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# IMF Working Paper

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Consumption in Brazil: Where to Next?

by Troy Matheson and Carlos Góes

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I N T E R N A T I O N A L M O N E T A R Y F U N D

**IMF Working Paper**

Western Hemisphere Department

**Consumption in Brazil: Where to Next?**

**Prepared by Troy Matheson and Carlos Góes**

Authorized for distribution by Alfredo Cuevas

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**Abstract**

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.

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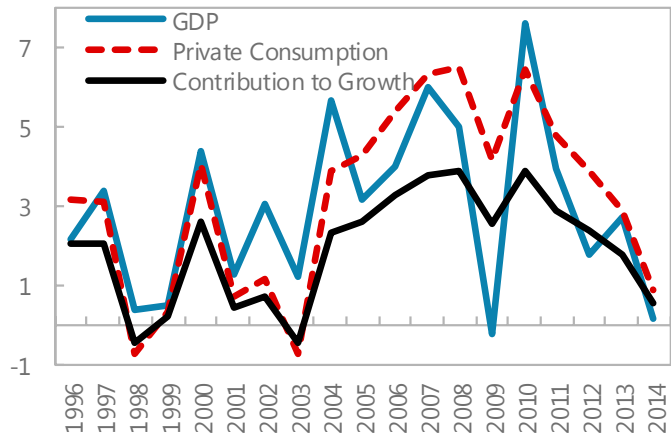
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## I. INTRODUCTION

By the end of 2014, private consumption had been a key driver of growth in Brazil 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.

Strong consumption growth was supported by a range of favorable factors, including economic and social policies. For instance, 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<sup>1</sup>. 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.<sup>2</sup>

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



Source: IBGE.

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 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.

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

<sup>1</sup> 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).

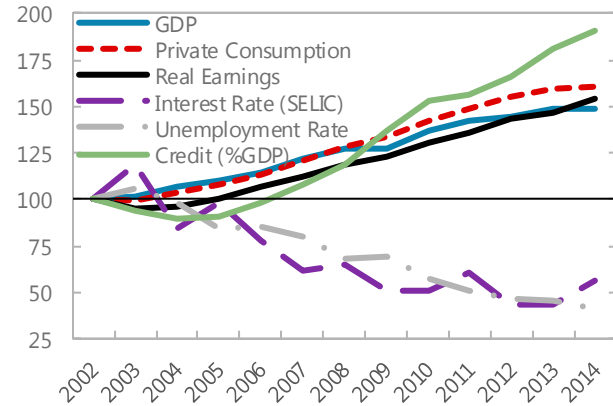
<sup>2</sup> In Brazil, the minimum wage has grown faster than productivity in real terms for many years. The minimum wage currently increases each year ( $t$ ) based on real GDP growth from 2 years before ( $t-2$ ) and inflation from the previous year ( $t-1$ ).

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.

The question this paper addresses is: is consumption-led growth sustainable going forward? In order to do so, it is organized as follows. 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.

## II. A CLOSER LOOK AT THE DATA: WHAT HAS DRIVEN CONSUMPTION IN BRAZIL?

### Bivariate Granger Causality Tests

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. Direction of 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.

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)

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  $\beta_0$  and  $\beta_1$  are constants and the residual,  $\epsilon_t$ , 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 Table 1, 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.

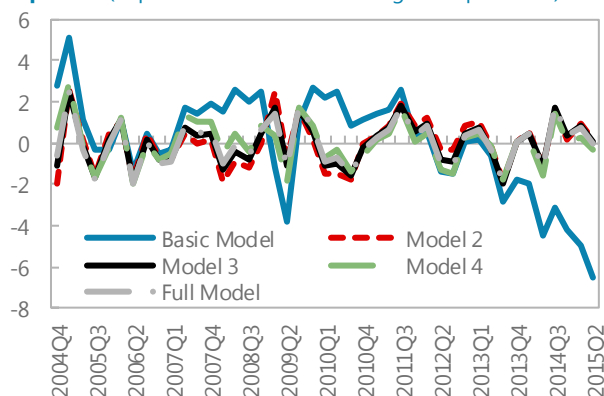
Four VECMs are estimated in addition to the basic model (see Table 2), where each model suggests there is single long-run relationship (cointegrating vector) between the included endogenous variables. The table includes the coefficients in the long-run relationships and the coefficients attached to the 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.<sup>3</sup> As can be seen in Figure 3 below, the basic model suggests very persistent consumption deviations from long run equilibrium and that allowing consumption

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<sup>3</sup> 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.

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.

**Table 2. VECM Results**

		Estimated Parameters (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
	ECM	0.11	0.26						
		(0.12)	(0.07)						
2	Long-run equation	1	= 0.98	-0.61	1.06			1	0.00
	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
	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
	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
	ECM	-1.20	0	0	0	0	0		
		(0.19)					(0.00)		

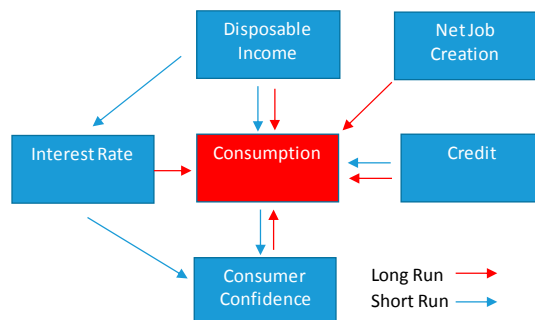
Source: Staff estimates.

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

- 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.<sup>4</sup>
- 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.
- 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.

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 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.

Figure 4. Granger Causality



Source: Staff estimates.

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

<sup>4</sup> 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.



Impulse responses and variance decompositions highlight the importance of disposable income and interest rates as drivers of consumption.<sup>5</sup> 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.<sup>6</sup>
- 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.

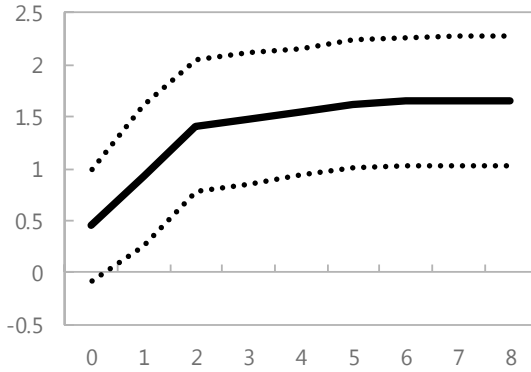
<sup>5</sup> The fully-specified VECM is identified with using a Cholesky decomposition, with consumption being the most endogenous variable. The causal ordering is:  $y_t \rightarrow r_t \rightarrow cc_t \rightarrow jc_t \rightarrow cr_t \rightarrow c_t$ . The results are robust to different orderings. 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.

<sup>6</sup> 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.

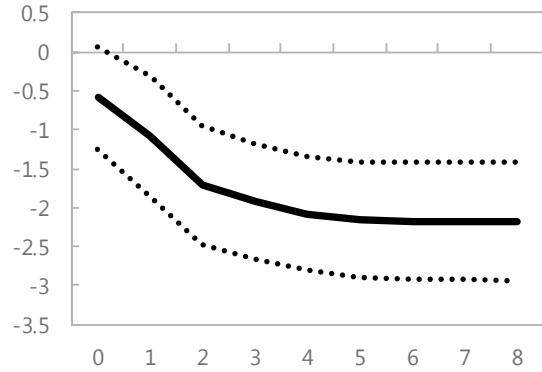
**Figure 6. Consumption Responses to Shocks**

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

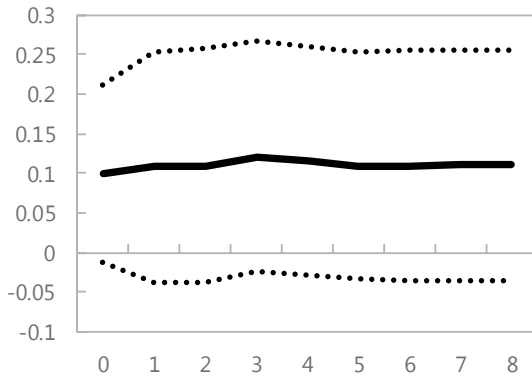
**Disposable Income Shock**



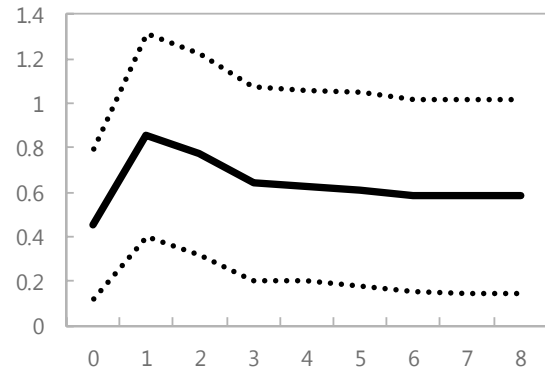
**Interest Rate Shock**



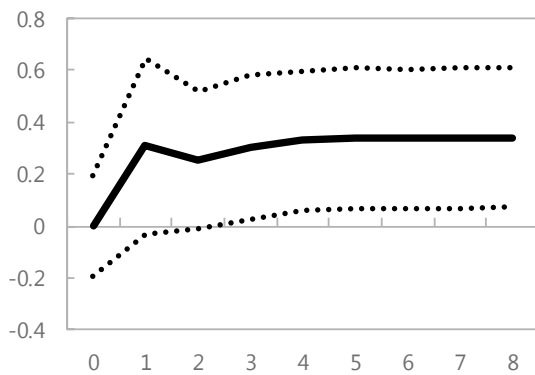
**Confidence Shock**



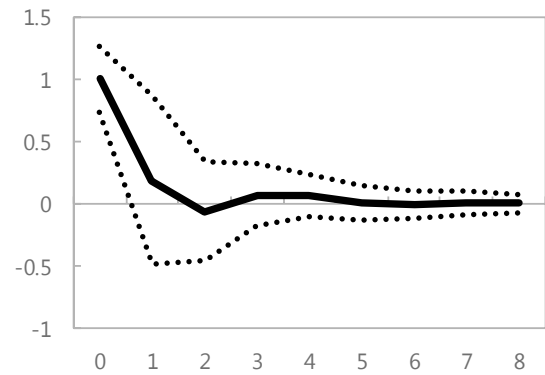
**Net Job Creation Shock**



**Credit Shock**



**Consumption Shock**



Source: Authors' calculations.

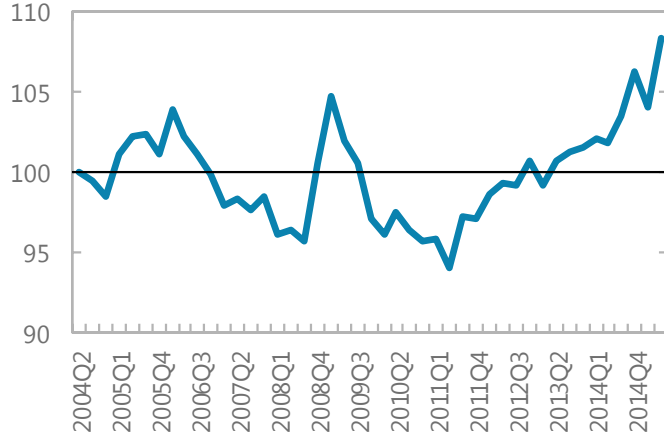
### III. WHERE TO NEXT FOR CONSUMPTION?

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.

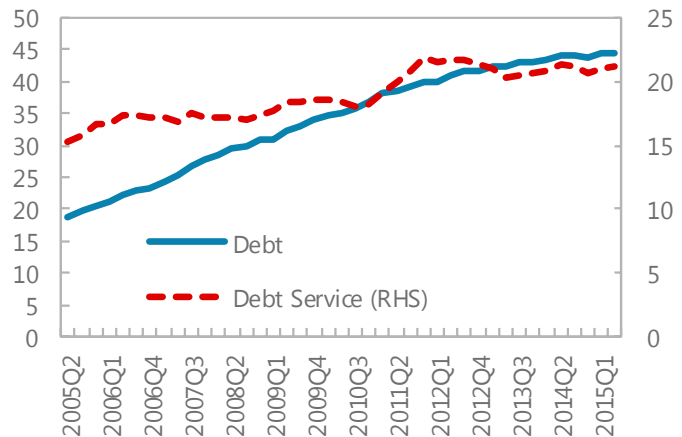
**Figure 7. Disposable Income as a Percent of GDP**  
(Index, 2004Q2 = 100)



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 disposable income)



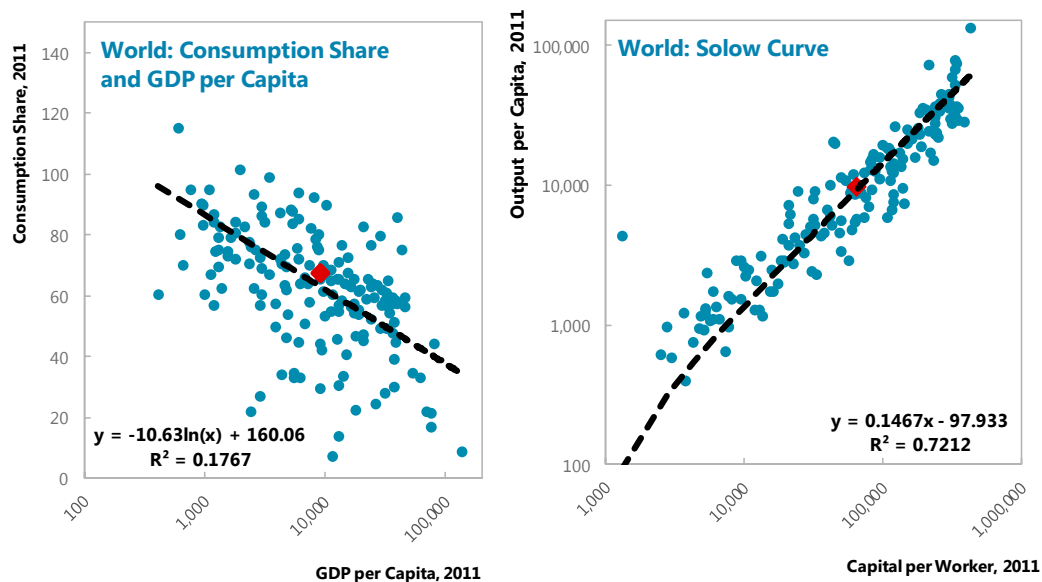
Source: Brazilian Central Bank.

- 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.

#### IV. HAS BRAZIL'S GROWTH MODEL RUN ITS COURSE?

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 high 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 competitiveness (see Garcia-Escribano and others, 2013).

**Figure 9. Relationship Between Capital Stock, Consumption Share, and Income Levels**



Source: Penn World tables.

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. Cross-Country Regressions of Investment and Consumption Shares**

	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	OLS	GMM	GMM	GMM	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
Number of countries	168	168	167	167	167	167
R-squared	0.063	0.110				
Sargan 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.

## V. POLICY IMPLICATIONS AND CONCLUSIONS

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.

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

**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).

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 disposable 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 (% working age population)	x	MTE/IGBE
Credit	Total credit (% GDP)	x	BCB
Interest Rate	Real interest rate (SELEC 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.<sup>1</sup> Thus, the Toda and Yamamoto (1995) procedure is used.<sup>2</sup>

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:

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

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

where the  $c$ s and  $\theta$ s are estimated parameters,  $\varepsilon$ s 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

<sup>1</sup> 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.

<sup>2</sup> 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.

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