

Quantitative Easing and Related Capital Flows into Brazil

Measuring its effects and transmission channels
through a rigorous counterfactual evaluation

João Barata R.B. Barroso

Research Department

Frankfurt, April 2014

Joint work with

Luiz Pereira da Silva and

Adriana Soares Sales

- The views expressed here are those of the authors and do not necessarily reflect those of the *Banco Central do Brasil* or its members.

Motivation

- Possible spillovers from advanced economies (AEs) quantitative easing policies (QE) to emerging market economies (EMEs).
 - Positive growth spillovers highlighted by AEs
 - Negative financial spillovers (and the burden of macro prudential policies) highlighted by EMEs
- Possible role for cross border capital flows
- Brazil a representative and focal point in policy debate
- This paper: (i) Robust evidence of macro and financial spillovers from Fed`s QE policies into Brazil (ii) Robust evidence of the importance of the capital flow channel.

Intuition

- Forecast domestic variables conditional on foreign policy (10y-3m spread) and foreign variables (CRB, EMBI,..)
 - Interim effect: difference of forecasts conditional on actual and counterfactual scenarios for foreign variables. This is random if the model is unknown.
 - Ex post effect: difference between actual domestic variables and its counterfactual forecast. This is random even if the model is known. Nice test for null effects.
- Grid of counterfactuals ensures robustness
- Multivariate linear model allows channel identification
- Note: to get “effect of interest” and “channel of interest” must include relevant variables...

Roadmap

- Motivation / Intuition
- Literature / Contribution
- Definitions / Propositions
- Model / Results
- Summary

Literature

- Counterfactual term spread: Pesaran and Smith (2012), Baumeister and Benati (2013), Chen *et.al.* (2012); large counterfactuals up to 200 bps; usually no test.
- Event study: Gagnon *et.al.* (2011), D'Amico and King (2010), Krishnamurthy *et.al.* (2011), Bauer (2012), Williams (2011)); around 100 bps (QE1) or 30 bps (QE2) upon announcement.
- Arbitrage free: D'Amico and King (2010), Hamilton and Wu (2012), Jarrow and Li (2012)); 75 bps for both QE1 and QE2.
- Other foreign variables: Neely (2012); Kim (2001); Anzuini, Lombardi and Pagano (2013); Bastourre *et.al.* (2012).
- Capital flows: BIS (2008), BIS-CGFS (2009), the IDB (2012); less benign view of capital flows

Contribution

- General:

- Decomposition of the transmission channels
- Test ex post effects pooling information across events.
- Agnostic principle when defining counterfactuals

- Specific:

- Estimation and test of spillover effects over more than 50 variables in the Brazilian economy
- Quantitative assessment of the capital flow channel for these effects

Notation

- y_t domestic variable
- x_t foreign policy (eg. term spread)
- z_t global variable (eg. CRB, EMBI)
- Ω_t their history up to period t
- $x_{t,h}^p$ with $p \in \{a, c\}$ actual or counterfactual policy up to period $t + h$.
- Similarly for global variables $z_{t,h}^a, z_{t,h}^c$

Definitions

$$\text{➤ } d_{t+h}^{interim} = E(y_{t+h} | \Omega_t, x_{t,h}^a, z_{t,h}^a) - E(y_{t+h} | \Omega_t, x_{t,h}^c, z_{t,h}^c)$$

$$\text{➤ } d_{t+h}^{ex post} = y_{t+h} - E(y_{t+h} | \Omega_t, x_{t,h}^c, z_{t,h}^c)$$

$$\text{➤ } AIE = \frac{1}{H} \sum_{h=1}^H d_{t+h}^{interim}$$

$$\text{➤ } AEE = \frac{1}{H} \sum_{h=1}^H d_{t+h}^{ex post} = AIE + \frac{1}{H} \sum_{h=1}^H \varepsilon_{t+h}$$

➤ How to set counterfactual global variables? Our proposal:

$$\text{➤ } z_{t+j}^c = z_{t+j}^a + \lambda \{ E(z_{t+j} | \Omega_t, x_{t,h}^a) - E(z_{t+j} | \Omega_t, x_{t,j}^c) \}$$

➤ Note: if the policy is anticipated must adapt notation so that forecast $j < h$ steps ahead uses policy information up to h . we do not consider this case in the paper.

Tests

➤ $H_0: AEE_r = 0 \Rightarrow t_r = \frac{1}{\hat{\sigma}_r} AIE_r \sim N(0,1)$

➤ Pool information on policy rounds

➤ $H_0: \sum_r AEE_r / R = 0$ pooled average is zero

$$t_{pool} = (\overline{\hat{\sigma}^2})^{-\frac{1}{2}} \frac{1}{R} \sum_{r=1}^R AIE_r \sim N(0,1)$$

➤ $H_0: (\forall r) AEE_r = 0$ each average is zero

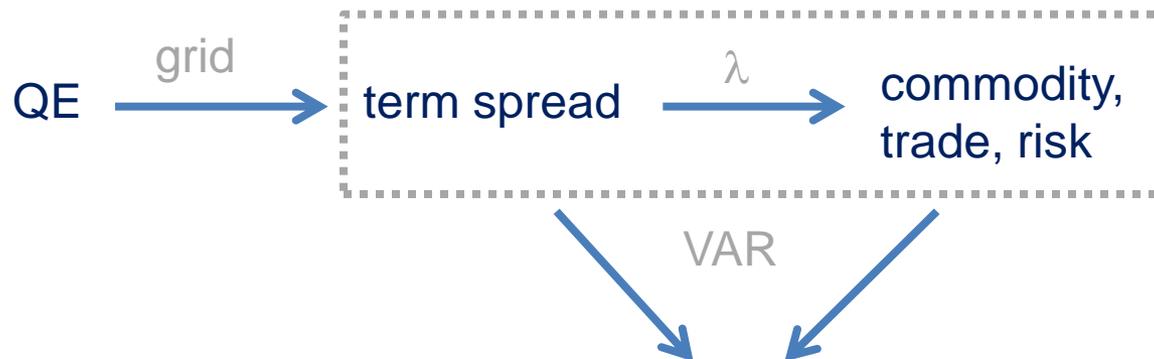
$$t_{each} = \sum_{r=1}^R \frac{1}{\hat{\sigma}_r^2} (AIE_r)^2 \sim \chi^2_{(R)}$$

➤ Note: similar in the cross section as well

Channel Decomposition

- Let the domestic variables be $y=(y_1,\dots,y_n)$.
- Conditional expectations from a Vector Autoregression
- As before, the *ex ante effect* uses the counterfactual foreign variables in each VAR equation to project the full scenario.
- Now, let the *marginal ex ante effect* of y_i uses the counterfactual policy only in the equation for y_i
- Proposition:
 - For a linear conditional model, the *ex ante effect* is the sum of the *marginal ex ante effects*.

Empirical Strategy in a Nutshell



core: inflation, activity, gross capital inflow,
policy rate, exchange rate

additional: credit, credit risk, interest rate,
spread, stock market, etc.. (50
variables)



propagation
through
domestic
channels

Note: Ideally, liquidity shocks should be the overwhelming driver the term spread in the sample, so that on average we get the right effects.

VAR Specification

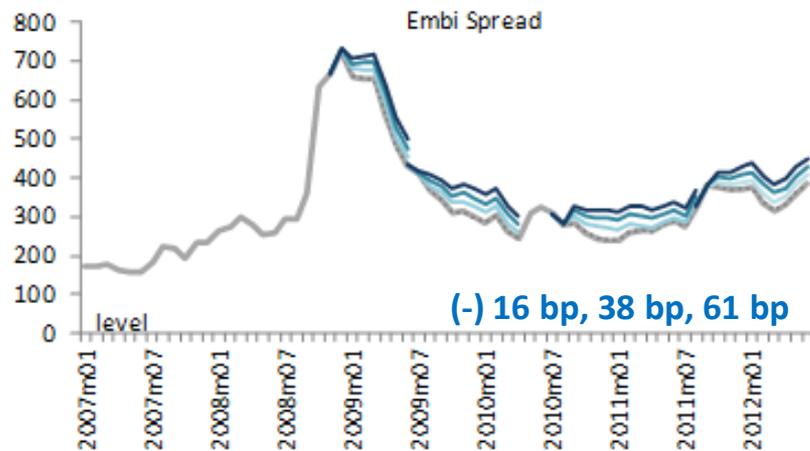
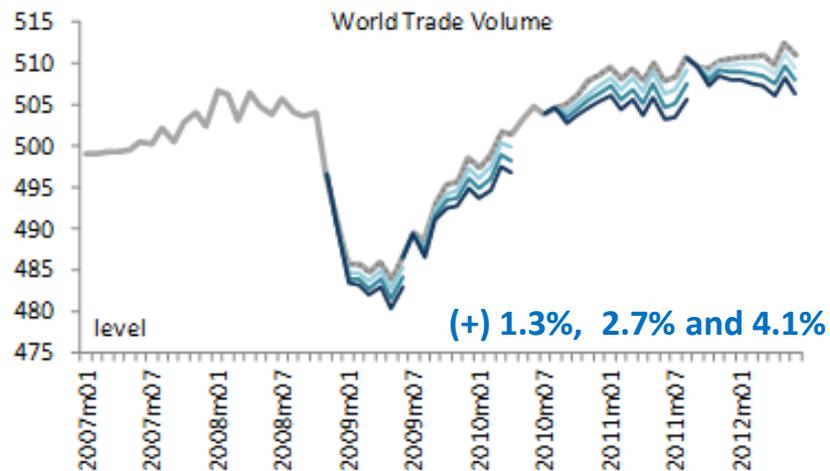
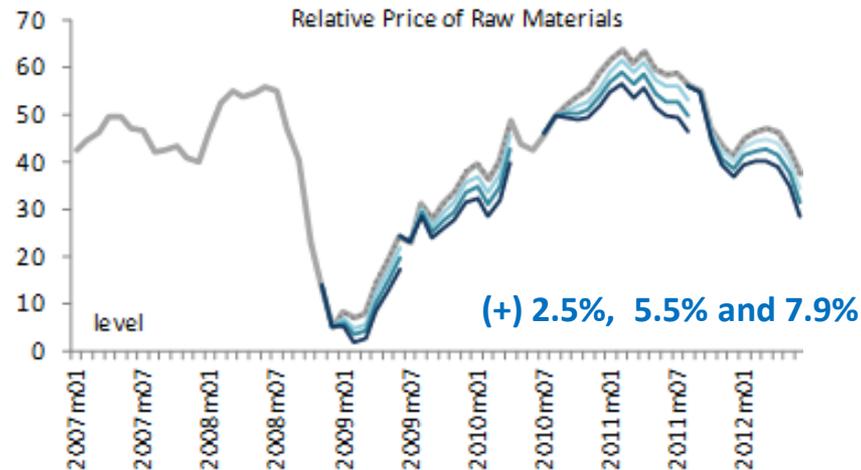
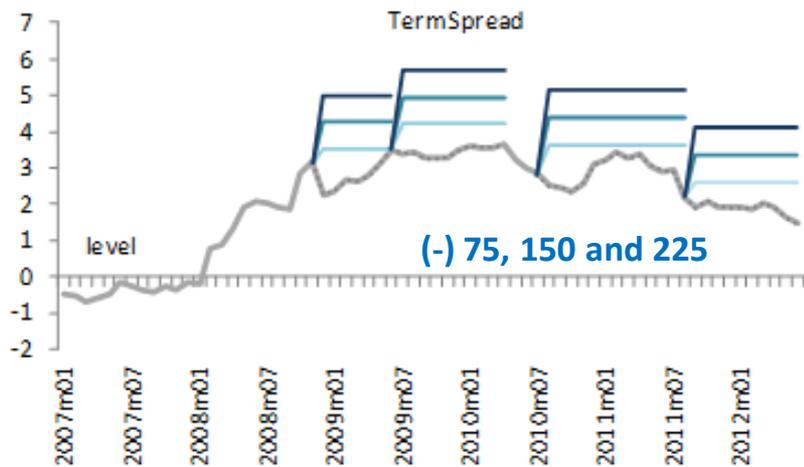
- VAR in levels (possible cointegration, parsimonious)
 - In particular, accumulated gross capital flows.
- Parameter stability according to fluctuation tests.
- Just to make sure, we report results for two samples:
 - Full sample: Jan 2000-Jun 2012;
 - Crisis sample: Jan 2006-Jun 2012.
 - Two years before NBER peak;
 - This allows forward looking behavior;
 - And avoids small sample problems.
- Extended VAR as in Kim (2001) and Jansen (2003).

Counterfactual Scenarios

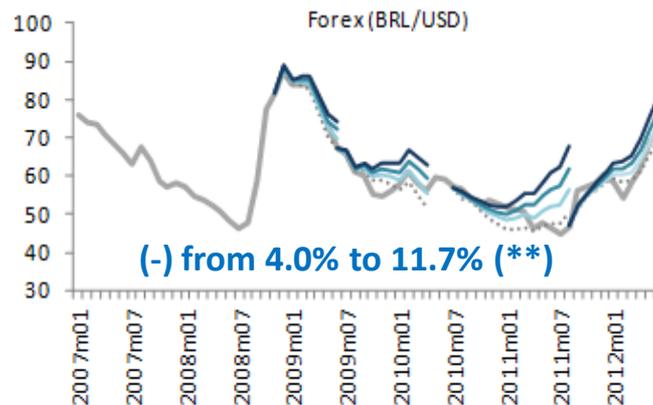
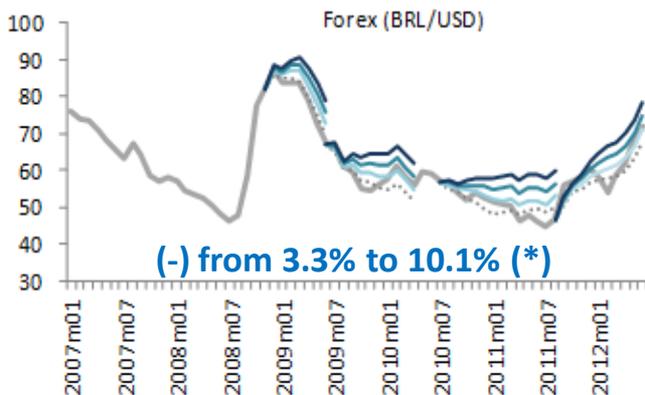
- QE1 - Dec 2008 to Jun 2009;
- QE1 extension - Jul 2009 to Apr 2010;
- QE2 - Aug 2010 to Aug 2011;
- Operation Twist - Sep 2011 to Jun 2012.

- We investigate a grid in the range of the literature:
 - From 75 to 225 basis points effect on the term spread.
 - For each of these, deduce the likely behavior of foreign variables, given historical correlations ($\lambda=1$)
 - Somewhat conservative, could use stressed correlations as suggested by the IMF
 - We actually do so as a robustness exercise

Counterfactual Scenarios



Effects on the Core Variables



Ex Ante Effect = relative to dotted line

Ex Post Effect = relative to actual series

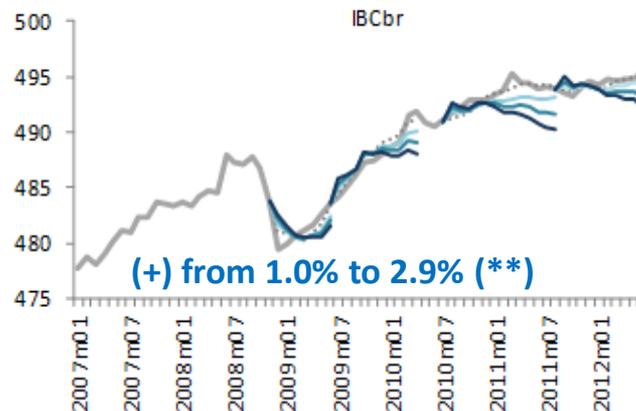
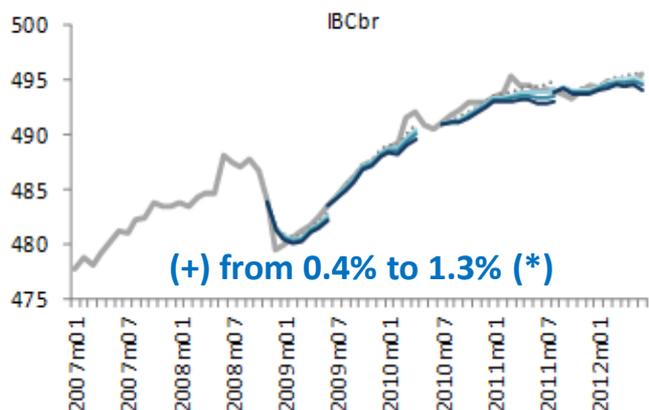
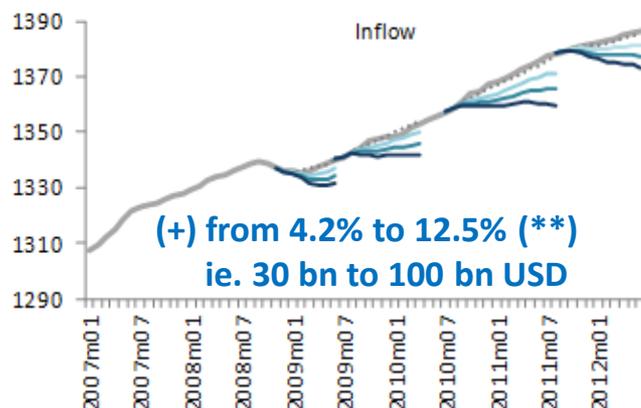
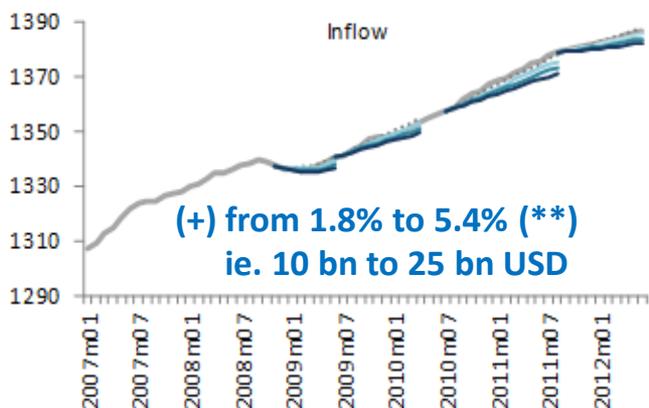
LHS = Full Sample

RHS = Crisis Sample

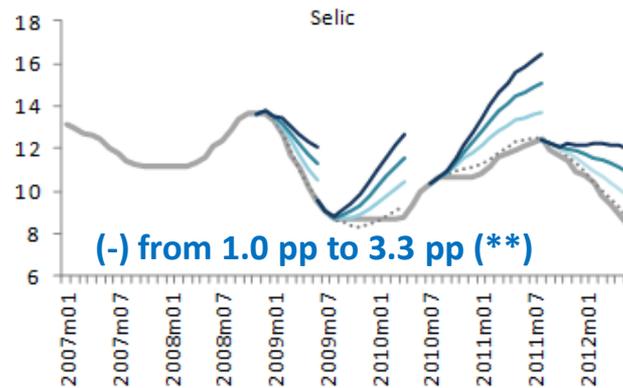
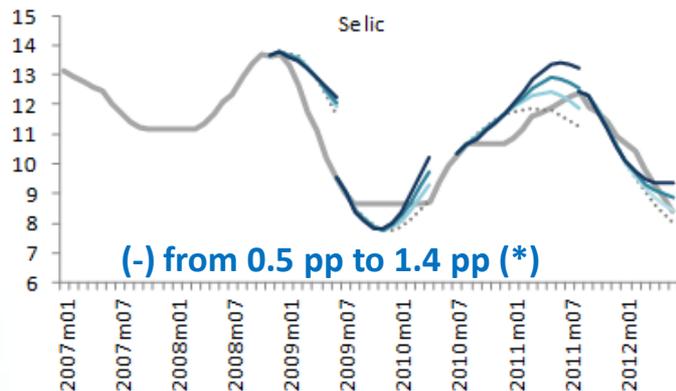
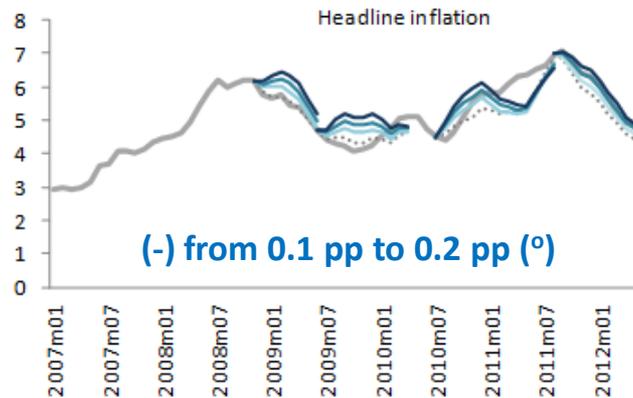
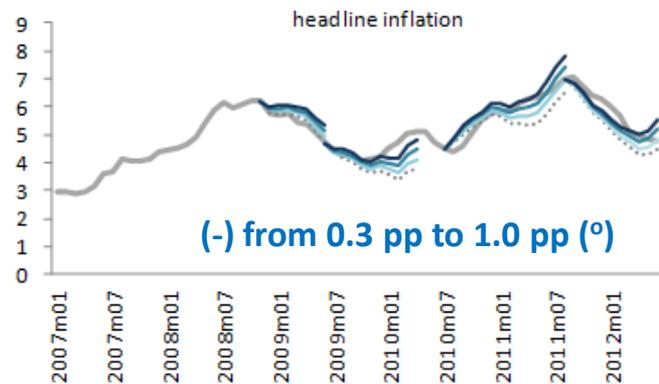
** = sign at 5%

* = sign at 10%

o = not sign



Effects on Core Variables



Ex Ante Effect = relative to dotted line

Ex Post Effect = relative to actual series

LHS = Full Sample

RHS = Crisis Sample

** = sign at 5%

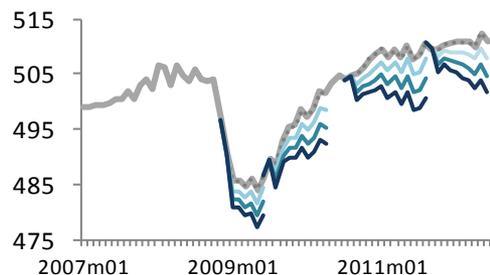
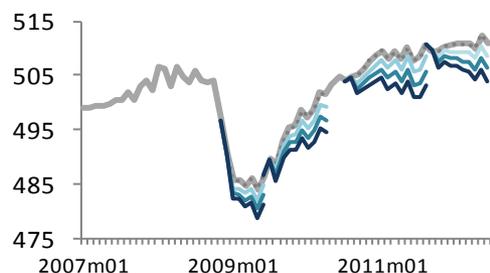
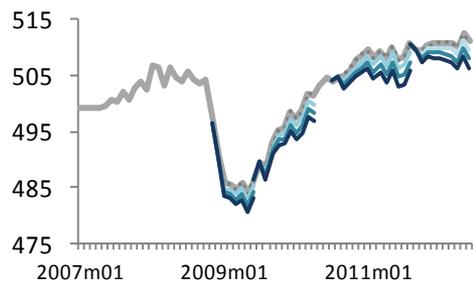
* = sign at 10%

° = not sign

Higher Global Correlation Exercise

Counterfactuals on world trade

Stronger priors on global activity channel



Accumulated Ex Ante Effect

Average across QE rounds

Full Sample
2000m01 to 2012m06

| <i>lambda</i> = 1.0 | 75 | 100 | 125 | 150 | 175 | 200 | 225 |
|---------------------|-------|-------|-------|-------|-------|-------|--------|
| Price | -0.34 | -0.45 | -0.56 | -0.67 | -0.78 | -0.89 | -1.00 |
| Activity | 0.43 | 0.57 | 0.71 | 0.85 | 0.98 | 1.12 | 1.26 |
| Inflow | 1.79 | 2.38 | 2.98 | 3.58 | 4.18 | 4.78 | 5.37 |
| Selic (p.p) | -0.46 | -0.61 | -0.76 | -0.90 | -1.05 | -1.20 | -1.35 |
| Forex | -3.26 | -4.41 | -5.55 | -6.69 | -7.84 | -8.98 | -10.13 |

| <i>lambda</i> = 1.5 | 75 | 100 | 125 | 150 | 175 | 200 | 225 |
|---------------------|-------|-------|-------|-------|-------|-------|-------|
| Price | -0.13 | -0.17 | -0.21 | -0.26 | -0.30 | -0.35 | -0.39 |
| Activity | 0.44 | 0.58 | 0.72 | 0.87 | 1.01 | 1.15 | 1.29 |
| Inflow | 1.23 | 1.64 | 2.06 | 2.48 | 2.90 | 3.32 | 3.74 |
| Selic (p.p) | -0.22 | -0.30 | -0.37 | -0.44 | -0.51 | -0.58 | -0.65 |
| Forex | -2.29 | -3.11 | -3.94 | -4.77 | -5.59 | -6.42 | -7.24 |

| <i>lambda</i> = 2.0 | 75 | 100 | 125 | 150 | 175 | 200 | 225 |
|---------------------|-------|-------|-------|-------|-------|-------|-------|
| Price | 0.08 | 0.11 | 0.13 | 0.15 | 0.17 | 0.19 | 0.22 |
| Activity | 0.44 | 0.59 | 0.74 | 0.88 | 1.03 | 1.18 | 1.33 |
| Inflow | 0.66 | 0.91 | 1.15 | 1.39 | 1.63 | 1.87 | 2.12 |
| Selic (p.p) | 0.01 | 0.02 | 0.02 | 0.03 | 0.03 | 0.04 | 0.04 |
| Forex | -1.31 | -1.82 | -2.33 | -2.84 | -3.34 | -3.85 | -4.36 |

Effects on Other Variables

➤ Credit

- Credit/GDP: (+) 0.2 pp to 0.6 pp (**) 0.4 pp to 1.0 pp (°)
- Interest rates: (-) 1.0 pp to 3.0 pp (**) 2.0 pp to 6.9 pp (**)
- Credit at risk: (-) 0.1 pp to 0.2 pp (°) 0.3 pp to 0.9 pp (**)

➤ Stock Market

- Market Cap/GDP: (+) 3.2 pp to 10.0 pp (**) 5.5 pp to 17.0 pp (**)
- Funds Cap/GDP: (+) 0.4 pp to 1.3 pp (**) 0.6 pp to 1.8 pp (**)

➤ Inflation

- Producer Price: (-) 1.8 pp to 5.4 pp (*) 0.8 pp to 2.6 pp (**)

➤ External Sector

- Portfolio inflow: (+) 2.8% to 8.6% (**) 6.7% to 19.6% (**)
- Int.Reserves: (+) 0.7 pp to 2.0 pp (**) 1.6 pp to 4.7 pp (**)

➤ Domestic Sector

- Retail Sales: (+) 1.0% to 2.8% (°) 1.5% to 4.2% (**)
- Ind.Prod.: (+) 0.0 pp to 0.2 pp (°) 1.2 % to 3.7% pp (**)

Test for Ex Post Effects

Crisis Sample

Null Hypothesis: Each average ex-post effect = 0
p-values for ChiSq(4) test statistics

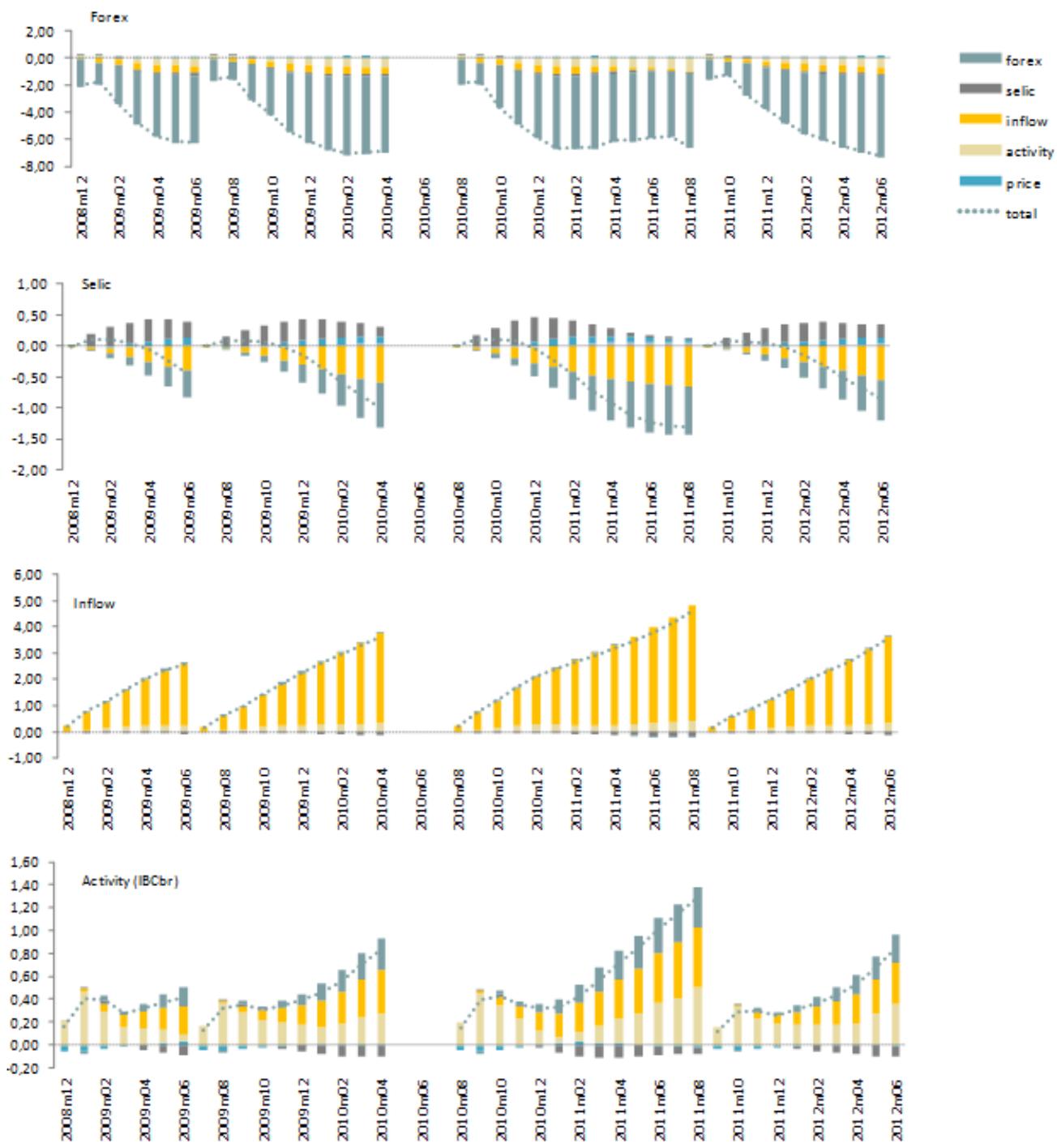
Crisis Sample
2006m01 to 2012m06

| | 75 | 100 | 125 | 150 | 175 | 200 | 225 |
|--|------|------|------|------|------|------|------|
| Price | 0,46 | 0,29 | 0,16 | 0,08 | 0,03 | 0,01 | 0,00 |
| Activity | 0,81 | 0,66 | 0,47 | 0,30 | 0,17 | 0,08 | 0,03 |
| Inflow | 0,12 | 0,01 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| Selic | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| Forex | 0,98 | 0,96 | 0,92 | 0,85 | 0,77 | 0,67 | 0,57 |
| non ear marked credit (%gdp) | 0,88 | 0,76 | 0,61 | 0,45 | 0,30 | 0,18 | 0,10 |
| non ear marked credit; firms | 0,86 | 0,75 | 0,62 | 0,48 | 0,35 | 0,23 | 0,15 |
| non ear marked credit; households | 0,48 | 0,20 | 0,06 | 0,01 | 0,00 | 0,00 | 0,00 |
| credit from private banks | 0,84 | 0,66 | 0,46 | 0,28 | 0,14 | 0,07 | 0,03 |
| credit from private banks; households | 0,31 | 0,09 | 0,01 | 0,00 | 0,00 | 0,00 | 0,00 |
| credit from private banks; manufacture | 0,88 | 0,75 | 0,57 | 0,40 | 0,25 | 0,14 | 0,07 |
| credit from private banks; retail | 1,00 | 1,00 | 1,00 | 0,99 | 0,99 | 0,99 | 0,98 |
| credit from foreign banks | 0,49 | 0,26 | 0,10 | 0,03 | 0,01 | 0,00 | 0,00 |
| credit from foreign banks; households | 0,63 | 0,36 | 0,16 | 0,05 | 0,01 | 0,00 | 0,00 |
| credit from foreign banks; manufacture | 0,88 | 0,75 | 0,58 | 0,41 | 0,26 | 0,15 | 0,07 |
| credit from foreign banks; retail | 0,81 | 0,66 | 0,50 | 0,35 | 0,22 | 0,13 | 0,07 |
| credit at risk; D or worse (p.p) | 0,72 | 0,47 | 0,25 | 0,10 | 0,03 | 0,01 | 0,00 |
| credit at risk; D or worse; households | 0,98 | 0,95 | 0,92 | 0,86 | 0,79 | 0,70 | 0,61 |
| credit at risk; D or worse; manufacture | 0,87 | 0,73 | 0,56 | 0,38 | 0,23 | 0,12 | 0,06 |
| credit at risk; D or worse; manuf+retail | 0,18 | 0,04 | 0,01 | 0,00 | 0,00 | 0,00 | 0,00 |
| interest rate; reference loans (p.p.) | 0,89 | 0,76 | 0,59 | 0,41 | 0,26 | 0,14 | 0,07 |
| interest rate; reference loans; households | 0,77 | 0,61 | 0,42 | 0,26 | 0,14 | 0,07 | 0,03 |
| interest rate; reference loans; firms | 0,32 | 0,12 | 0,03 | 0,01 | 0,00 | 0,00 | 0,00 |
| interest rate spread; reference loans | 0,98 | 0,95 | 0,92 | 0,86 | 0,79 | 0,70 | 0,61 |
| interest rate spread; reference loans; firms | 0,89 | 0,79 | 0,65 | 0,50 | 0,35 | 0,22 | 0,13 |
| stock market funds (%gdp) | 0,21 | 0,05 | 0,01 | 0,00 | 0,00 | 0,00 | 0,00 |
| stock market value | 0,70 | 0,47 | 0,26 | 0,12 | 0,05 | 0,01 | 0,00 |
| headline price index; services | 0,71 | 0,54 | 0,37 | 0,22 | 0,12 | 0,06 | 0,02 |
| headline price index; food | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| headline price index; core | 0,13 | 0,04 | 0,01 | 0,00 | 0,00 | 0,00 | 0,00 |
| producer price index | 0,95 | 0,89 | 0,81 | 0,70 | 0,57 | 0,44 | 0,33 |
| gross inflow; acm; direct investment | 0,78 | 0,65 | 0,50 | 0,35 | 0,23 | 0,14 | 0,07 |
| gross inflow; acm; portfolio | 0,19 | 0,04 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| gross inflow; acm; credit | 0,34 | 0,12 | 0,03 | 0,00 | 0,00 | 0,00 | 0,00 |
| export quantum | 0,77 | 0,61 | 0,44 | 0,29 | 0,17 | 0,09 | 0,04 |
| import quantum | 0,73 | 0,54 | 0,35 | 0,19 | 0,09 | 0,04 | 0,01 |
| import quantum; intermediate | 0,82 | 0,69 | 0,53 | 0,37 | 0,23 | 0,13 | 0,07 |
| international reserves (%gdp) | 0,07 | 0,01 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| international reserves (%m2) | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| unemployment rate | 0,88 | 0,78 | 0,65 | 0,52 | 0,38 | 0,26 | 0,17 |
| formal employment; retail and service | 0,89 | 0,79 | 0,66 | 0,51 | 0,36 | 0,23 | 0,14 |
| formal employment; construction | 0,36 | 0,16 | 0,06 | 0,02 | 0,00 | 0,00 | 0,00 |
| retail sales | 0,46 | 0,25 | 0,11 | 0,04 | 0,01 | 0,00 | 0,00 |
| retail sales; hypermarkets | 0,52 | 0,32 | 0,17 | 0,08 | 0,03 | 0,01 | 0,00 |
| auto sales | 0,80 | 0,65 | 0,48 | 0,32 | 0,20 | 0,11 | 0,05 |
| industrial production | 0,45 | 0,23 | 0,09 | 0,03 | 0,01 | 0,00 | 0,00 |
| industrial production; consumption goods | 0,67 | 0,47 | 0,28 | 0,14 | 0,06 | 0,02 | 0,01 |
| fixed capital absorption | 0,27 | 0,11 | 0,03 | 0,01 | 0,00 | 0,00 | 0,00 |
| inputs to civil construction | 0,77 | 0,61 | 0,44 | 0,28 | 0,16 | 0,09 | 0,04 |
| installed capacity utilization | 0,67 | 0,46 | 0,27 | 0,13 | 0,05 | 0,02 | 0,00 |

Decomposition: Core Variables

Full sample

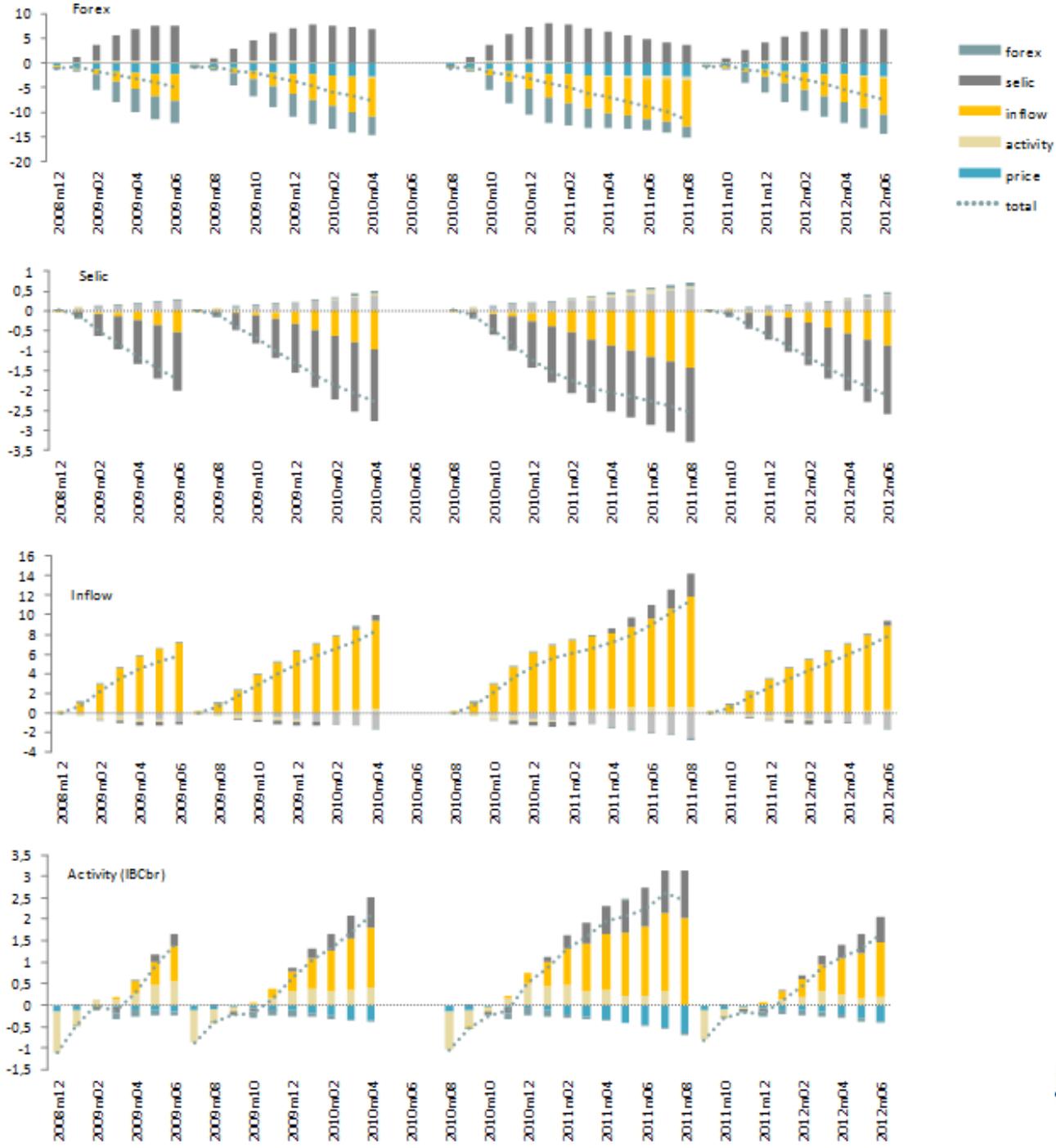
150 bp counterfactual



Decomposition: Core Variables

Crisis Sample

150 bp counterfactual



Caveat for Channel Decomposition

- Brazil implemented macroprudential policies
- Not included in the model
- However, should weaken the capital inflow channel
- Therefore, if anything, our channel estimation for capital flow is biased downwards, which strengthens our results.

Summary of Interim Effects

- QE has foreseeable spillover effects on the Brazilian economy:
 - large capital inflows;
 - exchange rate appreciation;
 - stock market price increases;
 - credit market boom;
 - stronger activity.
- This is consistent with EME policy makers argument of financial instability; but also with AE argument of growth spillovers.
 - The main message is that there are “collateral effects”.
- No robust conclusion on inflation

Summary of Ex post Effects

- Moreover, the actual difference between events and counterfactuals is statistically significant.
 - According to the evidence for the crisis sample.
 - For the test with the following alternative
 - At least one QE policy round had effects;
- Our test, which uses multiple policy rounds, has more power than previous ones suggested in the literature.

Summary of Transmission Channels

- Capital inflow is the most important transmission or propagation channel
 - Robust statistical significance across samples
 - Higher proportional contribution to the propagation
 - More than 2/3 of the effects propagate through the domestic capital inflow channel.

Further work

- We are applying similar methods in new research such as:
 - Explore the cross-section information when conducting inference in the context of Panel VAR models.
 - Estimate the effect of domestic macro prudential and other domestic intervention policy.
 - In particular, we are exploring both fronts to assess the consequences of tapering by the Fed.
 - In this respect, the results in this paper are suggestive.
 - But further work is necessary possible changes in the data generating process.

Thank you!

joao.barroso@bcb.gov.br