Did QE Unleash a Monetary Tsunami? An Exchange Market Pressure Approach

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Abstract

Emerging Market policymakers have claimed that Quantitative Easing (QE) unleashed a monetary tsunami on their financial markets. Academic studies, however, have so far found only small or even ambiguous effects. In part, this may have been because these studies examine the impact on capital flows, exchange rates, or interest rates separately, even though policymakers have clearly been referring to the combined pressure, which has been absorbed in many different ways. We propose a summary measure, a modern version of the Exchange Market Pressure (EMP) approach, which adds up the pressure absorbed in various markets based on their exchange rate change equivalents. We find that the initiation of QE1 and QE2 typically generated 2-3 months of unusually high exchange market pressure in emerging economies. On average, nearly 40 per cent of the pressure was absorbed by exchange rate changes, about 50 percent by intervention.

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1 Introduction

Quantitative easing (QE) in the US created fears that the Fed was unleashing a tsunami of capital flows, to emerging economies, leading to intense pressure on their currencies. For example, the President of Brazil said "... quantitative easing policies ... have triggered what can only be described as a monetary tsunami; have led to a currency war and have introduced new and perverse forms of protectionism in the world." [1] Fed Chairman Ben Bernanke, however, argued that the impact of QE on capital flows would be limited. This was because the links between advanced-economy monetary policies and international capital flows is "looser than is sometimes asserted". In addition, Bernanke argued that policy makers in emerging markets are equipped with the tools such as capital controls and monetary policy to deal with destabilizing flows that can be used to combat the pressure of capital flows on the currency. [2]

The argument can only be settled by examining the evidence. The emerging literature on this impact can be broadly divided into two strands. The first strand measures the impact of QE specifically on *capital flows* to emerging markets. Morgan (2011); IMF (2011b,a); Chen *et al.* (2012) use quarterly capital flow statistics or daily debt and equity outflows from the US through mutual funds. They find that QE in the US led to higher capital flows to emerging economies. The flows were of roughly the same magnitude as those during the capital surge of 2007. (Figure 1)

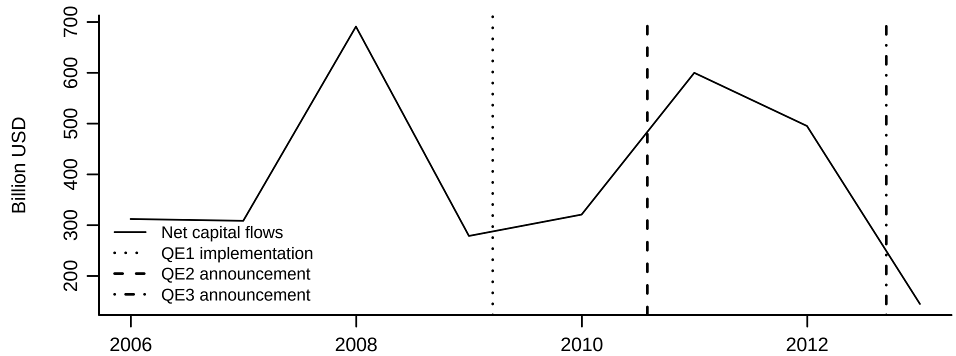
The second strand of literature consists of event studies using high frequency data, often daily, that look at the impact of QE announcements, or implementation on bond and equity flows to emerging economies, government bond yields, emerging market risk premium, exchange rates, equity prices or other asset prices (Morgan, 2011; IMF, 2011b; Glick and Leduc, 2013; Li, 2012). They again find modest effects. But they examine the impact on these indicators separately, whereas emerging market policymakers were clearly referring to the combined impact on their financial markets. This can easily lead to underestimates of the impact. For example, analysis of the impact of QE on exchange rates is limited to measuring the change in the exchange rate that was allowed to happen. If policy makers in emerging

[1] Dilma Rousseff, BRICS conference, March 31st 2012.

[2] "U.S. Monetary Policy and International Implications", Remarks by Ben S. Bernanke Chairman Board of Governors of the Federal Reserve System at Challenges of the Global Financial System: Risks and Governance under Evolving Globalization A High-Level Seminar sponsored by Bank of Japan-International Monetary Fund, Tokyo, Japan, October 14, 2012.

Figure 1 QEs and net capital flows to EMs. Source: IMF WEO (2013)

Net capital flows to emerging economies rose after quantitative easing by the US Fed. The vertical lines shown in the figure are the dates for QE considered are March 2009 when the implementation of QE1 began, and August 2010 when Ben Bernanke announced QE2 in his speech at Jackson Hole.



economies used instruments such as intervention, to prevent the exchange rate change, the analysis misses out on it.

Indeed, evidence suggests that EMs responded to the pressure triggered by QE in a combination of ways; by allowing some appreciation, by conducting some foreign exchange market intervention, by reducing interest rates, and in some cases by imposing capital controls.[3] Since pressure arising from QE was absorbed in a variety of ways, we need to combine these into an overall measure. In this paper, we attempt to do this by converting the pressure absorbed through different instruments into their exchange rate change equivalents, so that they can be added together into an overall measure of exchange market pressure. We further study how emerging economies reacted to that pressure – the extent to which they intervened, changed interest rates or allowed the exchange rate to change.

The concept of exchange market pressure was first proposed by Girton and Roper (1977). Creating a summary measure of EMP requires combining changes in prices (the exchange rate) with changes in quantities (intervention). Girton and Roper (1977) assumed that intervention was unsterilized (so intervention led to equivalent amounts of changes in base money), money neutrality (so percentage changes in base money led to equivalent changes

[3]Change in capital controls are difficult to assess using available de jure data bases. See, for example, Patnaik and Shah (2012) for an overview of details of capital controls in India.

in prices) and purchasing power parity (so percentage changes in domestic prices were essentially equal to exchange rate changes). Under these assumptions, they added the percentage changes in reserves and in exchange rates. However, monetary models had low predictive power for changes in exchange rates, thus, the resulting measures of EMP were misleading (Eichengreen *et al.*, 1996).

Eichengreen *et al.* (1996) in a study of currency crisis proposed an alternative way to combine exchange rate changes and intervention in order to create an index of exchange market pressure. They normalised all prices and quantities, then weighted these components of the index by the inverse of their historical volatilities.[4] Alternative weighing schemes were proposed by Sachs *et al.* (1996); Kaminsky *et al.* (1998); Pentecost *et al.* (2001); Klaassen (2011); IMF (2007) But all these measures of EMP suffer from their ad hoc nature. The indices cannot be compared across countries, since there are no clear units involved. Nor can indices for individual countries really be compared across time.[5] For example, if a country maintains a fixed exchange rate, then the volatility of that rate is zero, and the inverse of that volatility is infinite. Such a weight, based on historical experience, can not be used to calculate exchange market pressure if the country at some point shifts to a floating exchange rate regime. (Figure 2)

To obtain an EMP measure with consistent units, we propose to use the intuition of Weymark (1995), who argued that one needs to add the change in the exchange rate that was observed, with that of the change in the exchange rate that was *prevented* by the central bank through intervention or by reductions in the policy rate. This measure gives a consistent unit: the percent change in exchange rate (or its equivalent). But it gives rise to the challenge of measuring the impact of intervention or interest rate changes on the exchange rate. The impact of intervention is not constant across countries or across time as it depends on the size and liquidity of the market.

We propose a methodology to estimate this impact. The results make sense, in that the parameters thereby estimated correlate well with their theoretical determinants. Moreover, the resulting measure of EMP performs much better for cross country comparisons than the measures proposed in the earlier literature.

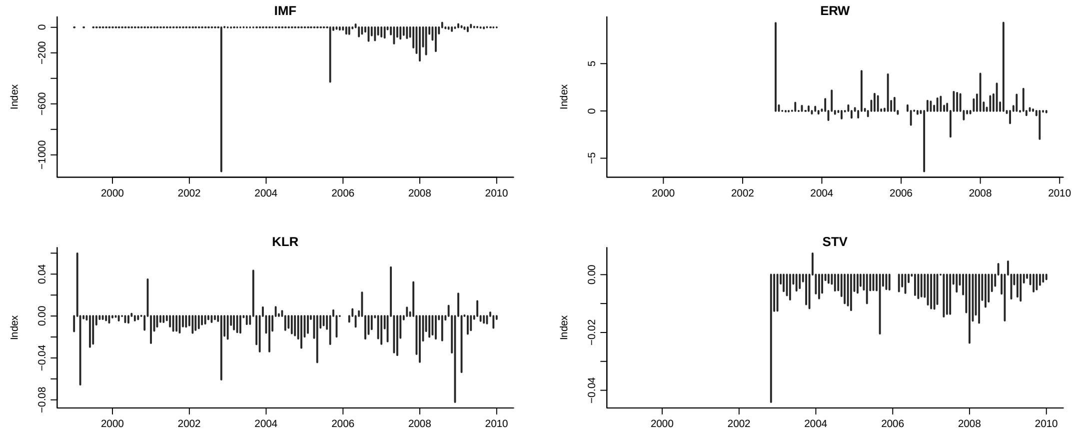
The remainder of this paper is organised as follows. In Section 2 we propose

[4] We discuss issues related to using existing EMP indices in Appendix 5.2

[5] Appendix 5.2 demonstrates the unsuitability of using currency crisis indices for our analysis

Figure 2 Various EMP measures for China

This panel shows various EMP indices calculated for China from the EMP literature. The indices are unable to give us meaningful estimates of EMP during the fixed exchange rate periods



a new method of measuring EMP and describe the estimation and imputation of the parameters needed for the measure. Section 3 measures the EMP after QE and the response of central banks in emerging economies. Section 4 concludes.

2 Measuring exchange market pressure

The first step for constructing our measure of EMP is to estimate the impact of a billion dollars of intervention for certain countries where identification opportunities exist. These estimates are subsequently used to impute parameters for other countries based on predictions related to size and turnover of the foreign exchange market. To the extent that interest rate changes are used by emerging economies to alleviate exchange market pressure, their impact depends on how far interest parity conditions hold. So, a measure of the extent of openness of the capital account is used to estimate the impact of interest rate changes on the exchange rate. The observed exchange rate changes and the exchange rate equivalents based on the impact of intervention and interest rate changes are then summed to derive total exchange market pressure. This measure, expressed in consistent units of percentage change of the exchange rate, is then used in Section 3 to make comparisons across countries and across time.

2.1 Unit consistent EMP measure

We propose to measure EMP in units of percentage change in exchange rate:

$$\text{EMP}_t = \Delta e_t + \rho_t I_t + \eta_t \Delta(i_t - i_t^*)$$

- where Δe_t is *the percentage change in the exchange rate*
- I_t is the intervention measured in billion dollars. This is measured by the change in foreign exchange reserves. [6]
- where ρ is the *the change in the exchange rate associated with $ 1 billion of intervention.*
- η_t is the percentage change in the exchange rate caused by a one percent change in the interest differential.
- $\Delta(i_t - i_t^*)$ is the change in the interest differential between domestic and foreign interest rates.[7]

In the EMP measure, Δe_t and I_t are measured in different units. They must be added in an economically meaningful way. The units of Δe_t and E_{1t} are in percentage change of the exchange rate. For consistency, we would require that ρ be interpreted as *the change in the exchange rate associated with $1 billion of intervention.* η_t also has a similar interpretation, where it is the *percentage change in the exchange rate caused by a one percent change in the interest differential.*

[6] Intervention is not reported by most central banks. Consequently the literature uses the change in reserves as a proxy for intervention. Changes in reserves may happen due to interest payments, or due to revaluation effects. It is not possible to accurately adjust for these without knowing the exact composition of reserves or the timing of interest payments. Further, intervention may be done through swaps, credit lines or intervention in derivatives markets, but this data is usually not publicly available. An estimate of intervention, as in Dominguez *et al.* (2011) was found to be noisy. We follow the literature and use change in foreign reserves as a proxy for intervention.

[7] We incorporate interest rates to the EMP calculation in the tradition of Eichengreen *et al.* (1996). We use the change in the interest rate differential between the domestic market and an international reference rate. For simplicity, we assume the reference foreign market to be the United States. We use treasury bill rate differentials (accounting for variations in tenor) as the interest rate variable. For countries who do not report treasury bill rates, we use money market rates from Datastream. The details are provided in Appendix 5.1.

E_{e1} is interpreted in units of percentage change of the exchange rate. It is the exchange rate change of the month if there had been no intervention, and is a number comparable across countries and across time.

2.2 Estimating ρ_t

We look for identification opportunities that allow us to measure ρ_t. Suppose we observe a country with both fixed and float periods. Suppose the country only uses intervention to influence the exchange rate.

Separately, we observe Δe_t in float periods and I_t in fixed periods.

$$\begin{aligned}\text{EMP}_t &= \Delta e_t + \rho_t I_t \\ \text{EMP}_{\text{float}} &= \Delta e_t \\ \text{EMP}_{\text{fixed}} &= \rho_t I_t\end{aligned}$$

Suppose we assume that macroeconomic shocks are similar across these periods and EMP volatility is stable:

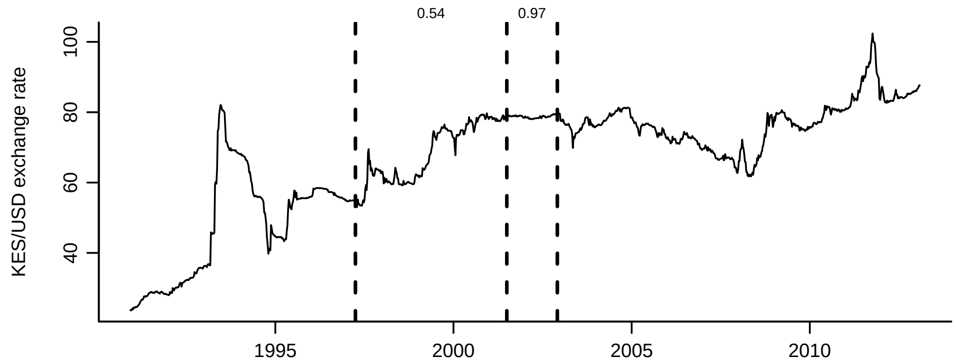
$$Var(\text{EMP}_{\text{fixed}}) = Var(\text{EMP}_{\text{float}})$$

$$\rho_t = \left(\frac{Var(\Delta e_{\text{float}})}{Var(I_{\text{fixed}})}\right)^{\frac{1}{2}}$$

In order to estimate ρ, we need to observe countries which have experienced both fixed and floating exchange rate regimes. These should be periods in which we can assume that the volatility of the exchange market pressure is roughly constant. The fixed and float regimes should be adjacent so that this is a relatively short window of time. We analyse 137 countries from Feb 1995 to Dec 2009 following Zeileis *et al.* (2010) to identify structural breaks in *de facto* exchange rate regime. We find the dates of structural change in the Frankel and Wei regression (Frankel and Wei, 1994). The R^2 of the Frankel-Wei regression is our measure of exchange rate flexibility. For this purpose, we define fixed exchange rate regimes as periods when $R^2 > 0.95$, and floating exchange rate regimes when $R^2 < 0.66$. Each period is required to be at least 12 months long. Regime dates are validated against the Reinhart and Rogoff (2004) exchange rate regime breaks. We exclude periods where macroeconomic shocks were known to be high in one of the periods and known crisis dates. We remove periods defined as "freely falling" by Reinhart and Rogoff (2004), when the volatility of the exchange market pressure cannot be assumed to be constant. This gives us 60 events where a country moved from a fixed to a floating, and 46 events when a country moved from a floating to a fixed exchange rate regime.[8]

For every episode we estimate the ρ_t for each window as the square root of the ratio of the variance of the exchange rate in the floating period to the variance of the intervention in the fixed period. This value of ρ_t is attributed to the mid-point of the window for estimation.

Figure 3 Kenya: Exchange rate



	Start date	End date	R^2	R&R Classification
Period 1	1997-04-11	2001-07-20	0.54	2
Period 2	2001-07-20	2002-12-27	0.97	2

To illustrate the methodology Figure 3 shows Kenya as an example. We detect a structural break from *a float to fixed* exchange rate regime in Jan 2001. From April 1997 to July 2001, the Kenyan Shilling was floating. This is followed by a period from July 2001 till Dec 2002 when the Kenyan Shilling was pegged to the USD and the Kenyan central bank was intervening in the currency market. Reinhart and Rogoff (2004) identify this period as a de-facto crawling peg regime. We can assume it was a relatively stable period and so the shocks to EMP in the full period were roughly the same. Equality of macroeconomic shocks implies:

$$Var(\text{EMP}_{\text{Apr 1997-Jul 2001}}) = Var(\text{EMP}_{\text{Jul 2001-Dec 2002}}) \tag{1}$$

[8] Country periods identified by us as float roughly match the Reinhart and Rogoff (2004) classification of managed float. See Appendix 5.3

$$\rho_t = \left(\frac{Var(\Delta e_{\text{float}})}{Var(I_{\text{fixed}})} \right)^{\frac{1}{2}} \tag{2}$$

$$\rho_{t\ Kenya} = 105$$

A million dollars of intervention by the Central Bank of Kenya in currency markets would have prevented a 0.105% change in the exchange rate in the period Jul 2001 to Dec 2002. The number makes intuitive sense when compared with other markets.

Figure 4 Kenya: Exchange Market Pressure

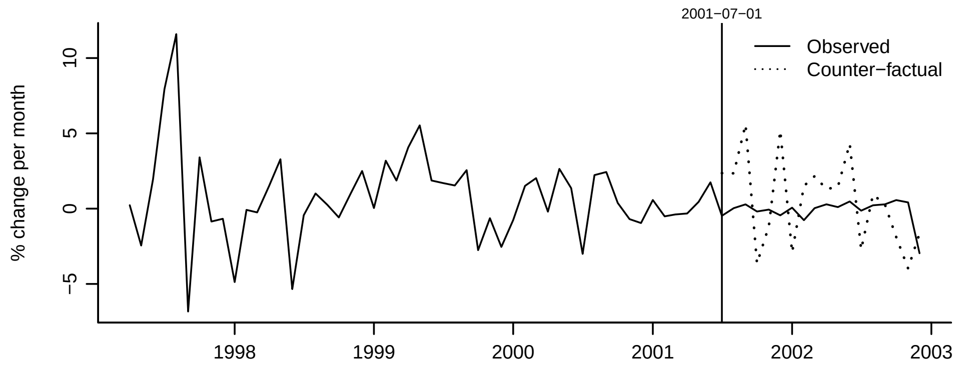


Figure 4 shows the exchange market pressure, the change in the exchange rate that would have occurred had the central bank of Kenya not intervened in the currency market. This forms the basis of the estimation of ρ_t.

Table 1 Float to fixed

This table shows float to fix country-periods which have been used to estimate ρ along with the ρ estimates for those periods

Country	Float period	R^2	Fix period	R^2	ρ_t
$Angola_c$	Nov 2006-May 2007	0.55	May 2007-Feb 2009	0.99	3.08
$Bangladesh_c$	Dec 2005-Jan 2007	0.62	Jan 2007-Oct 2010	0.95	6.85
Brazil	Jun 1994-Jul 1995	0.51	Jul 1995-Jan 1999	0.99	1.97
Belarus	Jun 2009-Apr 2010	0.59	Apr 2010-Apr 2011	0.97	5.41
Cape Verde*	Mar 1999-Sep 2001	0.31	Sep 2001-Oct 2002	1.00	669.26
Djibouti*	Jun 1996-May 1997	0.34	May 1997-Dec 1999	0.99	604.14
Djibouti*	Mar 2002-Oct 2002	0.53	Oct 2002-Jul 2004	1.00	376.19
$Ethiopia_c$	Sep 2002-May 2007	0.65	May 2007-Jan 2009	0.96	8.68
Guinea	Aug 1998-Sep 1999	0.55	Sep 1999-Aug 2001	1.00	268.97
Guyana*	Oct 1998-Jul 1999	0.48	Jul 1999-Jun 2005	0.99	442.47
India	Aug 1997-Aug 1998	0.50	Aug 1998-Mar 2004	0.97	1.55
Kenya	Apr 1997-Jul 2001	0.54	Jul 2001-Dec 2002	0.97	105.64
Comoros*	Jul 2004-May 2006	0.48	May 2006-Dec 2006	0.96	462.02
$Kazakhstan_c$	Mar 2006-Sep 2007	0.58	Sep 2007-May 2011	0.99	2.48
Laos	Jun 2001-Nov 2001	0.44	Nov 2001-Oct 2003	1.00	390.10
Sri Lanka	Jun 2000-Jun 2001	0.48	Jun 2001-Apr 2002	0.95	28.20
Mongolia	Sep 1998-Mar 2001	0.45	Mar 2001-Dec 2001	0.96	184.94
Maldives	May 2005-Apr 2006	0.46	Apr 2006-Jan 2007	0.96	79.04
Malaysia	Aug 1997-Aug 1998	0.21	Aug 1998-Jul 2005	1.00	5.35
Tunisia	Sep 1990-Sep 1991	0.47	Sep 1991-Aug 1992	0.99	38.69
Trinidad and Tobago	Sep 1996-Oct 1997	0.59	Oct 1997-Jun 1999	0.99	19.18
$Trinidad\ and\ Tobago_c$	May 2008-May 2009	0.58	May 2009-Sep 2010	0.96	7.52
$Ukraine_c$	Mar 2008-Nov 2009	0.18	Nov 2009-Dec 2011	0.99	6.49
$Venezuela_c$	Feb 2002-Sep 2003	0.34	Sep 2003-Jan 2010	1.00	8.82
Vietnam	Sep 2000-May 2001	0.66	May 2001-Mar 2008	1.00	1.07
$Antigua\ and\ Barbuda_c$	Feb 1996-Aug 2002	0.63	Aug 2002-Oct 2011	1.00	36.59

Notes: * GDP < 1 Billion USD, $_c$ Dropping crisis years
Source: Author's calculations

We estimate ρ using the above methodology for all the regime break points in our dataset for which such assumptions can be made. In Table 1 we show the estimated values of ρ_t using break dates that involve a movement from a floating exchange rate regime to a fixed exchange rate regime.

Even though we have dropped country periods for crisis years and freely falling years, it is possible that countries may be moving from fixed to floating because of changes in macroeconomic shocks. If so, this would imply that the currency volatility in the two sets of floating periods, one that precedes and one that follows a fixed regime, would be different. We test whether this difference is significant using the Welch two-sample t-test and the two-sample Kolmogorov-Smirnov tests but we find no significant difference in either the means or the distributions. [9] Therefore, we consider both fixed to float and float to fixed episodes in estimating

[9] The values for the tests comparing the means and the distribution of the volatility of the exchange rate during the floating period are as follows: The t-test gave us a t-value of -1.66 with a p-value of 0.1 with 40 degrees of freedom. The value of the Kolmogorov-Smirnov statistic was 0.26 with a p-value of 0.35.

ρ_t. Table 2 shows the values of ρ_ts estimated when countries move from a fixed exchange rate regime to a floating regime. Countries with GDP less than one billion USD are marked to indicate the small foreign exchange markets in these countries. The impact of USD 1 billion in these markets is expected to be very large.

Table 2 Fixed to float periods

This table shows fixed to float country-periods which have been used to estimate ρ along with the ρ estimates for those periods

Country	Fix period	R^2	Float period	R^2	ρ_t
Costa Rica	Mar 1996-Jan 1997	0.99	Jan 1997-Jul 1997	0.41	5.83
Cape Verde*	May 2003-Jul 2004	0.99	Jul 2004-Dec 2007	0.44	343.33
Djibouti*	Dec 1995-Jun 1996	1.00	Jun 1996-May 1997	0.34	206.08
Gambia*	Jul 1997-Dec 1998	0.95	Dec 1998-Nov 2003	0.50	691.35
Guyana*	Jul 1999-Jun 2005	0.99	Jun 2005-Dec 2005	0.49	269.32
Laos	Apr 2000-Jun 2001	1.00	Jun 2001-Nov 2001	0.44	519.76
Moldova	Apr 2000-Nov 2000	0.95	Nov 2000-May 2001	0.56	208.57
Mauritius	Apr 2001-Dec 2002	0.98	Dec 2002-May 2004	0.62	117.42
Malaysia	Nov 1989-Dec 1993	0.96	Dec 1993-Jul 1994	0.44	2.58
Tunisia	Sep 1991-Aug 1992	0.99	Aug 1992-Jan 1994	0.61	25.64
Ukraine	Aug 2002-Apr 2003	1.00	Apr 2003-Feb 2004	0.59	15.74
Vietnam	Nov 1997-Sep 2000	1.00	Sep 2000-May 2001	0.66	6.41
C African Republic	Jun 2001-May 2002	0.99	May 2002-Jan 2004	0.50	520.58

Notes: * GDP $<$ 1 Billion USD
Source: Author's calculations

Difference between fixed to float and float to fix break periods

Even though we have dropped country periods for crisis years and freely falling years, it is possible that countries may be moving from fixed to floating because of changes in macroeconomic shocks. If so, this would imply that the currency volatility in the two sets of floating periods, one that precedes and one that follows a fixed regime, would be different. We test for whether this difference is significant using the Welch two-sample t-test and the two-sample Kolmogorov-Smirnov tests but we find no significant difference in either the means or the distributions. Therefore, we consider both fixed to float and float to fixed episodes in estimating ρ_t. [10]

Macroeconomic shocks We have assumed that macroeconomic volatility across the two periods for which we calculated ρ_t. To enable us to make this assumption, we deleted periods in which the exchange rate was freely falling. Now we further check the validity of this assumption. If the ρ_ts calculated on the basis of this assumption can be explained by balance of payment shocks or by episodes of high inflation, we would need to take this into account. Table 3 shows that when

[10] The values for the tests comparing the means and the distribution of the volatility of the exchange rate during the floating period are as follows: The t-test gave us a t-value of -1.66 with a p-value of 0.1 with 40 degrees of freedom whereas the Kolmogorov-Smirnov reported 0.26 as the value of the KS-statistic with a p-value of 0.35.

we attempt to explain ρ_ts by macroeonomic shocks such as inflation or the ratio of current account deficit to GDP or the inflation rate, the coefficients are not significant. The macro variables do not explain much of the variation in the ρ_ts. This suggests that our assumption of similar macro economic shocks for the two periods in the calculation of ρ_t is reasonable.

Table 3 Do macroeconomomic shocks impact ρ_t?

	Model 1
(Intercept)	3.86*
	(0.95)
Log(inflation)	−0.41
	(0.47)
CAD/GDP	−0.06
	(0.03)
N	36
R^2	0.14
adj. R^2	0.09
Resid. sd	1.91

Standard errors in parentheses
* indicates significance at $p < 0.05$

ρ_t estimates and currency market turnover

The magnitude of ρ reflects the liquidity of the currency market. If one participant, the central bank, trades \$ 1 billion, what is the price change obtained on the currency market? The impact of central bank intervention on the foreign exchange market will vary by country, by time. As the size of a currency market changes, ρ will change. We will need a ρ_t time-series for each country to measure EMP. The numerical magnitude of ρ will tend to be smaller when the currency market is more liquid, i.e. for bigger and more internationalised countries with greater financial development. [11]

Estimates of the impact of intervention vary highly not only due to the difficulties due to identification problems but also because the impact depends on other policies such as sterilization, communication or inflation targeting by the central bank (Menkhoff, 2013). For example, Evans and Lyons (2006) estimate of the impact that ordinary order flow has on the exchange rate as 0.44 basis points per 10 million US dollar order flow in the highly liquid Deutsch Mark versus US dollar market in 1996. Scalia (2008) estimates an impact between 7 to 12 basis points per 10 million euro for the Czech Republic. Tapia and Tokman (2004) estimate that sales of US dollar in 1998/99 appreciated the Chilean peso. The elasticity is a 1 per cent exchange rate change on 500 million US dollar intervention. Guimares

[11] The literature notes that the extent of intervention depends on the turnover in the foreign exchange market (Klaassen and Jager, 2011) and BIS (1993) 63rd Annual Report, BIS, Basel.

and Karacadag (2004) estimate that 100 million US dollar sales has an impact on the Mexican peso of 0.4 per cent, whereas purchases have no effect. In other words, ρ estimates in this literature varies between 0 and 10. These estimates match our ρ estimates which for similarly sized markets i.e for Brazil, Turkey, India, Malaysia, Belarus, Indonesia are in this range. Very small markets have much larger ρ estimates.

Table 4 Estimated ρ_t and FX market turnover

Country	Year	ρ_t	FX market daily turnover (in Billion USD)
Brazil	1997	1.97	5*
India	2001	1.55	3
Malaysia	2002	5.35	1**

* FX size data for Brazil data from 1998

** FX size data for Malaysia data from 2001

To some extent the larger the size of the market as reflected in the market turnover of the spot and derivatives transactions for a currency, we would expect that smaller is the impact a given amount of central bank intervention. Foreign exchange market data is not available for most of the country periods for which ρ_t can be estimated. Table 4 shows the estimated values of ρ_t which refer to the percent change in the exchange rate caused by a billion dollars of intervention by a central bank in one month and the daily turnover in the spot and forwards currency market in or around the same years: Brazil in 1997, India in 2001 and Malaysia in 2002. If we assume that trading happens on an average of 20 days a month and the turnover in the market in one month in 2001 was USD 60 billion in India, a billion dollars of trade per month by the RBI would have lead to a change in the rupee dollar rate of 1.55 percent.

We expect that ρ_t is usually higher if the market is smaller i.e a billion dollars of intervention should impact the exchange rate more if the market is small. In a very large market a billion dollars may have little or no impact. We assume ρ_t remains constant for a year, yielding a ρ of annual frequency.

In the calculation for ρ_t we assumed that the two adjacent periods under consideration had similar macroeconomic volatility. If this assumption is true, the we would expect that macroeconomic shocks should not explain ρ_t. If we regress the calculated ρ_ts on various measures of macroeconomic shocks, the coefficients of these shocks should not be significant. Table 5 shows that for variables such as inflation and the current account we do not find significant coefficients. In these regressions we control for GDP, trade integration and capital flows which influence the size of the market and determine ρ_t.

Table 5 The assumption of macroeconomic stability

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Intercept	5.00*	3.39*	3.26*	6.22*	6.58*	6.31*	5.95*
	(0.90)	(0.32)	(0.31)	(1.55)	(1.68)	(1.92)	(0.45)
Inflation	−0.84				−0.24		−0.23
	(0.47)				(0.20)		(0.21)
CA balance		−0.00					
		(0.04)					
CAD to GDP			−0.06*			0.01	0.01
			(0.03)			(0.02)	(0.02)
Trade Int				−0.36	−0.35	−0.37	
				(0.27)	(0.29)	(0.32)	
GDP				−0.89*	−0.90*	−0.92*	−0.90*
				(0.06)	(0.07)	(0.07)	(0.07)
FDI to GDP				−0.25*	−0.26	−0.27	
				(0.11)	(0.14)	(0.14)	
N	39	41	41	38	33	36	36
R^2	0.08	0.00	0.11	0.88	0.88	0.88	0.84
adj. R^2	0.05	−0.03	0.09	0.87	0.86	0.86	0.83
Resid. sd	2.03	2.04	1.92	0.75	0.76	0.75	0.83

Standard errors in parentheses
* indicates significance at $p < 0.05$

2.3 Imputing ρ_t

The estimation of ρ_t only gives us some values for ρ_t for some country periods. As Table 6 indicates there are many country periods for which no values for ρ_t can be estimated by our method. The missing ρ_ts are imputed.

We expect that the larger the size of the foreign exchange market, the smaller would be the impact of intervention by the central bank. Data for size of the foreign exchange market, in terms of the daily dollar turnover in the spot and derivatives markets is available from the Bank of International Settlement [12]. However, the set of countries for which the data is available does not overlap adequately with the countries for which ρ_t has been estimated. The size of the economy, financial sector development and integration of the economy with the world economy determine the turnover in the foreign exchange market.

Figure 5 explores these relationships. As expected, we see a positive relationship between GDP and the turnover in the foreign exchange market and a negative relationship between ρ_t and GDP. We exploit these relationships to set up a regression model to predict ρ_t.

[12]BIS Triennial Central Bank Survey of Foreign Exchange and Derivatives Market Activity

Table 6 Estimated ρ_t

This table shows a panel of ρ_t estimates, highlighting the number of missing values

	1995	1996	1997	1998	1999	2000	2001	2002	..	..	2010
India	..	..	..	..	..	..	1.55	..	..	..	..
Angola	..	151	..	..	..	..	..	..	..	..	..
Belarus	..	..	..	..	..	..	..	..	..	..	5.41
Kenya	..	..	..	..	..	..	..	105.64	..	..	..
Sri Lanka	..	..	..	..	..	..	28.20	..	..	..	..
Gambia	..	..	691.35	..	..	..	..	..	..	..	..
Brazil	..	..	1.97	..	..	..	..	..	..	..	..
Romania	..	..	..	..	..	43.98	..	..	..	..	..
Turkey	..	..	..	..	..	..	..	4.42	..	..	..
Vietnam	..	..	..	..	..	..	6.41		..	..	..
Malaysia	..	..	..	..	..	..	5.35	..	..	..	..

Source: Author's calculations

Figure 5 Relationship between GDP, size of the market and GDP and ρ_t

We expect an inverse relationship between ρ_t and size of the foreign exchange market, or, as the size of the foreign exchange market increases, a billion dollars of intervention by the central bank has a smaller impact. These graphs show that at higher levels of GDP, turnover in the foreign exchange market is higher. Further, at higher levels of GDP, we see that ρ_t is smaller.

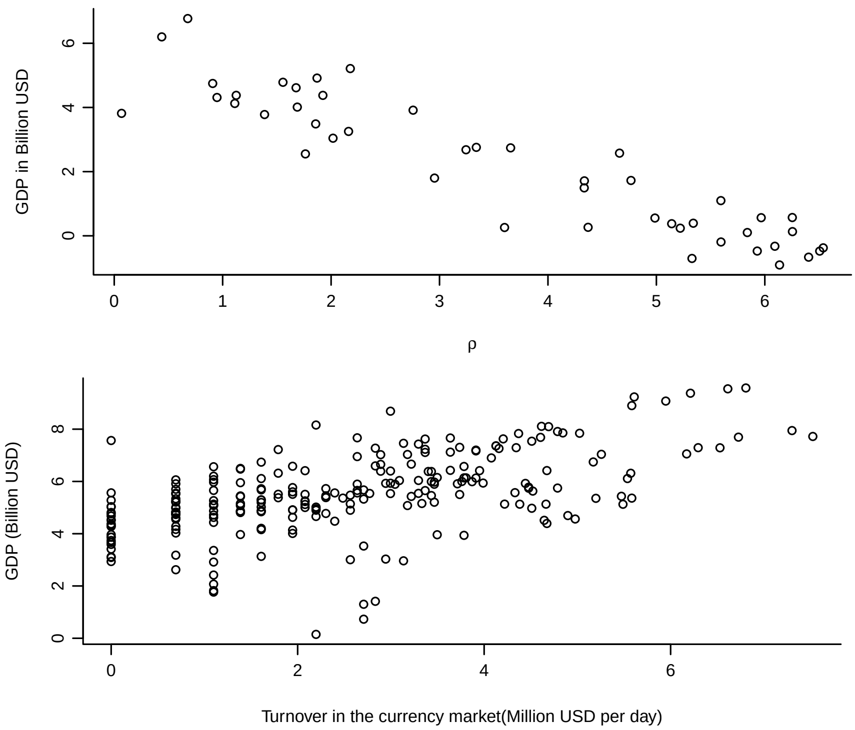


Table 7 shows the correlations between the size of the foreign exchange market and other macro-variables reflecting size, openness and financial development. For imputation of ρ_t since data for the size of the market is not available for all countries and all years, we use the variables that predict foreign exchange market turnover as instruments. Table 8 shows various models using the variables correlated with size being used as proxies for measuring ρ_t. We use model 4 presented in Table 8 as our base model. For countries for which financial sector data is not available, ρ_ts are imputed using GDP data. Annual values of ρ_t for 172 countries for the years 1995 to 2011 are imputed.

Table 7 Models explaining forex market size

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
Intercept	-1.03^*	-7.17^*	-6.59^*	-6.49^*	-3.92^*	-0.02	-5.01^*	-5.01^*
	(0.34)	(0.94)	(1.00)	(1.20)	(1.26)	(0.41)	(1.13)	(1.13)
GDP	0.65^*	0.89^*	0.94^*	1.02^*	0.97^*	0.84^*	1.01^*	1.01^*
	(0.06)	(0.07)	(0.07)	(0.07)	(0.07)	(0.06)	(0.07)	(0.07)
Trade to GDP		1.09^*	0.99^*	0.95^*	0.61^*		0.28	0.28
		(0.16)	(0.16)	(0.18)	(0.19)		(0.19)	(0.19)
Inflation			-0.46^*		-0.52^*	-0.59^*		
			(0.09)		(0.10)	(0.10)		
Net FDI to GDP				0.25^*	0.33^*	0.46^*	0.03	0.03
				(0.09)	(0.09)	(0.08)	(0.08)	(0.08)
LMF_n							0.84^*	
							(0.09)	
$LMF^2{}_n$								0.42^*
								(0.05)
N	244	243	226	217	202	203	176	176
R^2	0.32	0.44	0.53	0.52	0.58	0.55	0.69	0.69
adj. R^2	0.32	0.43	0.52	0.51	0.57	0.54	0.69	0.69
Resid. sd	1.42	1.31	1.20	1.24	1.17	1.20	0.99	0.99

LMF_n is the Lane-Milesi-Ferreti index after subtracting official reserves
Standard errors in parentheses
* indicates significance at $p < 0.05$

How good is the imputed rho?

We now compare the measures of ρ_t imputing using the above model to those originally calculated using the volatilities of the exchange rate and intervention. The comparison can be made only for the country years for which ρ_t could be calculated. Table 9 shows a few values for the purpose of illustration. The order of magnitude of the values are similar.

Table 9 Comparing calculated ρ_t and imputed ρ_t

Country	India	Malaysia	Turkey	Brazil	Vietnam	Kenya	Sri Lanka
Year	2001	2001	2002	1997	2001	2002	2001
Calculated ρ_t	1.55	5.35	4.42	1.97	6.42	105.6	28.2
Imputed ρ_t	1.9	4.64	3.64	1.14	9.13	54.97	27.09

Table 8 Model for predicting ρ_t

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
Intercept	5.55*	8.85*	9.00*	6.22*	6.58*	4.68*	6.72*	6.72*
	(0.17)	(1.02)	(1.11)	(1.55)	(1.68)	(0.51)	(1.71)	(1.71)
GDP	−0.89*	−0.93*	−0.93*	−0.89*	−0.90*	−0.88*	−0.83*	−0.83*
	(0.06)	(0.05)	(0.06)	(0.06)	(0.07)	(0.06)	(0.08)	(0.08)
Trade to GDP		−0.72*	−0.67*	−0.36	−0.35		−0.55	−0.55
		(0.22)	(0.23)	(0.27)	(0.29)		(0.32)	(0.32)
Inflation			−0.21		−0.24	−0.20		
			(0.18)		(0.20)	(0.19)		
Net FDI to GDP				−0.25*	−0.26	−0.33*	−0.30*	−0.30*
				(0.11)	(0.14)	(0.11)	(0.12)	(0.12)
LMF_n							0.47	
							(0.42)	
$LMF^2{}_n$								0.24
								(0.21)
N	46	44	37	38	33	35	31	31
R^2	0.85	0.88	0.88	0.88	0.88	0.88	0.88	0.88
adj. R^2	0.85	0.87	0.87	0.87	0.86	0.86	0.86	0.86
Resid. sd	0.80	0.74	0.75	0.75	0.76	0.75	0.76	0.76

LMF_n is the Lane-Milesi-Ferreti index after subtracting official reserves
Standard errors in parentheses
* indicates significance at $p < 0.05$

Figure 6 Comparing calculated ρ_t and imputed ρ_t

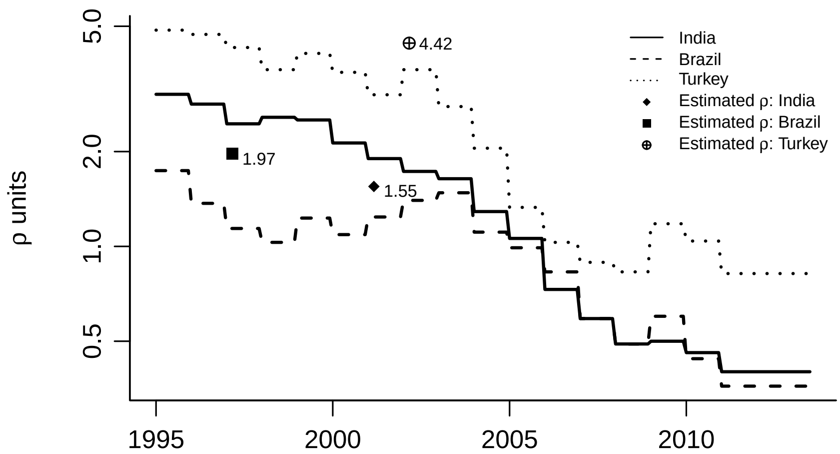
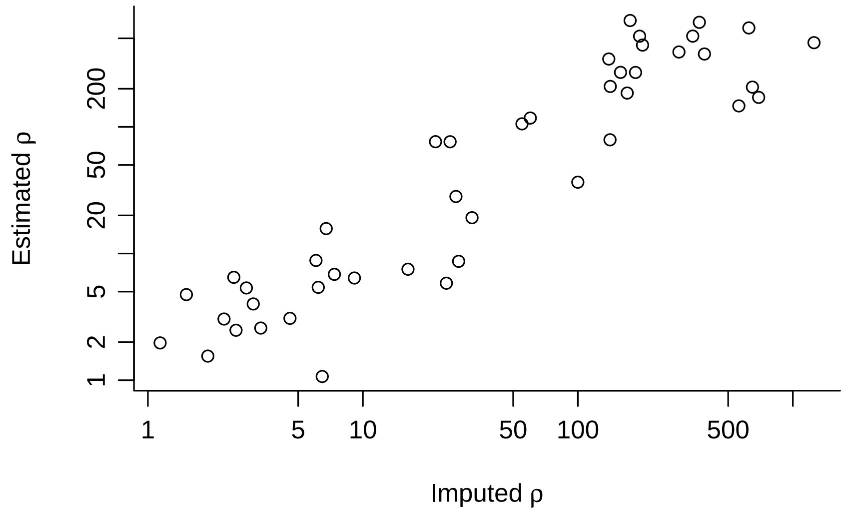


Figure 7 shows correlation between the estimated and the imputed ρ_t. The two are close to being on a 45 degree line. We thus go ahead with using the imputed ρ_t in our measures of EMP.

Figure 7 Scatter plot of Imputed versus Estimated ρ_t (logscale)



2.4 Measuring η_t

The impact of a change in the interest rate on the exchange rate depends upon how integrated the economy is with global financial markets. Under full capital account openness we assume that uncovered interest parity holds. Thus, for a fully open capital account we assume that $\eta_t \approx 1$. For a fully closed capital account we assume: $\eta_t \approx 0$. As a proxy for the level of openness we use the Chinn and Ito (2008) measure of capital account openness.[13] We re-scale the measure to lie between 0 to 1.

Table 10 η_t: Selected Countries

	1995	1997	1999	2001	2003	2005	2007
Romania	0.17	0.17	0.17	0.17	0.454	0.81	0.93
Uganda	0.40	0.40	0.81	0.93	1	1	1
China	0.17	0.17	0.17	0.17	0.17	0.17	0.17
Indonesia	1	0.93	0.66	0.69	0.69	0.69	0.69
Hong Kong	1	1	1	1	1	1	1
Egypt	0.29	0.59	0.72	0.84	1	1	1
Cyprus	0.4	0.17	0.17	0.17	0.17	0.75	0.87

Source: Author's calculations

[13] We choose the Chinn-Ito index of capital account openness as compared to the Quinn and Toyoda (2008) index as Chinn-Ito covers a larger set of countries. Chinn-Ito covers 181 nations between 1970 and 2008 whereas Quinn-Toyoda covers 122 countries between 1948 and 2007. There is a 83.9% correlation between the Chinn-Ito index and the Quinn-Toyoda index.

Table 10 shows some of the values η takes. There is variation across countries. For example, China is fairly closed at 0.17, while Hong Kong is fully open at 1. There is also variation across time. Cyprus moved from 0.4 in 1995 to 0.87 in 2007, as it opened up its capital account.

2.5 EMP estimates

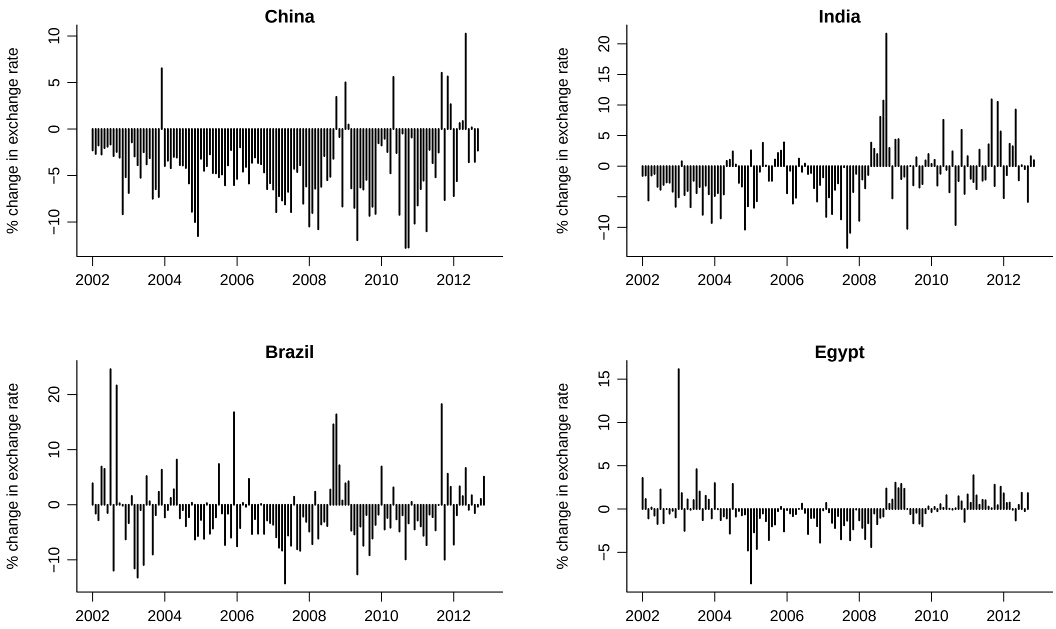
We now have an annual multi-country dataset of the two parameters, ρ_t and η_t required for measuring EMP. For a monthly EMP dataset we assume that the values of the two parameters remain the same over each year. We calculate monthly EMP for all countries in the database (excluding Euro zone countries) for the period January 1995 to December 2012. Values of ρ and η for the latest years for which they could not be imputed due to unavailability of data are assumed to remain unchanged at the last observed year.

Illustration

These estimates make intuitive sense. For example, since China is a country where, in the pre-crisis years of the 2000s the pressure was only one way i.e. either it witnessed reserve accumulation or the currency appreciated, the direction of EMP should be only one way. This is seen in Figure 8, where values less than zero represent a pressure to appreciate. Similarly, Figure 8 also shows EMP for Egypt and how it changed after the Arab Spring going from a pressure to appreciate to a pressure to depreciate.

Figure 8 EMP

This panel shows EMP for China, India, Brazil and Egypt



The proposed measure can also be used to meaningfully make comparisons of central bank policies across countries. If we define the **intervention index** as the proportion of exchange market pressure relieved by intervention, now both the numerator and denominator are measured in units of per cent change in the exchange rate. Or,

$$\text{Intervention Index}_t \quad = \quad (\rho_t * Intervention_t / EMP_t) * 100$$

Figure 9 shows that China was barely allowing its currency to move and relieving almost the entire exchange market pressure by accumulating reserves. Canada, for most part, was not intervening.[14]

[14] Canada's (absolute) average share of intervention in relieving EMP in the period it officially stops intervening is 19.66%. This is because of the noise introduced by using ΔR_t as the measure of intervention.

Figure 9 Index of intervention: China and Canada

This figure shows that China was relieving about 100 per cent of the exchange market pressure by accumulating reserves, while Canada, officially has not intervened in the forex market since Sept 1998. A -100 value means that 100% of the appreciation pressure on the currency was relieved by buying reserves; whereas a value of 100 means a 100% of depreciation pressure was relieved by selling reserves in that month

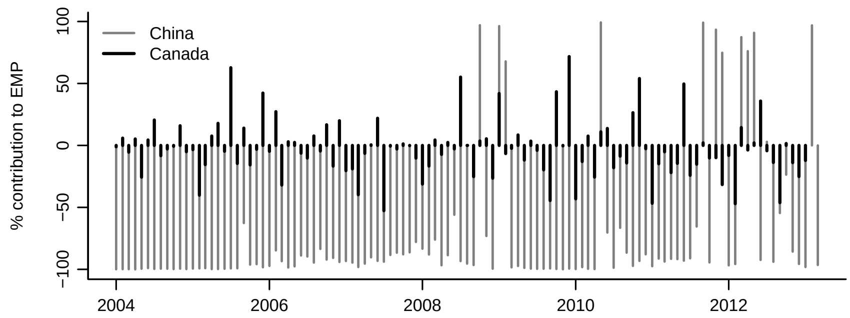


Table 11 shows that when we use our measure of EMP to estimate how much a country was intervening in its foreign exchange market, it makes intuitive sense. For comparison we use some of the other EMP measures for China, which was known to intervene, and Canada, where the Bank of Canada did not intervene for the full period, the capital surge and after QE. The results are not accurate as the change in reserves is an approximation of intervention. However, broadly our estimates agree much more than when we use existing EMP indices with what is known about the exchange rate regime in the two countries.

Table 11 Comparing share of intervention in EMP

EMP Measure	China (Surge)	China (QE 1,2)	China (Full)	Canada (Surge)	Canada (QE 1,2)	Canada (Full)
ERW	0.15	0.83	11.94	0.09	0.12	0.29
KLR	48	102	123.2	49	102	123
STV	48	102	123.2	1.57	13	59
Proposed Measure	**84**	**98**	**91**	**4**	**7**	**18**

Full : Jan 2002-Dec 2012
Surge: Oct 2007-Dec 2007
QE 1,2 : Apr 2009-Jun 2009 & Aug 2010-Oct 2010
See Appendix for details of other measures

3 EMP after QEs

To analyse the impact of QE, we examine exchange market pressure in 26 emerging economies. Individual countries EMPs shows an increase in EMP after QE

(Appendix 5.4) shows responses to the monetary easing by the US Fed. A rate cut of 25 basis points in the policy rate by US Fed June 25th 2003 also showed similar responses in most countries. For some countries this was roughly as much as that for QE. Most countries experienced some months of high EMP after QE. Not surprisingly these countries felt that the QE unleashed a monetary tsunami. For example, Brazil did not see a sustained pressure to appreciate after the rate cut, as it saw after QE.

The example of Brazil below shows the kind of pressure on the currency and the response of policy makers. The estimates offer an indication of the pressure faced and the response.

Illustration: Brazil during May 2009

- In May 2009, Brazil faced EMP that would have led to an 12.9 percent appreciation in the exchange rate.
- A 10.5 percent appreciation was observed in May 2009.
- Brazil responded by a buying 4.69 billion dollars. Brazilian foreign exchange reserves went up from 189.59 Billion USD to 194.22 Billion USD. The average ρ_t of Brazil was 0.6. Therefore, the central bank prevented a 2.8 percent appreciation of the exchange rate through its intervention.
- In this month, the central bank reduced interest rates by 57 bps from 9.99 % to 9.42% and the US t-bill rates increased by 2 bps, reducing the interest differential by 0.59 percent. The value of η_t was 0.64. Lowering the interest rate thus reduced the pressure on the currency to appreciate by 0.4 percent.

Table 12 shows the list of emerging markets and countries in each region for the analysis of the impact on exchange market pressure.

Table 12 EM country groups

Emerging Asia	Emerging Africa & Middle East	Emerging Latam	Emerging Europe
China	Morocco	Mexico	Ukraine
India	Egypt	Argentina	Czech Republic
Malaysia	South Africa	Brazil	Hungary
Indonesia	Lebanon	Chile	Russia
Philippines	Saudi Arabia	Colombia	Turkey
South Korea	South Africa	Peru	Romania
Thailand		Venezuela	

3.1 Preliminary graphical analysis

For a preliminary graphical analysis figures 10, 11, show EMP for individual countries with vertical lines for the implementation date of QE1 and the announcement dates of QE2 and QE3. The graphs suggest that countries might have experienced a change in EMP.

Figure 10 EMP in India, Indonesia and China

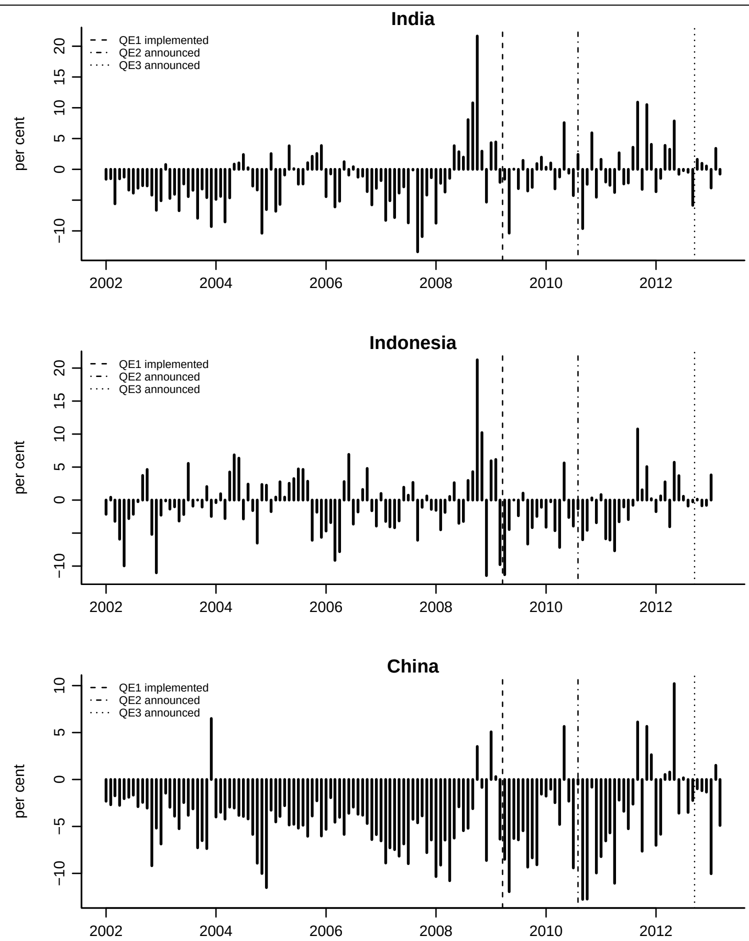
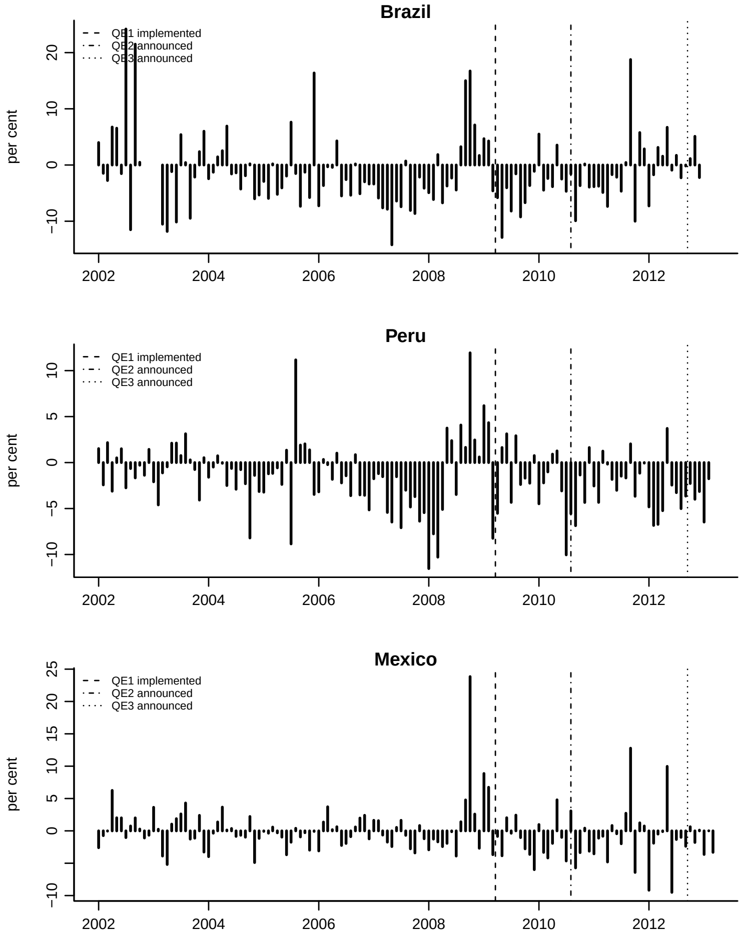


Figure 11 EMP in Brazil, Peru and Mexico

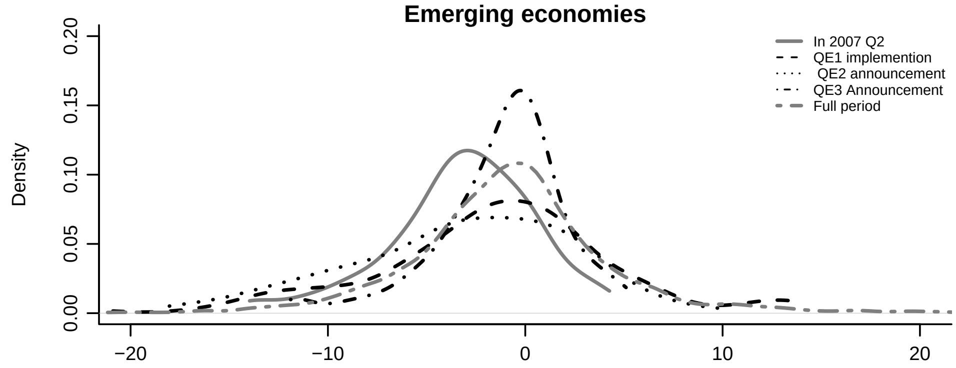


3.2 Event study

To analyse the effect of the two episodes of quantitative easing on emerging economies we use event study analysis with bootstrap inference as described in Patnaik *et al.* (2013). The event of interest to us is quantitative easing. The three dates for the easing constitute the event, i.e, quantitative easing. The dates for QE can be chosen to be the announcement date or the implementation date.

The empirical literature on the impact of the two is mixed for QE1. The announcement of QE1 did not see capital outflows from the US (Morgan, 2011). In contrast, the announcement of QE2 resulted in capital flows (IMF, 2011b). However, the implementation of QE1 is associated with the flow of capital to emerging

Figure 12 Emerging Economies EMP after QE1, QE2 and QE3



economies (Fratzscher *et al.*, 2012; Chen *et al.*, 2012; Moore *et al.*, 2013). We choose the event as comprising QE1 implementation date and the announcement dates of QE2 and QE3, which are lined up in the traditional manner of event studies as time t=0 .

We first run this event study on monthly nominal exchange rate returns and change in reserves for the entire set of emerging economies to determine whether there was any significant exchange rate appreciation after the QE events and whether this appreciation pressure coincided with a change in reserves.

Figure 13 Exchange rate returns after QE

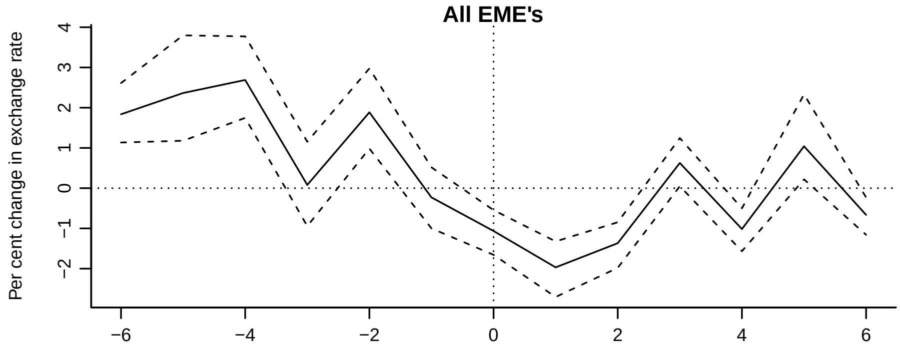


Figure 14 Change in reserves after QE

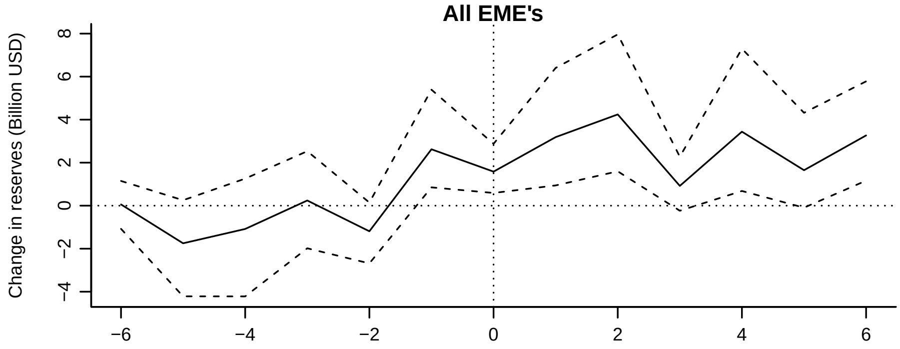
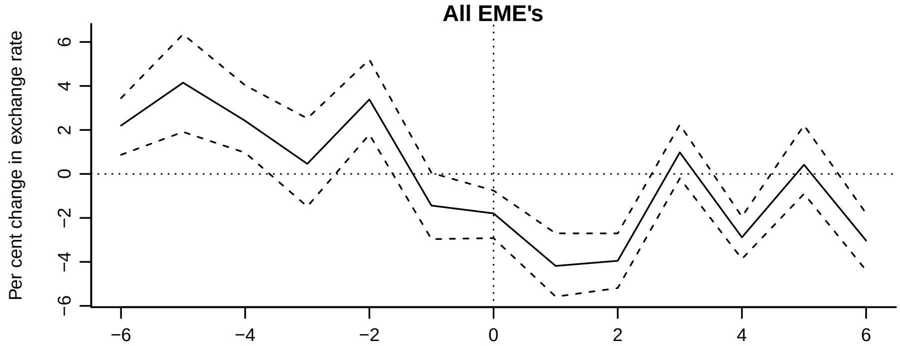


Figure 13 shows that there was a significant 1-3% appreciation in nominal exchange rates for our set of EM's two months after the QE events. There also seems to be a slight build up in reserves after the QE events. The increase in the foreign exchange reserves for our set on EM's on average in between $0.5-2 Billion, starting a month before the QE events and going up to two months after the event. This preliminary analysis indicates that there has been slight currency appreciation and reserves build up after the QE events for our set of EM's.

We run this event study for the EMP time-series of the entire set of emerging economies as well as regional subsets giving us an understanding of how QE affected EMP in event time. We examine the extent of exchange market pressure in EMs before and after the event in Figure 15. The graph shows that after quantitative easing the pressure on the exchange rate turned from that of depreciation to that of appreciation. The effect eased off after 2 months.

Figure 15 Emerging Economies



The pressure to appreciate in the immediate months after QE for emerging economies can be compared to what was witnessed during the capital surge of 2007, this pressure was higher than the full sample period (January 1995-May 2013) median value. [15]

3.3 Differential impact of QE

3.3.1 Regional differences in impact of QE

Figure 16 shows that in Emerging Asia the effect lasted the longest up to nearly 3 months as there was pressure on Asian currencies to appreciate. In Emerging Europe QE leads to a pressure on currencies to appreciate as well for two months. For Emerging Latin America the effect of QE putting pressure on the currency to appreciate lasted for a month. However, Emerging Africa did not see an impact.

3.3.2 Impact of different episodes of QE

The combined event study of QE1, QE2 and QE3 in figure 15 shows that emerging economies on average experienced two months of appreciation pressure after the QE events. Figure 16 shows that the results in figure 15 is driven by EM Asia and EM Europe as these continental blocs experience maximum pressure to appreciate after QE events

The literature on QE recognises that given the difference in both size of purchases, duration of purchases and signalling by the Fed; all three QE episodes are different in terms of their objectives as well as impact on emerging markets (Fratzscher *et al.*, 2012; Chen *et al.*, 2012; Moore *et al.*, 2013; Morgan, 2011). We use the same event study analysis to look at EM EMP split across QE1, QE2 and QE3.

[15] In Appendix 5.5, we present evidence showing how different regions were affected.

Figure 16 Impact of quantitative easing on EMP

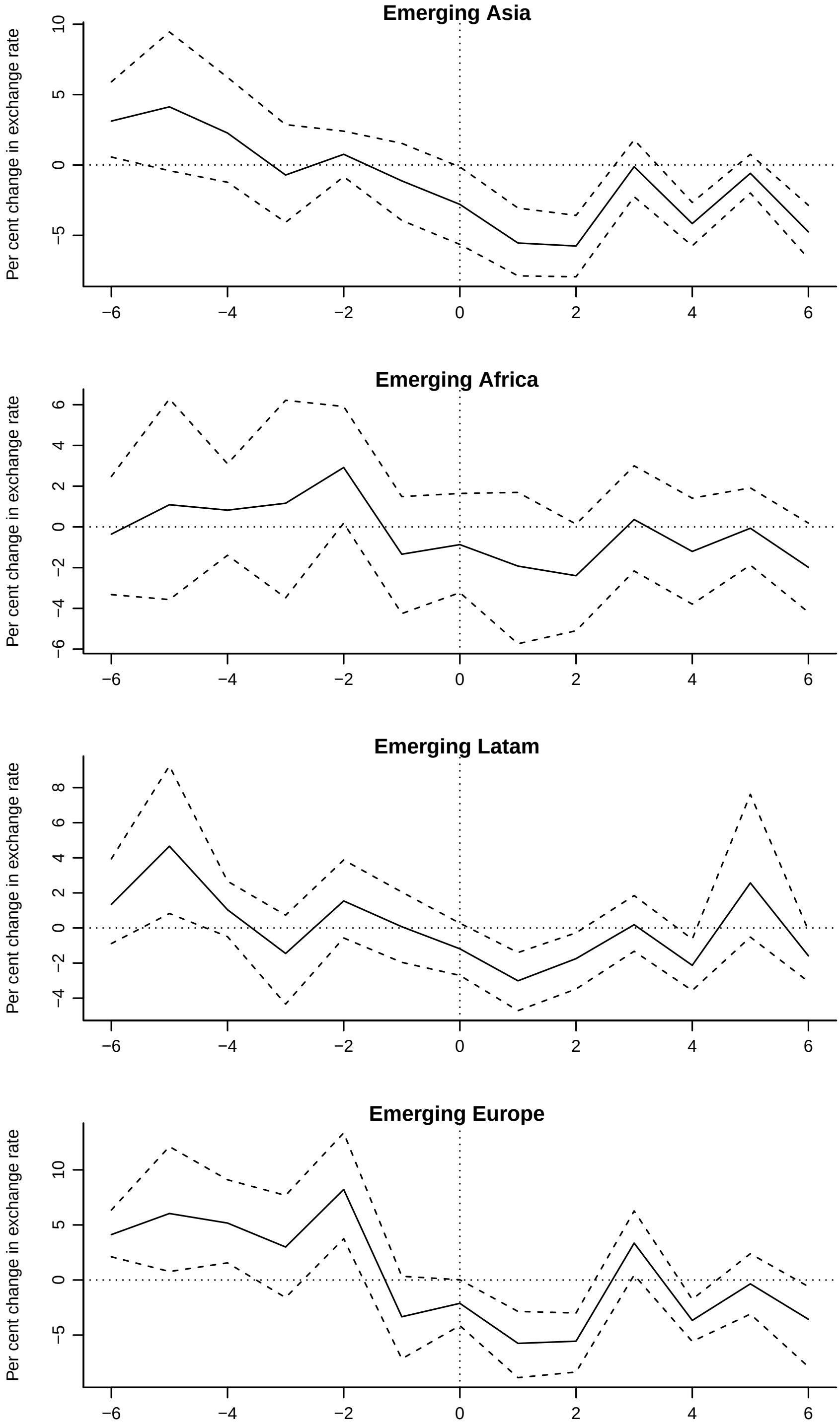


Figure 17 Event study on EM EMP split by QE episode

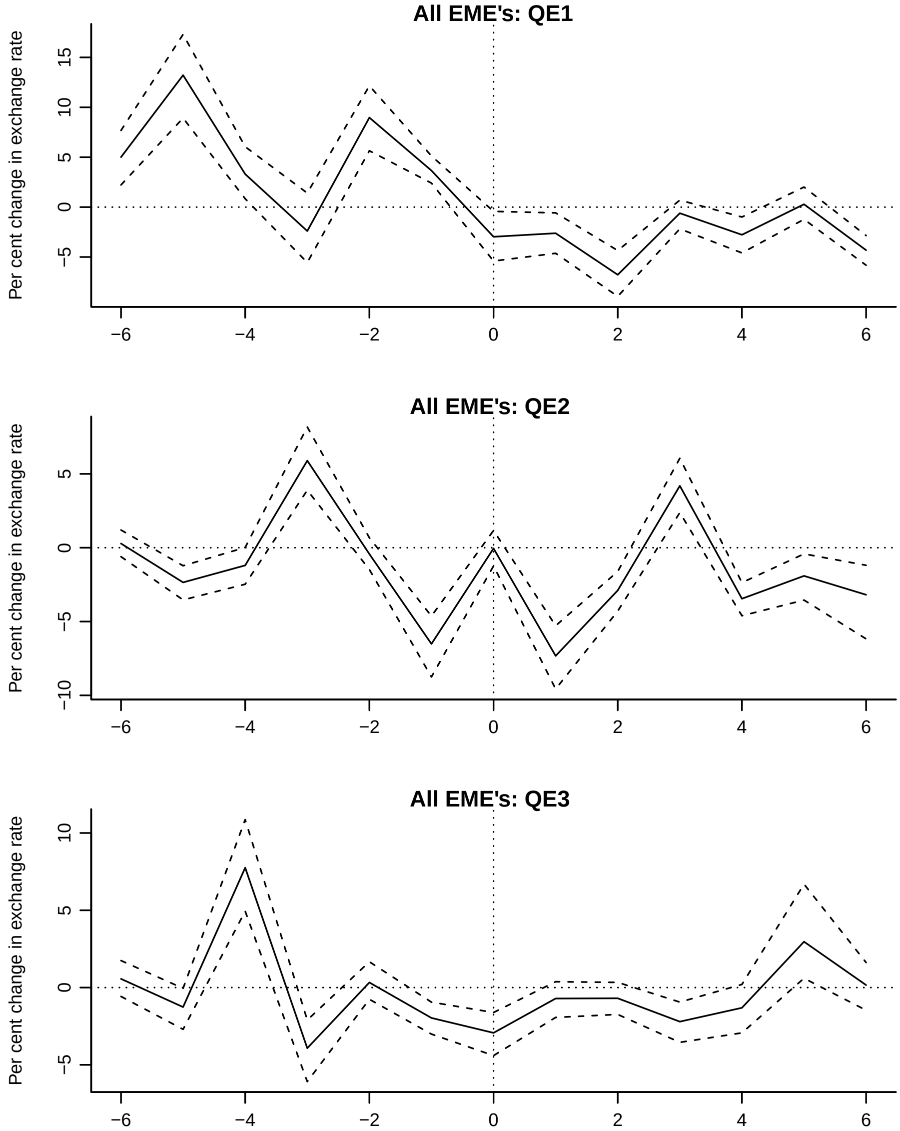


Figure 17 clearly shows that EM's faced maximum pressure to appreciate during QE2. EM's show appreciation pressure two months before the QE2 announcement. This pressure persists two months after the event. This is also in line with Fratzscher *et al.* (2012) that QE2 was marked with a "reach for yield"[16]. The impact on EM EMP after QE1 is also quite substantial. EM EMP reverses from

[16]BBVA research (2012) find that EM markets risk premiums have tightened around 70 bps and EM equities outperformed US equities three months after QE2

significant depreciation pressure 2 months prior to QE to appreciation pressure after QE1. The impact of QE3 on EM EMP was flat with no significant change in EMP before or after the event.

3.4 Response of emerging economies

The response to pressure on the exchange rate is shaped by the exchange rate policy, the level of the exchange rate and other considerations related to business cycle conditions. Also, the same volume of exchange market pressure may invoke different reactions in different countries depending on how effective policy makers find their intervention in the foreign exchange market or on interest rates to be. The central bank in a country with a very large foreign exchange market may have to trade billions of dollars to influence the exchange rate. A country with a very open capital account may choose to raise interest rates to defend its currency rather than sell foreign exchange reserves. Many emerging economies do not have completely open capital accounts or monetary policy frameworks and transmission mechanisms where exchange rates are very sensitive to changes in the policy interest rate.

To assess the response to quantitative easing we measure the share of each of the three responses as a share of EMP. For example, if out of a pressure of 10 percent on the exchange rate in one month, we find that 4 percent is the observed appreciation in the exchange rate, then the share of currency movement in relieving EMP is 40 percent. If ρ_t is one, or a billion of intervention would have prevented an appreciation of one percent in that year, and the central bank bought 5 billion dollars in those months, then the contribution of intervention in EMP is 50 percent. And, if η_t is 0.5, or the economy is partly open, and the interest differential between domestic and foreign interest rates has changed by 2 percent, the share of EMP relieved by the change in the interest rate differential is 1 out of the total EMP of 10, or 10 percent.

In order to put the response in perspective we compare this share to a benchmark based on the response of the full sample of emerging economies from 1995-2013 to establish a baseline and to give us a preliminary idea of what might have happened in these economies. The full sample is for the period: Jan 1995-May 2013. The effects of QE1 are examined for Apr 2009-Jun 2009, for QE2 from Aug 2010-Oct 2010 and for QE3 between Sep 2012-Nov 2012.

Table 13 shows the response of emerging economies to the quantitative easing. On average in the long term we see that intervention has relieved about 52 percent of the share of EMP, exchange rate movement about 37 percent and interest differentials about 10 percent. The average response of EMs to the QEs does not appear to be different from their overall average response in the full period. In comparison to the response to the capital surge of 2007, we see that responses were not different from the capital surge of 2007. [17] The response was, however, quite different from when EMs faced a pressure to depreciate immediately after the Lehman crisis. When faced with pressure to depreciate, most EMs allowed much more currency flexibility (Table 13).

Table 13 Share of EMP

Group	ΔI_t (Full)	Δe_t (Full)	$\Delta Idiff$ (Full)	ΔI_t (Surge)	Δe_t (Surge)	$\Delta Idiff$ (Surge)	ΔI_t (QE)	Δe_t (QE)	$\Delta Idiff$ (QE)	ΔI_t (GFC)	Δe_t (GFC)	$\Delta Idiff$ (GFC)
EM Asia	55.84	36.36	7.81	51.74	41.56	6.69	54.86	43.15	1.99	55.40	42.87	1.73
EM Africa	64.38	28.58	7.04	63.60	28.40	8.00	62.11	33.36	4.53	56.50	34.69	8.80
EM Latam	44.17	40.14	15.68	44.29	40.32	15.40	47.15	40.76	12.09	31.37	61.37	7.26
EM Europe	44.72	45.35	9.93	48.64	41.20	10.16	48.05	46.63	5.33	28.04	64.07	7.89
EM All	52.28	37.61	10.12	52.07	37.87	10.06	53.04	40.97	5.98	42.83	50.75	6.42

Full : Jan 1995-Oct 2012
Surge: Oct 2007-Dec 2007
GFC : Aug 2008-Oct 2008
QE : Apr 2009-Jun 2009, Aug 2010-Oct 2010, Sept 2012-Nov 2012

3.5 Heterogeneity in EM responses

Over the full sample period of 1995-2013, we know that most EM's have undergone financial liberalisation and may have moved to different exchange rate arrangements. Even though the similarity in average response is a surprising result, there is heterogeneity in the EM set that can be teased out across both the cross section and the time series.

3.5.1 EM responses over different QE episodes

Table 14 looks at EM group responses across all three QE episodes separately and compares it with the full period response. The EM average response for all EM's suggests that all three episodes of QE saw a similar response.

3.5.2 Regional responses

We find that countries in EM Asia allow for significantly greater currency flexibility during QE3 as compared to all the full period response. This is in contrast to the response of EM Europe during QE3, which allows very significantly lower currency flexibility during QE3. The response to QE may have been shaped by numerous factors. Countries that lost reserves may have intervened to build up

[17] Table 18 in appendix 5.6 shows country level responses to the capital flow surge, global financial crisis and the QE period

reserves again. Those who witnessed a sharp depreciation of the currency in the period immediately after the crisis may had been comfortable with the appreciation, seeing it as a correction.[18]

Table 14 Comparing QE1, QE2, QE3: By EM regions

Group	ΔI_t (Full)	Δe_t (Full)	$\Delta Idiff$ (Full)	ΔI_t (QE1)	Δe_t (QE1)	$\Delta Idiff$ (QE1)	ΔI_t (QE2)	Δe_t (QE2)	$\Delta Idiff$ (QE2)	ΔI_t (QE3)	Δe_t (QE3)	$\Delta Idiff$ (QE3)
EM Asia	55.84	36.36	7.81	57.10	40.25	2.65	58.20	40.51	1.28	49.28	48.69	2.03
EM Africa	64.38	28.58	7.04	64.00	31.96	4.04	56.35	37.11	6.54	65.99	31.02	2.99
EM Latam	44.17	40.14	15.68	32.10	45.06	22.84	53.01	36.07	10.93	56.36	41.15	2.50
EM Europe	44.72	45.35	9.93	42.67	50.30	7.03	42.28	56.76	0.96	59.19	32.82	7.99
EM All	52.28	37.61	10.12	48.97	41.89	9.14	52.46	42.61	4.93	57.70	38.42	3.88

3.5.3 EM responses across different countries

This heterogeneity in EM responses is illustrated clearly when we examine responses across countries over the different periods of QE. We illustrate this point by examining the countries of EM Asia in Table 15. We find that India, South Korea and China allow for maximum currency flexibility during QE3 with India almost looking like a freely floating economy as only 20% of EMP was relieved by intervention and interest rate changes during QE3. China's increased currency flexibility over the QE period, although incremental, was significantly higher than the full period average for China. South Korea accumulated reserves by intervening over QE1 and QE2 and gradually allows for more currency flexibility during QE3. Indonesia on the other showed high currency flexibility during QE1 but intervened heavily across QE2 and QE3. Malaysia and Thailand did not deviate much from their full period response over the QE episodes.

Table 15 Comparing QE1, QE2, QE3 for EM Asia

Country	ΔI_t (Full)	Δe_t (Full)	$\Delta Idiff$ (Full)	ΔI_t (QE1)	Δe_t (QE1)	$\Delta Idiff$ (QE1)	ΔI_t (QE2)	Δe_t (QE2)	$\Delta Idiff$ (QE2)	ΔI_t (QE3)	Δe_t (QE3)	$\Delta Idiff$ (QE3)
China	92.55	4.47	2.98	98.78	1.15	0.07	83.44	16.43	0.13	68.32	31.51	0.16
India	61.43	35.23	3.35	48.47	49.53	2	52.79	44.99	2.23	19.67	79.95	0.38
Indonesia	33.3	43.82	22.87	24.25	67.44	8.31	79.6	17.9	2.5	62.68	33.93	3.39
Malaysia	67.77	26.28	5.96	63.62	35.73	0.65	62.42	36.39	1.19	71.09	28.42	0.5
Philippines	23.9	62.13	13.97	23.59	69.86	6.56	5.13	92.78	2.09	18.02	77.39	4.59
South Korea	51.99	44.71	3.29	69	30.77	0.24	50.53	48.82	0.65	40.1	58.3	1.59
Thailand	59.91	37.85	2.24	72.01	27.29	0.7	73.52	26.29	0.19	65.05	31.35	3.6
EM Asia	**55.84**	**36.36**	**7.81**	**57.10**	**40.25**	**2.65**	**58.20**	**40.51**	**1.28**	**49.28**	**48.69**	**2.03**
EM All	**52.28**	**37.61**	**10.12**	**48.97**	**41.89**	**9.14**	**52.46**	**42.61**	**4.93**	**57.70**	**38.42**	**3.88**

Full : Jan 1995-Oct 2012
QE1 : Apr 2009-Jun 2009
QE2 : Aug 2010-Oct 2010
QE3 : Sep 2012-Nov 2012

[18] Table 19 in appendix 5.6 shows country level responses to QE1, QE2 and QE3

4 Conclusions and further research

The key contribution of this paper is a new measure of exchange market pressure based on a meaningful way of combining interest rates, prices and exchange rates. The measure proposed in this paper is able to offer a time varying cross country measures of the impact of intervention that are broadly in the range expected. This allows us to measure EMP. The proposed measure can be used to address a number of questions that involve comparisons across time and across countries. The database of EMP can be used for understanding the impact of global developments, domestic policies and the response of countries. The measure can also be used to monitor exchange market pressures building up for a country.

This research can be improved upon on various counts. On the estimation, improvements in measurement of the two parameters measuring the impact of a billion dollars of intervention and the impact of a one per cent change in the interest differential, can improve the EMP measure. For this both better data and better methods that measure the impact country by country taking into account various other factors such as central bank communication, sterilization of its intervention and policies to obtain time varying estimates of the impact of intervention would be useful. In terms of data, data for actual intervention, wherever available, instead of change in reserves could improve the measure. Similarly, data for the size of the foreign exchange market would be another source of improvement.

5 Appendix

5.1 Interest rate data

The choice of interest rates for home and foreign country is driven by availability of data for many countries. The asset and tenor for which the interest rate data for the home country is available then must be matched by the foreign country data. In the tradition of Eichengreen *et al.* (1996) we choose to use interest rate differentials with the United States using treasury bill data. Treasury bill data is reported by the IMF-International Financial Statistics (IFS) in line 60C. Using this we get a set of 106 countries for which treasury bill data is available. The tenor for the US treasury bill rate is chosen to be the same as that reported by the home country. For those countries for which treasury bill data is not available, we obtain money market rates from Datastream. We follow the same procedure with money market rates wherein we match the selected money market rate from a country to the matching tenor money market rate from the United States. Table 16 shows the details.

Table 16 Interest rate data

Treasury bill rates

Country	Tenor	Country	Tenor
Albania	3M	Algeria	6M
Antigua and Barbuda	3M	Armenia	3M
Australia	3M	Azerbaijan	3M
Bahamas	3M	Bahrain	3M
Barbados	3M	Belgium	20Y
Belize	3M	Bolivia	3M
Brazil	1M	Bulgaria	1Y
Burundi	1M	Canada	3M
Cape Verde	6M	Hong Kong	3M
Cyprus	3M	Czech Republic	3M
Dominica	3M	Egypt	3M
Ethiopia	3M	Fiji	AV
France	3M	Georgia	UK
Germany	1Y	Ghana	3M
Greece	1Y	Grenada	3M
Guyana	3M	Hungary	3M
Iceland	3M	Iraq	3M
Ireland	3M	Israel	UK
Italy	AV	Jamaica	6M
Japan	3M	Kazakhstan	UK
Kenya	3M	Kuwait	3M
Kyrgyz Republic	3M	Lao People's Dem.Rep	6M
Latvia	$3M, 6M^1$	Lebanon	3M
Lesotho	3M	Lithuania	$3M, 1Y^2$
Madagascar	AV	Malawi	3M
Malaysia	3M	Maldives	1M
Malta	3M	Mauritania	UK
Mexico	1M	Moldova	AV
Mongolia	AV	Montenegro	6M
Mozambique	3M	Namibia	1M
Nepal	3M	New Zealand	3M
Nigeria	UK	Pakistan	6M
Papua New Guinea	6M	Philippines	3M
Poland	AV	Portugal	3M
Romania	3M	Russian Federation	3M
Rwanda	3M	Saudi Arabia	3M
Seychelles	$3M, 1Y^3$	Sierra Leone	UK
Singapore	3M	Slovenia	3M
Solomon Islands	3M	South Africa	3M
Spain	1Y	Sri Lanka	UK
St. Kitts and Nevis	UK	St. Lucia	UK
St. Vincent & Grens	UK	Swaziland	3M
Sweden	3M	Switzerland	AV
Tanzania	3M	Thailand	3M
Trinidad and Tobago	3M	Turkey	3M
Uganda	3M	United Kingdom	3M
United States	3M	Uruguay	6M
Vietnam	1Y	Yemen	3M
Zambia	AV	Zimbabwe	3M
Netherlands Antilles	3M	Serbia	3M
Chile	3M	China	3M
Gambia	3M	Myanmar	3M
India	3M		

Weighted average money market rates

Country	Tenor	Country	Tenor
Aruba	1M	Bangladesh	1M
Colombia	1M	Estonia	3M
Dominican Republic	1M	Croatia	1M
Jordan	1M	South Korea	1M
Morocco	1M	Macao	1M
Mauritius	1M	Oman	1M
Peru	1M	El Salvador	1M
Tajikistan	1M	Tunisia	1M
Ukraine	1M	Venezuela	1M
Vanuatu	1M		

Interbank rates

Country	Tenor	Country	Tenor
Argentina	3M	Qatar	3M
Indonesia	3M	Costa Rica	1M

Key **M**=Months **Y**=Years **UK**=Unknown
AV= Averaged across tenors
[1] Average of 3M and 6M tenors reported
[2] 3M rate for 5 years, one year rate after that
[3] 3M rate for 7 years, one year rate after that

5.2 Suitability of other EMP measures

One difficulty with some of the existing EMP measures is that of inconsistent units. Dimensional analysis suggests that the units on both sides of an economically meaningful equation have to be consistent. As an example, consider the first and most often used EMP measure proposed by Girton and Roper (1977), $E_{gt} = \Delta e_t + \Delta \bar{r}_t$. This involves adding up two terms, the first term is in the units of percentage change of the exchange rate, and the second is in the units of percentage change of reserves. Such addition is logically suspect. Alternatively, this formula could only have been motivated by the very strong assumption that for all countries, at all time periods, a reserves change of 1% of M_0 has an impact on the currency market of 1%. But there is no basis for expecting foreign exchange market to have such a property for all countries and for all times.

EMP indices do not have the problem of adding inconsistent units as they are dimensionless. As an example, E_{et} adds up a standardised change in the exchange rate (which is dimensionless) and a standardised change in reserves (which is also dimensionless). While this is immune to the criticism rooted in dimensional analysis, it is not appropriate for cross-country comparisons. EMP indices were developed for analysing currency crisis. These, in general, are periods when policy makers were often trying to defend the exchange rate, using all possible policy options available. All three components of EMP are generally seen to move in this period. When each of these is first standardised, and then added up to obtain an index, the index has high values for periods of crisis. The definition of high is often defined as the index being some standard deviations away. This measure was developed for periods of crisis and adequate as such. However, there are difficulties in using these crisis indices for tranquil periods.

We tried a few alternative EMP indices for our analysis. We defined I_t as the intervention of the central bank in time t. The exchange rate is denoted by e_t and reserves by R_t. The percentage change in e_t is denoted by Δe_t; the percentage change in r_t is denoted by Δr_t. The change in reserves in levels is denoted by ΔR_t. $\frac{r_t}{M0} \times 100$ is denoted by $\bar{r}_t$. The following formulae describe the index specification tried by us:

E_{et} (Eichengreen *et al.*, 1996):

$$\text{EMP}_t = \frac{1}{\sigma_e}\frac{\Delta e_t}{e_t} - \frac{1}{\sigma_{\bar{r}}}\left(\frac{\Delta \bar{r}_t}{\bar{r}_t} - \frac{\Delta \bar{r}_{US_t}}{\bar{r}_{US_t}}\right) + \frac{1}{\sigma_i}\left(\Delta\left(i_t - i_{US_t}\right)\right)$$

where

$$\bar{r}_t = \frac{Reserves}{\text{Base money}}$$

E_{st} (Sachs *et al.*, 1996):

$$K_t = \frac{1}{\sigma_e} + \frac{1}{\sigma_r} + \frac{1}{\sigma_i} \tag{3}$$

$$E_{st} = \left(\frac{\frac{1}{\sigma_e}}{K_t}\right)\frac{\Delta e_t}{e_t} - \left(\frac{\frac{1}{\sigma_r}}{K_t}\right)\frac{\Delta r_t}{r_t} + \left(\frac{\frac{1}{\sigma_i}}{K_t}\right)\Delta i_t \tag{4}$$

E_{kt} (Kaminsky *et al.*, 1998):

$$E_{kt} = \frac{\Delta e_t}{e_t} - \left(\frac{\sigma_e}{\sigma_r}\frac{\Delta r_t}{r_t}\right) + \left(\frac{\sigma_e}{\sigma_r}\Delta_t\right) \tag{5}$$

and E_{pt} (Pentecost *et al.*, 2001): an index based on a principal components analysis of the sub-components in Eichengreen *et al.* (1996).

E_{imf} (IMF, 2007):

$$EMP = \frac{1}{\sigma_{\Delta\% e_{i,t}}}\Delta\% e_{i,t} + \frac{1}{\sigma_{\Delta\% res_{i,t}}}\Delta\% res_{i,t} \tag{6}$$

$$\Delta\% res_{i,t} = \frac{NFA_{i,t} - NFA_{i,t-1}}{Monetary\ base_{i,t-1}} \tag{7}$$

$$\Delta e_{i,t} = \frac{er_{i,t} - er_{i,t-1}}{er_{i,t-1}} \tag{8}$$

$$\tag{9}$$

Under a perfectly fixed exchange rate regime, the standard deviation of the exchange rate is zero. This results in giving an infinitely large weight to the coefficient of exchange rate movements. In general, when a country allows small changes in the exchange rate to occur, these show up as a high EMP because of the large weight being given to exchange rate changes. As an example, consider a highly inflexible exchange rate like that of China, where $\sigma_{\Delta e} \approx 0$. In months when a small exchange rate change takes place, and the numerator is non-zero, a very large value for EMP will be induced. This would spuriously signal exchange market pressure. To illustrate this, we measure EMP using the Eichengreen *et al.* (1996) index. The measure does not indicate the high pressure on the Chinese Renminbi to appreciate in the early 2000s.

Other EMP indices which do not include the US reserve money in their measure of EMP capture the direction of the exchange market pressure better. Figure 18 shows that as a consequence of the large weight given to exchange rate movements, and the small weight given to intervention due to the large variation in intervention,

Figure 18 Various EMP measures for China

This panel shows various EMP measures calculated for China from the EMP literature

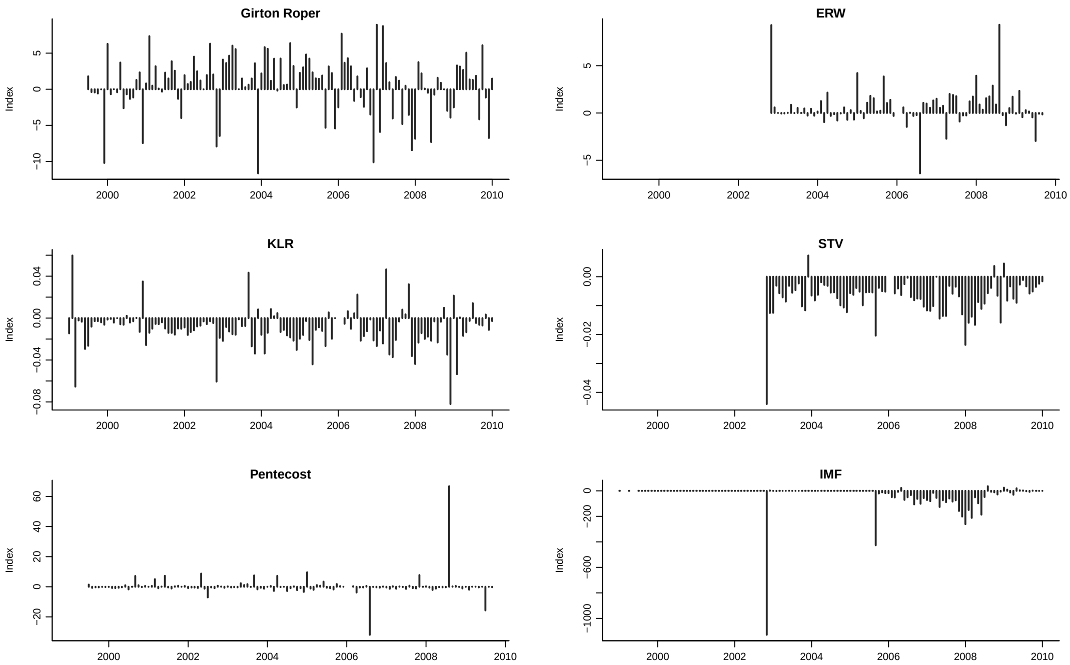
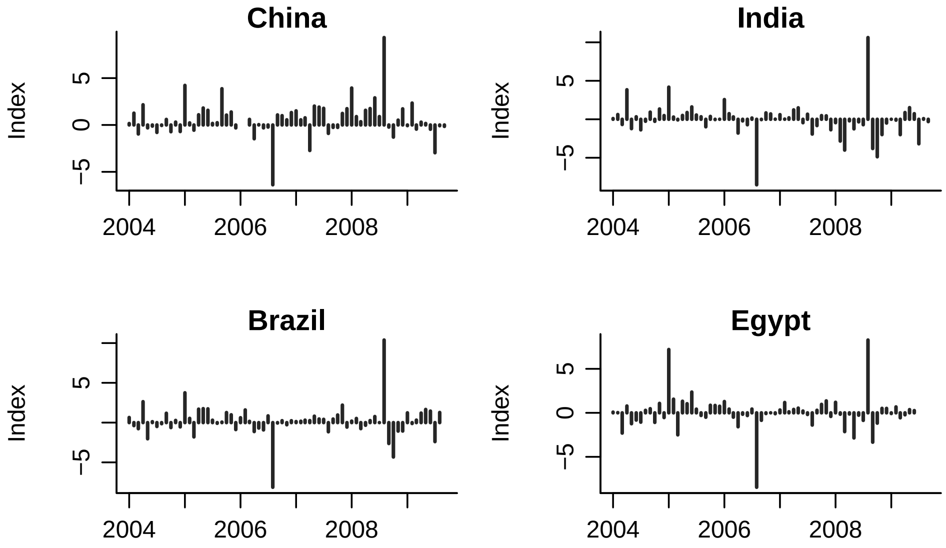


Figure 19 ERW EMP index



make the EMP appear low in periods when there was a large change in reserves, and higher when there was a small change in the exchange rate. The indices are all crisis indices, so that when $\sigma_e \Rightarrow 0$ the weight of exchange rate change $\Rightarrow 0$. Thus, under a completely fixed exchange rate, it is not possible to measure the index. Under a tight peg, when the weight given to the currency is very high because of the low variance of the exchange rate, we find that even small changes in the exchange rate appear as large exchange market pressure.

Similarly, under periods of floating exchange rate, the measure gives a large weight to intervention. Since most central banks do not publish intervention data, it is typical to approximate intervention by the change in foreign exchange reserves. But reserves change not merely due to intervention, but also due to revaluation effects and interest payments. These revaluation effects and interest income end up being given a large weight due to their low variance and show up as large EMP under a floating exchange rate.

Figure 19 shows the ERW index for 4 countries, China, India, Brazil and Egypt. When the index is examined for one country, say China, across time, where there is evidence that in the 2000s either the exchange rate appreciated, or China built up reserves, so both suggest that there was pressure to appreciate, the index does not reflect this clear direction of the pressure. In comparison to other countries also there is no difference between the EMP seen by China and that seen by other countries, as each country's EMP depends on its historical experience.

5.3 Defining exchange rate regimes using Zeileis *et al.* (2010)

Table 17 Comparing RR and ZSP for float periods used in the paper

The table shows the float periods detected by the Zeileis *et al.* (2010) (ZSP) methodology and compares it with the Reinhart and Rogoff (2004) (RR) de facto coarse currency classification. Majority of the country periods which are detected as floats by the ZSP methodology are categorised as crawling pegs or managed floats by RR database

Country	Float Period	ZSP R^2	RR Classification
Angola	Nov 2006 to May 2007	0.55	1
Bangladesh	Dec 2005 to Jan 2007	0.62	2
Brazil	Jun 1994 to Jul 1995	0.51	2
Cape Verde	Mar 1999 to Sep 2001	0.31	2
Ethiopia	Sep 2002 to May 2007	0.65	2
Guinea	Aug 1998 to Sep 1999	0.55	2
Guyana	Oct 1998 to Jul 1999	0.48	2
Guyana	Jun 2005 to Dec 2005	0.49	2
India	Aug 1997 to Aug 1998	0.5	2
Kenya	Apr 1997 to Jul 2001	0.54	2
Kazakhstan	Mar 2006 to Sep 2007	0.58	2
Laos	Jun 2001 to Nov 2001	0.44	6
Sri Lanka	Jun 2000 to Jun 2001	0.48	3
Mongolia	Sep 1998 to Mar 2001	0.45	1
Maldives	May 2005 to Apr 2006	0.46	1
Malaysia	Aug 1997 to Aug 1998	0.21	4
Tunisia	Sep 1990 to Sep 1991	0.47	2
Trinidad & Tobago	Sep 1996 to Oct 1997	0.59	2
Venezuela	Feb 2002 to Sep 2003	0.34	4
Antigua & Barbuda	Feb 1996 to Aug 2002	0.63	1
Angola	Nov 2006 to May 2007	0.55	1
Costa Rica	Jan 1997 to Jul 1997	0.41	2
Cape Verde	Jul 2004 to Dec 2007	0.44	2
Gambia	Dec 1998 to Nov 2003	0.5	2
Guyana	Jun 2005 to Dec 2005	0.49	2
Guyana	Jan 2007 to Jul 2007	0.47	2
Moldova	Nov 2000 to May 2001	0.56	2
Mauritius	Dec 2002 to Apr 2004	0.62	2
Malaysia	Dec 1993 to Jul 1994	0.44	2
Tunisia	Aug 1992 to Jan 1994	0.61	2
Ukraine	Apr 2003 to Feb 2004	0.59	1
Central African Republic	May 2002 to Jan 2004	0.5	1

5.4 EMP in emerging economies after QE

Figure 20 EMP in India, Indonesia and China

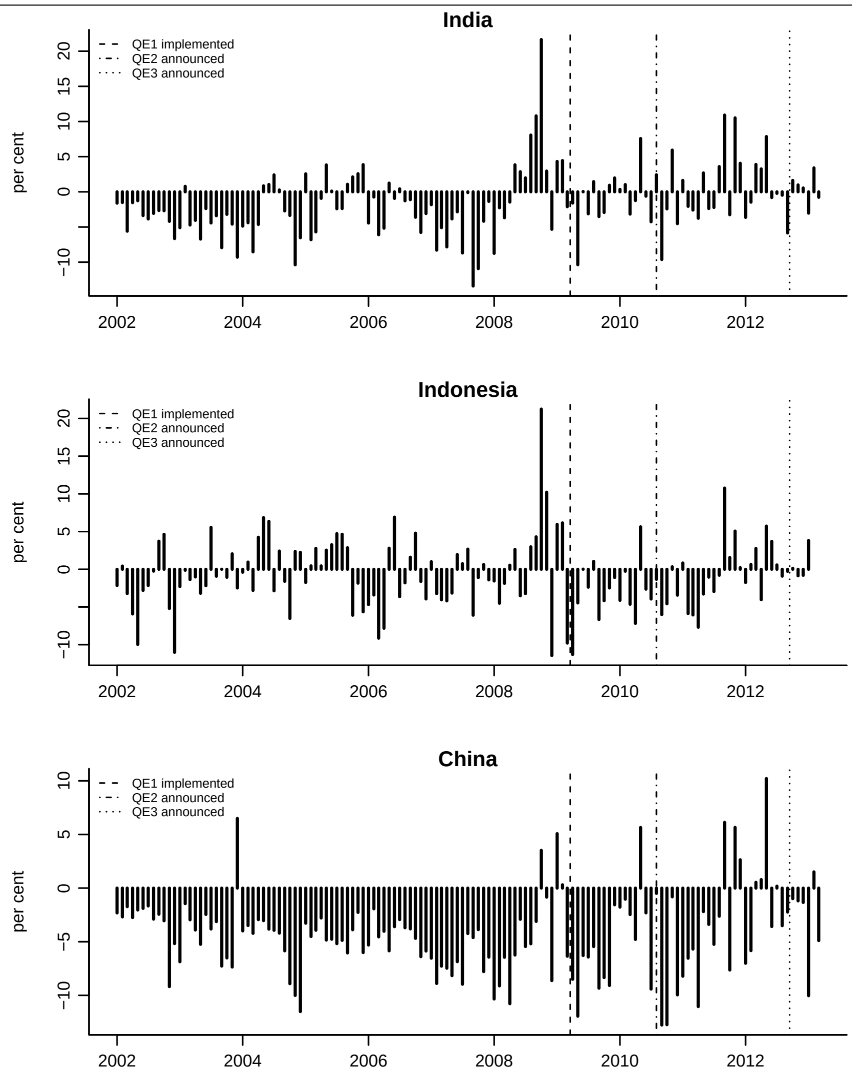


Figure 21 EMP in Brazil, Peru and Mexico

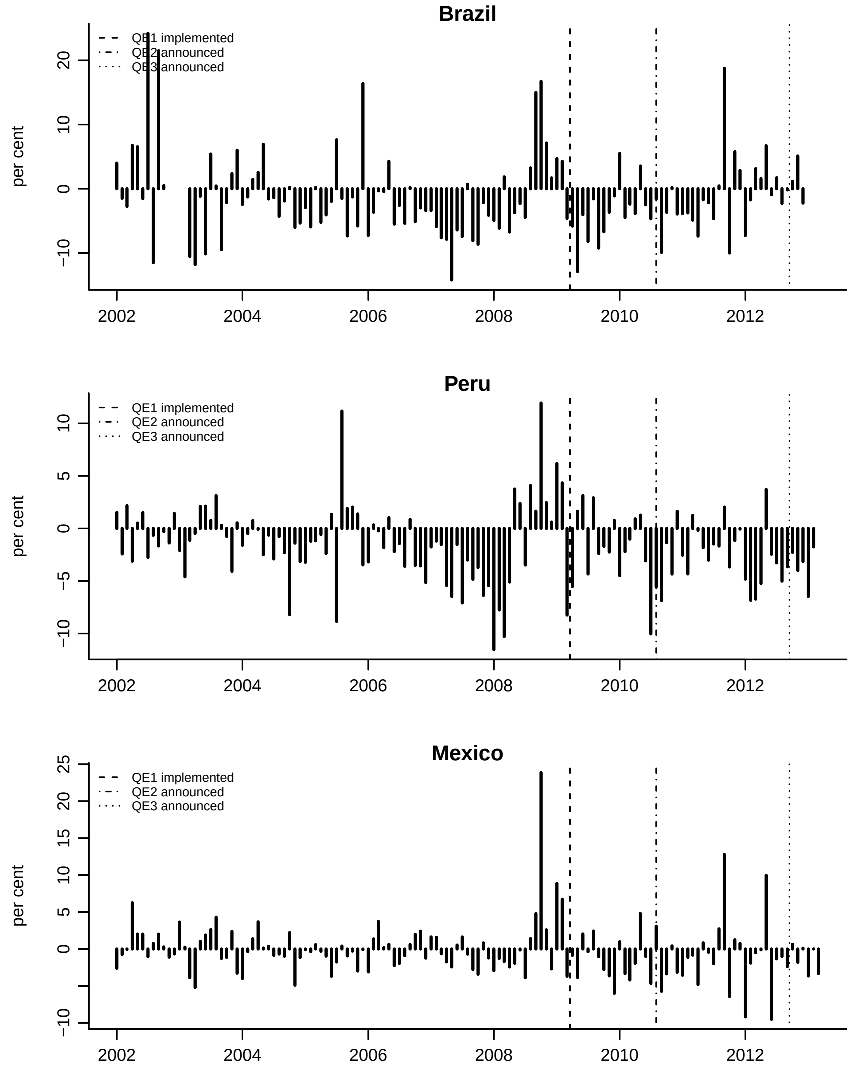


Figure 22 EMP in Egypt, Morocco, Lebanon and South Africa

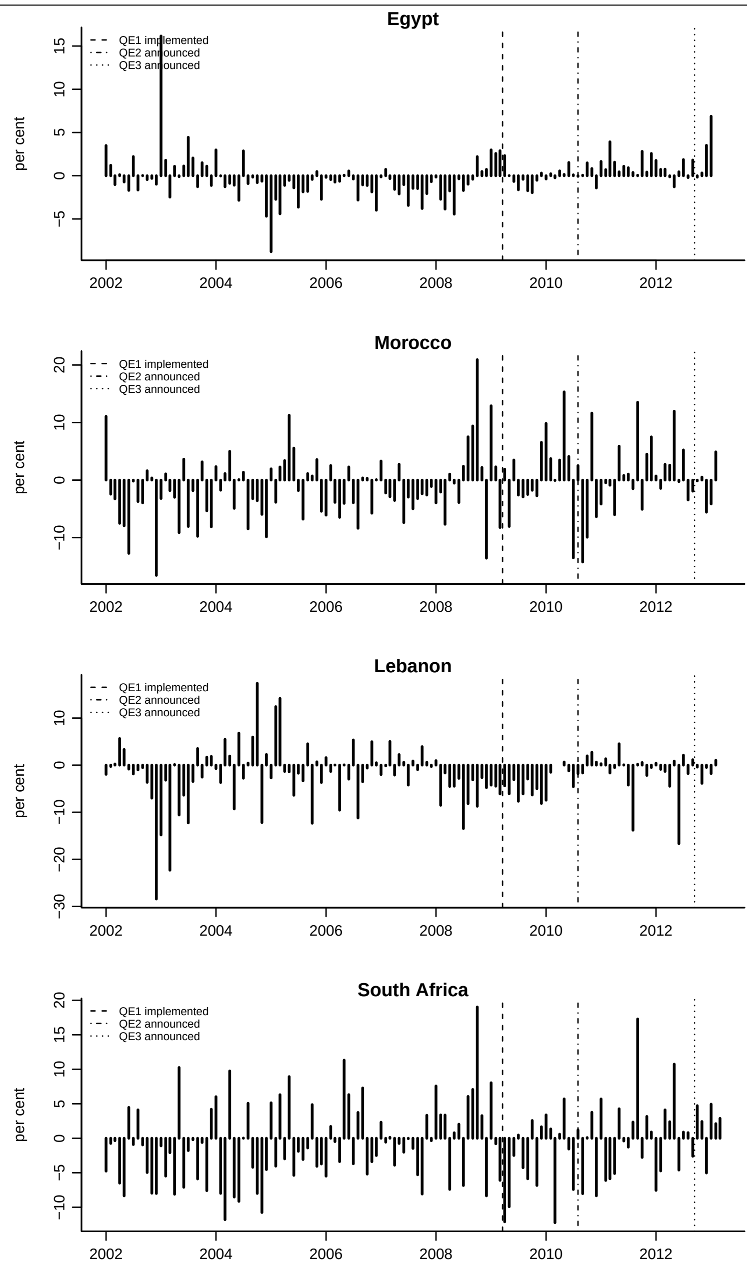


Figure 23 EMP in Korea, Malaysia, Philippines, Thailand

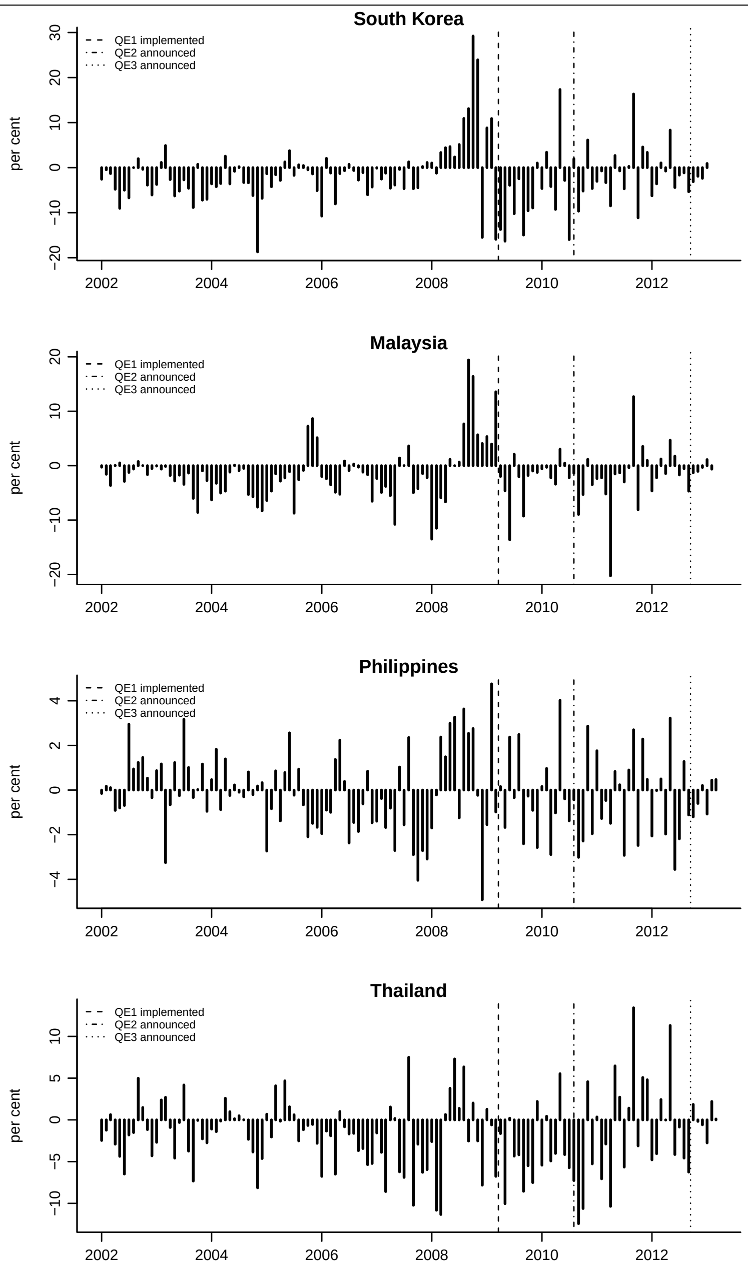


Figure 24 EMP in Romania, Ukraine, Hungary and Czech Republic

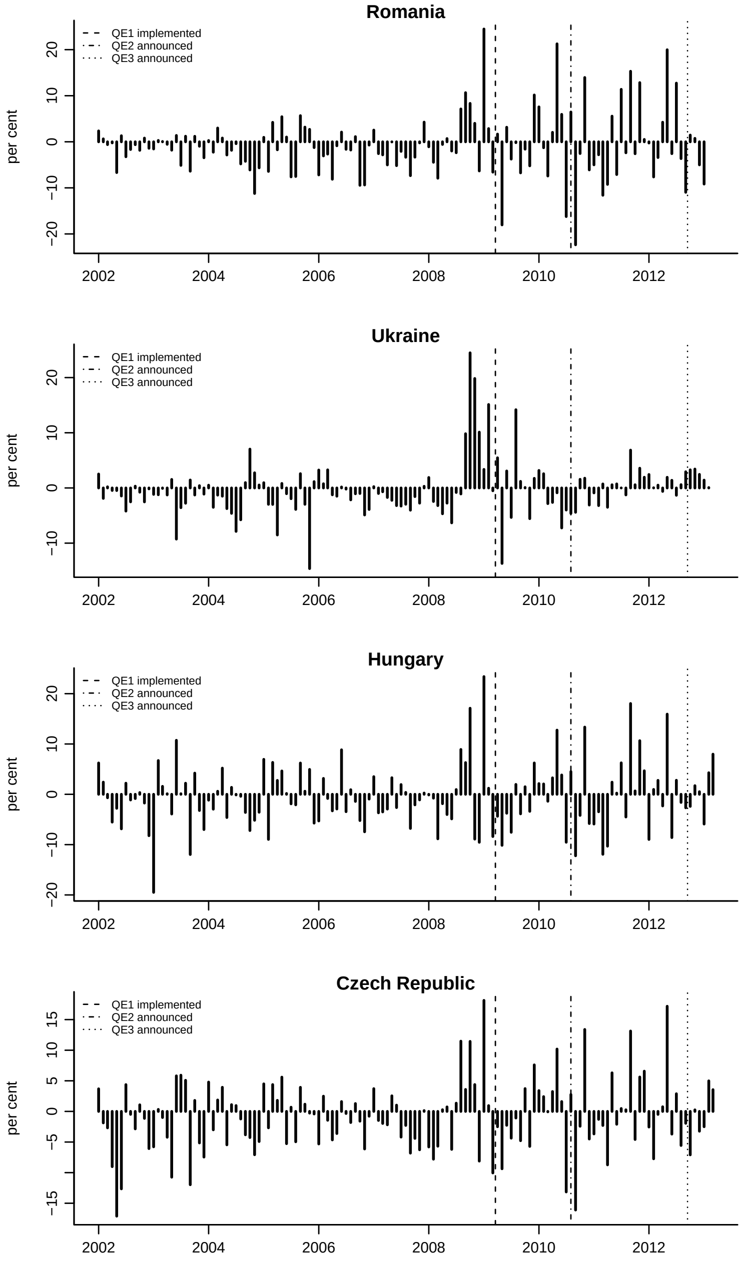


Figure 25 EMP in Argentina, Chile, Colombia and Venezuela

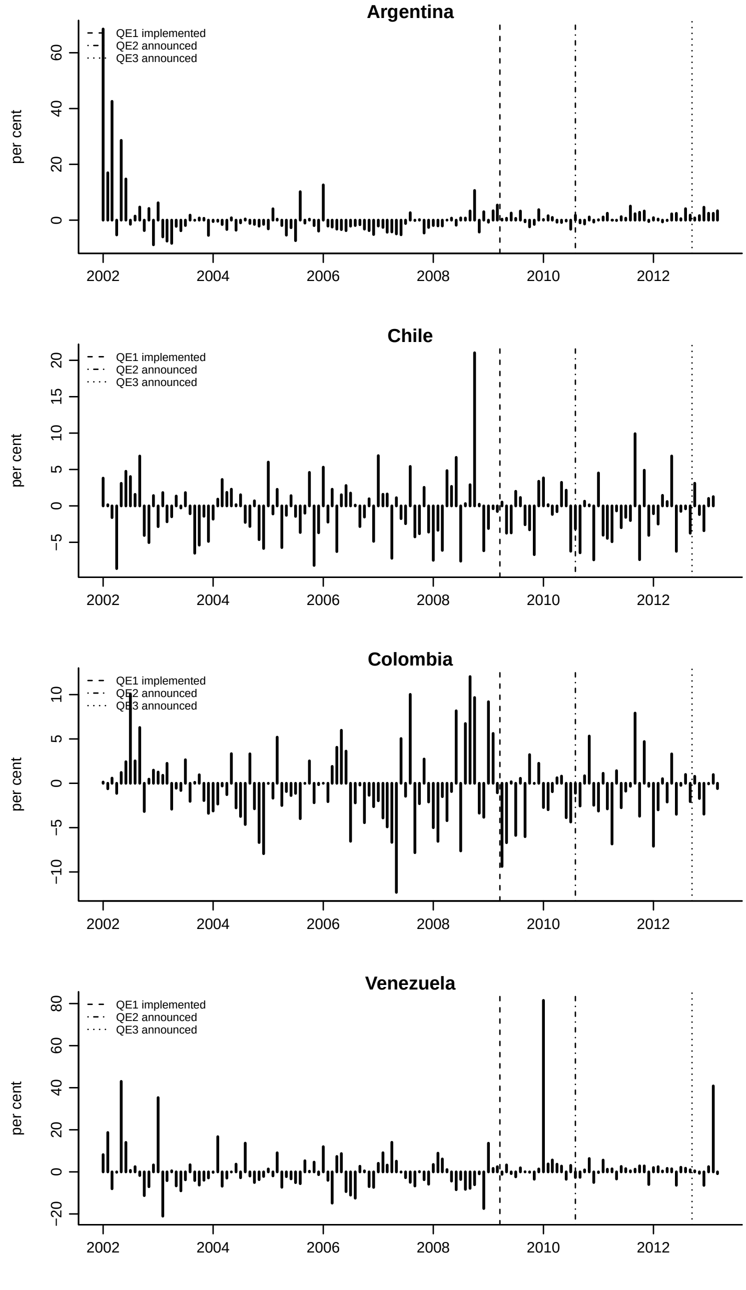


Figure 26 EMP in Nigeria, Saudi Arabia, Russia and Turkey

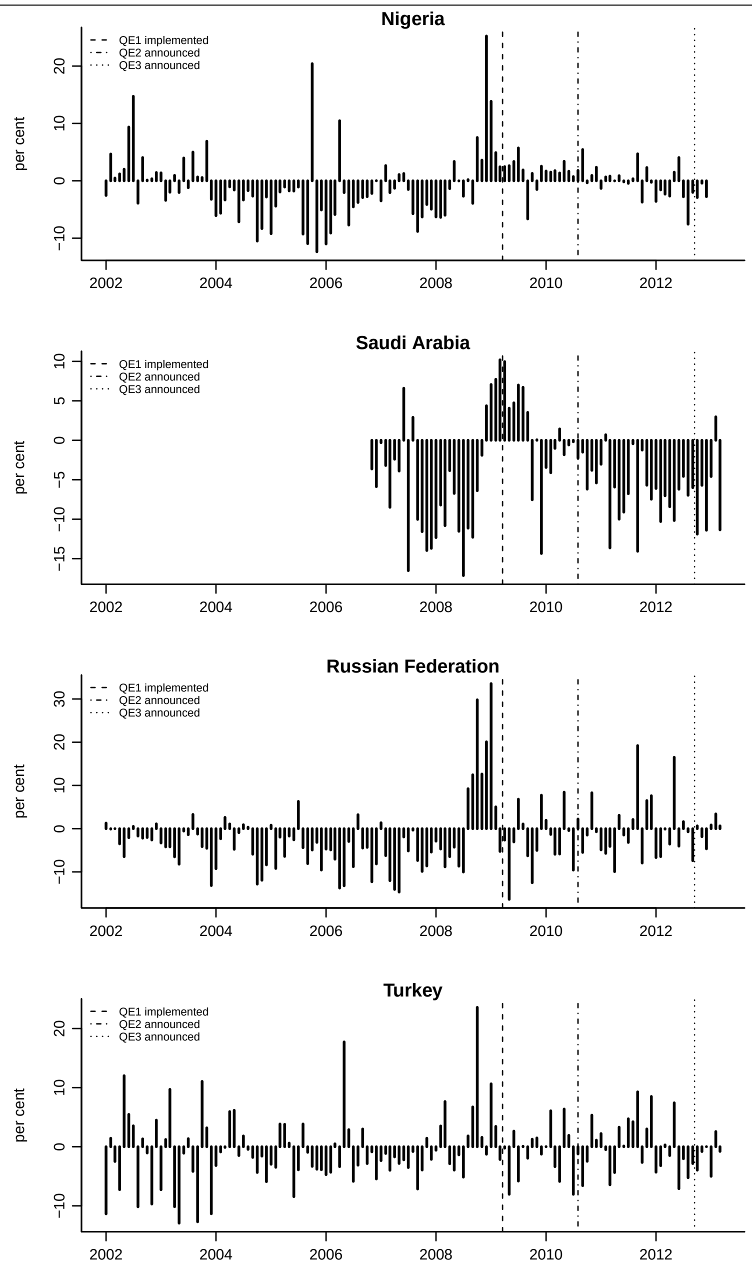
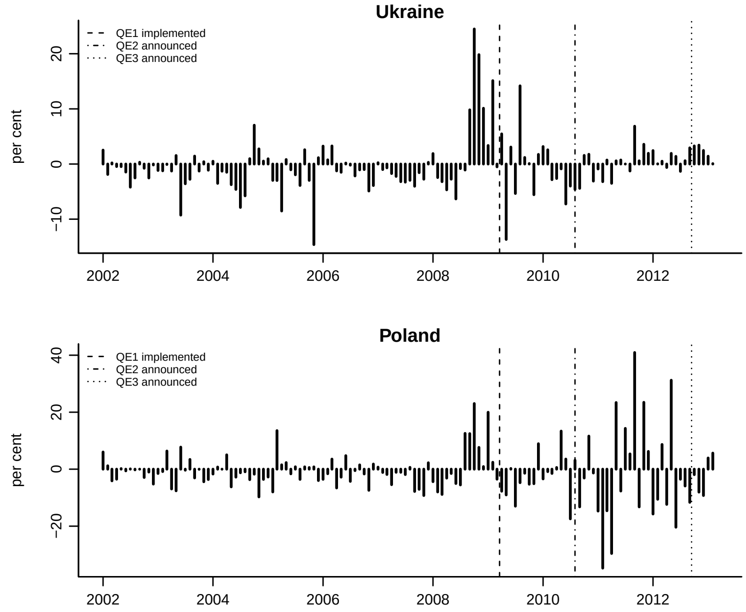


Figure 27 EMP in Ukraine and Poland



5.5 Regional distribution

We now present the distribution of each region - Emerging Asia, Emerging Africa and the Middle east, Emerging Europe and Emerging Latin America, as well as for all emerging economies. The analysis suggests that for all emerging economies as well as for some cases, the exchange market pressure after the quantitative easing was at least as high as that at the peak of capital inflows in 2007 Q2. However, there appears to be significant cross sectional heterogeneity across regions. We see that Emerging Asia showed highest appreciation pressure after QE1 implementation as compared to EMP during the capital surge of 2007 or after QE2.

Figure 28 Emerging Asia, Africa, Europe and Latam after QE1 and QE2: EMP distribution

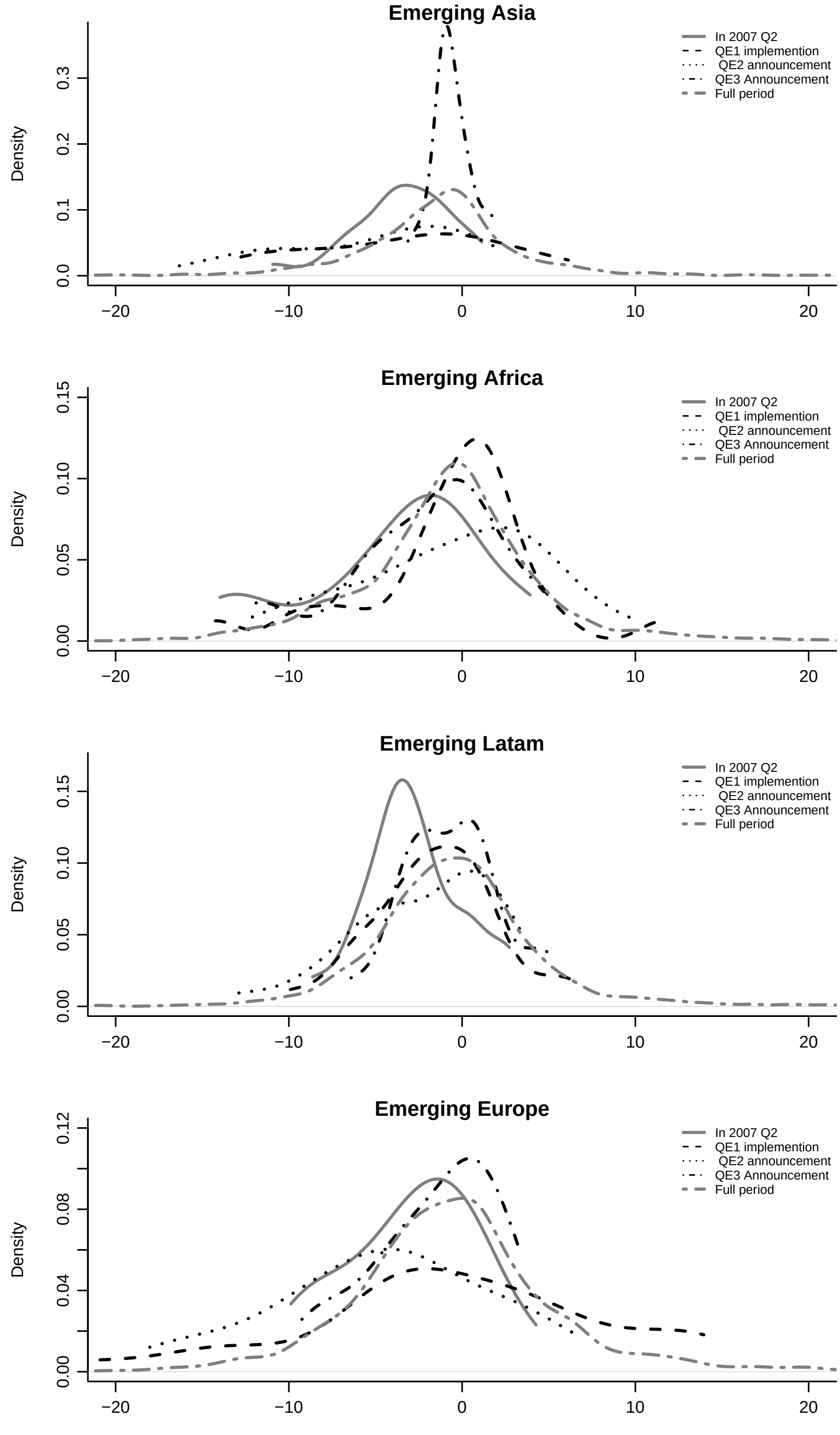


Table 18 Country Responses

Country	ΔI_t (Full)	Δe_t (Full)	$\Delta Idiff$ (Full)	ΔI_t (Surge)	Δe_t (Surge)	$\Delta Idiff$ (Surge)	ΔI_t (QE)	Δe_t (QE)	$\Delta Idiff$ (QE)
China	92.55	4.47	2.98	84.04	14.81	1.14	83.51	16.36	0.12
India	61.43	35.23	3.35	83.58	15.33	1.09	40.31	58.16	1.54
Indonesia	33.30	43.82	22.87	45.67	25.63	28.69	55.51	39.76	4.73
Malaysia	67.77	26.28	5.96	44.00	51.69	4.31	65.71	33.51	0.78
Philippines	23.90	62.13	13.97	3.70	91.57	4.73	15.58	80.01	4.41
South Korea	51.99	44.71	3.29	40.43	55.22	4.35	53.21	45.96	0.83
Thailand	59.91	37.85	2.24	60.79	36.66	2.55	70.19	28.31	1.50
EM Asia	**55.84**	**36.36**	**7.81**	**51.74**	**41.56**	**6.69**	**54.86**	**43.15**	**1.99**
Egypt	56.97	24.44	18.58	68.46	14.68	16.87	36.98	44.99	18.03
Lebanon	83.24	7.53	9.23	66.79	16.48	16.73	95.39	3.92	0.69
Morocco	60.65	37.57	1.78	62.54	34.59	2.87	59.44	40.12	0.43
Nigeria	63.13	30.31	6.56	56.38	36.82	6.81	66.95	27.13	5.93
Saudi Arabia	96.59	0.58	2.83	93.77	4.39	1.84	98.97	0.06	0.97
South Africa	25.70	71.06	3.25	33.68	63.46	2.86	14.95	83.94	1.10
EM Africa	**64.38**	**28.58**	**7.04**	**63.60**	**28.40**	**8.00**	**62.11**	**33.36**	**4.53**
Argentina	55.52	26.19	18.29	61.32	13.56	25.12	53.62	45.26	1.12
Brazil	45.22	48.59	6.19	46.30	41.77	11.93	46.74	48.29	4.97
Chile	34.47	58.31	7.22	17.81	71.57	10.63	37.73	48.11	14.15
Colombia	31.81	62.22	5.97	10.27	84.51	5.21	27.90	66.54	5.56
Mexico	32.30	49.07	18.63	42.93	45.00	12.07	35.87	56.34	7.78
Peru	52.00	25.97	22.03	68.68	25.81	5.51	65.90	20.75	13.35
Venezuela	57.88	10.66	31.46	62.70	0.00	37.30	62.32	0.00	37.68
EM Latam	**44.17**	**40.14**	**15.68**	**44.29**	**40.32**	**15.40**	**47.15**	**40.76**	**12.09**
Hungary	38.41	54.19	7.41	42.32	31.26	26.42	28.43	67.61	3.96
Poland	45.82	51.31	2.88	62.27	32.64	5.09	50.86	47.89	1.26
Romania	40.70	46.04	13.26	33.34	56.11	10.55	49.09	40.28	10.64
Czech Republic	31.11	64.30	4.59	24.19	63.95	11.86	31.24	65.87	2.89
Russian Federation	59.64	27.66	12.70	86.83	8.31	4.86	52.16	44.49	3.35
Turkey	38.91	52.57	8.52	18.99	80.10	0.90	55.36	43.58	1.05
Ukraine	58.45	21.39	20.16	72.52	16.02	11.46	69.19	16.67	14.15
EM Europe	**44.72**	**45.35**	**9.93**	**48.64**	**41.20**	**10.16**	**48.05**	**46.63**	**5.33**
EM ALL	**51.83**	**37.94**	**10.23**	**51.64**	**38.22**	**10.14**	**52.71**	**41.26**	**6.04**

Full : Jan 1995-Oct 2012
Surge: Oct 2007-Dec 2007
GFC : Aug 2008-Oct 2008
QE : Apr 2009-Jun 2009, Aug 2010-Oct 2010, Sept 2012-Nov 2012

5.6 Country responses

Table 19 Comparing QE1, QE2, QE3 for all EM's

Country	ΔI_t (Full)	Δe_t (Full)	$\Delta Idiff$ (Full)	ΔI_t (QE1)	Δe_t (QE1)	$\Delta Idiff$ (QE1)	ΔI_t (QE2)	Δe_t (QE2)	$\Delta Idiff$ (QE2)	ΔI_t (QE3)	Δe_t (QE3)	$\Delta Idiff$ (QE3)
China	92.55	4.47	2.98	98.78	1.15	0.07	83.44	16.43	0.13	68.32	31.51	0.16
India	61.43	35.23	3.35	48.47	49.53	2	52.79	44.99	2.23	19.67	79.95	0.38
Indonesia	33.3	43.82	22.87	24.25	67.44	8.31	79.6	17.9	2.5	62.68	33.93	3.39
Malaysia	67.77	26.28	5.96	63.62	35.73	0.65	62.42	36.39	1.19	71.09	28.42	0.5
Philippines	23.9	62.13	13.97	23.59	69.86	6.56	5.13	92.78	2.09	18.02	77.39	4.59
South Korea	51.99	44.71	3.29	69	30.77	0.24	50.53	48.82	0.65	40.1	58.3	1.59
Thailand	59.91	37.85	2.24	72.01	27.29	0.7	73.52	26.29	0.19	65.05	31.35	3.6
EM Asia	**55.84**	**36.36**	**7.81**	**57.10**	**40.25**	**2.65**	**58.20**	**40.51**	**1.28**	**49.28**	**48.69**	**2.03**
Egypt	56.97	24.44	18.58	42.13	42.8	15.06	21.08	48.61	30.31	47.73	43.57	8.71
Lebanon	83.24	7.53	9.23	98.54	1.08	0.38	89.16	10.68	0.16	98.46	0	1.54
Morocco	60.65	37.57	1.78	61.41	37.86	0.72	51.42	48.47	0.1	65.49	34.04	0.47
Nigeria	63.13	30.31	6.56	72.47	24.15	3.38	50.59	41.98	7.43	77.79	15.25	6.97
Saudi Arabia	96.59	0.58	2.83	97.35	0.02	2.63	99.72	0.13	0.15	99.84	0.04	0.12
South Africa	25.7	71.06	3.25	12.1	85.83	2.07	26.13	72.76	1.11	6.63	93.24	0.13
EM Africa	**64.38**	**28.58**	**7.04**	**64.00**	**31.96**	**4.04**	**56.35**	**37.11**	**6.54**	**65.99**	**31.02**	**2.99**
Argentina	55.52	26.19	18.29	43.37	54.74	1.88	84.19	14.43	1.38	33.29	66.61	0.1
Brazil	45.22	48.59	6.19	33.3	62.62	4.08	77.04	19.28	3.69	29.87	62.98	7.15
Chile	34.47	58.31	7.22	16.5	57.43	26.07	17.52	66.73	15.75	79.18	20.18	0.64
Colombia	31.81	62.22	5.97	17.81	66.97	15.22	30.3	69.53	0.17	35.59	63.13	1.28
Mexico	32.3	49.07	18.63	41.59	42.57	15.84	27.41	69.69	2.9	38.62	56.77	4.61
Peru	52	25.97	22.03	37.33	31.1	31.57	79.1	12.8	8.11	81.28	18.36	0.36
Venezuela	57.88	10.66	31.46	34.81	0	65.19	55.48	0	44.52	96.66	0	3.34
EM Latam	**44.17**	**40.14**	**15.68**	**32.10**	**45.06**	**22.84**	**53.01**	**36.07**	**10.93**	**56.36**	**41.15**	**2.50**
Hungary	38.41	54.19	7.41	24.44	72.32	3.25	9.77	88.7	1.53	51.09	41.8	7.11
Poland	45.82	51.31	2.88	44.83	53.6	1.57	25.2	74.5	0.3	82.54	15.56	1.9
Romania	40.7	46.04	13.26	45.29	31.12	23.6	43.28	55.3	1.43	58.71	34.42	6.88
Czech Republic	31.11	64.3	4.59	21.04	76.59	2.36	22.1	77.67	0.23	50.57	43.35	6.08
Russian Federation	59.64	27.66	12.7	55.31	42.77	1.92	58.16	41.27	0.56	43.01	49.42	7.57
Turkey	38.91	52.57	8.52	50.17	48.02	1.81	47.78	51.33	0.88	68.14	31.4	0.45
Ukraine	58.45	21.39	20.16	57.61	27.68	14.72	89.68	8.56	1.77	60.29	13.76	25.95
EM Europe	**44.72**	**45.35**	**9.93**	**42.67**	**50.30**	**7.03**	**42.28**	**56.76**	**0.96**	**59.19**	**32.82**	**7.99**
EM ALL	**52.28**	**37.61**	**10.12**	**48.97**	**41.89**	**9.14**	**52.46**	**42.61**	**4.93**	**57.70**	**38.42**	**3.88**

Full : Jan 1995-Oct 2012
QE1 : Apr 2009-Jun 2009
QE2 : Aug 2010-Oct 2010
QE3 : Sep 2012-Nov 2012

References

Chen Q, Filardo A, He D, Zhu F (2012). "International spillovers of central bank balance sheet policies." In BfI Settlements (ed.), "Are central bank balance sheets in Asia too large?", volume 66, pp. 220–264. Bank for International Settlements. URL http://EconPapers.repec.org/RePEc:bis:bisbpc:66-16.

Chinn MD, Ito H (2008). "A new measure of financial openness." *Journal of Comparative Policy Analysis*, **10**(3), 309–322.

Dominguez K, Hashimoto Y, Ito T (2011). "International Reserves and the Global Financial Crisis." *Technical report*, National Bureau of Economic Research.

Eichengreen B, Rose A, Wyplosz C (1996). "Contagious currency crises." *Technical report*, National Bureau of Economic Research.

Evans MDD, Lyons RK (2006). "Understanding order flow." *International Journal of Finance & Economics*, **11**(1), 3–23. URL http://ideas.repec.org/a/ijf/ijfiec/v11y2006i1p3-23.html.

Frankel JA, Wei SJ (1994). "Yen Bloc or Dollar Bloc? Exchange Rate Policies of the East Asian Economies." In "Macroeconomic Linkage: Savings, Exchange Rates, and Capital Flows, NBER-EASE Volume 3," NBER Chapters, pp. 295–333. National Bureau of Economic Research, Inc. URL http://ideas.repec.org/h/nbr/nberch/8537.html.

Fratzscher M, Lo Duca M, Straub R (2012). "A global monetary tsunami? On the spillovers of US Quantitative Easing." *CEPR Discussion Papers 9195*, C.E.P.R. Discussion Papers. URL http://ideas.repec.org/p/cpr/ceprdp/9195.html.

Girton L, Roper D (1977). "A monetary model of exchange market pressure applied to the postwar Canadian experience." *The American Economic Review*, **67**(4), 537–548.

Glick R, Leduc S (2013). "The Effects of Unconventional and Conventional U.S. Monetary Policy on the Dollar." *Technical report*, Federal Reserve Bank of San Francisco.

Guimares RPP, Karacadag C (2004). *The empirics of foreign exchange intervention in emerging markets: the cases of Mexico and Turkey*, volume 4. International Monetary Fund.

IMF (2007). "Managing large capital inflows." *Technical report*, International Monetary Fund.

IMF (2011a). "Unconventional Monetary Policies: Recent Experiences and Prospects." *Technical report*, International Monetary Fund.

IMF (2011b). "The United States: Spillover Report Chapter IV Consultations." *Technical report*, International Monetary Fund.

Kaminsky G, Lizondo S, Reinhart C (1998). "Leading indicators of currency crises." *Staff Papers-International Monetary Fund*, pp. 1–48.

Klaassen F (2011). "Identifying the Weights in Exchange Market Pressure." *Tinbergen Institute Discussion Papers 11-030/2*, Tinbergen Institute. URL http://ideas.repec.org/p/dgr/uvatin/20110030.html.

Klaassen F, Jager H (2011). "Definition-consistent measurement of exchange market pressure." *Journal of International Money and Finance*, **30**(1), 74–95.

Li H (2012). "The Impact of a Central Bank's Bond Market Intervention s on Foreign Exchange Rates." *Technical report*, Johnson Graduate School of Management, Cornell University.

Menkhoff L (2013). "Foreign Exchange Intervention in Emerging Markets: A Survey of Empirical Studies." *The World Economy*.

Moore J, Nam S, Suh M, Tepper A (2013). "Estimating the impacts of US LSAPs on emerging market economies local currency bond markets." *Technical report*, Federal Reserve Bank of New York.

Morgan P (2011). "Impact of US quantitative easing policy on emerging Asia." *ABDI Working Papers*.

Patnaik I, Shah A (2012). "Did the Indian Capital Controls Work as a Tool of Macroeconomic Policy&quest." *IMF Economic Review*, **60**(3), 439–464.

Patnaik I, Shah A, Singh N (2013). "Foreign Investors Under Stress: Evidence from India." *International Finance*, **Forthcoming**.

Pentecost E, Van Hooydonk C, Van Poeck A (2001). "Measuring and estimating exchange market pressure in the EU." *Journal of International Money and Finance*, **20**(3), 401–418.

Quinn DP, Toyoda AM (2008). "Does capital account liberalization lead to growth?" *Review of Financial Studies*, **21**(3), 1403–1449.

Reinhart CM, Rogoff KS (2004). "The Modern History of Exchange Rate Arrangements: A Reinterpretation." *The Quarterly Journal of Economics*, **119**(1), 1–48. URL http://ideas.repec.org/a/tpr/qjecon/v119y2004i1p1-48.html.

Sachs J, Tornell A, Velasco A (1996). "Financial crises in emerging markets: the lessons from 1995." *Technical report*, National Bureau of Economic Research.

Scalia A (2008). "Is foreign exchange intervention effective? Some microanalytical evidence from the Czech Republic." *Journal of International Money and Finance*, **27**(4), 529–546. URL http://ideas.repec.org/a/eee/jimfin/v27y2008i4p529-546.html.

Tapia M, Tokman A (2004). "Effects of Foreign Exchange Intervention Under Public Information: the Chilean Case." *Working Papers Central Bank of Chile 255*, Central Bank of Chile. URL http://ideas.repec.org/p/chb/bcchwp/255.html.

Weymark D (1995). "Estimating exchange market pressure and the degree of exchange market intervention for Canada." *Journal of International Economics*, **39**(3-4), 273–295.

Zeileis A, Shah A, Patnaik I (2010). "Testing, monitoring, and dating structural changes in exchange rate regimes." *Computational Statistics & Data Analysis*, **54**(6), 1696–1706.