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Emerson Fernandes Marçal
Ronan Cunha
Giovanni Merlin
Oscar Simões

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Emerson Fernandes Marçal[†] Ronan Cunha[‡] Giovanni Merlin[§] Oscar Simões[¶]

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Abstract

Financial events in 2008 had global impacts. We test whether U.S downturn had an impact on Brazilian economic activity and if it was unusual. We run policy ineffectiveness test (Pesaran and Smith [2014, 2016]) and Chow test. The rejection of the null hypothesis in the first test shows that financial events had impacts on Brazilian economy whereas rejection in the second is an evidence of contagion. Our estimates suggest that Brazilian industrial production dropped -9.34% at annual rate basis from December 2007 till June 2009 compared to a scenario of no effect and -6,34% when compared to a scenario of no contagion.

JEL codes: G01, C54.

Key words: counterfactual analysis, structural change.

*"Marolinha" is a Brazilian Portuguese expression that can be translated roughly as "smooth sea", "small wave" or "ripple" .

[†]Head of CEMAP -EESP-FGV, Lecturer at EESP-FGV and CCSA-Mackenzie. This author also acknowledge the support from CNPq (306172/2011-9), FAPESP (2013/22930-0) and FGV. E-mail: emerson.marcal@fgv.br

[‡]PhD Candidate at EESP-FGV.

[§]PhD Candidate at EESP-FGV.

[¶]PhD Candidate at EAESP-FGV.

"September and October of 2008 was the worst financial crisis in global history, including the Great Depression." - Ben Bernanke

1 Introduction

After almost a decade from the 2008 turmoil, there's a consensus that the event was an unexpected, severe and had global impacts. Such unique event generated a great challenge, for both theoretical and empirical macroeconomics. Emerging and developed markets were affected in many dimensions and simultaneously.

In this paper, we want investigate two questions. First we test and quantify the effects that United State (U.S.) downturn had on Brazilian economic activity. Second we estimate whether these can be classified as an extraordinary event. This goal is similar to the contagion literature of financial crisis. Interdependence is seen as co-movement driven by fundamentals whereas contagion has to do with instability of traditional mechanism of propagation during the crisis when additional channels turn on (Pesaran and Pick [2007], Forbes and Rigobon [2001] and Forbes and Rigobon [2002]).

In order to address the first question, we use policy ineffectiveness test proposed by Pesaran and Smith [2014, 2016]. The test is based on the difference between the post-intervention realizations of the outcome variable of interest and the counterfactual based on no policy intervention using forecasts of exogenous policy variable. If the null hypothesis of no effect is rejected means that Brazil was affected by the crisis.

We opt to run Chow [1960] and Brown et al. [1975] tests, to investigate whether there is evidence of instability in the Data Generator Process when before and after crisis period are confronted. If the null of the no structural change is rejected, we interpret it as evidence of contagion, i.e. another channel of propagation was active during the crisis.

Our results suggests that Brazilian industrial production dropped by 9.34% on an annual rate from December 2007 till June 2009 using Pesaran and Smith [2014]test. Using our counterfactual estimate of what would have been industrial production loss if contagion did not happen, estimated

loss amounts to -6,34% on an annual rate.

The paper has four sections. The first one is this introduction. The second section contains econometric methods are discussed. In the third section results are shown and discussed. Finally some final remarks are drawn in the last section.

2 Constructing a counterfactual

Counterfactual literature tries to deal with the lack of units by synthetic control method [Abadie and Gardeazabal, 2003, Abadie et al., 2012, 2015, Carvalho et al., 2016]. This approach relies on the idea that is possible to identify a synthetic control unit, using the information of a set of control units, and then check if, after some known intervention, outcome variable of the treated unit had a different path than the expected by the synthetic control unit.

Economist in applied macroeconomics exercises have to deal with Lucas Critique [Lucas, 1976]. Pesaran and Smith [2014, 2016], Barroso et al. [2015] seek to avoid Lucas Critique by using only information set available before the adoption of certain macroeconomic policy to estimate the parameters of the model. The test is derived in a context of a dynamic stochastic general equilibrium (DSGE) model with rational expectations and adapt the previous test to an Autoregressive Distributed Lag (ARDL) model. (Pesaran and Smith [2016]) Barroso et al. [2015] extend, under some assumptions, this approach by allowing for multiple policy rounds.

Pesaran and Smith [2014] base their tests on the difference between the post-intervention realizations of the outcome variable and the counterfactual forecasts under the assumption of no policy intervention. Counterfactual estimates embodies pre-intervention parameters while the post-intervention outcomes embody any effect of the intervention, for example, change in expectations or in parameters.

They start their analysis from the following model:

$$A_0 X_t = \sum_{k=1}^{K_1} A_{1k} E_t \left[X_{t+k} \right] + \sum_{j=1}^{K_2} A_{2j} X_{t-j} + \sum_{l=0}^{K_3} A_{3l} Z_{t-l} + u_t, \quad (1)$$

where X_t contains endogenous variables. $E_t(.)$ is the future expectation of the relevant variables given the information set till time period t. Structural shocks, u_t, are assumed to have zero mean, no serial correlation and constant variance matrix Σ_u. The exogenous variables, Z_t are assumed to have a VAR(1) dynamics. It is also possible to apply the test without exogenous variables, however, their inclusion increases the power of the test [Pesaran and Smith, 2014, 2016].

Assuming that all stationary conditions are satisfied, the solution to (1) is given by the VAR model:

$$X_t = \sum_{j=1}^{K_2} \Phi_k X_{t-j} + \sum_{l=0}^{K_3} \Psi_l Z_{t-l} + \Gamma \boldsymbol{u}_t, \tag{2}$$

where Φ and Ψ are the matrix with the parameters of the endogenous and exogenous variables, respectively and Γ is the matrix through which change in the parameters affects the variance.

The policy ineffectiveness test statistic is given by

$$\tau_{d,H} = \frac{\bar{\hat{d}}_H(\hat{\theta})}{\sqrt{\frac{\hat{\omega}_q^2+\hat{\omega}_x^2}{H}}} = \frac{\frac{1}{H}\sum_{j=1}^{H}(ipbra_{t+j} - \hat{ipbra}_{t+j})}{\sqrt{\frac{\hat{\omega}_q^2+\hat{\omega}_x^2}{H}}}, \tag{3}$$

where $\bar{\hat{d}}(\hat{\theta})$ is the mean policy effect calculated by the difference of endogenous variable forecasts values ($\hat{X}_t$) using the pre-intervention estimated parameters, the denominator is the variance of $\bar{\hat{d}}(\hat{\theta})$ as function of the uncertainties related to the estimators of the endogenous and exogenous variables, respectively, $\hat{\omega}_q^2$ and $\hat{\omega}_x^2$. Assuming that the error $u_{\cdot T_0+h}$ are normally distributed, then as $T \to \infty$, $\tau_{d,H} \to_d N(0,1)$.

In Pesaran and Smith [2014], the null hypothesis is the inefficiency of a specific macroeconomic policy. In this study we define the U.S. downturn as the policy that affected Brazilian economic activity.

2.1 Testing for contagious

In order to implement counterfactual analysis, we estimate an Vector Autoregression Model as in (2) and apply automatic model selection algorithm, Autometrics, developed by Doornik, 2009 to select a congruent and parsimonious model for pre intervention period. Our General Unrestricted

Model has 12 lags for each variable, seasonal dummies and corrections for outliers and structural breaks. These were identified by Impulse and Step Indicator Saturation technique (Ericsson, 2012).

In order to evaluate structural stability during the crisis, we also run Chow [1960] and Brown et al. [1975] tests.[1]. It is possible through this method to test for the existence of additional channels through which the financial crisis may have affected Brazilian economy. Formally, null hypothesis of no structural change in any parameter between the pre crisis (θ_1) and crisis period (θ_2) is $H_0 : \theta_1 = \theta_2; \Sigma_1 = \Sigma_2$, where $\theta_i = [\Phi_i \Psi_i \Gamma_i]$, $\Sigma_i$is variance-covariance matrix.

2.2 Defining the crisis period

We follow NBER cycle Dating Committee for United States economy. According the decline of the US economy due to Subprime financial crisis started in December 2007 and goes up to June 2009. Recession is defined a significant decline in economic activity that spread across all sectors and it lasts more than a few months by NBER. Thus, in our paper pre-intervention sample goes from January 1996 till November 2007. Figure 1 shows that this period coincides with three months of decrease in the American industrial production, but the sharpest drop happened after August 2008.

[1]While in Chow [1960], the structural break is known, Brown et al. [1975] test is based on the model's ability to predict the periods outside the range used to estimate the model.

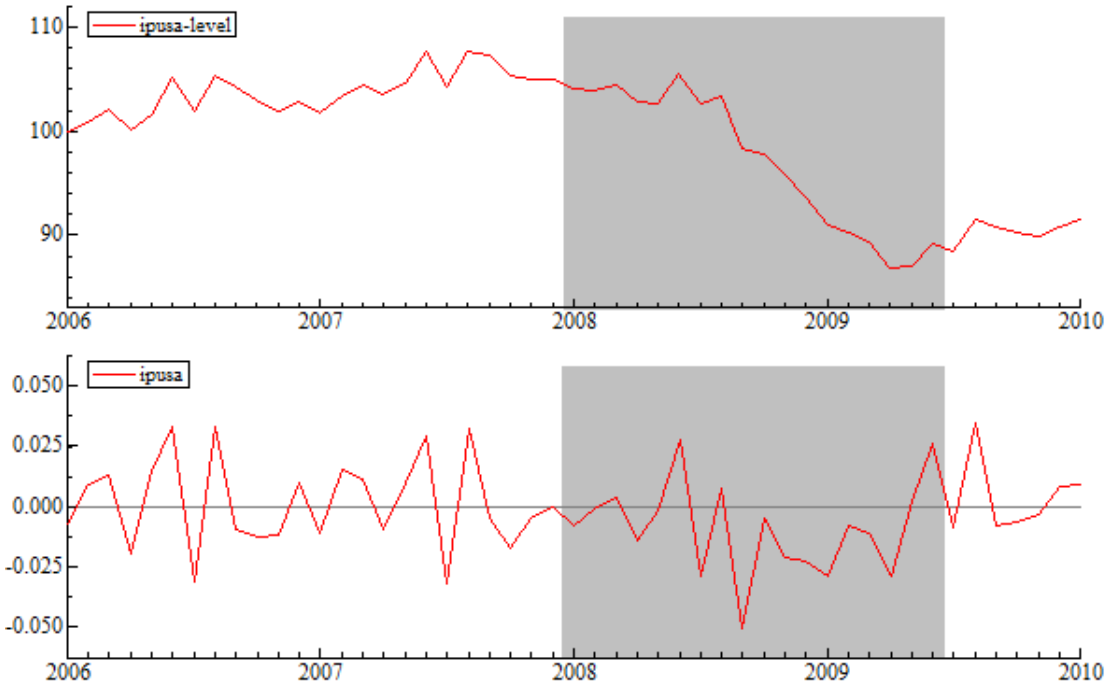

Figure 1: USA industrial production series and growth

3 Results: Aftermath of the crisis

We collect monthly variables from January 1996 till June 2009. Industrial production index and inflation rates are from *Instituto Brasileiro de Geografia e Estatística* (IBGE), Brazilian money market rate (known as Selic interest rate) and the Public Sector Deficit are from Central Bank of Brazil. The exogenous policy variables are the North American not seasonally adjusted industrial production from Board of Governors of the Federal Reserve System and one month T-bill rate from the Federal Reserve System (FED).

Table 1 presents estimates of final model. The only retained exogenous variable is USA industrial production. T-bill and U.S. monetary policy does not seem to have any direct effect on Brazilian industrial production. Second part of Table 1 shows results of diagnose tests for each equation and the whole system. Specifications tests results are good. Thus, it suits all the required assumptions to apply Pesaran and Smith [2014].

Variables	Equations					
	ipbra		rate		psd	
	Coef.	P-value	Coef.	P-value	Coef.	P-value
$ipbra_{t-1}$	-0.351	0.000	0.008	0.189	-9101	0.525
$ipbra_{t-7}$	-0.340	0.000	0.006	0.389	21903	0.165
$rate_{t-1}$	-3.035	0.000	0.823	0.000	34274	0.832
$rate_{t-2}$	2.206	0.000	-0.092	0.180	-97732	0.527
psd_{t-1}	0.000	0.184	0.000	0.051	-1.074	0.000
psd_{t-2}	0.000	0.191	0.000	0.727	-1.138	0.000
psd_{t-3}	0.000	0.396	0.000	0.292	-0.882	0.000
psd_{t-4}	0.000	0.245	0.000	0.391	-0.676	0.000
psd_{t-5}	0.000	0.657	0.000	0.146	-0.398	0.000
$ipusa_{t-8}$	1.155	0.000	-0.002	0.937	-157731	0.002
$ipusa_{t-9}$	-0.309	0.091	0.011	0.621	243858	0.000
$ipusa_{t-12}$	-0.515	0.058	0.099	0.004	-116366	0.128
$Constant$	0.013	0.003	0.002	0.000	361	0.759
Diagnostic tests for each equation						
AR 1-7 test:	2.404	0.025	1.266	0.274	1.784	0.098
ARCH 1-7 test:	0.696	0.676	0.793	0.594	1.705	0.113
Normality test:	0.911	0.634	3.687	0.158	3.340	0.188
Hetero test:	1.199	0.247	0.921	0.591	1.169	0.275
Diagnostic tests for the system						
	Coef.	P-value				
AR 1-7 test:	1.299	0.081				
Normality test:	7.675	0.263				
Hetero test:	1.031	0.389				
RESET23 test:	2.130	0.051				

Note: Seasonal Dummy and Impulse-indicator saturation were included but omitted to save space.

Table 1: Final model

Table 2 shows the τ_d for the whole period of the crisis. The null hypothesis is that the crisis does not affect Brazilian industrial production. The crisis negatively affected Brazilian industrial production with average yearly of -9.34%. This results can also be seen in Figures 2 and 3.

The results for contagious can be seen in Table 2 as well. Chow and Forecast tests suggest that there is evidence of structural change in Data Generator Process of Brazilian industrial production

after the beginning of the financial distress. Brazilian industrial production dropped, in yearly average, -6.57% based on conditional forecasts that uses actual values of United States industrial production.

Test	Average Lost	Statistic	P-value
Pesaran test N(0,1)	-9.334	-7.260	0.000
Forecast $\chi^2(19)$	-	79.091	0.000
Chow F(19,116)	-	3.452	0.000

Table 2: Structural Change and instability tests

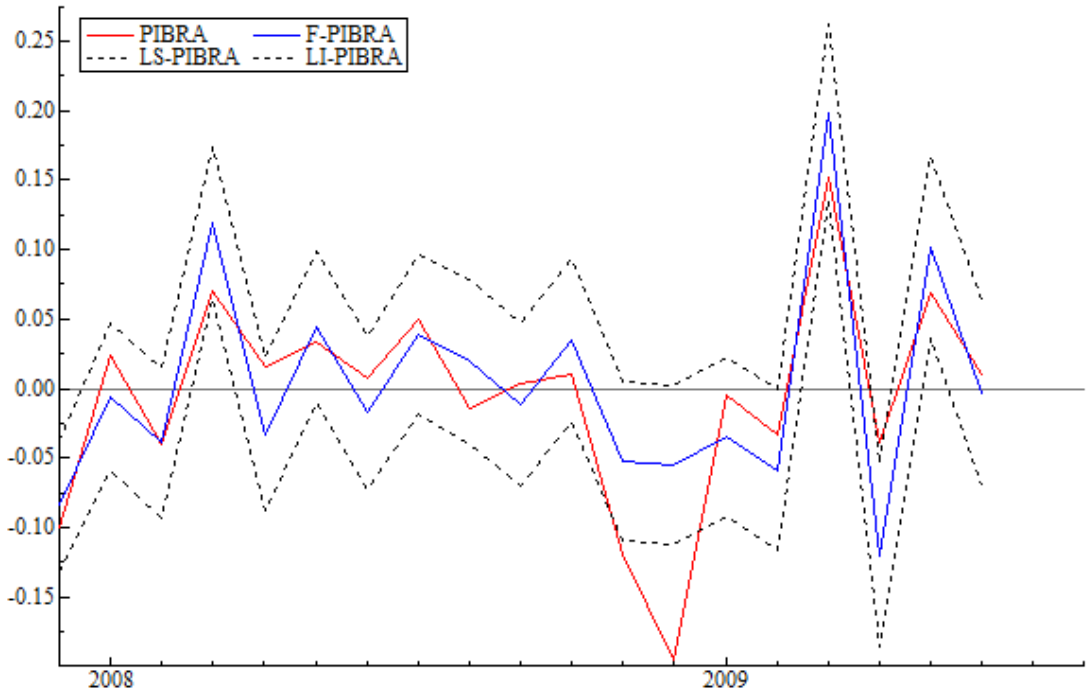

Figure 2: Forecast and Actual Industrial Production Growth

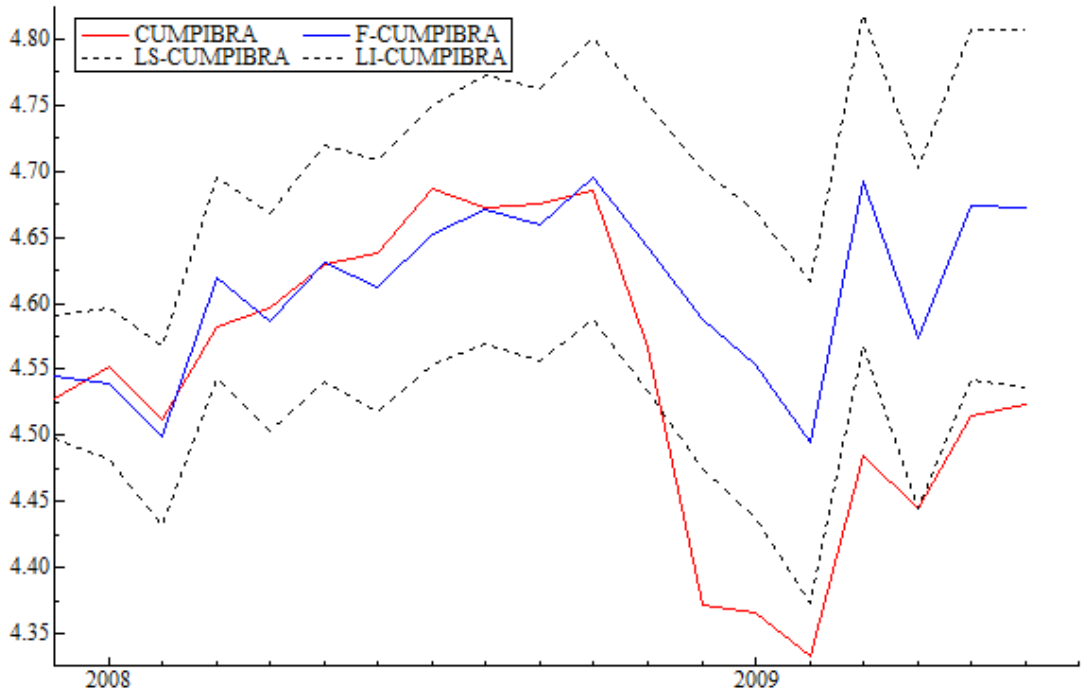

Figure 3: Conditional forecast and Actual Cumulative Logarithm of Industrial Production

4 Conclusions

In this note we investigate the effects of financial crisis events of 2008 on Brazilian output, specifically on industrial production output. In order to achieve this goal we apply the test of policy ineffectiveness proposed by Pesaran and Smith [2014, 2016] and rejected the null that Brazil was not affected by theses events. We also investigated whether there was evidence of contagion that is it was tested if industrial production overreacted to the shock. By that we want to collect evidence that the event can be classified as extraordinary. Our results suggests that Brazilian industrial production loss was about -9.34% on an annual rate from December 2007 till June 2009 using Pesaran and Smith [2014] test whereas an ex-ante conditional forecast based on actual value of United States industrial production index suggested a downturn of -6.34%. This difference can be seen as abnormal effect on Brazilian economic activity. There is evidence of structural change in the parameter of estimated model for the period of crisis.

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