary Base—External Sector Operations" in combination with the monthly data on spot intervention. In particular, we set the daily spot intervention variable to zero in months during which no intervention took place according to the monthly data; in months during which spot intervention was non-zero, we set the variable equal to the composite of external sector operations, namely the sum of spot, forward, FX repo and FX loan operations. While the variable is thus not a fully clean proxy for spot intervention in the earlier data, it would provide the best possible option for extending the sample.[11]

18. Detailed data on FX swap and FX Reverse swap auctions is available from the BCB at a daily frequency since 2002. We define the futures intervention term as the notional principal entailed in auctions of Reverse FX swaps minus that entailed in announcements of FX swap auctions in billions of U.S. dollars.[12,13] In other words, in line with the spot intervention term, futures intervention takes positive values when the BCB takes long dollar positions and negative values when it takes short dollar positions. Importantly, the magnitudes of the two variables are comparable in the following sense: US$1 of negative spot intervention (spot sales) takes US$1 of Brazilian *real* exposure off of investors' books; similarly, US$1 of futures intervention takes US$1 of Brazilian *real* exposure off of investors' books, although only temporarily and conditional on the absence of convertibility risk.

19. The main empirical challenge in studying the effectiveness of FXI is the endogeneity of the intervention terms to the contemporaneous movements in the exchange rate. To identify exogenous variation in both types of intervention we rely on the continuously updated generalized method of moments estimator (CUE). The method uses a vector of instruments Z_t for the vector of endogeneous variables given in Equation 2, where INT_t is a two-dimensional vector of the two modes of intervention. CUE estimates are robust to conditional heteroscedasticity and tend to

[11] When aggregating our spot intervention proxy at monthly frequency, it has a correlation of 97 percent with the monthly spot market intervention data available from the BCB in the baseline sample period. In the extended sample (going back to 2001), the correlation is 86 percent.

[12] Auctions tend to be announced a day in advance and settled several days later.

[13] We exclude FX swaps and reverse FX swaps auctioned to roll over existing swap contracts. The reason is that these could drive the exchange rate in either direction, depending on whether the roll-over rate surprised the market on the up- or the downside.

perform better than the standard two-stage least squares (2SLS) estimator in finite samples and in the presence of weak instruments (Hahn et al., 2004). Nevertheless, we also estimate Equations (1−2) using a 2SLS estimator for robustness.

20. Finding appropriate instruments for the two FXI terms is particularly challenging in our setup as candidate terms not only need to fulfill standard requirements for instruments; it is also essential that they allow identifying separate reaction functions that are sufficiently distinct to permit including the two modes of intervention jointly in our regressions. In part following the literature on spot interventions (see, inter alia, Ito and Yabu, 2007, Fatum and Hutchison, 2010), we include the following terms in our vector of instruments: (i) lagged trend exchange rate volatility, (ii) lagged exchange rate deviations from trend, (iii) lagged one year moving average of the exchange rate, (iv) the change in the monetary policy rate, (v) trend spot and futures intervention, and (vi) lagged trend FX flows.[14]

21. The first three terms capture the hypothesis that central banks react to exchange rate developments in various forms. The change in the local policy rate, in turn, captures potential linkages between monetary and foreign exchange intervention policies (Gnabo et al, 2010). The two trend intervention terms account for persistence in intervention, for instance during periods of trend appreciation. Finally, the trend FX flows variable captures net foreign exchange flows into Brazil. The intuition here is similar to that of the 'exchange rate deviation from trend' term. However, including the FX flows term separately aims to better distinguish flow pressures on the exchange rate from pure price pressures based on the hypothesis that the BCB may have a higher propensity to react to what it perceives as flow pressures using spot rather than derivatives based intervention. The term indeed turns out to be particularly important in distinguishing the reaction functions for spot and futures intervention. Our instruments pass a battery of validity and weak exogeneity tests.[15]

22. In selecting the vector of control variables X_t we follow the literature while trying to keep the specification parsimonious. In particular, our benchmark choice of controls includes: (i) the daily percent change in the Thomson Reuters Core Commodity (CRB) price index (both current and lagged), (ii) the daily percent change in the Chicago Board Options Exchange Market Volatility Index (VIX, both current and lagged), (iii) the lagged average change in the expected exchange rate depreciation over the coming 3 months (based on spot and forward rate differentials) and (iv) the lagged daily percentage change in the five year sovereign CDS spread for Brazil. The first two controls capture the importance of commodity prices (see also Kohlscheen and Andrade, 2014) and global risk aversion (Forbes and Warnock, 2012; Rey, 2013). The latter two control for the impact of changes in depreciation expectations and changes in investor perceptions of country risk (Della Corte et al, 2015); they enter only in lags to avoid potential endogeneity concerns. In the robustness section, we add several alternative controls (day of the week effects, local macroeconomic news

[14] All trend variables reflect short-term trends and are defined over a two-week window.

[15] In the robustness checks we include several alternative instruments and vary the moving average window for our benchmark instruments with no significant impact on the results.

surprises, regional and EM news sentiment, actual interest rate differential) with no impact on our results.

C. Estimation Results

23. The estimation section is divided into three parts: the first shows estimates of reaction functions for both types of intervention; the second presents estimates for regressions that use changes in the real/dollar exchange rate as the dependent variable; the third runs a similar set of regressions but uses the implied volatility in the exchange rate as the dependent variable. In the two latter sections, we ask whether or not one or both of the two modes of intervention are effective in the sense that we can establish a causal link to the dependent variable. Assuming that this first question can be answered with the affirmative, we ask whether one mode is more effective than the other.

D. Reaction Function Estimates

24. We begin our analysis by estimating central bank reaction function for both types of intervention. The instruments and control variables are those discussed in the previous section and defined in Table A1. The estimates of the reaction functions are reported in Table 1. All estimations report White's (1980) heteroscedasticity-consistent (robust) standard errors. The first two columns show the estimated reaction functions for the spot and futures based interventions using the CUE estimator. The following two columns report the 2SLS results, which, as expected, differ only marginally. The first six explanatory variables in the table are the second stage control variables included in X while the bottom six variables are the instruments.[16]

25. Estimated coefficients for the instruments generally carry the expected signs throughout the regressions in Table 1 and are statistically significant for at least one of the two modes of intervention. Moreover, the model diagnostics at the bottom of Table 1 suggest that the instruments are valid. Kleibergen and Paap's (2006) rank LM statistic strongly rejects the null hypothesis that the model is unidentified. In addition, the instruments pass weak identification tests. Kleibergen and Paap's (2006) Wald F statistic significantly exceeds the Stock and Yogo (2005) threshold of maximum size distortions.[17] We also compute Sanderson and Windmeijer's (2016) conditional F-test which additionally controls for cross-effects of multiple endogenous regressors. The results from the test strongly reject the weak instrument hypothesis.

[16] Estimated coefficients for further lags of the control variables were not statistically significant in the joint estimation and are dropped from the analysis.

[17] The Wald F statistic results may not be fully accurate as the critical values are tabulated under the assumption of conditional homoscedasticity in the regression errors. Nevertheless, the strong rejection of the null hypothesis as well as the results from the Sanderson and Windmeijer (2015) conditional F-test imply that these concerns should be small.

Table 1. First-Stage Regressions

	Spot	Futures	Spot	Futures	Spot	Futures
Lagged daily pct change in FX	-0.019*	0.012	-0.019*	0.012	-0.003	-0.005
	(0.01)	(0.02)	(0.01)	(0.01)	(0.07)	(0.05)
CRB index, percent change	0.027	0.018	0.027	0.018	-0.16	0.133
	(0.02)	(0.02)	(0.02)	(0.02)	(0.12)	(0.13)
CRB index, lagged percent change	-0.025	-0.029	-0.025	-0.029	-0.06	0.007
	(0.03)	(0.02)	(0.03)	(0.03)	(0.14)	(0.11)
VIX, percent change	0	-0.004**	0	-0.004**	-0.002	-0.017*
	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)
VIX, lagged percent change	0.002	0	0.002	0	0.001	-0.001
	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)
Trend spot forward differential	-0.047***	0.008	-0.047**	0.008	-0.413**	0.089
	(0.02)	(0.01)	(0.02)	(0.01)	(0.20)	(0.06)
5Y sovereign CDS return, lagged	-0.002	-0.016***	-0.002	-0.016**	-0.019	-0.053***
	(0.00)	(0.01)	(0.00)	(0.01)	(0.02)	(0.02)
Lagged pct FX deviation from trend	-1.115*	-2.741***	-1.115**	-2.741***	-11.689**	-16.992***
	(0.64)	(0.89)	(0.53)	(0.87)	(5.30)	(3.27)
Medium-run FX trend	-0.253	-0.758**	-0.253	-0.758**	-0.254	-2.872***
	(0.20)	(0.32)	(0.32)	(0.36)	(0.57)	(1.01)
Lagged trend FX volatility	-0.009***	-0.014***	-0.009***	-0.014***	0.018	-0.034***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)
Lagged trend FX transactions	0.000***	0	0.000***	0	0.000***	0
	0.00	0.00	0.00	0.00	0.00	0.00
Policy rate change	0.616***	-0.012	0.616***	-0.012	3.665***	-0.906
	(0.16)	(0.33)	(0.18)	(0.30)	(0.99)	(1.47)
Trend spot intervention, lagged	0.168**	-0.126*	0.168	-0.126**	2.476***	0.453***
	(0.08)	(0.07)	(0.11)	(0.06)	(0.16)	(0.14)
Trend futures intervention, lagged	-0.022	0.399***	-0.022	0.399***	0.271	2.372***
	(0.04)	(0.12)	(0.04)	(0.13)	(0.34)	(0.34)
Constant	0.291*	0.500**	0.291	0.500**		
	(0.15)	(0.22)	(0.23)	(0.25)		
N	1,100	1,100	1,100	1,100	1,100	1,100
F test	12.6 (0.00)	8.6 (0.00)	11.7 (0.00)	8.5 (0.00)	-	-
Kleibergen-Paap rk Wald F	12.6	8.6	11.7	8.5	-	-
Sanderson-Windmeijer F test	7.4 (0.00)	13.1 (0.00)	6.5 (0.00)	11.3 (0.00)	-	-
Kleibergen-Paap rk LM	71.1 (0.00)	47.3 (0.00)	17.8 (0.01)	24.7 (0.00)	-	-
Mc Fadden's R^2					0.485	0.407

Source: authors' calculations.

Notes: The dependent variable in columns 1 and 3 is spot intervention—in billions of U.S. dollars—while the dependent variable in columns 2 and 4 is futures intervention—in billions of U.S. dollar equivalent of notional principal—defined such that positive values imply that the BCB takes a long dollar position. The dependent variable in columns 5 (spot) and 6 (futures) takes the value +1 when the BCB takes a long dollar position, -1 for when it takes a short dollar position; and 0 in the absence of intervention. Explanatory variables are defined in Table A1. The first two columns report estimates using CUE, column three and four report estimates using 2SLS, the last two columns report estimates from an ordered Probit. Heteroscedasticity robust standard errors in parentheses. *, ** and *** denote statistical significance at 10 percent, 5 percent and 1 percent level. For test statistics p-values are reported in parentheses.

26. We now move to discussing the first-stage coefficient estimates in detail. The estimates in Table 1 would suggest that the two modes of intervention react to short-term trends in the nominal exchange rate and excessive FX volatility in the expected direction: the BCB would take short dollar positions when the real is depreciating or when volatility is elevated and long dollar positions in the opposite case. In contrast, the response to the remaining variables differs notably between the two modes of intervention.

27. First, the lagged change in the monetary policy rate is significantly positively associated only with spot intervention, suggesting that spot rather than futures intervention tends to be used to offset the exchange rate effects of tighter/looser monetary policy. Second, spot intervention appears to be used more in response to short-term movements in the exchange rate, as suggested by the signs and the significance of the coefficients on the daily change in the exchange rate and the expected depreciation term; futures intervention, in turn, appears to be used to smooth medium-term exchange rate trends (see one year moving average term). Third, the BCB responds to changes in country risk and global risk aversion through futures based intervention (the reaction of spot intervention has the expected sign but is not statistically significant). Fourth, the lagged trend FX transactions variable enters the spot regressions significantly with a positive coefficient while its coefficient is not significant in the futures regressions. This suggests that spot intervention is the mode of choice when responding to actual currency outflows rather than purely price based pressures on the exchange rate. Finally, there is evidence that both spot and futures intervention tend to cluster as illustrated by the positive and significant coefficient on their lagged moving averages. Conversely, the relationship between spot (futures) intervention and lagged futures (spot) intervention is, if anything, negative, although rarely significantly so.

28. In sum, the BCB appears to react to daily movements in the foreign exchange market and perceived flow pressures using spot interventions. On the other hand, futures interventions appear to be primarily used in reaction to trend movements in the exchange rate as well as to changes in country and global risk perceptions.

29. We perform several robustness checks of the reaction function results. Table A2 in the Appendix presents the estimates of the reaction functions when additional instruments are included and when the window over which the short term trend variables are calculated varies. Although some of the additional instruments are significant in the first stage regressions, this does not change the significance or the magnitudes of the coefficients of the baseline regressors.[18] In addition, Table A3 shows that changes in the instrument set do not impact the second stage results. Another potential concern is that the multiple zeros in the dependent variables in the reaction function regressions may bias the linear regression estimates. To assess the importance of this potential bias, Columns 5 and 6 of Table 1 report estimates from an Ordered Probit model (Ito and Yabu, 2007).[19] While the magnitudes of the estimated coefficients are not directly comparable to the linear

[18] For space considerations Table A2 and A3 do not report results from regressions using local macroeconomic news as instruments as the results remain the same as in the baseline.

[19] Ito and Yabu (2007) show that the ordered probit specification can be interpreted as a linearized version of the general friction model of central bank intervention (Almekinders and Eijffinger, 1996).

regression estimates, we confirm that neither the significance of the key variables nor their signs change much.[20]

E. Intervention and Exchange Rate Changes

30. The second stage results of our baseline regressions for the exchange rate changes equation (1) are summarized in Table 2. Columns 1 to 3 use the CUE estimator, Columns 4 to 6 use the 2SLS estimator and Column 7 uses simple OLS. In order to allow for delayed impacts of our control variables, we include them either as moving averages or with both their contemporaneous and lagged values.[21]

31. We begin by including the intervention terms separately in the regressions. The first regression in Table 2 shows that the spot intervention term is highly significant and carries the expected positive coefficient. Taken at face value, the coefficient of 1.03 suggests that US$1 billion of spot purchases (sells) would depreciate (appreciate) the exchange rate by 1.03 percent. Similarly, Regression 2 would suggest that futures intervention is a highly significant determinant of the real/dollar exchange rate, with futures intervention worth US$1 billion in notional equivalent moving the exchange rate by some 0.97 percent. Interestingly, these results not only suggest that both modes of intervention are highly significant determinants of the exchange rate, but their impacts on average are also very similar. The third regression in Table 2 includes both intervention terms in the regression simultaneously. Of crucial importance at this point is the fact that our instruments identify central bank reaction functions that are sufficiently distinct to permit including the two variables jointly in a single regression. The results in Column 3 confirm those from the first two regressions: while both coefficients are now somewhat smaller, they are still strikingly similar at 1 and 0.7 respectively, and the two variables remain highly significant. Indeed, the Wald-test cannot reject the null hypothesis the two coefficients are equal.

The estimated coefficients on the control variables are in line with theory, and they are frequently significant at conventional levels. Across Table 2, we find that the lagged dependent variable is significant with a negative coefficient. The commodity price index and its lag both carry the expected negative coefficient, indicating that rising commodity prices are associated with an appreciating *real*, but only the lagged term is consistently significant. The VIX term carries a positive coefficient and is highly significant as we would expect, suggesting that risk aversion in global financial markets is associated with depreciating exchange rates in emerging markets and the effect appears to be contemporaneous. Similarly, lagged depreciation expectations and a rise in the country risk are associated with Real depreciation.

[20] The only relevant difference is that the Ordered Probit model reduces the importance of the daily change in the exchange rate and FX volatility in the spot intervention regressions.

[21] Estimated coefficients for further lags of the control variables were not statistically significant in the joint estimation and are dropped from the analysis.

Table 2. Second-Stage Regressions

	1	2	3	4	5	6	7
Lagged daily pct change in FX	-0.053	-0.121*	-0.141**	-0.148*	-0.171**	-0.158**	-0.167**
	(0.06)	(0.07)	(0.07)	(0.08)	(0.08)	(0.07)	(0.07)
CRB index, percent change	-0.161*	-0.1	-0.138	-0.112	-0.097	-0.119	-0.064
	(0.10)	(0.10)	(0.10)	(0.08)	(0.11)	(0.11)	(0.10)
CRB index, lagged percent change	-0.406***	-0.435***	-0.420***	-0.413***	-0.421***	-0.415***	-0.423***
	(0.08)	(0.08)	(0.08)	(0.10)	(0.08)	(0.08)	(0.08)
VIX, percent change	0.012**	0.016***	0.012**	0.012*	0.015**	0.014**	0.013**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
VIX, lagged percent change	-0.009	-0.006	-0.009	-0.009*	-0.008	-0.009*	-0.006
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Trend FX forward differential	0.147***	0.087**	0.164***	0.146***	0.073*	0.130***	0.047
	(0.05)	(0.04)	(0.05)	(0.04)	(0.04)	(0.05)	(0.04)
5Y sovereign CDS return, lagged	0.112***	0.118***	0.111***	0.106***	0.118***	0.116***	0.104***
	(0.02)	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)	(0.02)
Spot intervention	1.026**		1.009**	1.294***		0.748*	0.248
	(0.49)		(0.49)	(0.43)		(0.42)	(0.21)
Futures intervention		0.973**	0.729**		0.876**	0.680*	-0.127**
		(0.39)	(0.37)		(0.38)	(0.37)	(0.06)
Constant	-0.024	0.227**	0.148	-0.016	0.256**	0.171	0.082
	(0.05)	(0.11)	(0.11)	(0.05)	(0.12)	(0.12)	(0.31)
R^2	0.23	0.11	0.15	0.23	0.14	0.18	0.28
N	1,100	1,100	1,100	1,100	1,100	1,100	1,100
Hansen's J stat.	8.4 (0.21)	8.8 (0.19)	5.2 (0.40)	8.5 (0.20)	12.1 (0.06)	9.3 (0.10)	
Kl.-Paap rk Wald F stat	12.6	8.6	7.8	11.7	8.5	6.1	
Kl.-Paap rk LM stat	71.1 (0.00)	47.3 (0.00)	49.2 (0.00)	17.8 (0.01)	24.7 (0.00)	22.7 (0.00)	
Stock-Wright LM S stat	21.4 (0.00)	21.4 (0.00)	21.4 (0.00)	21.0 (0.00)	22.4 (0.00)	23.5 (0.00)	
C test for endogeneity	15.0 (0.04)	15.0 (0.04)	15.0 (0.04)	23.4 (0.00)	21.4 (0.00)	24.1 (0.00)	
Wald statistic			0.17 (0.67)			0.01 (0.92)	

Source: authors' calculations.
Notes: The dependent variables is the percent daily change in the real/$ rate. Explanatory variables are defined in Table A1. Regressions 1−3 report estimates using CUE, regressions 4-6 report estimates using 2SLS, Regression 7 reports OLS estimates. Heteroscedasticity robust standard errors in parentheses. *, ** and *** denote statistical significance at 10 percent, 5 percent and 1 percent level. For test statistics p-values are reported in parentheses. Wald statistic tests the null hypothesis of equality of the spot and futures intervention coefficients.

33. The bottom five columns of Table 2 show that the baseline specification passes the J-test of overidentifying restrictions as well as the underidentification and weak identification tests. The Stock and Wright LM statistic, in addition, confirms that the impact of the interventions is significant even if we allow for the case of weak instruments. Finally, the C-test for endogeneity confirms that both types of interventions are endogenous to contemporaneous movements in the exchange rate. To assess the sensitivity of the results to our choice of estimator, Regressions 4 to 6 present the same regressions as in Columns 1 to 3 except that we now use the 2SLS estimator in place of our preferred CUE estimator. The results are barely affected by this specification change except that the magnitudes of the estimated coefficients for the intervention variables are slightly smaller when included jointly. Finally, in Column 7, we run the same regression as in Columns 3 and 6 except that we depart from the use of instruments and run a simple OLS regression of the percentage change in the exchange rate on the two intervention terms and controls. The coefficients on both terms become substantially smaller and turn negative in the case of futures intervention.

This is in line with the results from the endogeneity test since theory would predict that the OLS regression without instruments would likely introduce a negative bias in the estimated coefficients.[22]

34. We extend our baseline specification in several directions. The results are presented in Table 3. First, we extend the sample to 2002, the first year for which the futures intervention data is available. As we move the start date back to 2002 we lose the FX transactions instrument (which plays an important role in ensuring that the reaction function for the two modes of intervention are sufficiently distinct) as well as the implied volatility term due to lack of data availability. In place of lagged trend exchange rate volatility we now include an alternative forward-looking proxy of uncertainty in the FX market, namely the lagged trend difference between the onshore and offshore forward rate. The data for this variable is available from 2002, and is highly correlated with the volatility series (sample correlation 0.47 over the period).[23] The first two columns in Table 3 show that our main findings continue to hold in that both modes of intervention appear to be significant drivers of the exchange rate with only somewhat lower coefficients than before (0.83−0.92 for spot intervention and 0.55−0.58 for futures intervention).[24] The results in the first column, however, indicate that the specification does not pass the J-test. The second column shows that excluding the potentially problematic instrument (the long-run trend in the exchange rate—as suggested by the J-test) does not change the results.

35. Second, an important advantage of extending the sample period back to 2002 is that it allows us to test whether futures intervention loses its effectiveness in the presence of non-negligible convertibility risk. As discussed earlier, FX swap contracts settle in local currency. As such, they only provide effective hedge against currency movements to the extent that their holder is able to convert the proceeds at the time of maturity. In other words, we would expect futures intervention to be ineffective in the presence of non-negligible convertibility risk. In order to test this prediction, we define a dummy variable denoted "Convertibility Risk" that takes the value 1 on days on which the three-month onshore dollar interest rate (cupom cambial) was 1.5 standard deviations above its sample mean.[25] Including this variable alongside its interaction with futures intervention in Regression 3−4, we indeed find tentative evidence for our hypothesis: the interaction term is highly significant with a negative coefficient, indicating that futures intervention becomes less significant when convertibility risk is high.[26] In fact, the combined coefficient of futures intervention and the interaction term turns negative, suggesting that futures intervention moves the exchange rate with the wind in such an environment.

[22] A negative bias would result if the BCB responds to a depreciating (appreciating) exchange rate by taking short (long) dollar positions.

[23] The variable also passes the instrument redundancy test.

[24] The results from individual intervention regressions are also in line with the findings in the baseline regressions.

[25] The results do not change if we use a higher or lower threshold (2 instead of 1 standard deviation) or if we use the spread between the cupom cambial and the three month US$ Libor rate in place of the cupom cambial. Figure A1 in the Appendix shows that the period of heightened convertibility risk broadly matches the crisis episode of 2002−03.

[26] We interact the instruments with the convertibility risk dummy to obtain instruments for the interaction term.

36. Third, our baseline specification implicitly assumes that the impact of both types of interventions is symmetric. To allow for asymmetric effects we interact our intervention variables with a dummy variable denoted "Spot (Futures) Positive" that takes the value one on days when the BCB takes long dollar positions. Column five of Table 3 presents the estimates of regressions in which we use the interaction of "Spot (Futures) Positive" with lagged trend exchange rate volatility and trend intervention as additional instruments for the interaction terms.[27] The coefficient for the spot intervention interaction term is negative, but not statistically significant indicating that spot FXI has a broadly symmetric impact on exchange rate changes. The coefficient for the futures intervention interaction term, on the other hand, is negative and statistically significant, suggesting that derivatives based interventions are more effective when the BCB takes short dollar positions. The tentative evidence of asymmetries in the effects of futures interventions corroborates the findings of Kohlscheen and Andrade (2014) who show that FX swap auctions ("Futures negative") have much stronger impacts relative to Reverse FX swaps ("Futures positive") in their high frequency setting. The result may reflect the fact that the Brazilian foreign exchange market, as is the case in most other EMs, lacks sufficient depth in FX hedging instruments with long maturities. Futures based intervention may thus fill a market gap by providing hedging opportunities that would otherwise not exist in sufficient quantity. The resulting impact on exchange rates may be higher than the one that would materialize if the central bank simply took a position in an already existing market. Since in Brazil private foreign liabilities in local currency grossly exceed private domestic assets in foreign currency (such that downside risks for private investors are more likely to arise in the form of depreciations), this effect may be more relevant for private market participants when the central bank takes a short dollar position.

37. The final regression of Table 3 allows for a dynamic impact of the interventions. In addition to the instrumented contemporaneous value of interventions we add the first five lags of each intervention to the specification, however only the coefficients for the first lag of the futures intervention term and the first two lags of the spot intervention term turn out to be significant. Column 6 in Table 3 reports the cumulative impact of both types of intervention together with the Wald test of the null hypothesis of no difference in the cumulative effects. The results again suggest that both modes of intervention have significant and quite similar impacts on exchange rate changes.

[27] Both additional instruments enter the first stage regressions of the interaction terms significantly and pass the instrument validity tests.

Table 3. Second-Stage Regressions: Additional Results

	1	2	3	4	5	6
Lagged daily pct change in FX	-0.082*	-0.077*	-0.079*	-0.066	-0.120**	-0.197**
	(0.05)	(0.05)	(0.04)	(0.04)	(0.06)	(0.08)
CRB index, percent change	-0.177**	-0.166**	-0.179***	-0.182***	-0.142	-0.111
	(0.07)	(0.07)	(0.07)	(0.07)	(0.09)	(0.11)
CRB index, lagged percent change	-0.353***	-0.356***	-0.362***	-0.358***	-0.402***	-0.449***
	(0.06)	(0.06)	(0.06)	(0.06)	(0.09)	(0.08)
VIX, percent change	0.006	0.007	0.006	0.007*	0.011*	0.015**
	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)
VIX, lagged percent change	-0.001	-0.002	0.001	0	-0.008	-0.008
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Trend spot forward differential	0.164***	0.180***	0.163***	0.175***	0.159***	0.093
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.06)
5Y sovereign CDS return, lagged	0.091***	0.096***	0.090***	0.093***	0.103***	0.121***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)
Spot intervention	0.927*	0.831*	0.892*	0.781*	2.140**	0.839**
	(0.48)	(0.48)	(0.46)	(0.46)	(1.01)	(0.35)
Futures intervention	0.582*	0.556*	0.651**	0.512*	0.693*	0.926**
	(0.34)	(0.34)	(0.32)	(0.32)	(0.36)	(0.46)
Conv. Risk * Futures intervention			-2.179*	-2.269*		
			(1.29)	(1.34)		
Convertibility Risk			0.066	0.032		
			(0.66)	(0.65)		
Spot positive * Spot intervention					-1.188	
					(1.11)	
Swap positive * Futures intervention					-0.936**	
					(0.38)	
Constant	0.136	0.105	0.153	0.094	0.166	0.186
	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)	(0.12)
R^2	0.14	0.15	0.14	0.17	0.16	-0.03
N	2,202	2,202	2,202	2,202	1,100	1,068
Hansen's J stat.	13.9 (0.01)	4.4 (0.23)	17.3 (0.04)	7.7 (0.36)	8.0 (0.33)	4.6 (0.47)
Kl.-Paap rk Wald F stat	9.6	11.4	5.7	6.7	7.3	3.7
Kl.-Paap rk LM stat	54.9 (0.00)	53.7 (0.00)	64.2 (0.00)	63.0 (0.00)	72.0 (0.000)	24.5 (0.000)
Stock-Wright LM S stat	26.0 (0.00)	17.8 (0.00)	32.0 (0.00)	23.0 (0.01)	31.0 (0.00)	24.1 (0.00)
C test for endogeneity	23.1 (0.00)	11.5 (0.04)	29.5 (0.00)	16.1 (0.10)	26.4 (0.01)	15.4 (0.03)
Wald statistic	0.20(0.66)	0.30 (0.58)				0.04(0.85)
Wald statistic – short US$					1.80 (0.17)	
Wald statistic – long US$					6.01 (0.01)	

Source: authors' calculations.

Notes: The dependent variables is the percent daily change in the Real/$ rate. The Convertibility Risk variable takes the value one on days on which the three month local interest rate (cupom cambial) was 1.5 standard deviations above its sample mean. The Spot (Swap) positive dummy takes the value one on days when the BCB takes a long dollar position via the respective mode of intervention. Other explanatory variables are defined in Table A1. All regressions report estimates using CUE. Regressions 2 and 4 exclude the medium-run FX trend from the instrument set. The coefficients for spot and futures intervention in Regression 6 are cumulative effects. Heteroscedasticity robust standard errors in parentheses. *, ** and *** denote statistical significance at 10 percent, 5 percent and 1 percent level. For test statistics p-values are reported in parentheses. Wald statistic tests the null hypothesis of the equality of the spot and futures intervention coefficients. Wald statistic—short US$ tests the null hypothesis of equality of the spot and futures intervention coefficients. Wald statistic—long US$ tests the null hypothesis of equality of the sum of the level and interaction term coefficients for spot and futures interventions.

38. Table 4 includes a battery of robustness checks of our baseline specification, including one additional regressor at a time. Regression 1 repeats our baseline specification. Regression 2 includes Brazilian macroeconomic announcement surprises (for inflation, unemployment and industrial production). Regressions 3 and 4 include the Citi EM Economic Surprise Index and the Citi Latin America Economic Surprise Index, respectively, in the specification alongside their respective lags. Neither variable appears to add much to the regressions' explanatory power and neither variable changes our results in a notable way. The same is the case when we add additional lags of the dependent variable (Regression 5).[28] Regression 6 adds the actual interest rate differential and once again our results are unchanged. Finally, Regression 7 drops all remaining insignificant variables from the regression without affecting our findings.

39. In sum, we find that spot and futures based intervention have very similar impacts on the exchange rate. While both types of FXI could drive spot exchange rates through signaling, coordination and portfolio balance channels (discussed in the introduction), two design features of futures intervention may limit its effectiveness relative to spot intervention. First, theory would predict futures intervention to be ineffective when convertibility risk is high. While our analysis confirms this expectation, episodes of non-negligible convertibility risk are rare and have thus only a limited impact on the regression coefficients (Figure A1). Second, the finite maturities of the futures contracts potentially expose FX investors to roll-over risk. Our finding that spot and futures based intervention have very similar impacts would suggest that the maturities are sufficiently long to limit such risk.

F. Intervention and Implied Exchange Rate Volatility

40. The final part of the empirical analysis examines a potential role for the two modes of FXI in reducing exchange rate volatility. Indeed, containing FX volatility was named a prime motive for FXI in a recent BIS survey of EM central banks (Mohanty and Berger, 2013). Short of targeting a specific exchange rate level or range, a role for FXI in limiting volatility in foreign exchange markets may arise in the form of limiting private sector exposure to FX risk. When private foreign liabilities in local currency grossly exceed private domestic assets in foreign currency (as is the case in Brazil), downside risks for private investors are more likely to arise in the form of depreciations rather than appreciations. It is thus through reducing its own net long position in foreign exchange that the central bank can limit private sector FX risk during periods of high volatility. Testing the relevance of this link and comparing the relative effectiveness of the two modes of intervention is the focus of this sub-section.

41. The dependent variable throughout this sub-section is the implied volatility in the real/dollar exchange rate. We use the same set of instruments and the same control variables as before, allowing us to focus our discussion here only on the second stage results. The first three

[28] We report coefficient only for the second lag but the regression includes up to four lags which were all insignificant. We also included day-of-the-week dummies (not reported), with no effect on our results.

Table 4. Robustness Checks

	1	2	3	4	5	6	7
Lagged daily pct change in FX	-0.141**	-0.140**	-0.139**	-0.138**	-0.152**	-0.163**	-0.142**
	(0.07)	(0.07)	(0.07)	(0.06)	(0.06)	(0.06)	(0.06)
CRB index, percent change	(0.14)	(0.14)	(0.15)	(0.16)	(0.12)	(0.12)	
	(0.10)	(0.10)	(0.10)	(0.10)	(0.09)	(0.10)	
CRB index, lagged percent change	-0.420***	-0.423***	-0.432***	-0.418***	-0.415***	-0.424***	-0.416***
	(0.08)	(0.08)	(0.09)	(0.09)	(0.08)	(0.09)	(0.08)
VIX, percent change	0.012**	0.012**	0.012**	0.011*	0.01	0.012*	0.017***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
VIX, lagged percent change	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	
Trend spot forward differential	0.164***	0.163***	0.166***	0.184***	0.177***	0.137***	0.161***
	(0.05)	(0.05)	(0.06)	(0.06)	(0.06)	(0.05)	(0.05)
5Y sov. CDS return, lagged	0.111***	0.111***	0.109***	0.109***	0.107***	0.114***	0.103***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)
Spot intervention	1.009**	1.005**	1.090**	1.223**	1.072**	0.900*	0.934*
	(0.49)	(0.49)	(0.52)	(0.56)	(0.49)	(0.51)	(0.48)
Futures intervention	0.729**	0.729*	0.711*	0.670*	0.733**	0.944***	0.660*
	(0.37)	(0.37)	(0.39)	(0.38)	(0.35)	(0.36)	(0.37)
Inflation surprise		0.46					
		(2.03)					
Unemployment surprise		(0.13)					
		(0.41)					
Industrial production surprise		(0.08)					
		(0.09)					
Citi EM surprise index			(0.71)				
			(0.72)				
Citi EM surprise index, lagged			0.54				
			(0.71)				
Citi LATAM surprise index				1.75			
				(1.50)			
Citi LATAM surprise index, lagged				(1.88)			
				(1.51)			
Lag 2 of daily change in FX					0.01		
					(0.05)		
Interest rate differential, change						(0.34)	
						(0.43)	
Interest rate differential, lagged change						(0.18)	
						(0.42)	
Constant	(0.02)	0.15	0.02	0.09	0.15	0.197*	0.14
	(0.05)	(0.11)	(0.10)	(0.11)	(0.10)	(0.11)	(0.11)
R^2	0.23	0.15	0.16	0.15	0.14	0.10	0.17
N	1100.00	1100.00	1086.00	1088.00	1100.00	1058.00	1101.00
Hansen's J stat.	8.4 (0.21)	5.1 (0.41)	5.1 (0.41)	4.8 (0.44)	4.2 (0.53)	5.0 (0.42)	5.1 (0.41)
Kl.-Paap rk Wald F stat	12.60	7.80	7.90	8.30	7.90	7.80	7.80
Kl.-Paap rk LM stat	71.1 (0.00)	49.1 (0.00)	49.3 (0.00)	51.5 (0.00)	48.2 (0.00)	49.0 (0.00)	49.0 (0.00)
Stock-Wright LM S stat	21.4 (0.00)	21.3 (0.00)	22.4 (0.00)	21.7 (0.00)	21.5 (0.00)	23.0 (0.00)	19.7 (0.01)
C test for endogeneity	15.0 (0.04)	17.2 (0.02)	17.2 (0.02)	17.2 (0.02)	17.2 (0.02)	17.2 (0.02)	17.2 (0.02)

Source: authors' calculations.

Notes: The dependent variables is the percent daily change in the real/$ rate. Explanatory variables are defined in Table A1. All regressions report estimates using CUE. Heteroscedasticity robust standard errors in parentheses. *, ** and *** denote statistical significance at 10 percent, 5 percent and 1 percent level. For test statistics p-values are reported in parentheses.

regressions in Table 5 present the results from estimating our baseline specification using the CUE and including the two intervention terms individually and jointly. Regression 4 shows the results from estimating the same specification as in Regression 3 using OLS in place of the CUE. Regression 5 extends the sample period back to 2003 (when the volatility data starts), Regression 6 tests for asymmetric effects of interventions. Regression 1 in Table 5b allows for dynamic impact of interventions and the remainder of the regressions add additional control variables for robustness. Table A4 in Appendix reports results from additional robustness checks, including estimating the coefficients via 2SLS.

42. As in the previous sub-section, we find that the control variables in Table 5 generally carry the expected signs and are often significant. The lagged dependent variable is significant with a positive coefficient in most regressions, indicating some (small) persistency in volatility movements. Higher commodity prices are significantly negatively associated with volatility in the real/dollar exchange rate as expected, and the impact is primarily contemporaneous. The VIX, in turn, enters the regression with a positive coefficient in all regressions and is always highly significant. Intuitively, higher risk aversion in global financial markets implies higher volatility in emerging market exchange rates.[29]

43. Regressions 1 and 2 in Table 5a contain the results from estimating the baseline specification when including one intervention term at a time. We note that both intervention terms enter the regression with the expected positive coefficient and are significant. Analogously to the exchange rate regressions, the coefficient estimates are strikingly similar, ranging between 4.2 and 4.6. When including the two terms jointly in Regression 3, the coefficients fall notably but remain in a close range between 2.3 and 3. The Wald test once again fails to reject the null hypothesis of coefficient equality. Taken at face value, these findings imply that US$1 billion in short dollar spot intervention or short dollar futures intervention reduces implied volatility in the real dollar exchange rate by some 2.5 percent. Regression 4, in turn, shows that the coefficient on the intervention term drops significantly in the absence of instruments, signaling that these were important in attenuating a likely negative bias. In line with this finding, a battery of tests confirms the validity of our instruments and documents the endogeneity of the two intervention variables.

44. The remainder of Table 5 conducts a number of robustness checks. Regression 5 extends the sample period to 2003–13 by dropping the FX transactions term from our set of instruments. Compared to the baseline specification in Regression 3, we find that the coefficient on spot intervention increases somewhat while futures intervention loses its significance and carries a somewhat lower coefficient than before. Regression 6 tests for asymmetric effects by adding interaction terms between the intervention variables and a dummy variable indicating positive interventions.[30] The estimated coefficients for both interaction terms carry negative signs but are not

[29] The coefficients for the lagged forward exchange rate differential and the CDS spread change are not statistically significant at any lags and are excluded from the later baseline analysis.

[30] As in the previous section we use interaction terms between "Positive" and lagged trend exchange rate volatility as well as trend intervention as additional instruments for the interaction terms.

Table 5. Second-Stage Regressions: Implied Volatility

	1	2	3	4	5	6
Lagged daily pct change in IV	0.070*	0.107**	0.090**	0.070*	-0.087**	0.102**
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.05)
CRB index, % change	-2.119***	-2.037***	-2.100***	-1.685***	-1.672***	-1.929***
	(0.34)	(0.35)	(0.34)	(0.37)	(0.36)	(0.33)
CRB index, lag % change	-0.169	-0.202	-0.217	-0.449	-0.533*	-0.396
	(0.37)	(0.36)	(0.37)	(0.36)	(0.28)	(0.36)
VIX, percent change	0.260***	0.280***	0.274***	0.287***	0.257***	0.284***
	(0.02)	(0.02)	(0.02)	(0.03)	(0.02)	(0.02)
VIX, lagged % change	0.056*	0.053	0.051	0.057	0.085***	0.068**
	(0.03)	(0.04)	(0.04)	(0.04)	(0.03)	(0.03)
Trend spot forward differential	0.161	-0.215	0.083	-0.31	0.106	
	(0.26)	(0.19)	(0.26)	(0.19)	(0.25)	
5Y sov. CDS return, lagged	0.047	0.087	0.079	0.06	0.197***	
	(0.07)	(0.08)	(0.08)	(0.07)	(0.06)	
Spot intervention	5.887***		3.849*	1.003*	4.262**	5.115*
	(1.85)		(2.07)	(0.55)	(1.98)	(2.87)
Futures intervention		3.975***	2.421*	-0.281	1.847	2.304*
		(1.23)	(1.25)	(0.39)	(1.23)	(1.38)
Spot positive * Spot interv.						-2.623
						(3.44)
Swap positive * Futures interv.						-1.291
						(1.57)
Constant	0.193	1.358***	0.86	0.728	0.798	0.980*
	(0.43)	(0.51)	(0.55)	(1.05)	(0.54)	(0.54)
R^2	0.24	0.18	0.23	0.3	0.15	0.24
N	1,097	1,097	1,097	1,097	1,935	1,097
Hansen's J stat.	6.9 (0.33)	6.2 (0.40)	3.2 (0.67)		1.1 (0.89)	10.2 (0.18)
Kl.-Paap rk Wald F stat	12	8.9	7.4		7.4	7.4
Kl.-Paap rk LM stat	67.5 (0.00)	50.3 (0.00)	46.8 (0.00)		54.9 (0.00)	51.3 (0.00)
Stock-Wright LM S stat	20.7 (0.00)	20.7 (0.00)	20.7 (0.00)		15.7 (0.02)	32.1 (0.00)
C test for endogeneity	20.2 (0.01)	20.2 (0.01)	20.2 (0.01)		12.9 (0.04)	53.6 (0.00)
Wald statistic			0.25 (0.61)		0.82(0.36)	
Wald statistic – short US$						0.59 (0.44)
Wald statistic – long US$						0.61 (0.43)

Source: authors' calculations.

Notes: The dependent variables is the percent daily change in real/$ implied volatility. The Spot (Swap) positive dummy takes the value one on days when the BCB takes a long dollar position via the respective mode of intervention. Other explanatory variables are defined in Table A1. Regression 4 reports OLS estimates, all other regressions report estimates using CUE. The coefficients for the spot and futures intervention in regression 7 are cumulative effects. Heteroscedasticity robust standard errors in parentheses. *, ** and *** denote statistical significance at 10 percent, 5 percent and 1 percent level. For test statistics p-values are reported in parentheses. Wald statistic tests the null hypothesis of the equality of the spot and futures intervention coefficients. Wald statistic—short US$ tests the null hypothesis of the equality of the spot and futures intervention coefficients. Wald statistic—long US$ tests the null hypothesis of the equality of the sum of the level and interaction term coefficients for spot and futures interventions.

Table 5. Second-Stage Regressions: Implied Volatility (Concluded)

	1	2	3	4	5
Lagged daily pct change in IV	0.118**	0.101**	0.100**	0.103**	0.094**
	(0.05)	(0.04)	(0.04)	(0.04)	(0.04)
CRB index, % change	-2.133***	-2.110***	-2.253***	-2.209***	-2.125***
	(0.36)	(0.34)	(0.34)	(0.34)	(0.34)
CRB index, lag % change	-0.396	-0.361	-0.323	-0.412	-0.346
	(0.39)	(0.38)	(0.38)	(0.38)	(0.37)
VIX, percent change	0.286***	0.274***	0.271***	0.273***	0.273***
	(0.03)	(0.02)	(0.03)	(0.03)	(0.03)
VIX, lagged % change	0.069**	0.069***	0.071***	0.067**	0.071***
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Spot intervention	3.276*	3.699**	3.716**	3.697**	3.765**
	(1.81)	(1.64)	(1.89)	(1.78)	(1.66)
Futures intervention	2.706*	2.274*	2.445*	2.558*	2.206*
	(1.46)	(1.26)	(1.31)	(1.33)	(1.28)
Inflation surprise		-3.158			
		(7.34)			
Unemployment surprise		0.412			
		(1.83)			
IP surprise		-0.135			
		(0.30)			
Citi LATAM surprise index			2.144		
			(4.45)		
Citi LATAM surprise index, lag			-2.487		
			(4.42)		
Citi EM surprise index				-4.653	
				-2.896	
Citi EM surprise index, lagged				3.954	
				-2.877	
Lag 2 of daily pct change in IV					0.04
					-0.04
Constant	0.883	0.913*	0.861	0.446	0.890*
	-0.539	-0.512	-0.546	-0.591	-0.514
R^2	0.16	0.23	0.23	0.23	0.24
N	1,065	1,097	1,085	1,083	1,095
Hansen's J stat.	3.4 (0.63)	3.1 (0.69)	3.5 (0.63)	2.8 (0.72)	3.1 (0.69)
Kl.-Paap rk Wald F stat	3.5	3.5	3.5	3.5	3.5
Kl.-Paap rk LM stat	22.3	38.5 (0.00)	37.5 (0.00)	37.5 (0.00)	36.9 (0.00)
Stock-Wright LM S stat	27.6 (0.00)	23.7 (0.00)	24.4 (0.00)	24.4 (0.00)	22.8 (0.00)
C test for endogeneity	28.2 (0.00)	24.4 (0.00)	23.6 (0.00)	25.0 (0.00)	24.0 (0.00)
Wald statistic	0.04 (0.84)				

Source: authors' calculations.

Notes: The dependent variables is the percent daily change in real/$ implied volatility. The Spot (Swap) positive variable takes the value one on days when the BCB takes long dollar position via the respective mode of intervention. Other explanatory variables are defined in Table A1. All regressions report estimates using CUE. The coefficients for spot and futures intervention in regression 1 are cumulative effects. Heteroscedasticity robust standard errors in parentheses. *, ** and *** denote statistical significance at 10 percent, 5 percent and 1 percent level. For test statistics p-values are reported in parentheses.

statistically significant, suggesting that both modes of intervention have symmetric impacts on volatility Regression 1 in Table 5a allows for dynamic effects of the interventions by including the first five lags of each intervention term in the specification. Only the coefficient for the first lag of futures intervention, however, is found to be significant, in line with previous findings in the literature. The estimated (quasi) cumulative impacts—shown in the table instead of the individual coefficients—are again very similar for the two modes of intervention. Finally, Regression 2 adds the three announcement surprise terms to the regression while Regressions 3 and 4 add the Citi Latin America and EM Economic Surprise Indexes and Regression 5 adds additional lags of the dependent variable.[31] The results remain robust to all these additions.

45. In sum, the results of this section suggest that both spot and futures intervention have important impacts on implied exchange rate volatility. As in the previous section, we also find that these impacts are strikingly similar for spot and futures interventions of a comparable magnitude. While the channels through which FXI affects volatility are the same for the two modes of intervention, spot intervention would be more effective to the extent that the finite maturity of futures contracts or the prevalence of convertibility risk limit the ability of futures intervention to reduce private sector FX risk. As in the previous section, the similarity in the effectiveness of the two modes of intervention thus suggests that convertibility risk is generally negligible and that the maturities of the futures contracts are sufficiently long not to give rise to significant convertibility risk.

G. Conclusions

46. This paper studies the relative effectiveness of foreign exchange intervention in spot and derivatives markets. We focus on the case of Brazil where spot and non-deliverable futures based intervention have been used alongside each other since the early 2000s.

47. In particular, we compare the Brazilian Central Banks's purchases and sales of spot dollars to its auctions of non-deliverable futures settled in local currency (futures intervention) via instrumental variable regressions that seek to explain changes in the R$–US$ exchange rate and its implied volatility. Our set of instruments for the two intervention terms makes use of a rich data set and succeeds at identifying distinct reaction functions that permit including the two modes of intervention jointly in our regressions.

48. The analysis finds strong evidence in favor of a significant link between intervention through both spot and derivatives markets and changes in the real/dollar exchange rate. What is more, the impact of US$1 in net spot market intervention is statistically indistinguishable to that achieved through auctions of non-deliverable futures worth US$1 in notional principal. This main result of our paper survives a battery of robustness checks including extending the length of the

[31] We report only the coefficient for the second lag but regression includes up to four lags whose coefficients are not statistically significant.

sample period. The same result holds when using implied exchange rate volatility as the dependent variable.

49. The analysis also detects significant differences in the reaction function estimates of the two instruments. The BCB appears to use spot intervention more so than derivatives based intervention in reaction to daily movements in the exchange rate and to capital flow pressures. Conversely, it is more likely to use futures based intervention to smooth trend movements in the exchange rate and when price pressures dominate. Finally, we also find that spot rather than derivatives based intervention tends to be used to offset the exchange rate effects of tighter/looser monetary policy.

50. Our results contribute to the scarce literature on derivatives based intervention in at least two important ways. First, to our knowledge this is the first study that analyzes empirically the relative effectiveness of spot and derivatives based intervention in a common framework. By providing evidence suggesting that intervention in derivatives markets can be no less effective than intervention in spot markets, it highlights the usefulness of a broader central bank toolkit. Second, our study allows comparing central bank reaction functions for spot and derivatives based intervention, allowing us to understand which factors incentivize both intervention more generally and one mode of intervention versus the other in particular.

Appendix I. Figure and Tables

Table A1. Variable Definitions and Sources		
Variable Name	**Definition**	**Source**
Dependent Variables		
Exchange rate	Percent Daily Change in Real/$	Bloomberg; authors' calculations
Volatility	Percent Daily Change in implied Real/$ volatility	Bloomberg; authors' calculations
Intervention Terms		
Spot intervention	Spot purchases net of Spot sales	BCB and authors' calculations
Futures intervention	Reverse FX swaps net of FX swaps	BCB and authors' calculations
Spot purchases	In billions US$	BCB and authors' calculations
Spot sales	In billions US$	BCB and authors' calculations
Reverse swaps	In billions of notional outstanding principal in US$	BCB and authors' calculations
Swaps	In billions of notional outstanding principal in US$	BCB and authors' calculations
Instruments		
FX deviation from trend	The difference between the exchange rate and the two week moving average of the exchange rate in log terms.	Bloomberg; authors' calculations
Trend FX volatility	Two week moving average of implied volatility	Bloomberg; authors' calculations
Medium-run FX trend	One year moving average of the log of the exchange rate	Bloomberg; authors' calculations
Trend FX transactions	One-week average FX transactions In billions US$	BCB and authors' calculations
Trend spot intervention	One week moving average of the spot interventions	BCB and authors' calculations
Trend futures intervention	One week moving average of the futures interventions	BCB and authors' calculations
Policy rate change	One week change in the Selic target rate	Bloomberg; authors' calculations
Difference between the onshore and offshore forward rate	One-week moving average percent difference between offshore and onshore NDF	Bloomberg; authors' calculations
Control Variables		
5Y sovereign CDS return	Percent daily change in 5Y sovereign CDS spread	Bloomberg; authors' calculations
CRB index	Thomson Reuters Core Commodity (CRB) price index	Haver; authors' calculations
VIX	Chicago Board Options Exchange Market Volatility Index	Haver; authors' calculations
Trend FX forward differential	One-week average percent difference between spot and forward rate	Bloomberg; authors' calculations
Inflation surprise	The difference between actual announcement and Bloomberg expectations	Bloomberg; authors' calculations
Unemployment surprise	The difference between actual announcement and Bloomberg expectations	Bloomberg; authors' calculations
Industrial production surprise	The difference between actual announcement and Bloomberg expectations	Bloomberg; authors' calculations
Citi EM surprise	Citi EM surprise Index	Haver; authors' calculations
Citi LATAM surprise	Citi Latam surprise Index	Haver; authors' calculations
Interest rate differential	Difference between Selic and Fed Funds rate	Bloomberg and Haver.
Other		
Convertibility Risk	Value 1 on days when cupom cambial is 1.5 std above sample mean	Bloomberg; authors' calculations
Cupom cambial	Three-month onshore dollar interest rate	Bloomberg; authors' calculations

Table A2. First-Stage Regressions, Alternative Instruments

	Spot	Futures	Spot	Futures	Spot	Futures
Lagged daily change in FX	-0.018*	0.011	-0.026**	0.008	-0.019*	0.011
	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.02)
CRB index, percent change	0.03	0.017	0.029	0.017	0.029	0.02
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
CRB index, lagged percent change	-0.024	-0.03	-0.022	-0.029	-0.022	-0.024
	(0.03)	(0.02)	(0.03)	(0.02)	(0.03)	(0.02)
VIX, percent change	0	-0.004**	0	-0.004**	0	-0.004**
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
VIX, lagged percent change	0.001	0.001	0.002	0.001	0.002	0.001
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Trend FX forward differential	-0.048***	0.008	-0.055***	0.011	-0.049***	0.002
	(0.02)	(0.01)	(0.02)	(0.01)	(0.02)	(0.01)
5Y sovereign CDS return, lagged	-0.002	-0.016***	-0.002	-0.016***	-0.002	-0.016**
	(0.00)	(0.01)	(0.00)	(0.01)	(0.00)	(0.01)
Lagged FX deviation from trend (2W)	-1.067*	-2.740***			-1.057	-2.529***
	(0.65)	(0.89)			(0.67)	(0.90)
Medium-run FX trend	-0.335	-0.808**	-0.216	-0.699**	-0.202	-0.572*
	(0.21)	(0.34)	(0.20)	(0.32)	(0.21)	(0.33)
Policy rate change	0.506***	-0.017	0.610***	-0.03	0.647***	0.053
	(0.14)	(0.34)	(0.16)	(0.33)	(0.16)	(0.33)
Lagged trend FX volatility (2W)	-0.009***	-0.014***	-0.009***	-0.012***		
	(0.00)	(0.00)	(0.00)	(0.00)		
Lagged trend FX transactions	0.000***	0	0.000***	0	0.000***	0
	0.00	0.00	0.00	0.00	0.00	0.00
Trend spot intervention, lagged	0.161**	-0.129*	0.163**	-0.115*	0.189**	-0.074
	(0.08)	(0.07)	(0.08)	(0.07)	(0.08)	(0.07)
Trend swap intervention, lagged	-0.023	0.396***	-0.011	0.377***	0.006	0.453***
	(0.04)	(0.12)	(0.03)	(0.12)	(0.04)	(0.12)
Citi LATAM surprise index	0.042*	0.01				
	(0.02)	(0.03)				
Lagged FX deviation from trend (1M)			-0.123	-2.421***		
			(0.40)	(0.62)		
Lagged trend FX volatility (1M)					-0.007**	-0.008***
					(0.00)	(0.00)
Constant	0.355**	0.539**	0.262*	0.444**	0.24	0.327
	(0.16)	(0.24)	(0.15)	(0.22)	(0.16)	(0.23)
N	1,094	1,094	1,100	1,100	1,100	1,100
F test	11.3 (0.00)	7.6 (0.00)	12.6 (0.00)	8.7 (0.00)	12.2 (0.00)	6.2 (0.00)
Kleibergen-Paap rk Wald F	11.3	7.6	12.6	8.7	12.2	6.2
Sanderson-Windmeijer F test	6.5 (0.00)	11.2 (0.00)	8.8 (0.00)	13.8 (0.00)	6.1 (0.00)	13.1 (0.00)
Kleibergen-Paap rk LM	74.2 (0.00)	47.7 (0.00)	71.3 (0.00)	48.9 (0.00)	70.3 (0.00)	37.9 (0.00)

Notes: The dependent variables in all columns are spot intervention—in billions of U.S. dollars—and futures intervention - in billions of U.S. dollar equivalent of notional principal—defined such that positive values imply that the BCB takes a long dollar position. All columns report CUE estimates. Columns 1−2 add macro-surprise news to the list of instruments. Columns 3−4 add the regional news index (Citi LATAM). Columns 5−6 use the one month moving average of the exchange rate to approximate short-term trends. Columns 7−8 use one month moving average of the implied volatility to approximate short-term trends in volatility. Heteroscedasticity robust standard errors in parentheses. *, ** and *** denote statistical significance at 10 percent, 5 percent and 1 percent level. For test statistics p-values are reported in parentheses.

Table A3. Second-Stage Regressions, Alternative Instruments

	1	2	3	4
Lagged daily change in FX	-0.138**	-0.129**	-0.143**	-0.142**
	(0.06)	(0.06)	(0.07)	(0.06)
CRB index, percent change	-0.129	-0.138	-0.138	-0.141
	(0.09)	(0.10)	(0.10)	(0.10)
CRB index, lagged percent change	-0.423***	-0.422***	-0.425***	-0.417***
	(0.08)	(0.08)	(0.08)	(0.08)
VIX, percent change	0.012**	0.013**	0.013**	0.012**
	(0.01)	(0.01)	(0.01)	(0.01)
VIX, lagged percent change	-0.009	-0.008	-0.008	-0.008
	(0.01)	(0.01)	(0.01)	(0.01)
Trend FX forward differential	0.162***	0.165***	0.154***	0.161***
	(0.05)	(0.06)	(0.06)	(0.05)
5Y sovereign CDS return, lagged	0.112***	0.113***	0.114***	0.110***
	(0.02)	(0.02)	(0.02)	(0.02)
Spot intervention	0.961**	0.983**	0.789*	1.000**
	(0.48)	(0.50)	(0.48)	(0.49)
Futures intervention	0.707*	0.642*	0.907**	0.666*
	(0.36)	(0.36)	(0.38)	(0.36)
Constant	0.143	0.124	0.183	0.139
	(0.11)	(0.11)	(0.11)	(0.11)
R^2	0.16	0.17	0.12	0.16
N	1,100	1,094	1,100	1,100
Hansen J	5.9 (0.65)	5.2 (0.51)	5.5 (0.36)	5.0 (0.42)
Kl.-Paap rk Wald F	5.5	7	9.6	7.4
Kl.-Paap rk LM	49.7 (0.00)	50.4 (0.00)	60.2 (0.00)	46.1 (0.00)
Stock-Wright LM S	22.2 (0.01)	21.6 (0.01)	22.4 (0.00)	20.0 (0.01)
C test for endogeneity	16.0 (0.10)	15.1 (0.06)	14.8 (0.04)	14.4 (0.04)

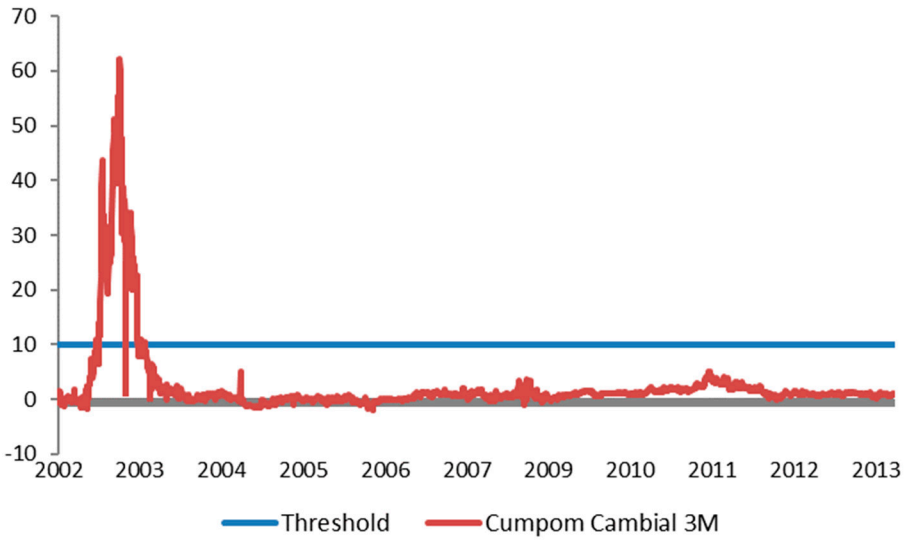
Notes: The dependent variables is the percent daily change in real/$. Explanatory variables are defined in Table A1. Regression 1 reports the second-stage results when macro-surprise news are added to the instrument set. Regression 2 adds the regional news index (Citi LATAM) to the instruments. Regression 3 uses one month moving average of the exchange rate to approximate short-term trends. Regression 4 uses one month moving average of implied volatility to approximate short-term trends in volatility. Heteroscedasticity robust standard errors in parentheses. *, ** and *** denote statistical significance at 10 percent, 5 percent and 1 percent level. For test statistics p-values are reported in parentheses.

Table A4. Second-Stage Regressions: Implied Volatility, Additional Regressions

	1	2	3	4
Lagged daily change in IV	0.157***	0.061**	0.104***	0.086***
	-0.04	-0.029	-0.033	-0.033
CRB index, percent change	-2.221***	-1.924***	-1.808***	-1.935***
	-0.337	-0.4	-0.367	-0.411
VIX, percent change	0.253***	0.282***	0.294***	0.288***
	-0.025	-0.029	-0.032	-0.03
Spot intervention	3.793**	6.426***		4.200**
	-1.632	-1.943		-2.089
Futures intervention	2.080*		3.647**	2.502**
	-1.245		-1.542	-1.207
CRB index, lagged percent change		-0.409	-0.396	-0.386
		-0.457	-0.471	-0.454
VIX, lagged percent change		0.044	0.045	0.04
		-0.034	-0.035	-0.035
Trend FX forward differential		0.198	-0.206*	0.12
		-0.222	-0.106	-0.202
5Y sovereign CDS return, lagged		0.074	0.106*	0.1
		-0.066	-0.061	-0.074
Constant	0.814	0.285	1.457**	0.976*
	-0.516	-0.297	-0.689	-0.52
R^2	0.22	0.23	0.2	0.22
N	1,105	1,097	1,097	1,097
Hansen J	3.5 (0.62)	7.7 (0.26)	7.8 (0.26)	4.2 (0.52)
Kl.-Paap rk Wald F	6.3	10.6	8.4	6
Kl.-Paap rk LM	38.2 (0.00)	19.2 (0.01)	12.4 (0.09)	16.7 (0.01)
Stock-Wright LM S	22.1 (0.00)	17.0 (0.02)	15.8 (0.03)	16.7 (0.02)
Endogeneity test	24.2 (0.00)	26.4 (0.00)	30.6 (0.00)	25.0 (0.00)

Notes: The dependent variables is the percent daily change in real/$ implied volatility. All explanatory variables are defined in Table A1. Regression 1 reports CUE estimates when all insignificant variables are excluded from the baseline specification. Regressions 2−4 report estimates of the baseline specification using 2SLS. Heteroscedasticity robust standard errors in parentheses. *, ** and *** denote statistical significance at 10 percent, 5 percent and 1 percent level. For test statistics p-values are reported in parentheses.

Figure A1. Convertibility Risk



Notes: The graph shows the evolution of Convertibility Risk proxied by the three month Cupom Cambial rate. The threshold is equal to one sample standard deviation above the sample mean. The cupom cambial is priced in basis points equal to the spread between the overnight interbank deposit rate and the expected exchange rate variation and serves as the onshore dollar interest rate.

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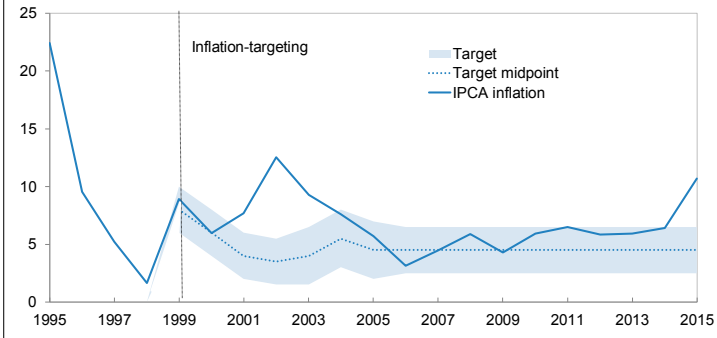
UPGRADING BRAZIL'S INFLATION-TARGETING FRAMEWORK[1]

Brazil was one of the early adopters of an inflation target in 1999. Its framework has proved resilient and inflation has stabilized at significantly lower rates than in previous decades. Since then, lessons from international research and the experience from other inflation-targeting countries have shown that it is possible to achieve better inflation and growth outcomes by enhancing central bank credibility and transparency. Brazil's experience also suggests that there could be room for improvement, as both inflation and inflation expectations have often deviated from the mid-point of the target range, increasing the cost of disinflation. This paper discusses how Brazil could upgrade its inflation-targeting framework in terms of its design, analytical framework and effectiveness of central bank communication. Central bank independence is the top priority, but Brazil could also benefit from adopting an inflation-forecast targeting framework. Whereas this paper focuses on monetary policy, a systematically consistent policy mix is also important to secure better inflation and growth outcomes.

A. Why Upgrade Brazil's Inflation-Targeting Framework?

1. Brazil's inflation-targeting framework has proved resilient, but inflation has often deviated from the mid-point of the target range. Brazil was one of the early adopters of an inflation-targeting (IT) framework in 1999 as the exit from a pegged exchange rate regime created the need for a new nominal anchor. The framework has proved resilient and inflation has stabilized at similar rates to those observed in the years immediately after the implementation of the *Plano Real* (1995–98) and significantly below those experienced during hyperinflation in previous decades.[2] However, inflation has often deviated from the mid-point of target range. Between 1999 and 2015, annual IPCA inflation oscillated between 3 percent and 13 percent, whereas the mid-point of the target remained close to 4.5 percent. In seventeen years of inflation-targeting, annual IPCA inflation was above the

Figure 1. Brazil Annual CPI Inflation, 1995-2015
(In percent)



Source: Brazilian Institute of Geography and Statistics (IBGE) and Banco Central do Brasil.

[1] Prepared by Sílvia Domit, Douglas Laxton and Joannes Mongardini (RES).

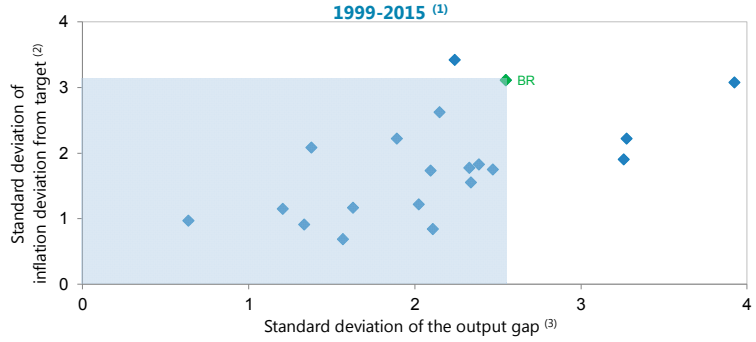
[2] Importantly, the new monetary policy regime was also supported by a strengthening of fiscal policy. For a comprehensive analysis of the early years of Brazil's IT framework, please see Bevilaqua, Mesquita and Minella (2007).

mid-point of the target range or its upper limit in 13 and 4 years, respectively. It has never been below the lower limit of the target range (Figure 1).

2. Reducing inflation and inflation volatility is important for a number of reasons.[3] High inflation is often associated with high inflation volatility.[4] This has been the case in Brazil since it adopted an IT system, as inflation volatility has come mostly from inflation outcomes being above the target (Figure 1). High and volatile inflation is not only costly to reduce, but it can also impair the efficient allocation of resources across the economy. Uncertainty about inflation also makes it more difficult for businesses and households to plan and make spending and saving decisions. Importantly, high inflation disproportionately affects low-income households, who have relatively limited access to financial instruments to protect their nominal income against inflation.

3. International experience suggests that it is possible to achieve better inflation and growth outcomes. IT became a popular monetary policy framework since it was first implemented by New Zealand in 1989.[5] It has now been adopted by about 30 central banks around the world. The framework has evolved in recent decades as new research and practice have shed light on how to achieve better outcomes, particularly in terms of lower volatility of inflation and GDP growth. By upgrading its IT framework, Brazil might also benefit from better economic outcomes. Indeed, many inflation-targeting countries (including in Latin America) have experienced lower inflation and output volatility than Brazil since 1999 (Figure 2).[6] Of course, the divergence in output and inflation volatility across countries also reflects differences in the structure of the economy and the type and magnitude of the shocks it is subject to. But the sample includes both advanced economies—which have been severely affected by the global financial and the European debt crises—and other emerging market economies—which, like Brazil, are particularly vulnerable to additional shocks, such as commodity price fluctuations and swings in capital flows. So, taken together, these also suggest that it might be worth investigating whether Brazil has room for enhancing its monetary policy framework.

Figure 2. Standard Deviation of Inflation and Output Across IT Countries, 1999-2015 (1)



Source: Fund Staff calculations.
(1) The sample includes only the years in which inflation-targeting was in place and countries where inflation-targeting had been introduced by the early 2000s, namely Australia, Brazil, Canada, Chile, Colombia, Czech Republic, Hungary, Iceland, Israel, Mexico, New Zealand, Norway, Peru, Philippines, Poland, South Africa, South Korea, Sweden, United Kingdom and Thailand.
(2) In percentage points. Target has changed over time in some countries.
(3) Output gap defined as the percent deviation of output from potential output. Based on central banks estimates where available and on HP filter estimates otherwise.

[3] See, for example, Svensson (2003).

[4] See, for example, Kiley (2007) and Alves (2014).

[5] Please see Freedman and Laxton (2009) for a discussion of the merits of IT and its intellectual roots.

[6] The same conclusion holds if 2015 (year of great macroeconomic volatility in Brazil) is excluded from the sample.

4. Lessons from theory and practice in recent decades have highlighted the role of expectations in achieving better inflation and growth outcomes. The key insights are that monetary policy is more effective when: (i) the central bank is credible such that inflation expectations are anchored; and (ii) when monetary policy can influence expectations of future interest rates, which the central bank can achieve with enhanced transparency. Over time, many central banks have adopted an inflation-forecast targeting framework, which has credibility and transparency as core principles. These are the topics covered in the next sections. Section B discusses why managing expectations (through improving central bank credibility and transparency) is crucial for increasing the effectiveness of monetary policy and how inflation-forecast targeting incorporates that insight. Section C discusses how Brazil can upgrade its IT framework to achieve lower inflation and output volatility. Section D uses a simple model to illustrate the potential benefits for Brazil of upgrading its IT framework.

5. Whereas this paper focuses on monetary policy, a systematically consistent policy mix is also important to secure better inflation and growth outcomes. Adopting measures to enhance the transmission of monetary policy and to promote broader macro stability are also important to achieve lower output and inflation volatility. For example, the large share of subsidized credit extended by public banks weakens the effectiveness of monetary policy, requiring higher policy interest rates to achieve a given inflation outcome.[7] And widespread price- and wage-indexation practices augment the effect of price shocks and spread their impact across the economy. In particular, the minimum wage indexation mechanism has contributed to the erosion of competitiveness, as real income gains in excess of productivity growth have boosted unit labor costs.[8] In addition, sound fiscal and macroprudential policies are essential for price stability. A deteriorating fiscal position and concerns over fiscal dominance pose challenges to the conduct of monetary policy.

B. Credibility, Transparency and Inflation-Forecast Targeting

6. Modern academic research and international best-practice have shown that effective monetary policy relies on successfully managing expectations. There are two key aspects to this finding: (i) the role of central bank credibility and anchored long-run inflation expectations; and (ii) the role of transparency in central bank communication in influencing expected future short-term interest rates and in anchoring inflation expectations. Both of these aspects are core principles of inflation-forecast targeting (IFT).

[7] As discussed in the IMF staff report for the 2014 Article IV Consultation and the 2013 Financial System Stability Assessment. Please see Bonomo and Martins (2016) for firm-level evidence on the impact of government-driven loans on the monetary transmission mechanism in Brazil.

[8] The current formula for minimum wage, by affecting the growth in pension and other benefits, is also a source of fiscal pressure.

How can central bank credibility reduce inflation and output volatility?

7. Reducing inflation volatility often comes at a cost of higher output volatility in the short run. Economies are often hit by shocks that move inflation and output in opposite directions. For example, higher energy prices push up on inflation, but reduce real disposable income and thus weigh on demand and growth. By trying to bring inflation back to target in response to such shocks, monetary policy would need to exacerbate the deviation of output from potential in the short run: in trying to reduce inflation volatility, monetary policy increases output volatility.[9] The policy decision involves choosing the best trade-off between output and inflation volatility in the short run, while anchoring long-term inflation expectations to the target.[10]

8. Central bank credibility can reduce <u>both</u> inflation and output volatility in the short run. Despite this short-run trade-off, monetary policy can achieve a better balance between inflation and output volatility when the central bank is credible.[11] This is because anchored inflation expectations reduce inflation persistence and increase the efficacy of monetary policy, reducing both the impact on inflation of a given shock and the change in output needed to bring inflation back to target. When inflation expectations are not anchored, shocks that move inflation away from the target will have an extra effect on future inflation through two main channels:

a. **Price and wage setting behavior**. By pushing up wages and prices, higher inflation expectations could lead to inflation becoming more persistent. If households expected inflation to remain high, they might demand higher nominal wages in order to avoid losing purchasing power. If firms expected prices to rise in the future, they might raise the prices of the goods and services they produce, and might also choose to raise wages. Recent survey evidence suggests that current inflation is a key driver of pricing decisions in Brazil.[12] The impact of current inflation on future prices and wages can be larger in the presence of price and wage indexation, as it is the case in Brazil. Indexation automatically increases inflation persistence and is itself a symptom of low monetary policy credibility.

b. **Expected real interest rates, exchange rates and asset prices**. Inflation expectations act as shock amplifiers or absorbers depending on whether the central bank is credible. When the central bank is not credible, a shock that shifts inflation above the target will raise inflation expectations, lowering expected real interest rates, boosting asset prices (through the lower real discount rate) and depreciating the exchange rate. These would affect households and

[9] Whereas the central bank should look through the direct effects of such shocks, it would need to offset any second round effects, ie: ensure that the rise in the prices of a particular good does not lead to faster increases in the price of other goods and services.

[10] Monetary policy has no impact on real variables such as output in the long run. The short-run trade-off has been extensively discussed in the monetary policy literature and is often represented by the Taylor efficiency frontier, which shows combinations of lowest volatility of inflation and output volatility for a given degree of interest rate volatility.

[11] See Freedman and Laxton (2009), Kumhof and Laxton (2007) and Svensson (2003) for a discussion of how a credible monetary policy regime can result in improvements in inflation and output volatility.

[12] Correa, Petrassi and Santos (2016).

companies spending decisions and stimulate demand, amplifying the upward pressure on inflation. In contrast, if the central bank were credible and committed to adjusting policy to bring inflation back to target following the adverse shock, inflation expectations would remain anchored, current and future short-term real interest rates would be higher, resulting in an exchange rate appreciation and lower asset prices, which would weigh on demand and help absorb the impact of the original shock.

As a result, when inflation expectations are anchored, both policy interest rates and output need to move by less to bring inflation back to target. So whereas a central bank will always face a short-term trade-off between stabilizing inflation and output, this trade-off will be better when monetary policy is credible, resulting in lower inflation and output volatility over the medium-term.[13]

How can transparent central bank communication reduce inflation and output volatility?

9. Effective monetary policy relies on successfully influencing expectations about the future path of short-term interest rates. This is because whereas the central bank controls the short-term policy interest rate, what matters most for private-sector spending decisions (and thus inflation and output) is the impact of monetary policy on the public's expectations about future policy and, as a result, on longer-term interest rates, asset prices and the exchange rate.[14]

10. Transparent central bank communication is crucial to influence expectations of future policy rates and to secure credibility.[15] Policy decisions that are neither well-communicated nor clearly explained could have little or even the opposite effect on expectations of future policy rates, and thus on the economy. They could also damage central bank credibility and de-anchor inflation expectations. In contrast, the more the public understands the aims of future policy and how the central bank would react in various circumstances, the less monetary policy itself might need to adjust. And the more the central bank explains its reasoning in detail, the more convincing the promise to return inflation to target becomes. Improving transparency through communication about *what variables the central bank responds to*, *how aggressively* and *why* is crucial to improve policy effectiveness, and thus achieve lower inflation and output volatility.[16]

The policy frontier: inflation-forecast targeting

11. Credibility and transparency are core principles of inflation-forecast targeting. As the critical role of credibility and transparency has become clearer, both advanced and emerging market economies have upgraded their frameworks to flexible inflation-targeting, or inflation-forecast targeting (IFT). Nearly two thirds of the countries currently with an inflation target (or objective) are

[13] See, for example, Svensson (2003) or Woodford (2005).

[14] See, for example, Yellen (2012) and Woodford (2005).

[15] Transparency is equally important to ensure the central bank remains accountable to the public for its actions.

[16] See, for example, Woodford (2005) and Bernanke (2010).

inflation-forecast targeters. The three distinguishing features of IFT central banks—which embed the role of credibility and transparency—are:

I. A well-defined long-term target
II. Forecasts based on endogenous interest rates and exchange rates
III. Central bank's inflation forecast used as intermediate target and communication tool

In practice, IFT frameworks function as follows. First, a well-defined long-term target (namely a continuous point target) is announced. Second, the central bank publishes a forecast where inflation returns to the target over its preferred horizon and explains which policies are consistent with this forecast. Finally, it *credibly* communicates the rationale behind the policy decision, as well as why previous forecasts were or were not fulfilled and the key judgments and risks around the latest forecasts. IFT frameworks also share a number of features with traditional IT frameworks, namely central bank independence; the use of the inflation target as a nominal anchor; accountability mechanisms; and the need for sound fiscal and macroprudential policies to support monetary policy. [17]

12. Well-defined long-term targets increase the effectiveness of monetary policy.[18] Two characteristics of an inflation target are essential for anchoring inflation expectations and thus improving the effectiveness of monetary policy. First, clarity about what the central bank's target truly is, allowing long-run inflation expectations to anchor around it. Second, the target should acknowledge both the short-run output-inflation trade-off and the long lags in the transmission of monetary policy. Effectively, these mean that it is neither possible (given lags) nor optimal (given the trade-off) to keep inflation on target at all times or to aim to hit the target at a given time (eg: at the end of the year). An inflation target defined as a range to be reached at the end of the year, as it is the case in Brazil, is at odds with these concepts. The target range provides flexibility, which can be used to accommodate shocks that monetary policy cannot or chooses not to offset by the end of the calendar year. But this comes at the cost of lack of clarity about what inflation rate the policymaker truly wants. This can be particularly challenging when the central bank is not independent. In periods of persistent deviation of inflation from the target, this could lead inflation expectations to anchor at the upper or lower bounds of the target range instead of its mid-point. Also, because of the lags with which monetary policy operates, occasionally it might be optimal to allow year-end inflation to be outside the target range (for example, when large price level shocks happen close to the end of the year). But that could also damage credibility. In contrast, a well-defined long-term target, namely a continuous point target, is clear about what inflation rate the policymaker truly wants. Its long-run focus communicates that whereas inflation will remain close to the target on average,[19] it will deviate from it when optimal, provided long-term expectations

[17] For further discussion of inflation-forecast targeting, please see Freedman and Laxton (2009a, b), Clinton and others (2015), Svensson (2003), Svensson and Woodford (2003) and Friedman and Woodford (2011).

[18] Please see Clinton and others (2015).

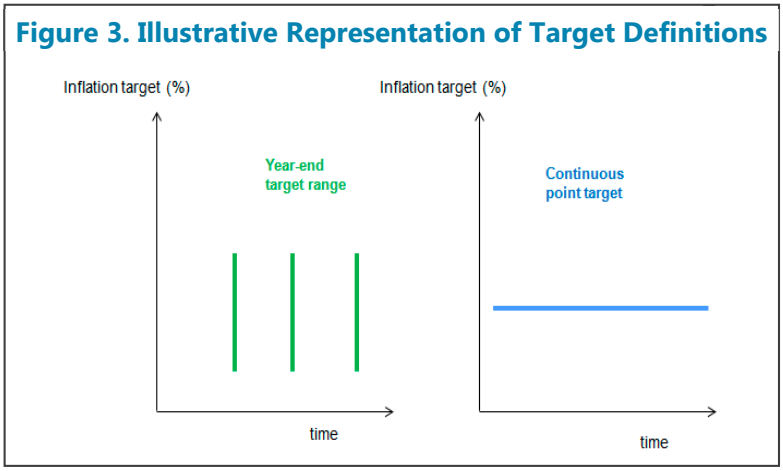
[19] While the policymaker does its best to minimize deviations from the point target, over long periods, inflation will be about equally likely to fall on either side of the target.

remain anchored and the central bank credibly communicates how it will bring inflation back to target (Figure 3 and Table 1).[20]

Table 1. Inflation Target Credibility and Transparency Checklist

	Year-end target range	Continuous point target
Effectively anchors long-term inflation expectations (clarity about what policymaker truly wants)	χ	✓
Long-term focus (acknowledges output-inflation trade-off and lags in monetary policy transmission)	χ	✓

Figure 3. Illustrative Representation of Target Definitions



13. Forecasts based on endogenous interest and exchange rates enhance transparency, credibility and thus make monetary policy more effective. Under IFT, the monetary policy committee (MPC) chooses, at each policy meeting, a policy-rate path consistent with the forecast for inflation being at target over the forecast horizon. This approach is superior to producing forecasts based on exogenous interest rates and exchange rates (such as constant or market-implied paths). This is because it recognizes that it is the entire path of expected future policy rates (rather than the MPC's current target for the short-term policy rate) that affects the interest rates which are relevant for output and inflation. The approach also allows the central bank to influence the expected path of future short-term rates, making monetary policy more effective.[21] Some IFT central banks influence expectations by describing their preferred interest rate path with words. The most transparent—such

[20] Some IFT central banks also add a band around their long-term point target as a way of explicitly communicating that inflation will deviate from the point target at times even if, on average, inflation will remain close to the point target. In contrast to the range target, the upper and lower bounds of the band are not the target.

[21] Other reasons why forecast based on exogenous interest rates and exchange rates are inferior include concerns about appropriately measuring market expectations and technical difficulties regarding model solvency and stability. Please see Woodford (2005) and Rosenberg (2007) for comprehensive theoretical and practical explanations on why using exogenous paths is an inferior approach. Woodford (2005), in particular, discusses the experience of the Bank of England with exogenous interest rate assumptions.

as in the Czech Republic, New Zealand, Norway and Sweden—go as far as publishing that path. The Federal Reserve Board has moved in a similar direction, by publishing FOMC participants' median assessment of the appropriate path for policy rates. Importantly, publishing the MPC's current preferred path for interest rates does not preclude it from deviating from it when the future comes. The fear that the public would understand these paths as a promise has proved unwarranted by the experience of the countries who have published it.

14. Inflation forecasts in IFT central banks are effectively an intermediate target and a key communication tool. As it is neither possible nor ideal to keep inflation at target at all times, the inflation forecast based on endogenous interest rates is effectively an intermediate target, as it communicates at what speed the central bank plans to bring inflation back to target. It incorporates the preferences of the policy makers, their views about the economy and about the transmission mechanism of monetary policy. In addition to using the forecast as a communication tool, IFT central banks aim to convincingly explain the reasoning behind individual policy decisions; publish their assessment of the economic outlook as well as the analysis behind that assessment; and discuss the risks around those views. Taken together, these allow IFT central banks to be transparent about how they expect to manage the short-run output-inflation trade-off. This, in turn, helps affect both inflation expectations and expectations of future policy, making monetary policy more effective.

C. How can Brazil Achieve a Better Short-run Output-Inflation Trade-off?

15. Brazil could benefit from upgrading its IT framework in terms of its design, analytical framework and effectiveness of central bank communication. The purpose of this section is two-fold. First, it discusses evidence on central bank credibility and transparency in Brazil. Second, it presents key measures Brazil could take to upgrade its IT framework. Over time, these measures would increase the credibility and effectiveness of monetary policy by affecting the public's expectations of future policy and anchoring inflation expectations, allowing for better inflation and output outcomes.

C.1 Central bank credibility and transparency in Brazil

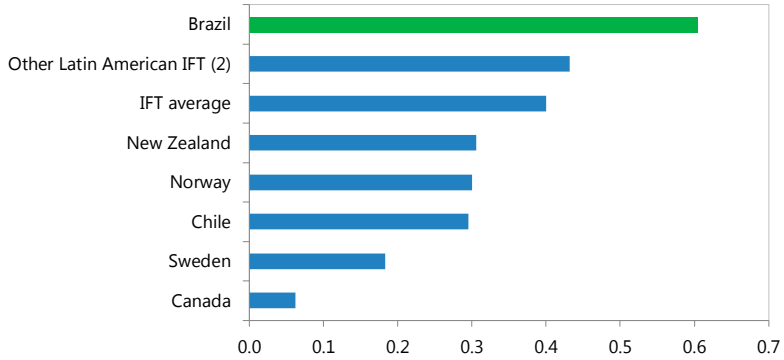
16. Credibility is typically measured by comparing inflation expectations to the target over the medium– to long–run. Whereas central bank credibility is not directly observable, better-anchored IT frameworks tend to have smaller deviations of inflation expectations from the target, lower dispersion of inflation forecasts, and minimum correlation between long-run inflation expectations and current inflation or inflation surprises. Focusing on longer horizons (typically beyond 5-years-ahead, but at least 3-years ahead) is important because short-term measures are highly correlated with current inflation – which is affected by price level shocks – and because it accounts for the long lags of monetary policy transmission. Another way of assessing credibility is to compare private-sector forecasts with those of the central bank (typically available at shorter horizons). Finally, it is important to capture a representative set of expectations: international best-

practice has been to regularly monitor expectations from a wide set of economic agents, including households, firms, professional economic forecasters and financial markets.[22]

17. Available data suggest that Brazil can improve central bank credibility. Whereas data on inflation expectations are relatively limited for Brazil, available information suggests the system could be better-anchored.[23] In Brazil, the deviation of longer-term inflation expectations from the mid-point of the target range has been higher than in other countries, particularly the most anchored inflation-forecast targeters, such as Canada and Chile (Figure 4).[24] Large deviations have been frequent in recent years (Figure 5). At the same time, market participants have consistently expected higher inflation than the central bank's forecast produced using interest rate expectations from market participants (Figure 6). The dispersion of inflation forecasts in recent years has also been somewhat high relative to the experience of the top countries (Figure 7). Finally, previous Fund Staff work has shown that, starting in 2011, upside inflation surprises had begun to affect inflation expectations at 18-month horizons.[25] Taken together, these suggest that there is room for improving central bank credibility in Brazil.

Figure 4. Longer-Term Inflation Expectations, 1999-2015 Average (1)

(Absolute deviation from target, percentage points)



Source: Consensus Forecasts and Fund Staff calculations

(1) 3-year-ahead inflation expectations

(2) Average of Colombia, Mexico and Peru from start of respective inflation-targeting framework

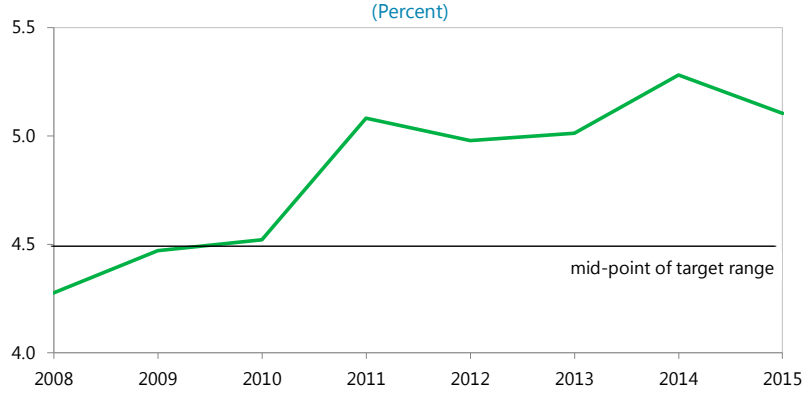
[22] See, for example, Anderson and Maule (2014) or Domit, Jackson and Roberts-Sklar (2015).

[23] Data availability is rich when it comes to inflation expectations of professional forecasters, but coverage of other sectors is limited. The most comprehensive sources are the BCB's (Relatório Focus) and Consensus Economics (Long Term Consensus Forecasts) surveys, which cover professional forecasters' expectations 1 to 5 years ahead. Market-based measures (derived from the difference between yields on nominal and inflation-linked government bonds) exist, but are not readily available to the general public (mainly due to the technical expertise required to compute estimates of inflation and liquidity risk premia). Households' expectations are available from the FGV IBRE (Sondagem de Expectativas do Consumidor), but data only start in mid 2014. We are unaware of reliable measures of firms' expectations.

[24] Consensus Forecasts used to allow for international comparison, but BCB survey shows similar results. Longer-term inflation expectations measured at the 3-year-ahead horizon to ensure sample size is representative, but 5-year-ahead expectations exhibit similar pattern.

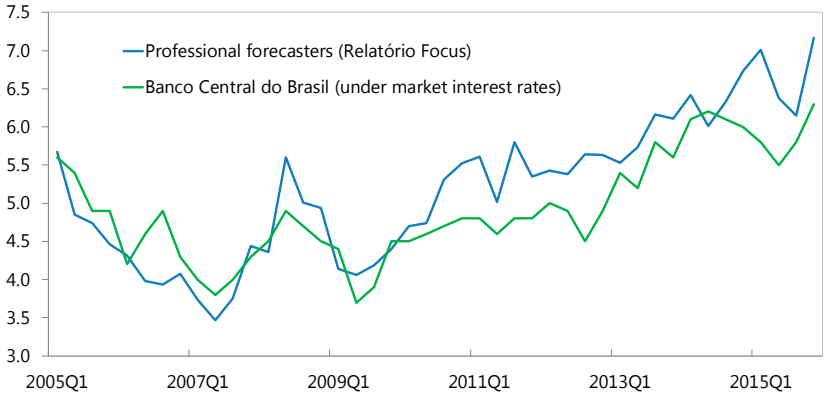
[25] Roache (2014).

Figure 5. Longer-Term Inflation Expectations in Brazil (1)



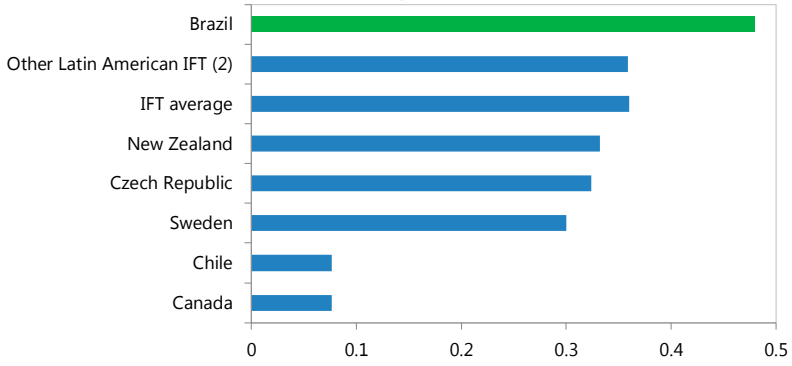
Source: Consensus Forecasts and Fund Staff calculations
(1) 3-year-ahead inflation expectations

Figure 6. Short-Term Inflation Forecasts (1-year-ahead)



Source: Banco Central do Brasil.

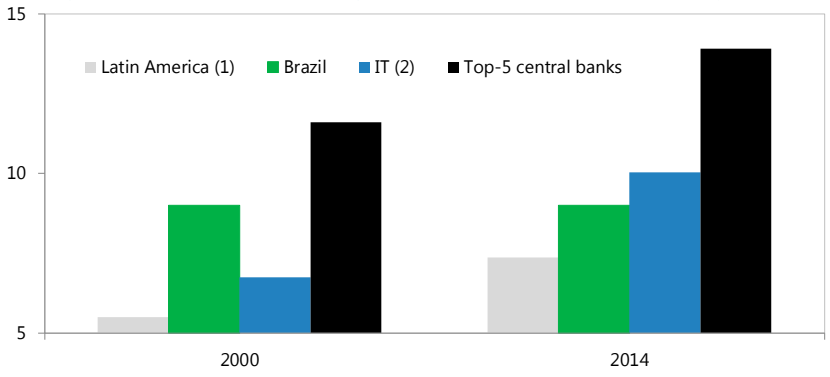
Figure 7. Dispersion of Long-Term Inflation Expectations, 2011-2015 Average (1)



Source: Consensus Economics and Fund Staff calculations
(1) 3-year-ahead inflation expectations, standard deviation of sample of forecasts
(2) Average of Colombia, Mexico and Peru

18. Brazil could also make monetary policy more effective by increasing central bank transparency. Both research and international practice have shown that increased transparency in central bank communication makes monetary policy more effective (Section B). As such, central bank transparency has increased significantly across the globe in recent years. It also played a key role during the Great Financial Crisis, helping advanced economies overcome challenges posed by the effective lower bound for policy interest rates. Whereas measuring transparency is inherently difficult, published academic research has relied on transparency indices such as the one produced by Dincer and Eichengreen, which scores central banks in a number of categories.[26] According to this comprehensive measure, central bank transparency in Brazil has tended to be higher than in other Latin American IFT countries. However, central bank transparency has not generally improved in Brazil since the IT framework was adopted, whereas it has been steadily increasing in other central banks, particularly those currently at the frontier. The gap between the Banco Central do Brasil (BCB) and the most transparent central banks is large and has widened, suggesting there is room for improvement (Figure 8).

Figure 8. Dincer and Eichengreen Central Bank Transparency Index



(1) Average of Chile, Colombia, Mexico and Peru
(2) Average of all central banks with an inflation target
Source: Dincer and Eichengreen (2014)

C.2 What could Brazil do to upgrade its inflation-targeting framework?

19. Brazil could reduce output and inflation volatility by increasing central bank independence and upgrading to an inflation-forecast targeting framework. This section discusses specific measures, summarized in Table 2.

Central Bank Independence

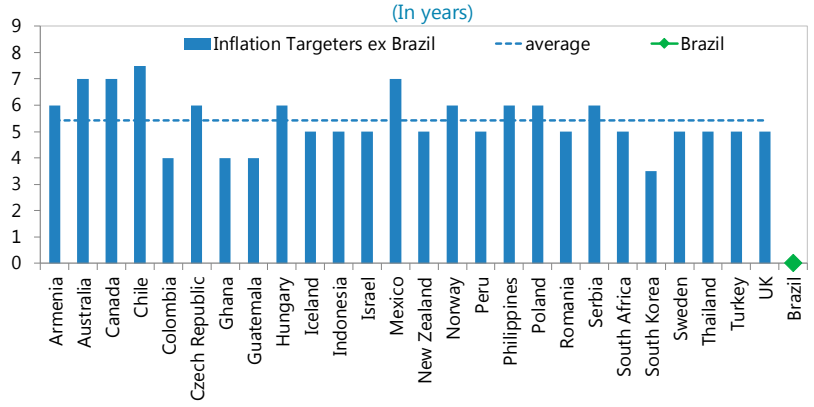
20. The case for central bank independence is well-established in the literature and has been validated by international experience. The technical argument in favor of central bank independence is simple: an independent central bank is more credible because it is free from either perceived or actual political interference to either boost short–run growth or finance the budget deficit at the expense of higher inflation. Increased credibility translates into better-anchored

[26] Dincer and Eichengreen (2014) construct an index of central bank transparency which acknowledges various dimensions of transparency covering five broad aspects: political, economic, procedural, policy and operation transparency. For each category, the authors establish three criteria, and award central banks a score of 0, ½ or 1 depending on the extent of transparency. Under this scoring system, the maximum score awarded to any central bank is 15 and the minimum is 0. The underlying data are gathered from central banks' statutes, annual reports and other published documents. Whereas any measure of this nature is bound to be imperfect, the broad scoring patterns may be a reasonable approximation of international trends.

inflation expectations, allowing the central bank to achieve better inflation and output outcomes. This has been well-established in an extensive literature which dates back to the late 1970s and continues to be supported by today's policymakers.[27] Also, international experience shows that central bank independence has been associated with better inflation outcomes with no cost to economic growth.[28]

21. Brazil is an outlier for its lack of 'legal' (or '*de* jure') central bank independence.[29] The two distinctive features which Brazil lacks are: (i) a law that gives the central bank the mandate to achieve monetary and financial stability,[30] and (ii) fixed-term appointments for members of the monetary policy committee (MPC) which do not overlap with the political cycle (to insulate them from political pressure) (Figure 9). Once *de jure* independence is granted, *de facto* independence is secured through systematically appointing analytically strong board and staff members. Central bank independence should be accompanied by mechanisms to ensure the central bank remains accountable to the public and it has enough resources to achieve its mandates. These mechanisms would be part of the central bank law/act and often take the form of regular testimonies to Congress by the central bank governor (which the BCB already has in place) and members of the MPC, as well as annual reports on the central bank's management and financial accounts.

Figure 9. Terms of Employment of MPC Members: Length of Contract (1)



(1) Average of fixed contract legth for Governor and Deputy Governors
Source: Hammond (2012)

A well-defined long-term target

22. Brazil could better anchor inflation expectations and improve central bank credibility by adopting a well-defined long-term target. Brazil's design of its inflation target follows international best-practice in that it uses as benchmark a reliable index of headline inflation which is not computed by the central bank itself. But there is room for improvement. The target is defined as

[27] See Kydland and Prescott (1977), Calvo (1978), Barro and Gordon (1983), Bernanke (2010) and Fischer (2015).

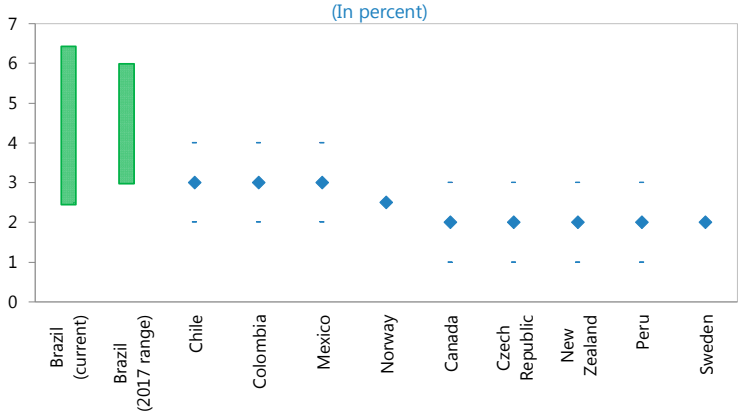
[28] See, for example, Cukiermand and Neyapti (2001), Alesina and Summers (1993) and Joyce, Lildholt and Sorensen (2010).

[29] By central bank independence, we refer specifically to independence from political influence in setting policy. The Banco Central do Brasil has autonomy to make monetary policy decisions.

[30] Decree no. 3088 (21 June, 1999) only goes as far as establishing the inflation-targeting framework. For examples of central bank acts, please see: http://www.federalreserve.gov/aboutthefed/fract.htm, http://www.bankofengland.co.uk/about/Pages/legislation or http://laws-lois.justice.gc.ca/eng/acts/B-2/FullText.html

a 'tolerance interval' which allows inflation to range between 2.5 percent and 6.5 percent and is considered met as long as inflation is anywhere within this interval at the end of the year.[31] This is in contrast to IFT countries, which have long-term point targets (Figure 10).[32] The distinction between a point and a range target, as well as the difference between a short- and long-term horizon are both important. The lack of a well-defined long-term point target permits outcomes which, while formally in compliance with the framework, can erode its credibility and contribute to a de-anchoring of long-run inflation expectations (Section B).

Figure 10. Inflation Targets, Cross-Country Comparison[(1)]
(In percent)



(1) Established IFT central banks and Brazil
Source: Central banks or monetary authorities

A structured forecasting framework with endogenous interest rates and exchange rates

23. The BCB could increase policy effectiveness and credibility by enhancing its forecasting and policy analysis framework. Through an IFT forecasting and policy analysis system (FPAS), BCB staff would provide economic analysis and produce a model-based staff forecast using endogenous interest rates and exchange rates. The staff forecast would be used as a baseline for the MPC's discussions of the economic outlook, policy options and scenario analysis. The MPC forecast would then incorporate the MPC's view about the economy, their preferred path for policy rates as well as their assessment of the balance of risks.[33]

Effectiveness of central bank communication

24. The BCB uses most of the central bank communication tools adopted internationally. For example, it publishes a quarterly *Inflation Report* with updated inflation and GDP forecasts and it holds a press conference to explain those. COPOM's policy decisions are accompanied by press statements and minutes from the policy meeting and the votes of the committee members are published. Also, the background material presented to the COPOM is released following a deferral period. Finally, open letters and testimonies to Congress are used as accountability tools. One area

[31] Please see Decree no. 3088 (21 June, 1999).

[32] For examples of how the target is defined in IFT countries, please see:

http://www.rbnz.govt.nz/monetary-policy/policy-targets-agreements

http://www.norges-bank.no/en/about/Mandate-and-core-responsibilities/Monetary-policy-in-Norway/

http://www.bcentral.cl/en/faces/pmonetaria/ipom

[33] For a discussion of how central banks have developed an FPAS to support IFT regimes, please see Clinton and others (2015).

where the BCB could expand its toolkit is through a more extensive use of speeches and media interviews by COPOM members.[34]

25. The room for transparency improvement in the case of the BCB is mostly on the effectiveness of its communication rather than on the range of tools used. In particular, official central bank communication could benefit from: a) publishing endogenous inflation and growth forecasts, ie: forecasts which are internally consistent with the COPOM's preferred policy path (even if the policy path itself is not published), as opposed to based on exogenous interest and exchange rates; b) placing less emphasis on a factual description of historical data in favor of a more in-depth assessment of the key drivers of growth and inflation;[35] c) explaining how (and why) these key drivers are assumed to evolve in the central forecast (and, when updating the forecast, discussing how these evolved relative to expectations); d) better explaining monetary policy strategy issues and the motivation behind the policy decision (namely, policymakers' preferences on how to manage the short-term output-inflation trade-off); and e) providing a more substantive discussion of the risks around the central forecast.

26. The latest changes to the COPOM's communication style are an important step in the right direction, but further progress can be made. In recent months, a number of important changes have been introduced by the BCB, affecting the Inflation Report, the policy statement and the minutes from the policy meeting (now called 'notes'). These have helped improve central bank communication. In particular, there is less emphasis on a factual description of historical data in favor of a more detailed discussion of the balance of risks and the divergence of views within the committee. But there is scope for further gains from introducing new enhancements, as discussed above and summarized in Table 2.

Central Bank governance

27. Measures to enhance MPC credibility and internal transparency could also be beneficial. Whereas central bank governance is a broad topic, we focus on three measures which could be particularly helpful for credibility and transparency:

a. First, it is best-practice for the MPC to follow a code of conduct for external engagement. Such code would provide guidelines for MPC members on issues such as liaison with the media, speeches, political involvement, conflicts of interest and purdah (or blackout) periods for external engagement, amongst others.[36] Such guidelines would serve to reinforce the reputation and integrity of the monetary policy process.

[34] Another available tool is publishing endogenous interest rate paths (section B).

[35] For example, a discussion of the evolution of labor supply, productivity, cost pressures, wages, margins, savings, the degree of slack in the economy, pass-through from price level shocks, foreign demand and prices, etc.

[36] For examples of MPC codes of conduct, please see: https://www.federalreserve.gov/monetarypolicy/files/FOMC_ExtCommunicationParticipants.pdf and www.bankofengland.co.uk/monetarypolicy/Documents/mpccoc.pdf

b. Second, it is also best-practice for the MPC to be composed only by individuals with expertise in the field of economics and monetary policy. In Brazil, instead, directors of departments with responsibilities in other fields (such as management, supervision, regulation and external liaison) are also part of the COPOM.[37]

c. Third, increased internal transparency could help strengthen the policy debate. Allowing staff from the monetary policy directorate to follow the policy decision process allows specialists to increase the effectiveness of their analysis, as well as challenge and surface alternative views about the key issues and risks discussed by the MPC. This could be done, for example, by allowing staff to watch meetings at early stages of the policy cycle (such as briefings on the economic outlook, the baseline forecast and selected key forecast issues) and adopting a process whereby senior management debrief staff on the content of more sensitive (eg: policy decision and final forecast) meetings. It is not clear whether this is current practice at the BCB.

Summary table of how Brazil could upgrade its inflation-targeting framework

28. The measures proposed to upgrade Brazil's inflation-targeting framework should be treated as complements, but there is a sense of priority. Table 2 summarizes key aspects of Brazil's IT framework which could be upgraded. It is important to treat these measures as complements and not substitutes, as many of them are interlinked. Even so, there is a sense of priority. The lack of complete central bank independence is the most pressing issue, as either actual or perceived government influence on monetary policy could jeopardize the benefits from other measures. Once the central bank is independent, enhancing the definition of the inflation target as well as moving to endogenous policy variables in the forecasting process would facilitate the adoption of measures to improve the effectiveness of central bank communication. However, some of the proposed measures—particularly those concerning governance and effectiveness of communication—could be adopted even before central bank independence. Please see Table 2 for a description of priority and responsibility for each of the proposed measures.

[37] http://www.bcb.gov.br/Adm/sobre/port/regimentointerno.asp

Table 2. Credibility and Transparency Best-Practice Checklist

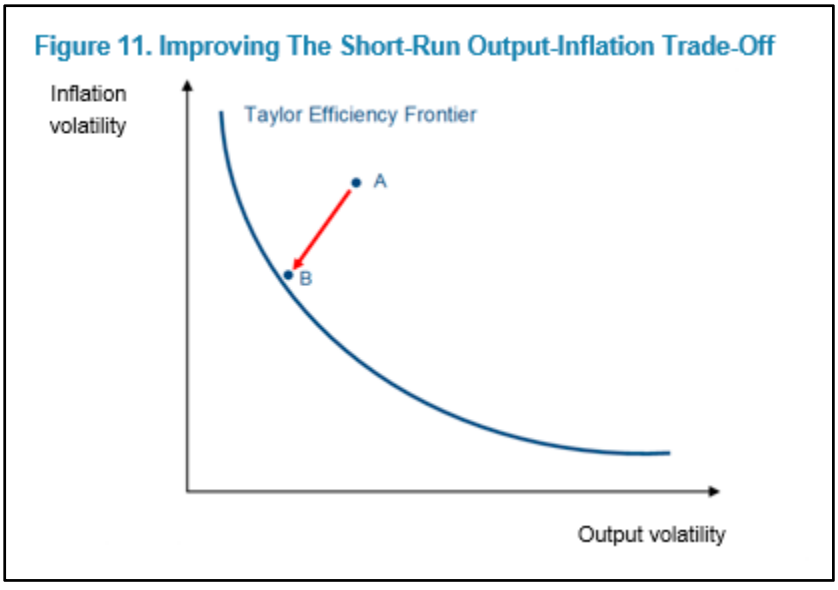
Topic	Best-practice	Brazil	Responsibility of	Priority
Central bank independence	- Central Bank Act defines monetary policy and financial stability mandates; establishes accountability mechanisms and budgetary independence - Fixed-term contracts for central bank's Governor and Deputy Governors (not overlapping with political cycle) - Once *de jure* independence is granted, analytically strong board, MPC and staff needed to ensure *de facto* independence - Operational independence: central bank controls policy intrument (eg: interest rates) - Central bank governor regularly testifies to Congress (accountability)	- Brazil has no Central Bank Act - COPOM members can be dismissed at any time (*'ad nutum'*) - *De jure* independence not yet granted ✓ ✓	National Congress	Top priority
Inflation Target	- Precise (point target) - Long-term focus (continuous long-term target) - Reliable inflation index - Headline inflation	- Imprecise (target range) - Short-term focus (year-end) ✓ ✓	Conselho Monetário Nacional (CMN)	Not recommended until inflation expectations fully achored and inflation has converged to the mid-point of current range or until central bank independent
Forecast assumption on interest rates and exchange rates	Endogenous	Exogenous (forecast conditional on constant and market-based paths)	Banco Central do Brasil	Possible to start upgrading internal processes straight away, but not recommended externally until inflation expectations fully achored and inflation has converged to the mid-point of current range or until central bank independent
Communication (Tools)	- publish monetary policy report - hold press conferences - publish minutes of policy meetings - publish complete macro forecasts with confidence bands - publish MPC votes - publish staff work prepared for policy meetings with a deferral period - Speeches by MPC members on topics relevant to monetary policy	✓ ✓ ✓ ✓ ✓ ✓ - Not all members of the COPOM give speeches on a regular basis	Banco Central do Brasil	- Possible to start straight away (ideally with code of conduct)
Communication (Effectiveness)	- use endogenous inflation forecasts to communicate how central bank will manage the short-run output-inflation trade-off - explain or publish preferred interest rate path consistent with inflation forecast (inc. risks around it) - discuss evolution of key drivers of inflation and growth - explain key forecast judgements (ie, how key inflation drivers are expected to evolve in the forecast) and risks around them - credibly explain why past forecasts were/were not fulfilled - describe differece in views across MPC using staff forecast as a reference point - publish regular assessment of wide range of inflation expectations measures	- not possible with exogenous interest rates and exchange rates - not possible with exogenous interest rates and exchange rates - emphasis on description of historical data has lessened, but discussion about underlying drivers of inflation and growth can be enhanced - key forecast judgements not fully disclosed - Discussion of changes to short-term forecast. Can expand on how new evidence has affected key forecast judgements. - Difference in COPOM members' views started being communicated in the latest COPOM 'notes'. No staff forecast. - regular description of historical data from *Relatório Focus*, but no high-level assessment of whether inflation expectations are anchored	Banco Central do Brasil	- Requires endogenous interest rates and long-term point target - Requires endogenous interest rates and long-term point target - Possible to start straight away - Possible to start straight away - Possible to start straight away - Possible to start straight away - Possible to start straight away
Governance	- MPC code of conduct. Governs issues such as: communication with the media, rules governing speeches, purdah periods for external engagement, political involvement, conflict of interest, etc - MPC formed by individuals with expertise in the field of economics and monetary policy - Internal transparency: monetary policy staff watch early policy and forecasting meetings with the MPC; senior staff debrief monetary policy staff on meetings at later stage of the process	- There is no code of conduct for the members of COPOM - Some COPOM members have expertise in other fields - It is not clear whether this is internal practice at the BCB	Banco Central do Brasil	- Possible to start straight away

D. Illustrating the Benefits of Upgrading Brazil's IT Framework

29. This section uses a simple FPAS model to illustrate the benefits of upgrading Brazil's IT framework. The exercise consists of using an FPAS model to provide illustrative estimates of what the volatility of output, inflation and policy rates would be if Brazil improved its monetary policy framework. The model used is a small open-economy gap model, with equations for output (IS curve), inflation (based on an expectations-augmented Phillips curve), and the short-term interest rate (policy reaction function). The model is forward-looking, in that expectations and the policy reaction function are driven in part by the model's own future solved values (in the long run, both expectations and outcomes converge to steady-state paths). Demand shocks are represented by the stochastic term in the output gap equation, and supply shocks by that in the headline and core inflation equations. Please see Appendix 1 for more information on the model.

30. The benefits from a better policy framework can be thought of as moving the short-run output-inflation trade-off closer to the frontier, as well as improving the frontier itself. The Taylor Efficiency Frontier (TEF) is defined as the best possible combinations of inflation and output volatility that can be achieved if the MPC adjusted interest rates optimally to stabilize inflation and the output gap, given the demand and supply shocks hitting the economy (Figure 11). Points above the TEF are inefficient as it takes a larger output gap to reduce inflation (Point A). Improving the monetary policy framework could shift the short-term output-inflation trade-off closer to the TEF (Point B), by increasing the forward-looking behavior of households and firms, as well as allowing the central bank to pursue optimal monetary policy. Improving the framework could also shift the frontier inwards (towards lower output and inflation volatility), by reducing the volatility of the shocks hitting the economy. This could be due, for example, to a better anchoring of inflation expectations as monetary policy becomes more credible and the central bank is granted independence.

Figure 11. Improving The Short-Run Output-Inflation Trade-Off



31. The FPAS model can provide illustrative estimates of the gains from moving closer to the frontier.[38] The results of this exercise are in Table 3, which shows the volatility of selected macro variables in alternative cases. Under a better framework, optimal monetary policy would take into account the entire path of expected short-term interest rates and it would reduce uncertainty about policy objectives and the MPC's preferences. In the model, this improvement is captured by adopting an optimal control policy, where the policymaker minimizes a loss function which incorporates expected future output gaps and inflation deviations from the target and which also places relatively more weight on large deviations (column 2 vs 1 in Table 3). In addition, a more credible monetary policy would reduce the impact of past price changes on future inflation through reduced inflation indexation. In the model, this can be proxied by a more forward-looking Phillips curve equation. For this illustrative exercise, we assume the degree of backward-looking behavior falls by half (column 3 vs 2). Taken together, a better monetary policy framework would result in lower volatility in output and inflation. The improved framework would actually allow for the nominal policy rate to move less once credibility was established (fourth row), as increased transparency and credibility make monetary policy more effective in managing policy and inflation expectations.

Table 3. Gains from Adopting an IFT Framework – Illustrative Estimates
(Unconditional Sample and Theoretical Standard Deviations)

	Baseline*	Loss Function	Loss Function and Higher Credibility
Output gap (%)	2.6	2.2	2.1
Headline CPI inflation (% YoY)	3.7	3.5	3.3
Core CPI inflation (% YoY)	2.6	2.2	1.7
Policy rate (%)	1.9	1.5	1.2

* The baseline unconditional standard deviations are based on the model-based historical reaction function for the BCB

Source: IMF Staff estimates

32. These estimates are a lower bound. The illustrative estimates above do not account for the fact that a better framework could also reduce the volatility of the shocks hitting the economy. This means that, by upgrading its IT framework, Brazil would not only move outcomes closer to the frontier, but it could also shift the frontier itself. For Brazil, the main channels would be shifts in confidence and more anchored inflation expectations, which could reduce the volatility of inflation shocks. The gap between Brazil and the top IFT countries in terms of anchoring of inflation expectations (Section C) suggests that the magnitude of the gains through less volatile shocks would likely be nontrivial. And so does international evidence. In the U.K., for example, the introduction of central bank independence and a well-defined point target for inflation in 1997 led to a dramatic reduction in long-term inflation expectations.[39] Also, long-run inflation expectations were better-anchored in Canada and Chile (both inflation-forecast targeters) than in the United States before it adopted an explicit numerical inflation objective and started publishing interest rate forecasts in 2012.[40]

[38] The benefits from improving the frontier itself are not captured in this exercise.

[39] Goretti and Laxton (2005).

[40] Gurkaynak and others (2010).

Appendix I. The FPAS Model Equations[1]

IS Equation

The output gap ($\hat{y}_t$) is defined as the difference between the log-level of output (y_t) and potential output ($\bar{y}_t$). The IS equation relates Brazil's output gap ($\hat{y}_t$) to past and expected future output gaps, the deviations of the lagged one-year real interest rate and the real effective exchange rate from their equilibrium values, and the rest-of-the-world output gap.

$$y_t = \bar{y}_t + \hat{y}_t$$

$$\hat{y}_t = \beta_1 \hat{y}_{t-1} + \beta_2 \hat{y}_{t+1} + \beta_3 (r4_{t-1} - \bar{r}4_{t-1}) + \beta_4 (reer_{t-1} - \overline{reer}_{t-1}) + \beta_5 \hat{y}_t^{World} + \varepsilon_t^{\hat{y}}$$

Phillips Curve

In the Phillips curve, core inflation (π_t^C) depends on inflation expectations ($\pi 4_{t+4}^C$) and past year-on-year core inflation ($\pi 4_{t-1}^C$), with coefficients on both terms adding up to one, and the lagged value of the output gap (($\hat{y}_{t-1}$). It also depends on the rate of real effective exchange rate depreciation ($\Delta\widehat{reer}_t$), as well as the deviation of the real effective exchange rate from its equilibrium value, as a real depreciation raises the domestic cost of imported intermediate inputs and final goods and creates upward pressure on prices. Finally, we allow some small pass-through from oil and food price inflation to core inflation.

$$\pi_t^C = \lambda_1 \pi 4_{t+4}^C + (1 - \lambda_1) \pi 4_{t-1}^C + \lambda_2 \hat{y}_{t-1} + \lambda_3 \Delta\widehat{reer}_t + \lambda_4 \widehat{reer}_t + \lambda_5 (\widehat{rp}_t^{Oil} + \hat{z}_t) + \lambda_6 (\widehat{rp}_t^{Food} + \hat{z}_t) + \varepsilon_t^{\pi^C}$$

Policy Interest Rate

Monetary policy follows an inflation-forecast-based reaction function.

$$i_t = \gamma_1 i_{t-1} + (1-\gamma_1)[\bar{r}_t + \pi 4_{t+3}^C + \gamma_2(+ \pi 4_{t+3}^H - \pi^*) + \gamma_3 \hat{y}_t] + \varepsilon_t^i$$

[1] The authors would like to thank Sarma Jayanthi for his assistance with this section.

The three-quarter-ahead inflation projection ($\pi 4^{C}_{t+3}$ and $\pi 4^{H}_{t+3}$) is to ensure more robustness as policy is reacting to a mix of current data, near-term forecast, and model-based projection in the initial periods. Alternatively, monetary policy could follow a risk-management or risk-minimization strategy through a loss function. The loss function incorporates the principal objectives of the central bank in policy making – taking the appropriate actions to bring inflation back to its long-term target over time and closing the output gap.

$$Loss_t = \sum_{i=0}^{\infty} \beta^i [\omega_1 (\pi 4^{H}_{t+i} - \pi^*)^2 + \omega_2 \hat{y}^2_{t+i} + \omega_3 (i_{t+i} - i_{t+i-1})^2]$$

The loss function or objective function typically associated with inflation targeting uses a quadratic formulation, implying that large deviations are more important in the thinking of central banks than small errors or deviations. The loss function has equal weights in minimizing the deviations of inflation expectations from the inflation target and the output gap. The loss function also includes a term in the change of the policy interest rate. This term has the effect of preventing very sharp movements in the policy interest rate, which could otherwise occur on a regular basis, and which would not reflect the behavior of central banks in practice. By taking account of both current and expected future values of output and inflation, this formulation enables the central bank to incorporate into its decision making any information currently available to it about likely developments in the economy over the next few quarters.

Real Interest Rates and Real Exchange Rates

The real interest rate (r_t) is defined as the nominal interest rate minus expected core inflation.

$$r_t = i_t - \pi^C_{t+1}$$

The bilateral real exchange rate between Brazil and the United States (z_t) is defined in terms of Brazil's core CPI (p^C_t), and in such a way that an increase means a depreciation of the Brazilian real. The equilibrium real exchange rate is assumed to be determined by the equilibrium terms-of-trade.

$$z_t = s_t + p^{US}_t - p^C_t$$

$$z_t = \bar{z}_t + \hat{z}_t$$

$$\bar{z}_t = \bar{z}^{TOT}_t$$

The real effective exchange rate is the trade-weighted bilateral real exchange rates of Brazil versus seven regions in the world (U.S., Euro Area, Japan, China, Emerging Asia, Latin America, and the rest of the world).

$$reer_t = \varpi^{US} \hat{z}_{US,t} + \varpi^{EU} \hat{z}_{EU,t} + \varpi^{JA} \hat{z}_{JA,t} + \varpi^{CH} \hat{z}_{CH,t} + \varpi^{EA} \hat{z}_{EA,t} + \varpi^{LA} \hat{z}_{LA,t} + \varpi^{RC} \hat{z}_{RC,t}$$

Risk-adjusted UIP Condition

The risk-adjusted uncovered interest parity condition links the bilateral exchange rate between Brazil and the U.S. with the interest rates in the two economies (i_t and i_t^{US}).

$$i_t - i_t^{US} = 4(Es_{t+1} - s_t) + \sigma_t^{CTRY} + \varepsilon_t^s$$
$$Es_{t+1} = \emptyset s_{t+1} + (1-\emptyset)[s_{t-1} + 2(\Delta\bar{z}_t - (\pi^{*,US} - \pi^*)/4]$$

The equation allows the expected exchange rate (Es_{t+1}) to be a linear combination of the model-consistent solution (s_{t+1}) and backward-looking expectations (s_{t-1}) adjusted for trend exchange rate depreciation ($2/4(\Delta\bar{z}_t - \pi^{*,US} + \pi^{*)}$). The factor ¼ which multiplies the inflation differential ($\pi^{*,US} - \pi^*$) de-annualizes the inflation rates (which are expressed in annual terms), while the factor 2 which multiplies the expected trend depreciation ($\Delta\bar{z}_t - (\pi^{*,US} - \pi^*)/4$) is necessary as we extrapolate the nominal exchange rate in the past period (s_{t-1}) two-periods into the future using the steady-state growth rate in the nominal exchange rate. The factor 4 before the expected depreciation ($Es_{t+1} - s_t$) annualizes the expected quarterly depreciation rate, to make it consistent with the interest rate quoted on the annual basis. A time-varying variable (σ_t^{CTRY}) is also included to account for shocks to country-risk premium.

Relative Prices

Headline inflation is characterized mainly through the dynamics of relative price movements (core CPI (p_t^C) relative to headline CPI (p_t^H)). In the long run, headline inflation is assumed to be equal to underlying (core) inflation, though it can diverge over prolonged periods of time (eg: when there is a trend in the relative prices of non-core items such as unprocessed food or energy). The dynamics of relative prices (rp_t) are modeled as the sum of the relative price trend ($\overline{rp}_t$) and the relative price gap ($\widehat{rp}_t$). The relative price gap depends on the real price of oil and food in international markets adjusted for exchange rate effects, while the relative price trend growth is assumed to be an autoregressive process with mean zero.

$$rp_t = p_t^C - p_t^H$$
$$rp_t = \overline{rp}_t + \widehat{rp}_t$$
$$\widehat{rp}_t = \rho^{\widehat{rp}}\widehat{rp}_{t-1} - c_1^{\widehat{rp}}\left(\widehat{rp}_t^{Oil} + \hat{z}_t\right) - c_2^{\widehat{rp}}\left(\widehat{rp}_t^{Food} + \hat{z}_t\right) + \varepsilon_t^{\widehat{rp}}$$
$$\Delta\overline{rp}_t = \rho^{\Delta\overline{rp}}\Delta\overline{rp}_{t-1} + \varepsilon_t^{\Delta\overline{rp}}$$

Unemployment Rate

The unemployment rate (u_t) is characterized by a "gap version" of Okun's law. The equation implies that a one percentage point increase in the unemployment gap ($\hat{u}_t$) is associated with approximately two percentage points of negative output gap. The NAIRU ($\bar{u}_t$) is assumed to follow a stochastic process that has both shocks to the level and shocks to the growth rate.

$$u_t = \bar{u}_t + \hat{u}_t$$
$$\hat{u}_t = \rho^{\hat{u}}\hat{u}_{t-1} - C_1^{\hat{u}}\hat{y}_t + \varepsilon_t^{\hat{u}}$$
$$\bar{u}_t = \bar{u}_{t-1} + \Delta\bar{u}_t + \varepsilon_t^{\bar{u}}$$
$$\Delta\bar{u}_t = \rho^{\Delta\bar{u}}\Delta\bar{u}_{t-1} + \varepsilon_t^{\Delta\bar{u}}$$

Potential Output

The potential growth rate ($\Delta\bar{y}_t$) is assumed to converge to its steady state level ($\Delta\bar{y}^{ss}$) in the longer term. However, it can deviate from the steady-state level for prolonged periods of time.

$$\Delta\bar{y}_t = \rho^{\bar{y}}\Delta\bar{y}_{t-1} + (1-\rho^{\bar{y}})\Delta\bar{y}^{ss} + \varepsilon_t^{\Delta\bar{y}}$$

Rest of the World

The rest-of-the-world output gap relevant for the Brazilian economy is defined as a weighted average of output gaps in the seven regions (U.S., Euro Area, Japan, China, Emerging Asia, Latin America, and the remaining countries), using export shares as weights.

$$\hat{y}_t^{World} = \varpi^{US}\hat{y}_t^{US} + \varpi^{EU}\hat{y}_t^{EU} + \varpi^{JA}\hat{y}_t^{JA} + \varpi^{CH}\hat{y}_t^{CH} + \varpi^{EA}\hat{y}_t^{EA} + \varpi^{LA}\hat{y}_t^{LA} + \varpi^{RC}\hat{y}_t^{RC}$$

Commodities and Terms-of-Trade

The real price of oil (rp_t^{Oil}) is defined as the global oil price (p_t^{Oil}) in U.S. dollars relative to the U.S. CPI (p_t^{US}). In equilibrium, the real price of oil is assumed to grow at a rate of zero, although the actual growth rate can deviate from zero for long periods of time. The real price of oil gap ($\widehat{rp}_t^{Oil}$), defined as the difference between the real price of oil and its equilibrium value, is modeled as an autoregressive process with a shock.

$$
\begin{aligned}
rp_t^{Oil} &= p_t^{Oil} - p_t^{US} \\
rp_t^{Oil} &= \overline{rp}_t^{Oil} + \widehat{rp}_t^{Oil} \\
\Delta\overline{rp}_t^{Oil} &= \rho^{\Delta\overline{rp}^{Oil}} \Delta\overline{rp}_{t-1}^{Oil} + \varepsilon_t^{\Delta\overline{rp}^{Oil}} \\
\widehat{rp}_t^{Oil} &= \rho^{\widehat{rp}^{Oil}} \widehat{rp}_{t-1}^{Oil} + \varepsilon_t^{\widehat{rp}^{Oil}}
\end{aligned}
$$

We follow similar modeling strategy for the real price of food.

$$
\begin{aligned}
rp_t^{Food} &= p_t^{Food} - p_t^{US} \\
rp_t^{Food} &= \overline{rp}_t^{Food} + \widehat{rp}_t^{Food} \\
\Delta\overline{rp}_t^{Food} &= \rho^{\Delta\overline{rp}^{Food}} \Delta\overline{rp}_{t-1}^{Food} + \varepsilon_t^{\Delta\overline{rp}^{Food}} \\
\widehat{rp}_t^{Food} &= \rho^{\widehat{rp}^{Food}} \widehat{rp}_{t-1}^{Food} + \varepsilon_t^{\widehat{rp}^{Food}}
\end{aligned}
$$

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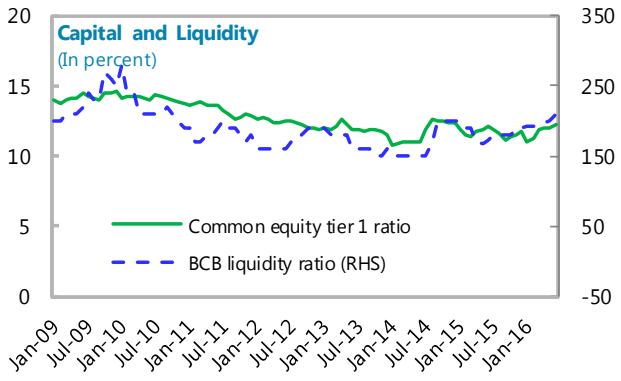
ASSESSING BANKING SECTOR HEALTH IN THE ECONOMIC DOWNTURN[1]

This paper assesses the health of the banking sector under different scenarios. We use a balance sheet approach and publicly available data to assess the solvency risk of the largest six banks in Brazil. The results of the analysis suggest that those banks will cope well in the baseline scenario from the July 2016 IMF World Economic Outlook. However, some banks may temporarily fall below the regulatory threshold in the stress scenario characterized by a longer and deeper recession along with a large increase in funding costs.

A. Introduction

1. Brazil is in a deep recession. Activity has contracted in seven of the past nine quarters amid low confidence—reflecting domestic policy uncertainty, weakening terms of trade, tightening financial conditions, and low competitiveness. With the slowdown in economic activity, unemployment (in the six largest metros) tilted up (from 4.3 at the end of 2014 to 8 percent at the end of 2015). Credit growth has stalled in July 2016. Between September and December 2015, S&P and Fitch downgraded Brazil to below investment grade status, triggering a spike in funding costs for the government, banks and non-financial corporates.

2. The health of the banking sector deteriorated in 2015, but recovered in the first half of 2016. In 2015, banks reported one of the lowest net income before taxes in the last 10 years. This was mainly due to a spike in provisions for loan losses and higher funding costs in 2015Q3. Against the backdrop of a deteriorating macroeconomic environment, banks' non-performing loans have gradually increased over 2015 and 2016 and reached 3.6 percent of loans in July 2016. In 2015, capital ratios were affected by high unrealized losses on fixed income securities, an expansion of balance sheets as a result of exchange rate depreciation, and a significant increase in deferred tax assets (DTAs[2]) following an increase in the tax rate. Comparing to end of 2014 overall liquidity risk has increased at the beginning of 2015 with a reduction in liquid assets and higher withdrawals of



Source: Brazil Central Bank.

[1] Prepared by Ivo Krznar (MCM).

[2] Provisions for loan losses in Brazil are not tax-deductible and are only recognized for tax purposes once the borrower actually defaults on the loan. This means that Brazilian banks have a tendency to build up large amounts of deferred tax assets. Brazil's Law 12,838, passed in July 2013, allows banks to convert DTAs relating to loan loss provisions into a tax credit when the bank reports a loss, is liquidated or becomes bankrupt.

saving deposits. However, liquidity risks decreased in the first half of 2016, due to growth of high quality liquid assets and stability in stressed bank's cash flows, in the context of economic slowdown and contraction of credit to the real economy. Profits before taxes increased substantially in the first half of 2016 driven mainly by lower interest expense and funding costs. However, profits after taxes have continued to fall and were 35 percent lower than in 2015.

3. Economic activity is expected to remain weak. Growth contracted by 3.8 percent in 2015 and is expected to contract by a further 3.3 percent in 2016 (IMF's World Economic Outlook projection) before turning positive in 2017. This projection assumes that uncertainty related to the political situation and the corruption probe diminishes over the course of this year, and that other downward economic shocks (such as the large administered-price adjustments of 2015 and the major investment cuts in Petrobras) will run their course and will not reoccur, contributing to a recovery in investment and a gradual return to positive sequential growth over that latter part of 2016.

4. An immediate risk to the outlook is that that the government fails to implement planned fiscal reforms. This would represent a serious threat to fiscal sustainability, the credibility of the policy framework, financial stability, and the growth outlook. Other risks relate to a protracted period of slower growth in advanced and emerging economies, further declines in export commodity prices, and tighter global financial conditions.

5. Intensification of political uncertainties or a major policy mistake could exacerbate downside risks. This could potentially result in a "sudden stop" of capital inflows, a sharp asset price adjustment and widening of credit spreads, which would in turn increase the cost of funding for the corporates and banks. Higher funding costs would also trigger losses on fixed income securities for banks, while a deeper recession could result in larger loan losses and possible capital shortfalls for some banks.

6. This paper assesses the health of the six largest banks under two scenarios, a baseline and a stress scenario, over a five-year horizon. The baseline scenario reflects the IMF's World Economic Outlook projection as of July 2016. The stress scenario assumes a severe shock preventing Brazil from emerging from its ongoing recession—that is, it combines a deeper and longer recession than in the baseline, with a large increase in funding costs. The methodology follows the balance sheet-based approach which assesses solvency of individual banks under different scenarios through changes in net income and risk-weighted assets. This is the first attempt to design sensitivity analyses for Brazilian banks mostly based on publicly available data[3]. A more comprehensive solvency exercise with larger coverage and possibly based on supervisory data will be conducted as part of the 2017 Brazil FSAP. Liquidity stress

[3] The main difference between the approaches of the IMF and the authorities' is on the forecast horizon and the scope of the exercise. While the authorities only forecast NPLs and provisions while keeping other income statement items constant, we explicitly projected the main categories of the income statement. Regarding the forecast horizon, the authorities use a six quarter forecast horizon. The IMF test focused on a five-year horizon.

tests, network analysis and spillover risks were not conducted since relevant data is not publicly available. Liquidity and spillover risks will be examined in the context of the 2017 Brazil FSAP.

7. Our results suggest that while the largest banks can cope with adverse developments in the baseline, some banks would temporarily fall below the regulatory threshold during more severe economic distress. CET1 ratios of all banks would stay above the supervisory thresholds during the 5-year horizon, which is due to positive net incomes driven mainly by positive net interest income. System-wide CET1 ratio would fall in 2016−17 in the stress scenario, just below the hurdle rate and two banks would fall below the regulatory threshold damaging the fiscal position with recapitalization costs and the realization of deferred tax credits. This is mainly due to the large GDP shock and interest rate shock hitting the banks in the stress scenario. It should be emphasized that the results of the analysis are not forecasts of banks' solvency as they are based on hypothetical scenarios and other assumptions used for the sole purpose of conducting the analysis. Also, the model, as explained below, does not permit an endogenous response by banks (e.g. equity issuance or other capital actions) to the severe shocks. Therefore, the results should be interpreted as indicators of pressures on capital.

B. Scope of the Test

8. The analysis used publicly available, consolidated data of the six largest banks using the central bank's data and data from banks' financial reports. The test covered Banco do Brasil, Itau, Caixa, Bradesco, Santander, BNDES which together account for about 80 percent of the banking sector's asset. The data was adjusted for mergers and acquisitions by the banks included in the analysis (see Appendix Section F, Table A4 for details on M&As). The cut-off date for the data was June 31, 2016.

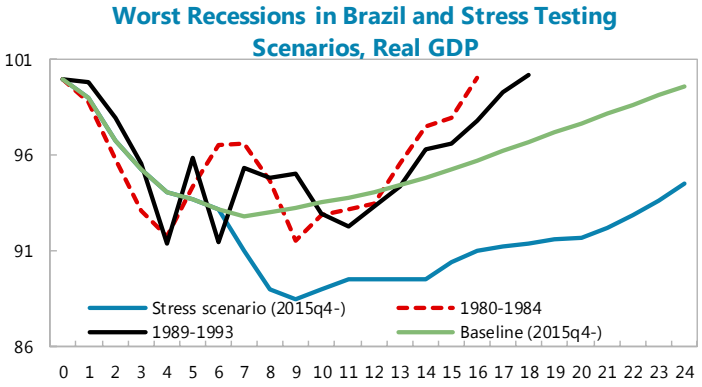
9. The test assessed the level of banks' common equity Tier 1 ratios against the regulatory threshold consistent with the Basel III transition schedule but also accounting for capital conservation buffer and a domestic systemically important bank (D-SIB) capital surcharge as minimums.

C. Macroeconomic Scenarios

10. The tests examined two macroeconomic scenarios: baseline and stress scenario over a five year forecast horizon (Figure 1). For the baseline scenario, our latest projections for Brazil were consistent with WEO projections. For the stress scenario, we simulated a tail risk scenario which was informed by the dynamics of the main macro and financial variables during the two largest recessions in Brazil in the 1980s as well as the BCB structural break scenario (Table A6). Each scenario is characterized by the dynamics of a set of macro and financial variables which were mostly projected using simple econometric models (Table A5).

11. The stress scenario features a deep and long recession in Brazil, significant declines in asset prices and increases in risk premia (Appendix Figure A1). In fact, the stress scenario

represents the most severe recession that Brazil has ever seen (at least in the last 100 years). There are two reasons for choosing such a severe stress scenario. First, the baseline projection is already close to the worst recessions Brazil has encountered (in the 1980s and 1930s). And second, the stress scenario was based on dynamics of the main macro variables (GDP, monetary policy rate, the exchange rate) in the BCB structural break scenario (at least in the first six quarters of the testing horizon). This takes the worst outcomes from a distribution of each variable without factoring their relationships and therefore may not be internally consistent. However, the scenario can be considered a "perfect storm" scenario and a combination of the 2002 episode with the materialization of risks in the current baseline scenario, which features a sudden stop in combination with unanchored inflation expectations that justify a substantial hike in the policy rates.

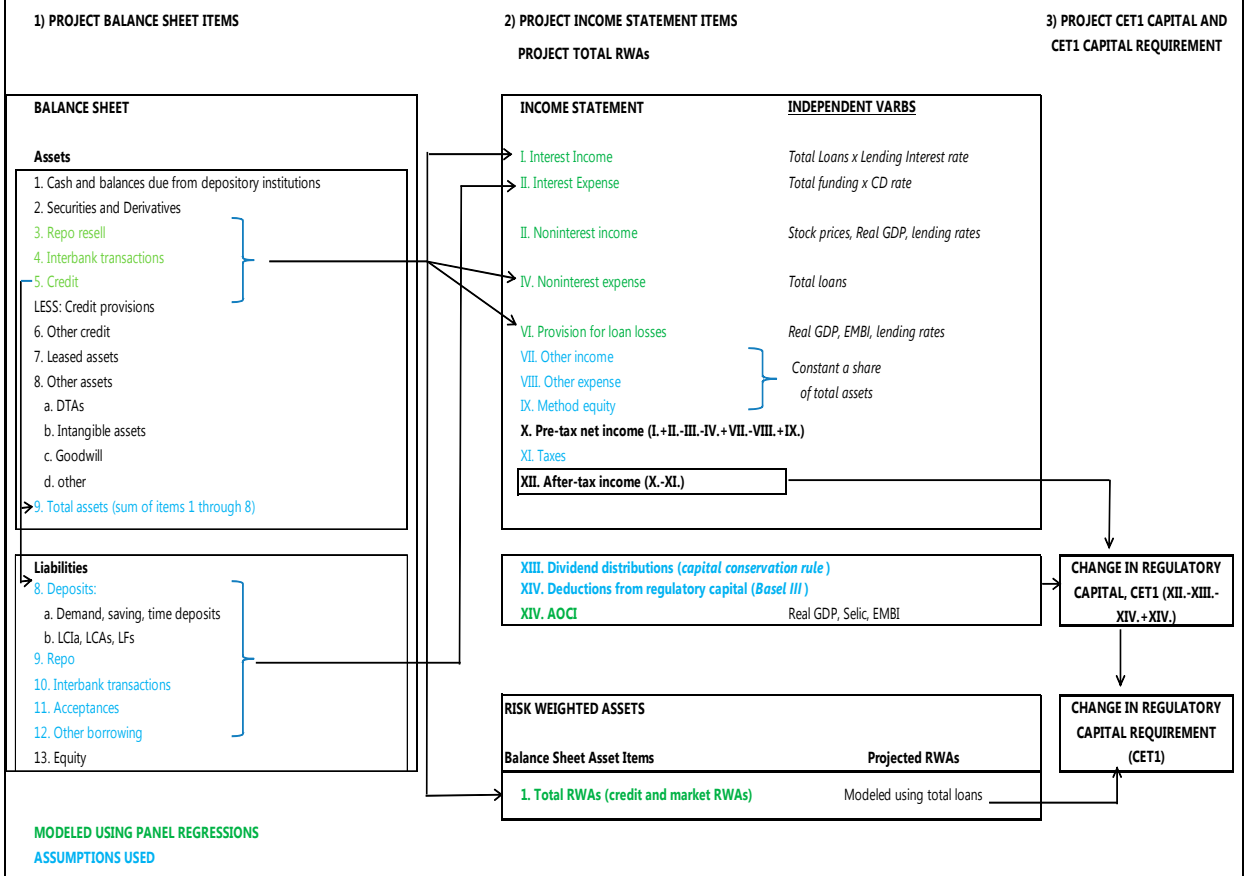


Sources: Haver and Fund staff estimates.

D. Methodology

12. We used historical quarterly data and a set of simple panel regression models to forecast each banks' main components of balance sheets and income statement items (see Appendix for details). The publicly available data (via the central bank's webpage) spans from 1995Q4 to 2016Q2. The panel regression models were intended to capture how the balance sheet, RWAs, and net income of each bank are affected by the macroeconomic and financial conditions (as independent variables) described in the scenarios (Table 1). Projections of balance sheets (Step 1) over the testing horizon were used for the purposes of calculation of RWAs as well as income statement items (Step 2). Projections of RWAs and net income—with assumptions on dividend distribution, CET1 deductions and AOCI,—determined capital requirements over the testing horizon (Step 3). Asset disposals and acquisitions over time, or any other management action or endogenous reaction of banks were not considered.

Table 1. Methodology



Source: Fund staff estimates.

E. Caveats

13. There are many caveats that highlight the fact that results should be considered carefully. These will be addressed during the upcoming FSAP.

- **Coverage and scope of the analysis:** The note focuses on assessing the solvency risks of six largest banks only. Medium size and small banks might be more vulnerable to shocks as their buffers in terms of profitability and provisions relative to NPLs are smaller comparing to buffers of the largest banks. Furthermore, their business model might be riskier than that of largest banks. Moreover, liquidity and contagion risks and links between liquidity, solvency and contagion were not examined in this note. Liquidity problems of the seventh largest bank, BTG, in November 2015 highlight the importance of monitoring and analyzing liquidity risks more closely.

- **Underestimation of results:** The results might be underestimated since the estimation of model was based on historical evidence since 1995, the period when banks did not

experience any major losses. However, rapid credit expansion by public banks in the past couple years, including into higher-risk credit segments, as well as rapid deterioration of corporate balance sheets that could impact the health of the banks is a concern but is not captured in this framework. Moreover, public banks' change of liabilities' structure (from cheap government funds and saving deposits towards more expensive market funding) that is still ongoing and is likely to continue in the future is not captured by the exercise. This factor could put additional pressure on the net income of the public banks and the capital needs in the future. Renegotiations of loans that could lead to under-provisioning are also not taken into account. In practice, renegotiations could lead to higher provisions in the future if the economic activity remains weak.

- **Exchange rate effects:** The analysis may be distorted by foreign exchange adjustments related to reclassifications within the income statement and investment in foreign subsidiaries and its hedge dissonance tax/accounting treatment. This occurred mainly in 1999Q1, 2001H1, 2002Q3, 2008Q3, 2015H1 and 2015Q3. For example, in the 2nd half of 2015, the banking system's net income before taxes was -R$8.0 billion (not considering exchange rate adjustments) and R$23.1 billion (when considering exchange rate adjustments). This difference represents 4.0 percent of the banking system regulatory capital in December 2015. Furthermore, in the same period, the estimated funding cost for the banking system was 9.7 percent (if one considers exchange rate adjustments) and 14.0 percent (not considering exchange rate adjustments).

- **Stress scenario:** Stress scenario is severe, especially with respect to interest rates, and combines the worst realization of shocks for each variable independently.

- **Publicly available data:** Publicly available data are not granular enough to do a comprehensive analysis of loan losses or assess trading losses.

- **Goodwill amortization:** Goodwill in Brazil follows local accounting and tax rules, being amortized monthly. By doing so, net income is negatively affected. FSAP standard stress tests assume goodwill to be directly discounted from capital, with no amortization. This exercise was run on publically available data on net income affected by goodwill amortization. This may negatively impact the results of the exercise should goodwill be material.

F. Results

14. The solvency exercise suggests that banks are in good position to withstand further recessionary developments under the baseline scenario (Figure 1). CET1 ratios of all banks would stay above the supervisory thresholds during the 5 year horizon. This is due to positive net incomes driven mainly by positive net interest income. Provisions for loan losses are broadly stable in 2016−17 and at the same level as in 2015, partly a result of high loan loss

reserves above the NPLs that serve as a first line of defense against credit losses[4]. Net income was stable as well in 2016. Due to positive net incomes, the system-wide CET1 ratio increases by 1.6 percentage point by the end of 2016 (comparing to 2016Q2) and additional 1.2 bps each year over the period from 2017 to 2020—reaching 18 percent in 2020 mainly due to higher lending and net interest income, lower provision and higher non-interest income.

15. Two banks would temporarily fall below the regulatory threshold in the stress scenario (Figure 2). System-wide CET1 ratio would fall in 2016 but would stay above the hurdle rate. The decline in the CET1 ratio is mainly due to the large GDP shock and interest rate shock hitting the banks. The system-wide CET 1 ratio would fall by 1.2 percentage points in 2016 and by 0.4 in 2017. In comparison to the baseline scenario, the system wide CET1 would be lower by 4.3 percentage points on average each year over the whole testing horizon.

16. The results in the years of downturn (2016–17) were mainly driven by lower net interest income and provision for credit losses.

- ***2016:*** Net income (after taxes and dividends) falls sharply from R$86 billion in 2015 (and R$60 billion annualized in 2016Q1–Q2) to a R$3.5 billion net loss in the overall 2016 due to the impact of the lower net interest income in 2016, driven by higher funding costs and lower demand for credit—net interest income falls from R$312 billion in 2016Q1–Q2 (on an annual basis) to R$142 billion in 2016. Unrealized losses on fixed income securities also play a role at the end of 2016, subtracting 60bps from CET1 ratio, as the interest rates spikes in 2016q4. Negative shocks on credit losses/provisions in the second half of 2016 are cushioned by extra loan loss buffer and they subtract 2.9 percentage points from CET1 ratio in 2016.

- ***2017:*** The positive impact of unrealized gains[5]—reflecting lower interest rates and recovery in loan growth rates—are the main driver of changes in capital ratios in 2017. However, the effects of still high provisions and lower non-interest income prevail and the system wide CET1 ratio falls. Moreover, higher deductions from CET1 subtract -0.6 percentage points from system-wide CET1 ratio.

- ***Individual banks:*** Two out of six banks would fall below the hurdle rate in the downturn but they would return to the threshold before the end of the testing horizon.

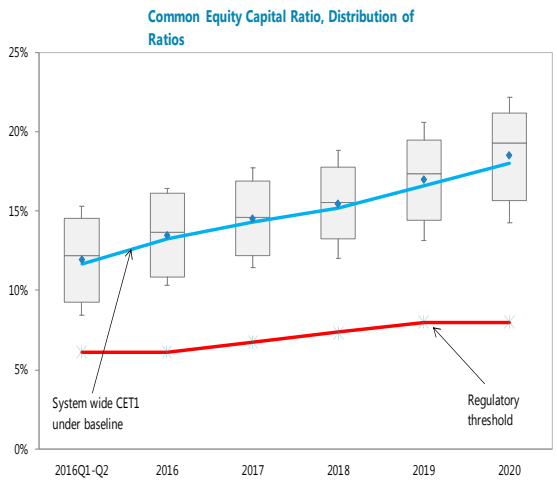
- ***Recapitalization needs:*** Recapitalization needed to bring all banks to the hurdle thresholds peaks in 2016 at 16 percent of their 2015 net income—which corresponds to 0.1 percent of 2016 nominal GDP.

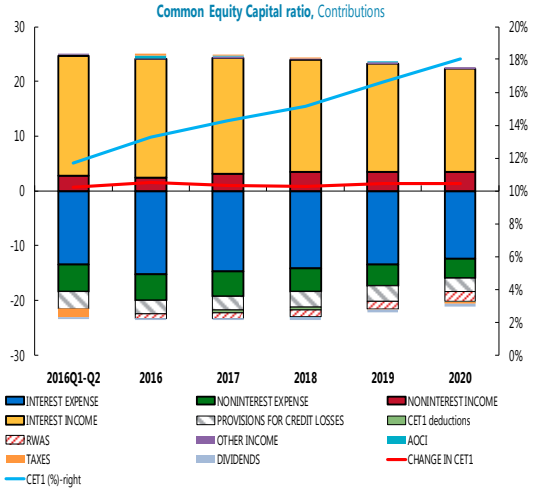
[4] The system wide extra buffer is equal to 14 percent of system wide CET1 in 2015. It would increase the system wide CET1 ratio by 150 bps if it would be counted as capital. If the extra loan loss reserves buffer is not assumed to act as a first line of defense the provisions in 2016 would be 30 percent higher than in 2015.

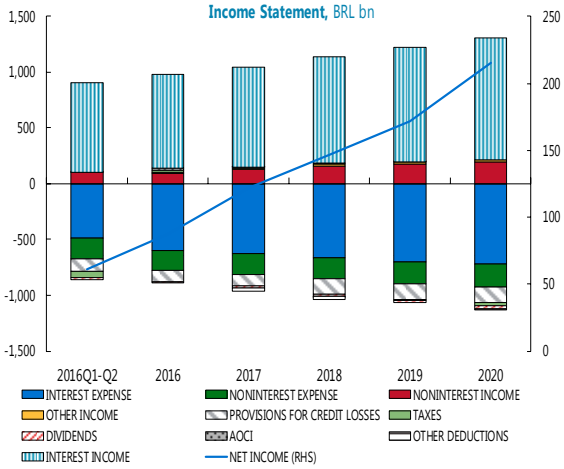
[5] The positive contribution of unrealized gains on fixed income securities for CET1 ratio was 180bps due to sharp drop in the interest rate.

17. The system wide CET1 ratio would increase in in the recovery period. The system-wide CET1 would increase by about 3.1 percentage points from 2018 to 2020 driven mainly by the recovery in net interest income and non-interest income reflecting the favorable economic environment and higher demand for loans. The deductions from CET1 were still a drag on capital ratios in first year of the recovery (2018).[6]

Figure 1. Results: Baseline Scenario



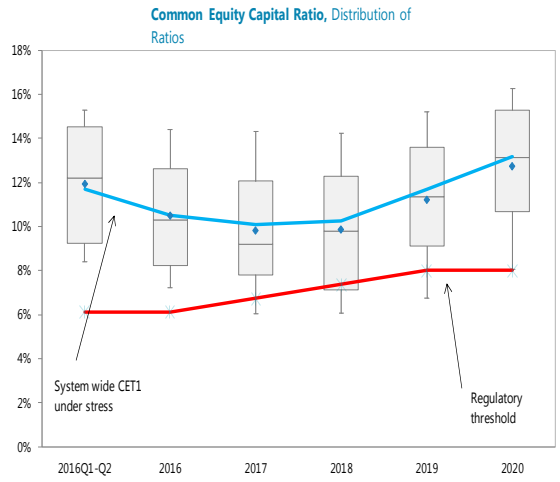


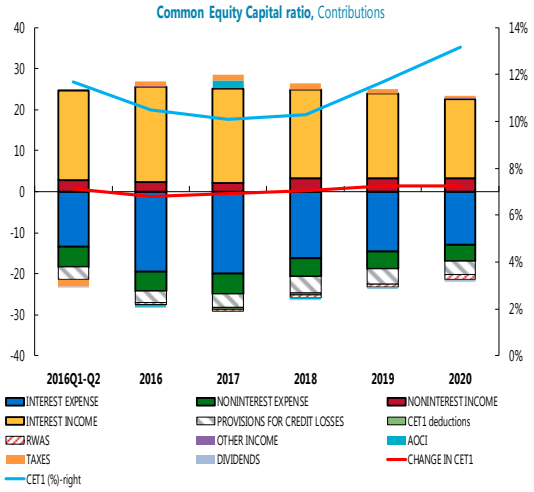


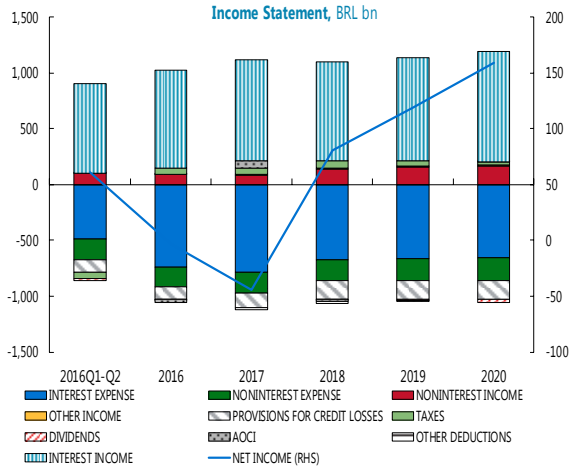
Source: Fund staff estimates.

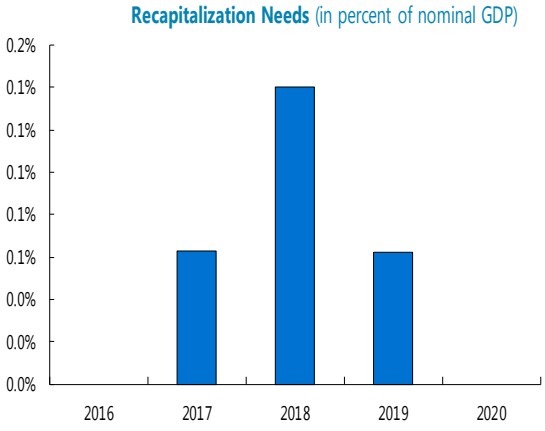
[6] Due to Basel III transition rules on deductions, their impact on capital ratios dies out in 2018.

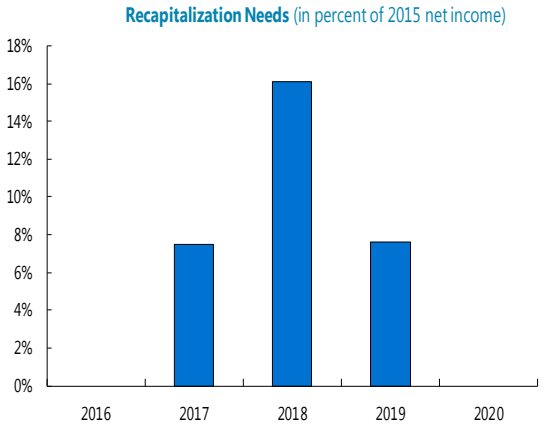
Figure 2. Results: Stress Scenario

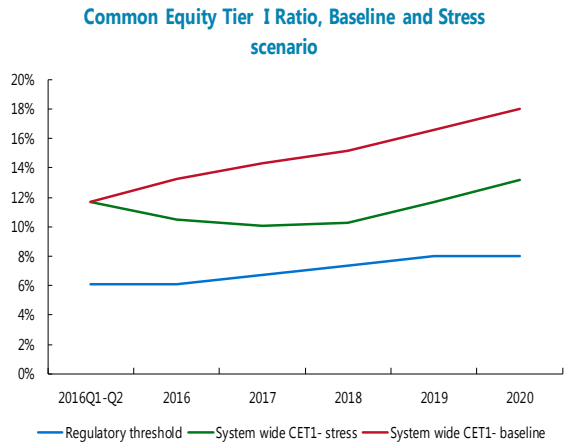












Source: Fund staff estimates.

G. Policy Implications

18. While the health of the banking system remains largely sound, the resilience of the banking sector should be bolstered. Private restructuring frameworks should be strengthened with the aim of expediting the bankruptcy process and reducing default losses incurred by creditors. The operational procedures and systems for providing emergency liquidity assistance should be strengthened. A new resolution regime with tools consistent with FBS's key attributes of effective resolution regimes for financial institutions should be implemented. Moreover, a committee comprising all financial safety net providers should be given an explicit mandate for systemic risk monitoring and crisis management supported by enhanced stress testing framework. Stress-testing procedures should be improved to become more effective supervisory tools.

19. While the central bank's stress testing framework is extensive, it should be enhanced in a number of directions.

- *The framework*. The central bank's stress testing toolkit should be expanded to include a balance sheet based stress test similar to the one developed in this note. This stress testing framework should be based on projection of all major income statements and balance sheet items. The results in this note and the net interest losses in 2015Q3 highlight the importance of net interest income for the dynamics of the total net income and capital. Moreover, in the stress environment, banks might not be able to pass on higher funding cost to higher lending rates and/or to offset lower business volumes.

- *Projection of provisions*. The projection of NPLs and mapping into provisions for loan losses should be supplemented with projection of net charge offs. Provisions for loans losses are large relative to the loan loss provisions (the stock of provisions) implying that net charge offs have to be large as well.

- *Stress testing horizon*. The stress testing horizon should be expanded beyond six quarters in order to analyze the effects of long recessions and/or sluggish recoveries.

Appendix I. Methodology

This section explains in details the top-down solvency analysis of the IMF FSAP team. The section covers: (i) definitions of capital and risk weighted assets that we used for calculating and reporting results; (ii) the details of the methodology (Table A1) and satellite models that map the macroeconomic scenarios into projections of balance sheet and income statement items; and (iii) the behavioral assumptions governing capital actions (dividend distribution).

A. Capital

1. **The capital definition applied in the analysis corresponded to that required by local regulation i.e. Basel III capital requirements** (Table A1).

Table A1. Capital Standards, in Percent

	2016	2017	2018	2019	2020
I. Basel III phase-in minimum CET1	4.5	4.5	4.5	4.5	4.5
II. Capital conservation buffer	0.625	1.250	1.875	2.5	2.5
III. Total CET1 ratio (I.+II.)	5.125	5.750	6.375	7.0	7.0
IV. D-SIB surcharge \1	1.0	1.0	1.0	1.0	1.0
V. Total CET for DSIBs (III. + IV.)	6.1	6.8	7.4	8.0	8.0
Phase in of deductions from CET1 \2	60	80	100	100	100
Phase out of existing AOCI capital adjustments	0	0	0	0	0

Source: Fund staff estimates.

1/ Applied to all banks.

2/ Included intangible assets, goodwill, DTAs.

2. **Consistent with Brazilian regulation, we incorporated 100 percent of accumulated other comprehensive income (AOCI) into CET1 capital in 2016 and onwards.** We modeled total AOCI of each bank as a function of interest rates and real GDP growth using panel regression models and supervisory data from 2002.

3. **The nominal value of deductions from CET1 including goodwill, intangible assets, and DTAs was held constant over the testing period.** Basel III transition provision factors and provisions specific to Brazilian capital regulation were applied to calculate deductions from CET1 over the testing horizon.

4. **We took into account that the transition provisions for deductions have started already in 2014** and **have followed the Basel III transition provisions since then.**

5. **The only difference[1] between the deduction in period t+1 and t was subtracted from CET1 capital in period t since CET1 in period t and was already defined as CET1 after adjustments and deductions.[2]** No assumptions were made about banks' behavioral responses to phase-ins.

B. Risk Weighted Assets

6. **The dynamics of total RWAs[3] of each bank follows closely the dynamics of total loans.** Therefore, we projected the year-on-year growth rate of total RWAs in a panel regression model with fixed effects as a function of year-on-year growth rate of total loans. Projected net provisions (gross provisions minus DTAs stemming from provisions) were deducted from projected RWAs.

C. Balance Sheet

7. **The growth rate of the balance sheet of each bank was assumed to be equal to the growth rate of the largest asset category, which corresponds to the growth rate of the loan portfolio.** The loan portfolio, or "total loans", was defined as net credit + repo loans + interbank loans.[4] The prediction of total assets was used when projection income statement items which were estimated as a share in total assets. Projections of total loans were used in projection risk weighted assets.[5]

8. **The model of loans growth rate was estimated at the level of individual banks using a panel regression model.** A panel, fixed-effects model of a year-on-year growth rate of total loans was estimated and projected at the bank by bank level. It was assumed that lower economic activity, increases in interest rates and higher market turbulence (we used EMBI as a proxy for risk aversion) would lower the demand for loans (Table 2A). Spreads, which we include to account for loan supply factors, were not statistically significant. Therefore, independent variables included: year-on-year growth rate of real GDP, lending interest rates, and EMBI. The model also included lagged dependent variable to account for large persistence in the growth rate of loans. Despite counter-cyclical role of public banks during the last financial crisis, dynamics of loan growth projections of all banks were relatively similar.

[1] The amount for intangible assets, and DTAs reported in 2015Q4 were already a result of applying transition provisions in 2015 (40 percent).

[2] In other words, what matters for CET1 is the marginal effect of higher transition provision factor.

[3] Ideally, RWAs would be projected for each bank that will participate in the exercise. Three components of RWAs would be projected: credit RWAs, market RWAs and operational RWAs. Unfortunately, long time series of granular RWAs were not publicly available.

[4] The definition of loans has been chosen based on the quality of the model of loans.

[5] The only reason total assets were not used as an explanatory variable in the RWAs' regression is because the model with total loans explained more variation of RWAs than with total assets.

9. **The growth rate of loans was used in projection of interest income and indirectly in projection of interest expense**. The growth rate of total funding (including deposits, acceptances, interbank borrowing, repos, and other borrowing from the BCB data) was assumed to be equal to the growth rate of loans due to their close co-movement in the past.

D. Income Statements

10. **The projections of revenues, expenses, and loan losses for each bank were based on projections of the balance sheet (total loans and total funding) and macro variables.** Most components of pre-provision net revenue were projected using historical data and simple panel regression models (Table A2).[6] In particular:

- **Provisions for loan losses.** To assess **the credit risk**, we estimated panel models that captured the historical behavior of provisions/total loans relative to changes in macroeconomic and financial market variables.[7] Since provisions are not tax deductible and since the tax rate is 45 percent, only 55 percent of projected provisions affect net income since the remaining (45 percent of projected provisions) increases DTAs and represents a tax credit and contingent liability of the government. Moreover, it was assumed that the excess loan loss reserves (loan loss reserves—NPLs in 2016Q2) serve as the first buffer again credit losses. These were equally distributed in 2016 and 2017.

- **Interest income.**[8] To assess **interest rate risk** in the banking book, interest income was projected using panel regression of the y-o-y growth rate of interest income on the y-o-y growth rate of a product of total loans and lending interest rates as the explanatory variable and fixed effects. By including loans as an independent variable, we took into account macroeconomic environment as well as bank specific characteristics. Projections of loans were taken from the projection exercise of each bank balance sheets. For the purposes of estimation, the loan interest rate was defined as the average lending rate.[9] The loan interest rates were estimated based on projection of aggregate lending rate determined through using a simple econometric model with monetary policy rate as the only explanatory variable. TJLP was used as the lending interest rate of BNDES.

[6] The models are based on a fixed-effect panel data regressions performed on 6 banks, which, may resulted in a lot of noise in the parameter estimates, as suggested by the quarterly forecasts.

[7] Explanatory variables included lags of real GDP growth rates, y/y growth rates of EMBI and lending rates. We also explored possible non-linear effects between provisions and independent variables by including an interaction terms with GDO growth rate and a dummy variable that takes 1 if the growth rate of an independent variable is positive and 0 if it is negative.

[8] Defined as a sum of interest revenue on loans and leases, securities, derivatives, foreign exchange, required deposits and derecognition of financial assets.

[9] We also defined a lending rate (for each bank) as weighted average of interest rates on non-earmarked loans to non-financial corporates, non-earmarked loans to households, earmarked loans to non-financial corporates, earmarked loans to households where weights come from each banks' structure of loan portfolio. Overall, the results did not change by much.

- **Interest expenses.**[10] The other side of assessing the **interest rate risk** is to project interest expenses. The y-o-y growth rate of interest expenses was regressed on y-o-y growth rate of a product of total funding and certificates of deposits (CD) rates as the explanatory variable and fixed effects. The aforementioned total funding was assumed to grow at y-o-y growth rate of loans. CD rates were projected using as model that has monetary policy rate as the only independent variable.

- **Non-interest income.**[11] This item was projected using a panel regression model with non-interest income over total assets as the dependent variable and the growth rate of stock exchange index, real GDP growth rate, a "non-linear" variable with real GDP growth rate squared, and lending rates as independent variables. It was expected that during period of market turbulence (lower growth rates of stock prices) trading from fees and commissions goes down as brokerage, underwriting, and securitization fall. The same would be true if real GDP growth rate is low. Lending rates were included in the regression to control for the substitution effect—it was expected that higher lending rates would make banks shift from lower demand interest income activities to non-interest income activities.

- **Non-interest expenses.**[12] This item was modeled as a year-on-year growth rate in a panel regression with year-on-year growth rate of total loans as the only independent variable and fixed effects. The assumption was that non-interest expenses depend on the size of the business which is ultimately related to the size of the largest balance sheet item, i.e. loan portfolio. The growth rate of total loans was taken from loans' projection exercise.

- **Other income,**[13] **other expense,**[14] **method equity** were too volatile to be modeled on a bank by bank basis but have no trend as a share in total assets. Therefore, it was assumed that, over the testing horizon, the sum of all three income statement items stays constant as a share in total assets.

- **Taxes and DTAs.** Taxes were set at the pooled average effective tax rate in the period from 1995 to 2015 in case of positive net income. Forty-five percent of provisions were considered as tax income and equal to increase in DTAs. DTAs from credit loan loss provisions are guaranteed, by law, by the Federal government. Therefore, any increase in DTAs from loan loss provisions was not deducted from CET1 capital over the testing horizon. To calculate the fiscal costs related to realization of DTAs it was assumed that a bank is reimbursed from the fiscal authorities if it reports net income loss up to the amount

[10] Defined as a sum of interest expense on deposits, acceptances and repos, borrowing, leases, foreign exchange, derecognition of financial assets.

[11] Defined as a sum of service charges, bank charges.

[12] Defined a sum of expense bank charges, payroll, overhead, tax expanses.

[13] Defined as other operating income and non-operating income.

[14] Defined as other operating expense.

of its DTAs. This reimbursement was not taken into account when reporting the testing results.

Table A2. Panel Regression Results

MODELS USED IN PROJECTING INCOME STATEMENTS, BALANCE SHEETS	Interest income	Interest expense	Non-interest income	Non-interest expense	AOCI	Provisions	Total loans	Risk weighted assets
Dependent variable specification	d^4	d^4	Share in total assets	d^4	Share in total assets	Share in total loans	y/y	y/y
Lag of dependent variable	No	No	No	No	No	No	Yes	No
d^4(Total Loans x Lending rate)	0.001108***							
d^4(Total funding x CD rate)		0.002163***						
Total loans, y/y				2917.514***				0.7599***
Lending rates, lags			0.0000149**			1.96E-05**		
Lending rates							-0.158402***	
Real GDP, y/y, lags			0.0000845***		0.000444***	-6.54E-05		
Real GDP, y/y							0.481882***	
Real GDP^2, y/y, x dum (y/y<0)								
Real GDP, y/y, x dum (y/y<0)			0.000147			-5.76E-05		
Stock exchange index, y/y			0.00000645***					
Selic, d^4					-0.00033***			
EMBI, y/y						5.72E-06**		
EMBI							-0.002903**	
EMBI, d^4					-1.88E-06***			
Constant	393919.9**	222467.2**	0.004261***	219670.0***	-0.001839***	0.006584***	8.117908***	2.439141**
R^2	0.32	0.35	0.76	0.16	0.35	0.49	0.69	0.43
Number of observations	462	462	456	373	358	434	378	342

Source: Fund staff estimates.

E. Dividend Distribution Assumptions

11. We assumed that banks do not issue new shares or make repurchases during the test horizon. Moreover, the following rule for determining dividend payments was also assumed. Dividend payouts were payable out of the current year's profit using the Basel III capital conservation rule taking into account transition provisions. Dividends were assumed to be paid out of current period net income after taxes by banks that were in compliance with supervisory capital requirements (CET 1 thresholds). A maximum allowed dividend payout was assumed to be equal to the dividend payout ratio (dividends over net income after taxes) in 2016Q1−Q2 or before the recession. If a bank fell below the supervisory CET1 threshold before dividend distribution, it was considered capital-constrained and followed a schedule of dividend payouts per Table A2. If a bank fell below the supervisory threshold because of dividend distribution, it was assumed that the bank's dividend payout was limited to a level that ensures the supervisory threshold is not breached. This rule was applied only if a bank earned a positive net income. If net income was negative, it was assumed that there is no dividend payout. If a bank was above the threshold, it paid a maximum allowed proportion of dividend.

Table A3. Dividends Distribution Schedule 1/

Capital ratio (CET 1): 2015	Capital ratio (CET 1): 2016	Capital ratio (CET 1): 2017	Capital ratio (CET 1): 2018	Capital ratio (CET 1): 2019	Capital ratio (CET 1): 2020	Assumed dividend payout
	4.5-4.656	4.5-4.813	4.5-4.969	4.5-5.125	4.5-5.125	0% x Net income (t)
	4.656-4.813	4.813-5.125	4.969-5.438	5.125-5.75	5.125-5.75	20% x EDPR x Net income (t)
	4.813-4.969	5.125-5.438	5.438-5.906	5.75-6.375	5.75-6.375	40% x EDPR x Net income (t)
	4.969-5.125	5.438-5.75	5.906-6.375	6.375-7.0	6.375-7.0	60% x EDPR x Net income (t)
>4.5	>5.125	>5.75	>6.375	>7.0	>7.0	Effective div. payout rate in 2015 (EDPR)

Source: Fund staff estimates.

1/ The schedule also took into account D-SIB surcharge (not shown in the Table).

F. Tables from the Main Text

Table A4. Mergers and Acquisitions 1/

BB	Santander	BNDES	Caixa	Itau	Bradesco
2008Q2: Banco do Estado de Santa Catarina (Besc)	1998Q4: Banco Real via Amro	-	-	1996Q2: Banco do Estado do Rio de Janeiro (Banerj)	1997Q4: Banco de Credito Real SA
2008Q4: Banco do Estado do Piaui	2000Q4: Banco do Estado de Sao Paolo (Banespa)			1998Q2: Banco do Estado de Minas Gerais (BEMGE)	1997Q4: BCN
2008Q4: Banco Nossa Caixa	2000Q2: Banco Meridional			2000Q3: Banco do Estado do Parana (Banestado)	1999Q2: Banco Estado da Bahia (Baneb)
	1997Q4: Banco de Inversiones Bozano Simonsen			2001Q4: Banco do Estado de Goias (BEG)	2000Q3: Banco BoaVista
	2008Q2: ABN Amro Real			2003Q3: Banco Sudameris	2001Q4: Banco Mercantil de Sao Paolo
				2002Q1: Banco Fiat	2002Q1: Banco BEA
				2002Q3: Banco BBA-Creditanstalt	2002Q1: Cidade
				2006Q2: Bank of America	11/2003: Zogbi
				2008Q3: Unibanco	2003Q1: BBVA
					2004Q1: Banco do Estado do Maranhao
					2005Q2: Banco Morada
					2005Q4: Banco do Estado do Ceara
					2006Q2: American Express
					2007Q2: Banco BMC
					2008Q3: Agora Carretera
					2009Q3: Banco Ibi
Data not available since the bank is not in Top 50 banks on the BCB website					2015Q3: HSBC (still not part of Bradesco in 2015Q3)

Source: Brazil Central Bank.

1/ The dates represent the last date before the bank was not part of the BCB dataset on the Top 50 banks.

Table A5. Variables Used to Design Scenarios

	Specification of Dependent Variable	Independent Variables
Real GDP	y/y	Given (IMF WEO for baseline); given for stress scenario
EMBI	level	Real effective ex. rate, real gdp (y/y, lags); taken from BCB stress test in the stress scenario
Monetary policy rate	level	for the stress scenario)
Lending rates	level	Mon. policy rate
CD rate	level	Mon. policy rate
Share prices	q/q	EMBI (q/q), real GDP (q/q, lead)

Source: Fund staff estimates.

Table A6. IMF Scenarios and BCB's Scenario

BASELINE	2015	2016	2017	2018	2019	2020
Real GDP, y/y	-3.8	-3.3	0.5	1.5	2.0	2.0
Lending rates, EOP	29.8	32.6	31.7	31.7	30.8	29.8
Certificate of deposits rates, EOP	12.5	12.6	11.8	11.7	10.8	9.8
Unemployment rate, EOP	9.0	11.8	11.6	10.9	10.3	10.1
Stock exchange, index, EOP	43,350	55,484	57,054	63,032	68,934	71,868
SELIC rate, EOP	14.3	14.3	13.3	13.2	12.2	11.0
BRL/USD, EOP	3.9	3.5	3.6	3.7	3.8	3.9
EMBI, EOP	548	363	349	345	312	290
Inflation, EOP, y/y	10.7	7.2	5.0	4.8	4.5	4.5

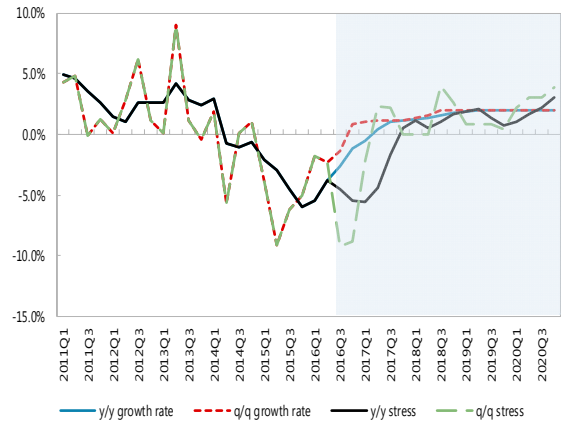
STRESS	2015	2016	2017	2018	2019	2020
Real GDP, y/y	-3.8	-4.8	-2.8	1.1	1.5	2.0
Lending rates, EOP	29.8	39.4	33.3	31.7	30.6	29.3
Certificate of deposits rates, EOP	12.5	19.5	13.3	11.8	10.7	9.3
Unemployment rate, EOP	9.0	12.3	13.0	13.2	13.5	13.5
Stock exchange, EOP	43,350	34,392	42,139	52,247	62,001	66,001
SELIC rate, EOP	14.3	22.0	15.0	13.3	12.0	10.5
BRL/USD, EOP	3.9	6.8	6.3	6.6	6.8	7.0
EMBI, EOP	548	843	512	388	320	280
Inflation, EOP, y/y	10.7	18.5	10.0	6.5	5.5	4.5

BCB stress test	Baseline			Stress (Structural Break)		
	2015q4	2016q2	2016q4	2015q4	2016q2	2016q4
Economic activity, y/y	-2.3	-1.5	-0.2	-1.9	-3.1	-4.6
Lending rates, EOP						
Deposit rates, EOP						
Unemployment rate, EOP	6.9	6.9	6.9	7.7	9.3	10.8
Stock exchange, index, EOP						
SELIC rate, EOP	14.30	13.60	12.00	20.10	26.90	26.40
BRL/USD, EOP	3.5	3.5	3.6	4.0	5.1	4.8
EMBI, EOP	304	304	304	572	438	304
Inflation, EOP, y/y	8.9	5.9	5.4	14.3	18.5	19.8

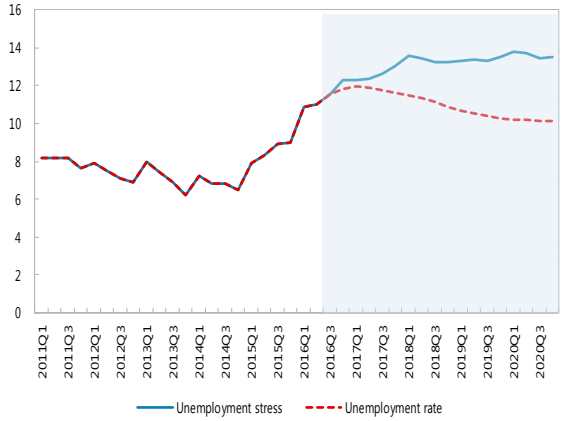
Sources: Fund staff estimates and Brazil Central Bank.

Figure A1. Baseline and Stress Scenario

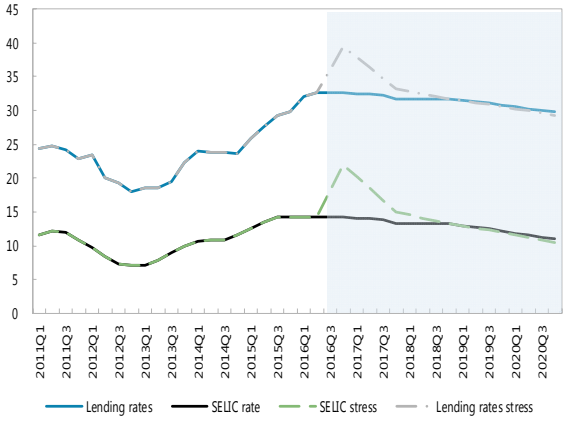
Real GDP, y/y and q/q



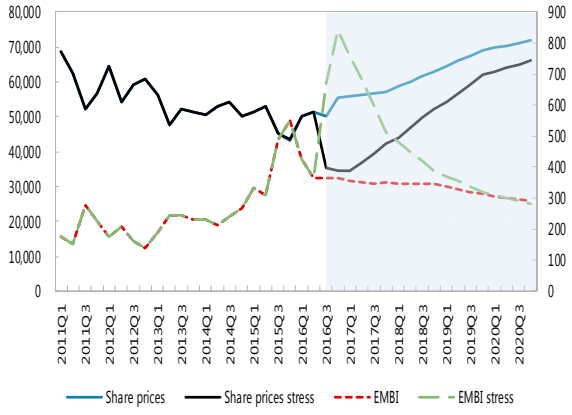
Unemployment Rate, in Percent



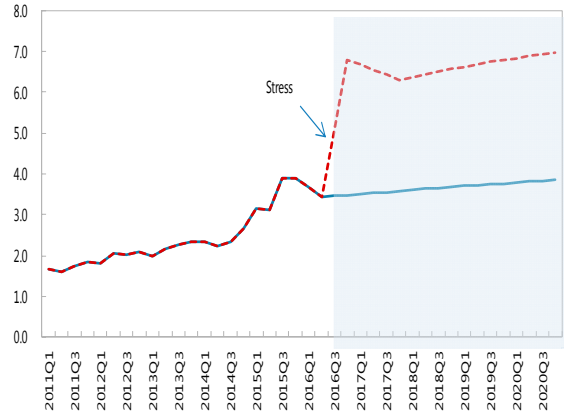
Interest rates, in Percent



Share prices, EMBI



R$/US$



Sources: Haver and Fund staff estimates.