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Equilibrium Real Interest Rates for the BRICS Countries

Jens Klose*

Abstract

The equilibrium real interest rate is one of the most discussed variables in economics, although it is unobservable. While it has been estimated with respect to various developed countries, this paper is the first to estimate it for five developing countries - the BRICS countries. To do so the most widely used model in this respect - the Laubach and Williams model - is used. Moreover, the results are compared to the actual real interest rate to give an indication whether e.g. monetary policy was too tight or too loose in certain periods. The results indicate that we indeed have substantial differences between the actual and the equilibrium real interest rate going either way. While for China and India monetary policy tends to be too loose in many periods, thus boosting economic growth even further, the reverse seems to be true with respect to Brazil especially in the late 1990s and the beginning of the 2000s. In Russia and South Africa the actual real rate is mainly in line with the equilibrium one, thus monetary policy is neither to loose nor too tight.

Keywords: equilibrium real interest rate, BRICS, state-space-models

JEL-codes: E43, F45, C32

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1 Introduction

The equilibrium or natural real interest rate is an important variable in economics. It is broadly defined as the long-term interest rate consistent witha closed output-gap (thus GDP equaling its potential) and stable prices. This concept dates back to Wicksell (1898). Unfortunately the equilibrium real interest rate is an unobservable variable. Thus it has to be estimated. While this was done for industrialized countries as the US quiet extensively, the equilibrium real interest rate for emerging economies is by now largely unknown. We will try to fill this gap.

However, the equilibrium real interest rate is of even larger importance when it is compared to the actual real interest rate, thus giving an indication whether monetary policy is too tight or too loose. If the prior is true than the actual real interest rate exceeds the equilibrium real rate. The reverse is true with respect of a too loose monetary policy. Therefore, we will compare our estimates of the equilibrium real interest rates with the actual values to draw inference upon this issue.

We do so for the five most important emerging market economies Brazil, China, India, Russia and South Africa, the so-called BRICS countries. These countries are chosen on the one hand because of their importance in the world economy and on the other hand since they provide the best data basis of all developing countries. Moreover, all of these countries referenced on average higher growth rates than industrialized countries, thus leading to a catching-up process with developed countries. This development comes also with a process of disinflation thus bringing these economies closer to stable prices which are one goal achieved at the equilibrium real interest rate.

This paper proceeds as follows: First, the role of the real interest rate and its equilibrium value is explained. Second a literature review on estimates of the equilibrium real interest rate is presented. Third, the Laubach-Williams model

is introduced, which is needed to estimate the unobserved equilibrium real rate. Fourth, the data are explained. And fifth, we present and discuss our results. The final section concludes.

2 Actual and Equilibrium Real Interest Rates

While the actual real interest rate is also influenced by short-term economic fluctuations, e.g. in monetary policy, the equilibrium is a medium- to long-term concept. It represents the rate that equals aggregate savings and investments in an economy at a normal level of output (closed output-gap), thus guaranteeing a stable price evolution. In the short run monetary policy may influence both via e.g. an accommodative monetary policy lowering the real rate. However, in the long-run those policies should be neutral since lower interest rates tend to increase inflation.

But also when abstracting from those short-term disturbances, aggregate savings and investments are by no means stable. They change according to long-term trends in an economy and thus also alter the equilibrium real interest rate. In literature several of these determinants have been identified. These can be separated into three groups: First, determinants influencing only aggregate savings, second, determinants influencing only aggregate investments and third, determinants influencing both. We will discuss potential determinants in each of the three groups in the following.

Determinants only influencing aggregate savings are the preference for safe assets and income inequality. Caballero and Farhi (2014) propose that the prior has become especially important in the wake of the financial crisis because market participants tend to prefer to hold their savings in presumably safer assets if economic uncertainty is high. Therefore, especially in the BRICS countries it is supposed that capital flew out of the countries since those countries are supposed to be less safe. This leads to lower aggregate savings in the BRICS countries, thus increasing the equilibrium real rate all else being equal.

A high level of income inequality, however, tends to increase aggregate savings, as individuals with high incomes have a higher marginal rate of saving. This in turn tends to lower the equilibrium real rate, all else being equal. According to the Worldbank database the BRICS are among those countries with higher income inequality with Gini-coefficients to be highest among the five countries in South Africa with 63.4 percent and lowest in India with 35.2 percent.

Factors influencing only aggregate investments are the degree of innovation, regulation and investment prices. In the prior case a low degree of innovation, typically measured by total factor productivity, may result in lower aggregate investments, as new machinery does not generate a significant benefit in comparison to older equipment. Gordon (2014), however, believes that low total factor productivity is the new normal rather than a temporary exception, and assumes lower growth rates on this basis. However, forecasting total factor productivity is a difficult task. Mokyr (2014) and Glaeser (2014), for example, argue that some innovations still have the potential to boost total factor productivity, such as information technology, biotechnology, or new materials. However, a low degree of total factor productivity is currently only observed in some industrialized countries and not so much in the BRICS, thus this should be less of an issue in our case.

Moreover, a high degree of regulation in the product markets tends to decrease aggregate investments permanently, thus increasing the equilibrium real interest rate all else being equal. However, these regulations can also be changed by the governing political parties. This can have a large effect (Jimeno et al., 2014 and Barnes et al., 2013). The same holds with respect to labor market reforms, which tend to increase employment. Moreover, long-term unemployment leads to skill atrophy (Eurosclerosis, Blanchard and Summers, 1986), thereby permanently lowering the potential rate of employment and potential growth (hysteresis).

The third determinant influencing only aggregate investments are investment prices, more precisely falling investment prices. Those lead by construction to a

downward shift in the investments curve (Summers, 2014 or Glaeser, 2014), thus increasing the equilibrium real interest rate all else being equal. Lower investment prices are simply due to the altered structure of investment goods. In a nutshell, investments in such IT-technologies as social networks are not as expensive as investments in industrial machinery. While this is a global trend, this should also hold for the BRICS countries.

Finally, there are two determinants influencing both aggregate savings and investments. These are demographics and debt. Demographics change aggregate savings, on the one hand, according to the life cycle hypothesis (Browning and Crossley, 2001), which proposes that savings are highest in economies with a relatively large proportion of the population being close to retirement. Moreover, savings may rise with increasing life expectancy and uncertainty about future pension payments, irrespectively of the life cycle (Jimeno et al., 2014). On the other hand, investments fall in aging economies because revenue expectations drop when the population is about to shrink (Gros, 2014). Thus, both channels point to a lower equilibrium real rate in aging economies.

Debt, separated in public and private debt, is becoming a problem when it is too high, thus individuals and fiscal authorities need to consolidate even at low interest rates. Moreover, savings are increased in order to reduce the level of debt. Both tends to lower the equilibrium real interest rate all else being equal.

3 Literature Review

Equilibrium real interest rates are mainly estimated using the procedure introduced by Laubach and Wiiliams (2003). We will follow the very same estimation here for the BRICS countries. While we are the first to estimate the equilibrium real interest rate explicitly for this group of developing countries, the procedure has been frequently used to give an intuition of this unobservable variable for various

developed countries. All of these studies show that the equilibrium real interest rate has fallen considerably for the countries under investigation especially since the financial crisis period of 2008/09.

While Laubach and Williams (2003) estimated the equilibrium real rate for the US to have fallen only slightly since up to 2002 which large swings of about five to one percent, [1] later studies by these authors show that the equilibrium real interest rate has decreased from levels of about three percent in the beginning of the 2000 to slightly below zero in 2015 (Laubach and Williams, 2015 or Holsten et al., 2017). A somewhat similar trend although of a different magnitude was identified by Holsten er al. (2017) also for Canada, the Euro-Area and the United Kingdom.

The studies focusing on the Euro-Area come to somewhat similar conclusions. Mesonnier and Renne (2007) estimate the equilibrium real interest rate to have fallen from about six percent in the late 1980s to about zero in the mid 2000s. This decrease is also estimated by Garnier and Wilhelmsen (2009) although to a lesser extent with of drop from about four to only two percent in the same period. For twelve individual Euro-Area countries Belke and Klose (2017) are also able to verify that the equilibrium real interest rate has fallen significantly for most countries, thus being even considerably negative as in the case of Greece. The negative trend in the equilibrium real interest rate was also verified with respect to five European countries not being a member of the European monetary union as Klose (2017) found out.

Finally, Wynne and Zhang (2018) estimate the "world" equilibrium real interest rate. The approximate the world by the OECD-countries and find that the equilibrium real interest rate for this country sample decreased from about two percent in the 1960s to slightly above zero in 2010 with a modest recovery thereafter. However, as a robustness check Wynne and Zhang (2018) also added the BRICS to the

[1] Clark and Kozicki (2005)come up with quite similar results when using real time data for the US.

OECD countries, so these authors are to the best of our knowledge the only ones to present at least some evidence with respect to the BRICS-countries real equilibrium interest rates although they do not present individual country results. For a considerably shorter sample period ranging only from 1999 to 2015 they find that the world equilibrium interest rate including the BRICS countries is much more volatile than the estimates without this group of countries. More precisely, the estimates tend to be higher in the early 2000s but are decreasing even more afterwards, so the equilibrium becomes even negative in 2007/08 the beginning of the financial crisis. Thereafter, it is slightly recovering. Comparing this result to the equilibrium real interest rate excluding the BRICS countries shows that including the BRICS leads to higher estimates in the beginning of the 2000s and lower estimates since 2005. We, however, will be able to verify whether this result is driven by one or more of the BRICS-countries, since we explicitly estimate equilibrium real interest rates for all of them individually.

But before doing so, we present the Laubach-Williams model used for economic inference.

4 The Laubach-Williams Model

The equilibrium real interest rate is an unobservable variable. Thus, it has to be estimated. Laubach and Williams (2003) established an estimation method for this variable which employs a state-space approach. It still is the most important model in the context of equilibrium real interest rate determination. Besides the unobservable equilibrium real interest rate, the unobservable potential output is also estimated in this procedure.

The model consists of two signal equations and three state equations. All variables are measured as quarterly growth rates. The signal equation (1) is an IS-curve measuring the effect of the first two lags of the real interest rate gap $(r - r^*)$ on

the output gap $(Y - \bar{Y})$. Additionally, two lags of the output gap are added to the equation. Equation (2) is the second signal equation, which measures a Phillips curve estimating the influence of the output gap on prices (π). Moreover, the prices are supposed to vary with lagged energy prices (π^o) since those are a crucial input factor in the production process.[2] Again, lagged values of the dependent variable are added. In this case, and strongly in line with Laubach and Williams (2003), we add eight lags assuming the second to fourth and fifth to eighth lags to have the same influence. Moreover, the coefficients of the lagged inflation rates are restricted to unity, in line with the seminal paper.

$$\begin{aligned} Y_t - \bar{Y}_t =& \alpha_{y,1}(Y_{t-1} - \bar{Y}_{t-1}) + \alpha_{y,2}(Y_{t-2} - \bar{Y}_{t-2}) \\ &+ \alpha_r[(r_{t-1} - r^*_{t-1}) + (r_{t-2} - r^*_{t-2}) + \epsilon_{1,t} \end{aligned} \tag{1}$$

$$\begin{aligned} \pi_t =& \beta_{\pi,1}\pi_{t-1} + \frac{\beta_{\pi,2}}{3}(\pi_{t-2} + \pi_{t-3} + \pi_{t-4}) + \frac{1 - \beta_{\pi,1} - \beta_{\pi,2}}{4}(\pi_{t-5} + \pi_{t-6} + \pi_{t-7} + \pi_{t-8}) \\ &+ \beta_y(Y_{t-1} - \bar{Y}_{t-1}) + \beta_o(\pi^o_{t-1} - \pi_{t-1}) + \epsilon_{2,t} \end{aligned} \tag{2}$$

$$\bar{Y}_t = \bar{Y}_{t-1} + g_{t-1} + \epsilon_{3,t} \tag{3}$$

$$g_t = g_{t-1} + \epsilon_{4,t} \tag{4}$$

$$z_t = z_{t-1} + \epsilon_{5,t} \tag{5}$$

$$r_t = i_t - \pi_{t-1} \tag{6}$$

[2]Laubach and Williams (2003) also use import prices as a variable in the Phillips curve. We are unable to proceed in that manner here because import price data for are not available for a longer sample period. This would have shortened our sample period considerably, leading to imprecise estimates owing to low degrees of freedom. Moreover, Laubach and Williams (2003) added hours worked to their Phillips curve as a robustness check. We also refrain from adding this specification because of data availability.

$$r_t^* = cg_t + z_t \tag{7}$$

The state equations model the time-series generating process of the two unobservable variables, potential output and equilibrium real interest rate. The potential output $\bar{Y}$ is a function of its lagged own value and its unobservable growth rate g (Equation (3)). The growth rate of the potential output is in itself a state variable following a random walk (Equation (4)) as well as the last state variable z (Equation (5)), measuring additional determinants of the equilibrium real rate, such as the time preference of households. The last two equations, (6) and (7), show how the real rate and its equilibrium value are built. In order to save degrees of freedom, the inflation expectations in the real rate are modelled simply by the using adaptive expectations, thus being the lagged inflation rate. The equilibrium real rate is generated in line with Laubach and Williams (2003), representing the sum of trend growth and any additional factors. These additional factors are restricted to having an influence of unity on the equilibrium real rate.

However, Laubach and Williams (2013) point out that the error terms in the state equations (4) and (5) are biased towards zero if the model is estimated in one step. This is due to the so-called pile-up-problem (Stock, 1994).[3] They therefore recommend estimating the model in sequential steps and computing the median unbiased estimator (Stock and Watson, 1998) to solve this problem. We follow this procedure strictly, estimating the model in four steps.

Firstly, both signal equations are estimated separately via OLS to generate reliable starting values. Potential output is proxied by the HP-filter of Y (Hodrick and Prescott, 1997). In the IS-equation the real interest rate gap is omitted at this stage.

[3]The pile-up-problem emerges when pure maximum likelihood methods tend to estimate the standard deviations equal to zero. Given that this is very likely to be the case in our random-walk equations (4) and (5), we have to correct for this.

Secondly, the signal equations are estimated with the Kalman filter, assuming the growth rate of potential output is constant. With these results we are able to compute the median unbiased estimator $\lambda_g = \frac{\sigma_4}{\sigma_3}$.

This relationship is used in the third step as a starting point. There we also add the real interest rate gap to the IS-equation and model the growth rate of potential output as a time-varying variable. Based on these results, we compute the median unbiased estimator for the additional variables affecting the equilibrium real interest rate as $\lambda_z = \frac{\sigma_5}{\sigma_1} \cdot \frac{\alpha_r}{\sqrt{2}}$.

In the fourth and final step we estimate the whole model via maximum likelihood, using the two signal-to-noise ratios.

5 The data issue

We estimate the model for the five BRICS countries Brazil, Russia, India, China and South Africa. For those countries data on interest rates, real GDP, consumer and energy prices are collected.[4] The latter is simply modelled by as the quarter on quarter percentage change in the crude oil price WTI since country specific energy prices are not available. The remaining variables are all country specific. For South Africa the sample period dates back until 1980Q1, for China until 1993Q2, for Russia until 1995Q1, for India until 1996Q2 and for Brazil until 1996Q4. All sample periods proved to be long enough to generate reliable results. The end of the sample period is 2017Q3 for all countries under investigation, owing to data availability.

All data is seasonally adjusted. As the relevant interest rate we use the three-month interbank rate in line with studies in this field. The interpretation of our results is based on a comparison of the estimated equilibrium real rate and the

[4]We use quarterly growth rates throughout as it is also done in the seminal paper. All data except for the Chinese real GDP are collected from the OECD. Chinese real GDP is computed by deflating the nominal GDP series of China available from the Federal Reserve Bank of St. Louis by the GDP-deflators available from the World Bank. The result corresponds closely to the real GDP available from the Federal Reserve Bank St. Louis at a yearly frequency.

observed real rate. For this purpose, we make use of two concepts in measuring the latter: ex-ante and ex-post real rates. The former represents the nominal interest rate minus the expected inflation, which in our case are adaptive expectations and thus lagged inflation rates ($r_t = i_t - \pi_{t-1}$), while the latter is formulated as the interest rate minus the observed inflation rate until maturity ($r_t = i_t - \pi_t$).[5] Even though the real interest rates differ depending on the concept used, this has only a minor influence on the results.

6 Results

In this section we present the estimation results of our model for the equilibrium real interest rate[6] and compare these to the observed real interest rates. We have restricted the two coefficients α_r and c to lying in the range of -0.3 to 0 and 0.5 to 1.5, respectively in line with Belke and Klose (2017). Moreover, these restrictions are well in line with the findings of previous studies where all estimated coefficient parameters fall within this margins.

- Table 1 about here -

Our results (Table 1) indicate that these restrictions are generally valid, since none of the estimated coefficients hits the boundary set by us. However, especially with respect to α_r, the influence of the real interest rate gap on output, we are unable to find significantly parameter estimates even though the estimates are with about -0.15 rather stable across countries. Note that other studies (Mesonnier and Renne, 2007 and Garnier and Wilhelmsen, 2009) face similar problems when estimating the model.

The parameter c, the influence of potential growth on the equilibrium real rate, again hits not the boundaries set by us. However, in China and India the estimates

[5] See also Hamilton et al. (2015) on this issue.

[6] Only the final estimates of the fourth step are presented here. The results for the previous steps are available from the authors upon request.

turn out to be rather low with about 0.5 while for the remaining three countries the estimates are well above unity. But only in Russia and South Africa the coefficient turns out to be significant.

Our median unbiased estimators λ_g and λ_z are generally in line with estimates for other countries in previous studies. This holds for the remaining parameter estimates and variances as well. Thus, we feel legitimized in concluding at this stage that the parameter estimates are generally comparable to other studies. We can therefore proceed to our estimates of the unobserved variables.

As in Laubach and Williams (2003), we will present the results for the unobserved variables using a one-sided (predicted) measure and a two-sided (smoothed) version. One-sided estimates make use only of the data prior to the respective point in time, while the two-sided version uses data from the whole sample period. Although the estimated time series differ depending on which method is used, the policy implications remain the same for both indicators. We proceed by showing the results separately for the unobserved state variables, starting with the potential output/output gap, before turning to the ex-ante and ex-post equilibrium real interest rates.

6.1 Output gap

Our estimates of the output gaps are given in Figure 2. The estimated output gaps tend to correspond closely with other output-gap estimates of international organisations especially when the one-sided estimates are considered. For the two sided estimates the output-gaps turn out to be closer to zero with the exception of South Africa.

- Figure 1 about here -

While we do not want to comment too much on the evolution of the output-gaps, it becomes obvious that the estimates cover closely the cycle of the BRICS countries.

This is especially evident in crisis periods, i.e. the Russian crisis in 1998/99 or the financial crisis in in 2008/09 both associated with a sharp decline in the output gaps of Russia and all BRICS countries, respectively.

6.2 Ex-ante real interest rates

We now turn to a comparison of the ex-ante real interest rate and its equilibrium value. Figure 3 shows the one-sided estimates. Firstly, the equilibrium real interest rate in the BRICS countries do not tend to follow a downward trend as the equilibrium real rates in most developed countries do according to other studies. Only for China and to some extend in Russia there is indeed a tendency towards lower equilibrium real rates.[7] For the remaining three countries we find in fact also periods of increasing equilibrium real interest rates, e.g. in Brazil from 2003 to 2008, India in 1999 to 2000 or South Africa between 1992 and 2007. Thus for India and South Africa the end of sample estimates of the equilibrium real rate are almost unchanged to the sample starting values. Only for Brazil the equilibrium real rates tends to slope downwards after 2014 turning even negative in 2015. But possibly this development may be temporary.

- Figure 2 about here -

Secondly, the real interest rates in the BRICS countries tend to be much more volatile than those in developed countries. This is especially true for Brazil and Russia in the end 1990s and beginning 2000s but also for the other three countries. So for all countries except Brazil substantially positive and negative real interest rates are found. The range of those rates is more than 103 percentage points in Russia, about 42 percentage points in Brazil, 25 percentage points in South Africa,

[7] Note, however, that the decline in the Russian equilibrium real rate seems to be solely driven by a decline in the year 2009, thus the midst of the financial crisis. Therefore, the effect may be temporary once the financial crisis is fully solved.

21 percentage points in China and 16 percentage points in India.[8]

The larger values in the real interest rates lead, thirdly, also to larger variations of the equilibrium real interest rate in the BRICS countries compared to industrialized countries. Especially in Russia, the range of estimates in the equilibrium real interest rate is with about 22 percentage points rather high. For the other four countries it is with 8, 6, 2.5 and 2 percentage points in Brazil, South Africa, China and India, respectively, considerably smaller.

When comparing the real interest rates with their equilibrium levels it is evident that they deviate substantially for all five countries in certain periods. However, these deviations are very different from country to country. We can identify three different groups in this respect: First, China and India tend to have set the real interest rate systematically below its equilbrium level for most of sample period. Moreover, the real interest rate is not only below the equilibrium estimates but also significantly lower than it as measured by the one standard deviation band around our equilibrium real rate estimates. This signals that monetary policy in these countries was even too loose, thus economic growth and also inflation have been boosted further.[9]

Second, in Brazil the real interest rate is set well above its equilibrium value thus depressing economic activity and slowing growth. This holds especially for the end of the 1990s and the beginning of the 2000s where real interest rates exceeded its equilibrium by about 35 percentage points at times. However, it seems to be true even at the end of the sample due to a decline in the equilibrium real interest rate

[8]The corresponding maximum and minimum values of the real interest rates: Russia: maximum 71 percent (1998Q2), minimum -32 percent (1999Q3). Brazil: maximum 44 percent (1999Q1), minimum 2 percent (2013Q1). South Africa: maximum 17 percent (1998Q3), minimum -8 percent (1986Q4). China: maximum 7 percent (1997Q4), minimum -14 percent (1995Q1). India: maximum 7 percent (2000Q1), minimum -9 percent (1999Q1).

[9]Please note that the real interest rate in India is even significantly above the equilibrium real rate in the end of the sample, thus opposing our statement we made above. However, this period is too short to draw inference whether there is indeed a systematical change in monetary policy of the Indish central bank. In fact, we have already observed a short period where the real rate was significantly above its equilibrium in 1999.

into negative territory while the actual real rate stays at levels of about 5 percent.

For the third group, incorporating Russia and South Africa, inference is mixed. In fact, we find periods where the real rate is significantly above and below the equilibrium value. However, for most periods both variables are not statistically different from each other, thus the central banks of both countries neither supported nor depressed the economy by their policies. With respect to Russia we can only identify a substantial deviation of actual and equilibrium real interest rates around the time of the Russian crisis in 1998/99. Here the monetary policy tends to be too restrictive at first and too loose thereafter. For South Africa we find one period in the mid-1980s where monetary policy tends to be too loose, while it seems to have been too tight in the mid-1990s. However, at the end of the sample in both countries actual and equilibrium real interest rates are rather similar.

When we estimate the model and smooth the results via a two-sided filter, the results do not change significantly (Figure 4). The only difference is that estimates of the equilibrium real rate are less volatile, which is exactly what we expect when smoothing the time series.

- Figure 3 about here -

Hence, the three groups identified above can also be found when using smoothed estimates, which are countries setting the real interest rate significantly below (China and India), above (Brazil) or mainly equal (Russia and South Africa) to its equilibrium value.

6.3 Ex-post real interest rates

When we employ ex-post realized real interest rates instead of ex-ante rates, the estimates for the equilibrium real interest rates are almost unchanged. More precisely, they are only shifted backwards by four quarters, but the estimates themselves remain the same (see Figure 5 for the one-sided time-series, Figure 6 for the two-sided

estimates). However, the empirical realizations of the real interest rates might be different. While we observe that the values are indeed altered as compared to the ex-ante data, the overall results remain robust. Again we find the three groups of countries: The first consists of China and India which tend to set real interest rates systematically above the equilibrium real rate. The second incorporates Brazil where the reverse is true, thus monetary policy tends to be too tight. However, using ex-post real interest rates this deviation at the end of the sample becomes even clearer. While the equilibrium real rate falls to levels below zero, the actual real interest rate even increases to over 10 percent. Finally, the third group with Russia and South Africa set their real interest rates well in line with the equilibrium rates.

- Figures 4 and 5 about here -

7 Conclusions

With this paper we present the first estimates of the equilibrium real interest rate for the five most important developing countries, the BRICS countries. Using the most widely used model to do so, the Laubach-Williams-model (Laubach and Williams, 20013), we are indeed able to generate reliable results for this unobservable variable. Moreover, we compare our estimate of the equilibrium real interest rate with the actual real rates to draw inference whether monetary policy in those countries was too loose or too tight at certain times.

In fact, we can identify all three possible outcomes in our set of five countries. Two of them, China and India, tend to have set the real interest rate systematically below its equilibrium value, thus boosting economic growth and possibly inflation even further. The reverse is true with respect to Brazil. Here the actual real interest rate is mostly well above the equilibrium one. This means that the Brazilian central bank even depressed economic activity with their restrictive monetary policy.

Finally, in Russia and South Africa actual and equilibrium real interest rates are well in line with each other. So monetary policy is neither too loose nor too tight in those countries.

What are the implications of these results for economic policy? We strongly recommend to adjust monetary policy so that the actual and equilibrium real interest rate are at least close to each other in order to minimize disturbances resulting from too loose or too tight monetary policies. This means for the five BRICS countries that China and India should implement policies to increase the real rate. The latter country is possibly doing something of that kind as our end of sample results show. The reverse holds for Brazil. The central bank in this country should lower the real rate thus no longer depressing economic growth. Possibly a good starting point for those countries currently deviating from the equilibrium real interest rate is to implement some kind of monetary policy rule, like e.g. the Taylor-rule (Taylor, 1993) which should by construction bring the actual real rate close to its equilibrium value.

Russia and South Africa do not need to change anything in this respect. However, also these countries should keep an eye on the equilibrium real interest rate and make sure that its actual value does not deviate too much from it in the future.

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Table

Table 1: Parameter estimates

	BR	CN	IN	RU	SA
$IS-curve$					
$\alpha_{y,1}$	1.37***	0.75	0.47	1.37***	1.51***
	(0.09)	(0.45)	(0.71)	(0.19)	(0.11)
$\alpha_{y,2}$	-0.96***	-0.27	-0.46	0.07	-0.59***
	(0.07)	(0.18)	(0.66)	(0.19)	(0.12)
α_r	-0.15	-0.16	-0.15	-0.16	-0.15
	(0.15)	(0.15)	(0.15)	(0.15)	(0.11)
c	1.25	0.50	0.50	1.47***	1.38*
	(1.32)	(1.50)	(1.50)	(0.11)	(0.74)
$Phillips-curve$					
$\beta_{\pi,1}$	0.61***	0.26*	0.40***	-0.02	0.48***
	(0.07)	(0.15)	(0.08)	(0.17)	(0.07)
$\beta_{\pi,2}$	0.31***	-0.26	0.41***	0.57***	0.17
	(0.12)	(0.29)	(0.11)	(0.08)	(0.11)
$1-\beta_{\pi,1}-\beta_{\pi,2}$	0.08	-0.11	1.00	0.45	0.35
β_y	0.13	-0.01	-0.26	5.30***	0.07*
	(0.08)	(0.04)	(0.29)	(0.86)	(0.04)
β_o	-0.03	-0.05	-0.19**	-0.12	0.00
	(0.04)	(0.09)	(0.08)	(0.09)	(0.05)
$Variance$					
σ_1	0.0000	0.4382	0.0000	0.8518	0.2508
σ_2	0.7132	1.3562	2.4176	0.0000	0.7032
σ_3	1.2474	0.0000	0.9043	1.3093	0.1019
σ_4	0.0085	0.0000	0.0012	0.0088	0.0001
σ_5	0.0000	20.2413	0.0000	0.0099	0.0037
λ_g	0.0828	0.0177	0.0365	0.0820	0.0198
λ_z	0.0007	0.0230	0.0007	0.0007	0.0007
$\log-likelihood$	-235.74	-270.46	-274.52	-428.40	-320.11

Notes: ML-estimation; BR=Brazil, CN=China, IN=India, RU=Russia, SA=South Africa; standard errors in parenthesis; ***/**/* means significance at the 1%/5%/10% level.

Figures

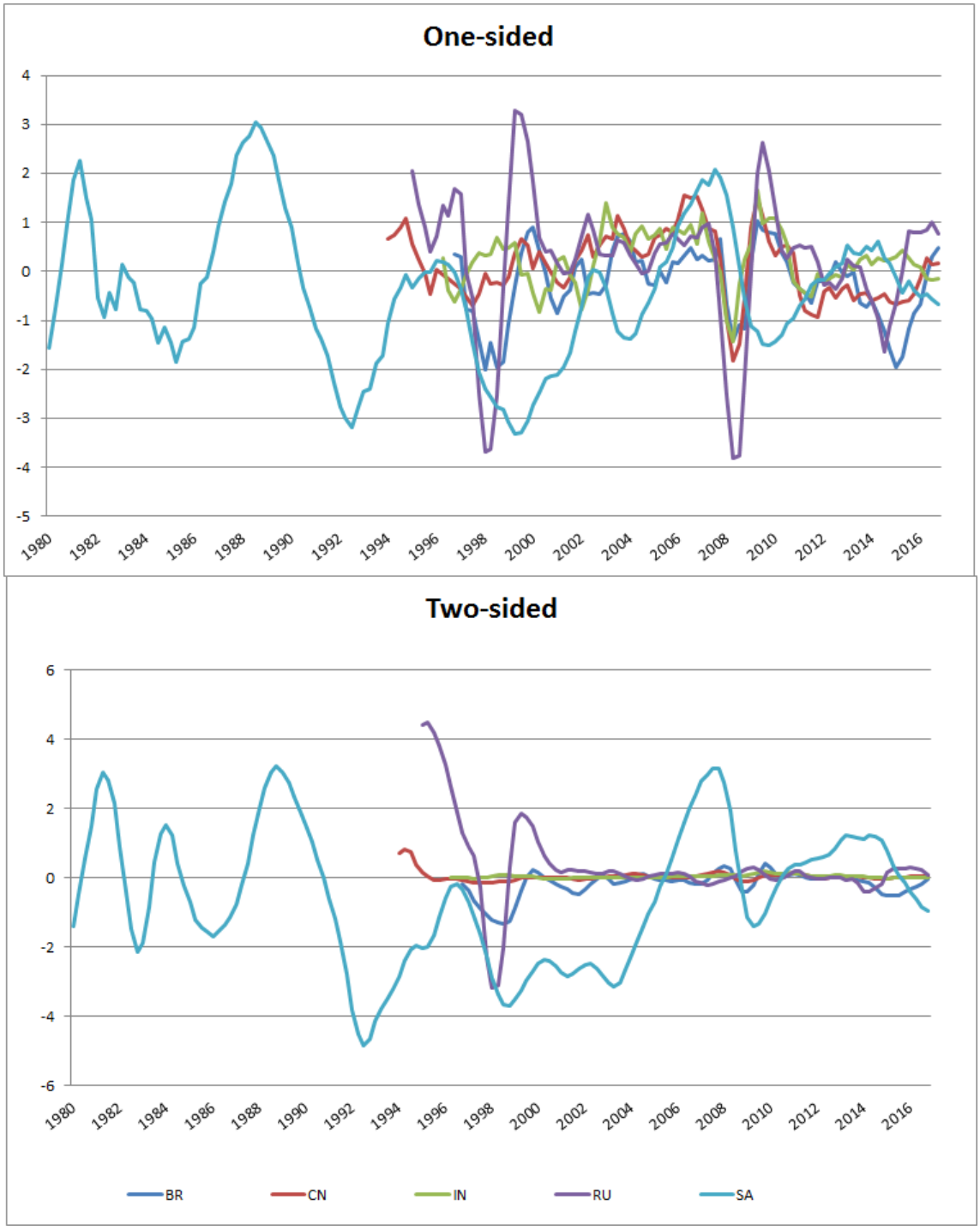

Figure 1: One- and two-sided output gap estimates; *Notes*: One-sided=predicted estimates, two-sided=smoothed estimates; BR=Brazil, CN=China, IN=India, RU=Russia, SA=South Africa.

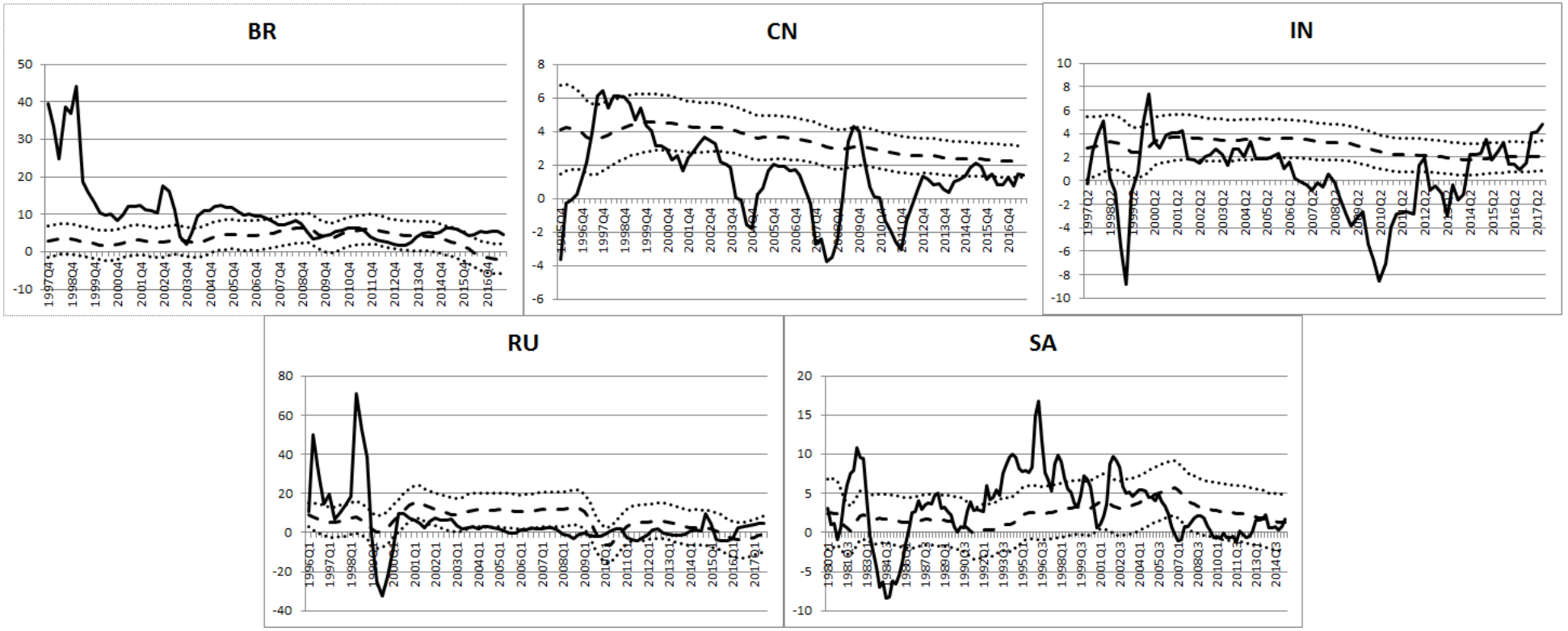

Figure 2: Ex-ante real rates and one-sided equilibrium estimates; *Notes*: Solid line=real rate, dashed line=equilibrium real rate, dotted lines=+/- one standard deviation equlibrium real rate; BR=Brazil, CN=China, IN=India, RU=Russia, SA=South Africa.

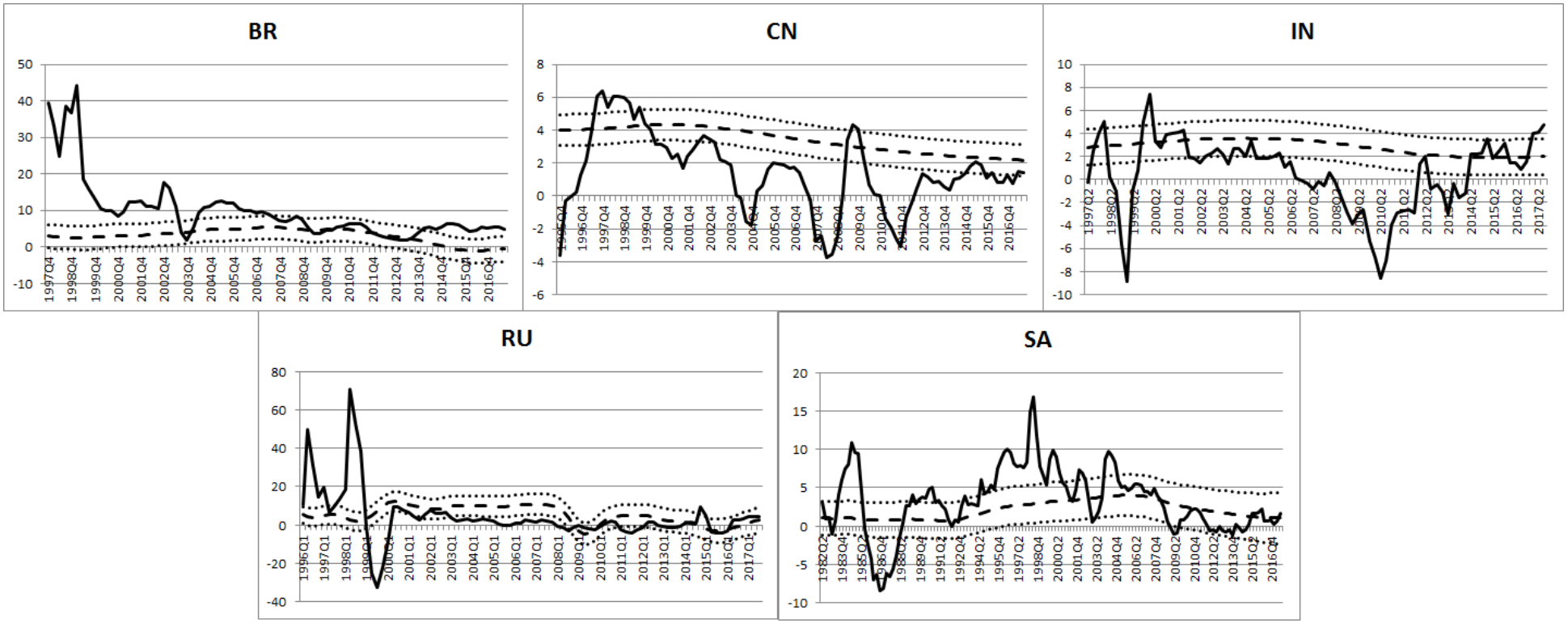

Figure 3: Ex-ante real rates and two-sided equilibrium estimates; *Notes*: Solid line=real rate, dashed line=equilibrium real rate, dotted lines=+/- one standard deviation equlibrium real rate; BR=Brazil, CN=China, IN=India, RU=Russia, SA=South Africa.

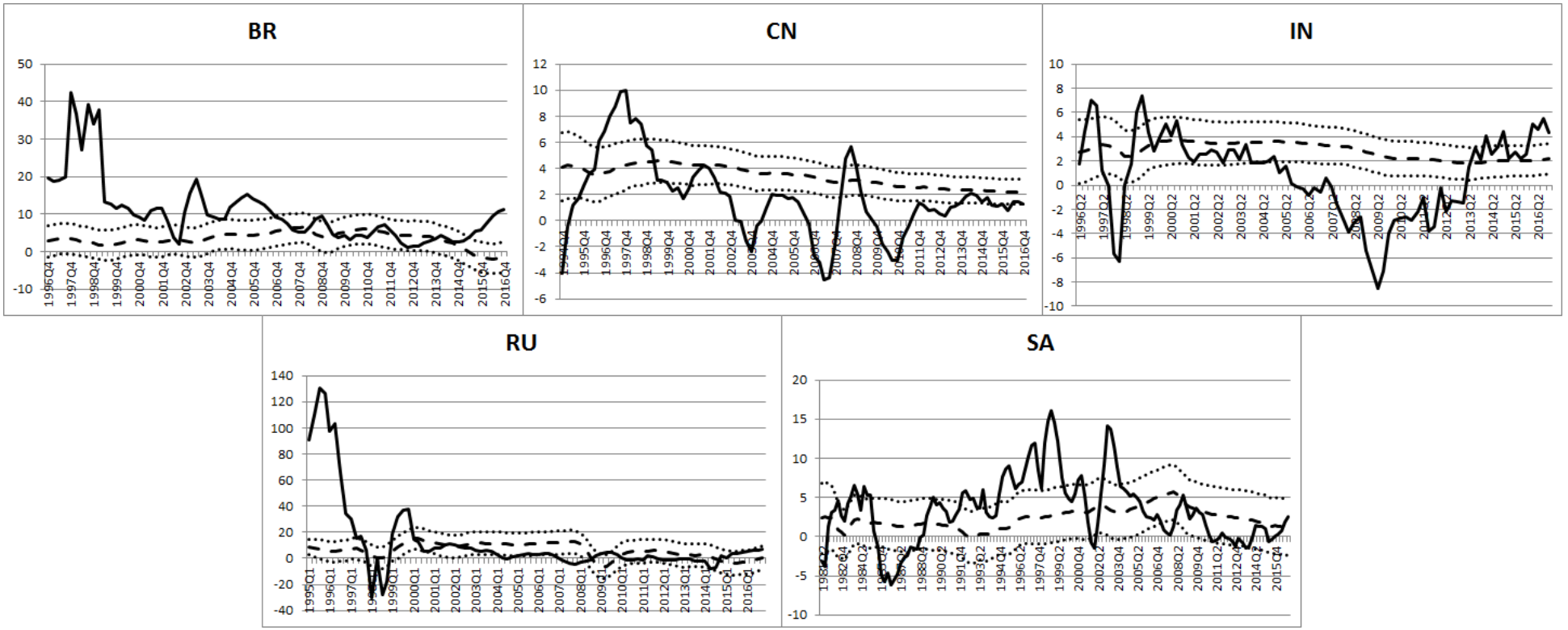

Figure 4: Ex-post real rates and one-sided equilibrium estimates; *Notes*: Solid line=real rate, dashed line=equilibrium real rate, dotted lines=+/- one standard deviation equlibrium real rate; BR=Brazil, CN=China, IN=India, RU=Russia, SA=South Africa.

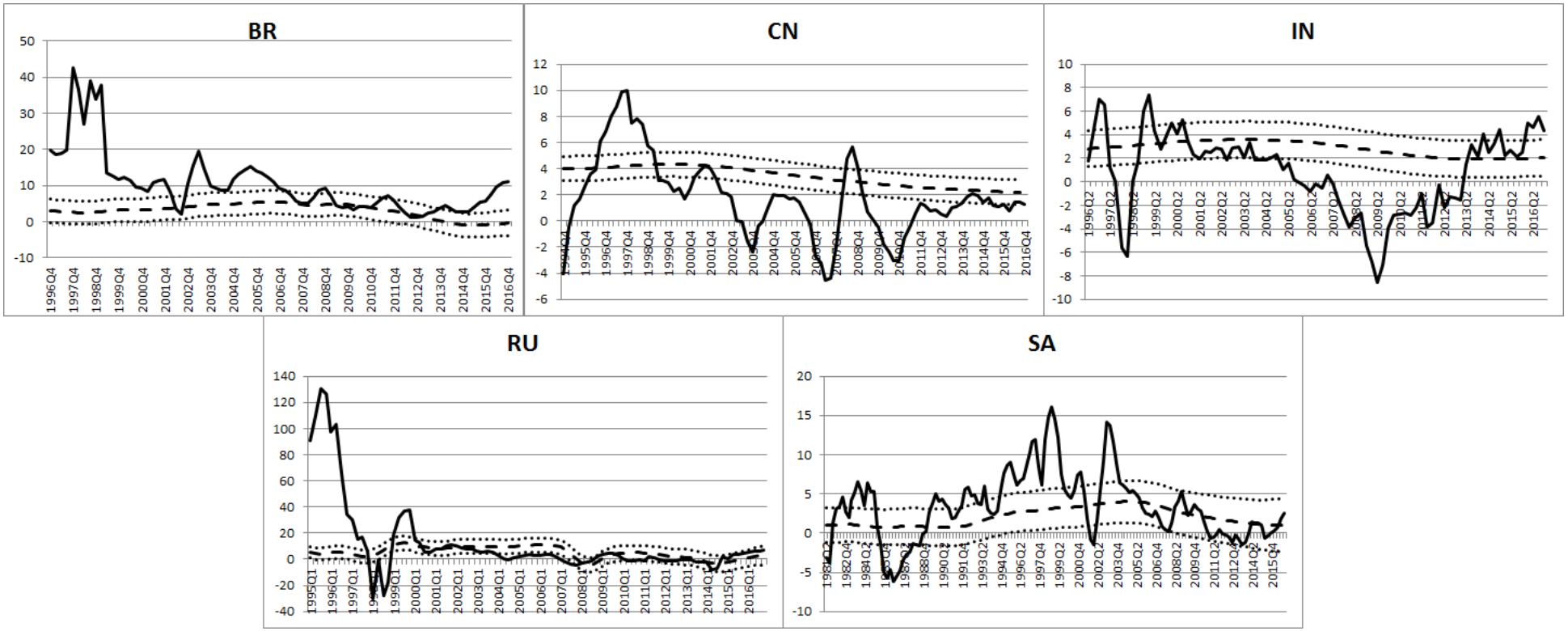

Figure 5: Ex-post real rates and two-sided equilibrium estimates; *Notes*: Solid line=real rate, dashed line=equilibrium real rate, dotted lines=+/- one standard deviation equlibrium real rate; BR=Brazil, CN=China, IN=India, RU=Russia, SA=South Africa.