A cross-country analysis investigating the impact of global crises on the conduct of monetary policy

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Declaration

I hereby declare that this is my own unaided work, the substance of or any part of which has not been submitted in the past or will be submitted in the future for a degree to any university and that the information contained herein has not been obtained during my employment, or working under aegis of, any other person or organization other than this university.

Daniela Lamparelli **Signature**

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1 Introduction

The first two decades of the 21st century have seen two global crises of historic proportions, namely the 2008-2009 Financial Crisis and the ongoing COVID-19 pandemic. During such events, central banks are often the first line of defence against shocks that threaten to destabilise the economy. For institutional and political reasons, monetary policy's interest rate responses can be deployed more rapidly than fiscal policy interventions such as spending, taxation and borrowing changes. Despite their relative speed, such monetary policy interventions normally have far-reaching impacts in both financial markets and in the real economy. The chief objective of this paper is to study how monetary policy authorities across a range of countries have responded to global shocks, and to show, using the Taylor (1993) Rule and other related tools of analysis, how this conduct has differed from the conduct of monetary authorities during non-crisis periods.[1]

In this paper, Taylor Rule regressions are used to examine the monetary policy conduct of ten central banks: that of South Africa, Brazil, Colombia, Mexico, Peru, Israel, the Republic of Korea, the United Kingdom (UK), the United States (US) and the European Central Bank (ECB) for the Euro Area. Particular focus is placed on South Africa and how its monetary policy behaviour compares to that of the other countries in the sample. In accordance with the existing literature, two econometric techniques, namely Structural Break Analysis and Markov Switching Regressions, are used in order to identify whether there were changes in monetary policy conduct after the 2008 Financial Crisis. Therefore, the central question this paper seeks to answer is: How did the monetary policy conduct of South Africa's central bank change after the 2008 Financial Crisis and how did this compare to the impact of the Crisis on the policy conduct of a number of other central banks? As a secondary question, the same methods are used to consider, tentatively, given the ongoing nature of the crisis, the impact of the 2020 COVID-19 Crisis on central bank monetary policy conduct. It is hypothesised that the impact of global crises is to cause at least one of the time series parameters to change, thereby altering the coefficients or weightings within monetary policy rules.

The paper is structured as follows: Section 2 contextualises this study through a review of the existing relevant literature on the conduct of monetary policy. Section 3 specifies the theoretical framework

[1] Robert Lucas's (1976) critique of economic policy, which Rudebusch (2002) considers to be particularly relevant for monetary policy, calls for economic models to treat policy implementations as dynamic and stochastic processes, as opposed to constant rules or relations. This is not to say that monetary policy rules should not be used. On the contrary, using rules as opposed to discretion is widely regarded to improve the credibility of monetary policy, as well as avoid the credibility and time-inconsistency problems associated with discretion (Mishkin, 2011). However, these rules should adapt along with the economy in order to be most effective. Ignoring structural changes that potentially arise from shocks could result in inaccuracies in the forecasts that guide policymakers in making their decisions (Hansen, 2001).

for the monetary policy rule used in this paper. Section 4 lays out the econometric methodology. Section 5 provides a presentation and analysis of the data. Section 6 discusses the empirical results for South Africa, alongside some notable results for the other central banks. Section 7 concludes with the key findings of the study, as well as a brief discussion of the possible avenues for future research.

2 Literature Review

Literature on the conduct of monetary policy relevant to this study is extensive. Following the 2008 Financial Crisis, several studies have explored the conduct of central bank actions when responding to this Crisis, as well as the role central banks have played in dampening and, in some cases, exacerbating financial instability (see Frappa & Mésonnier, 2009: Taylor, 2009). However, there is a limited selection of studies that empirically compare the conduct of monetary policy before and after the 2008 Financial Crisis at a country level.

Cukierman (2013) reviewed the changes in the monetary conduct and choice of instruments used by the US Federal Reserve and the European Central Bank (ECB) before and after the 2008 Crisis. The author highlighted the surge in unconventional monetary policy instruments and reported an insensitivity of inflation to expansionary monetary policy changes during such a crisis. Da Silva and Vieira (2016) used a panel data GMM model to compare the pre- and post-Crisis differences in monetary and fiscal policy in 113 advanced and developing countries. The study found that developing countries displayed a lower degree of interest rate smoothing compared to developed countries in response to the crisis (da Silva & Vieira, 2016). That is, developing countries were, on average, more responsive and cut interest rates more quickly and to a larger extent than did advanced countries, in an effort to boost economic activity. In addition, after the crisis, developing countries displayed a reduced responsiveness to inflation, while advanced economies increased their responsiveness to inflation and reduced their responsiveness to output gaps (da Silva & Vieira, 2016). The authors did not analyse the changes at an individual country level.

Drakos and Kouretas (2015) investigated structural changes in the ECB's monetary policy conduct before, during and after the Financial Crisis. The authors used Qu and Perron's (2007) structural break test and Hamilton's (1989) Markov-Switching (MS) regression methodology. They identified a structural break in the fourth quarter of 2008, and a regime change in the third quarter of 2008, corresponding to the peak of the Financial Crisis (Drakos & Kouretas, 2015).[2] In contrast to da Silva

[2] An important assumption of such time series analysis is stationarity, which says that the statistical parameters of the data (such as the mean and variance) remain constant over time (Hansen, 2001). However, economic time series data can become nonstationary if a shock moves the economic relationships off of their established paths. Changes in the parameters of time series data are what characterise structural changes or structural breaks.

and Vieira (2016), Drakos and Kouretas (2015) found a decreased response to inflation and an increased response to the output gap in the EU region.

Several country-level studies have examined how monetary policy has changed over the course of a country's own economic and political history. Many of these studies employ a combination of structural break tests and MS regressions in their analyses. Sims and Zha (2006) used a MS regression to identify four distinct regimes associated with different chairs of the US Federal Reserve Board of Governors between 1959 and 2003. Their main conclusion was that the regimes are distinguished by the different types of economic shocks that occurred during them (including oil price shocks and the Vietnam War), and not necessarily by how the economy responded to the shocks (Sims and Zha, 2006). Similarly, Murray et. al. (2015) used MS methods to identify distinct monetary regimes in the US. The authors highlight the value of using MS regressions to find regime switches that are endogenous to the data, rather than manually dividing the data according to *a priori* expectations before estimating results.

Creel and Hubert (2010) used both of the aforementioned econometric techniques to determine whether the implementation of an inflation-targeting framework changed the conduct of monetary policy in Canada, Sweden and the United Kingdom. They found consensus among their methodologies and conclude that the adoption of an inflation targeting framework did not shift monetary policy toward a greater response to inflation in these countries. De Medeiros et. al. (2016) ran structural break tests on a nonlinear optimal monetary policy rule to assess how the conduct of monetary policy in Brazil changed over the period 1999 to 2013. Despite acknowledging that a number of shocks occurred over the period, the authors identify the most significant structural breaks to have occurred in 2003 (a date coinciding with a change of President for the Central Bank of Brazil), and in 2008 during the Financial Crisis (de Medeiros et. al., 2016).

Another econometric technique that has been used to identify changes in the conduct of monetary policy is the time-varying parameters (TVP) technique (see Boivin (2005) and Baxa et. al (2010)). However, this approach seems best-suited to identifying gradual, permanent changes in time series parameters, rather than the abrupt (and possibly temporary) changes associated with a sudden shock, such as a global crisis. For this reason, the TVP technique has not been used in this research paper, although it could prove useful in checking the robustness of the results in future research.

The current study appears to be the first to compare the conduct of monetary policy in South Africa before and after the shock in 2008. However, Coco and Viegi (2020) examined how the monetary policy stance and credibility of the South African Reserve Bank (SARB) evolved over the period

2000 to 2018. Using a variety of open-economy Taylor Rule specifications to estimate the SARB's reaction function, the authors found that the SARB was better able to control inflation expectations after 2009 (Coco & Viegi, 2020). At the same time, policy rate changes became smaller and more infrequent, and the monetary policy response to the output gap was lower after the crisis than before it (Coco & Viegi, 2020).

In addition, Kabundi and Rapapali (2019) investigated the differences in the transmission of monetary policy in South Africa before and after the global Financial Crisis. Unlike the conduct of monetary policy, the transmission of monetary policy refers to how a country's economic output and its inflation rate respond to changes in the local policy rate. The authors used a Bayesian vector autoregressive model and found that there was a considerable change in the transmission of monetary policy after the 2008 Crisis: the impact of monetary policy on output was reduced and the impact on inflation became statistically insignificant after 2008 (Kabundi and Rapapali, 2019). The conclusions drawn in the Coco and Viegi (2020) and Kabundi and Rapapali (2019) papers will be helpful in interpreting the results of this paper.

Moreover, the results of the current study could provide some indication as to whether the identified changes in the transmission of monetary policy have occurred concurrently with changes in the conduct of monetary policy in South Africa. For instance, a reduced impact of monetary policy on inflation may occur simultaneously with a situation where monetary policy itself is less responsive to inflationary movements. Similarly, the reduced transmission-related responsiveness of output to the policy rate may coincide with a finding that the SARB has reduced its conduct-related response to output shocks.[3]

While studies involving a number of countries (or regional blocs) are informative and provide important insights into general trends, thereby serving as a basis for comparative analysis, the current study instead turns its attention to analysing monetary policy responses resulting from the impact of global economic crises in specific countries. In particular, the study undertakes an empirical analysis of the impact that the 2008 Financial Crisis had on monetary policy in specific countries. The study also establishes the foundations for an analysis of the impact of the COVID-19 pandemic.

In this study, monetary policy is narrowly defined as focusing on the process of stabilising economic activity through the setting of policy interest rates by monetary authorities. Incorporated into this

[3] However, it would need to be taken into account that numerous other factors have impacted South Africa's output growth during the period. Negative supply side factors which have slowed the country's economic growth rate would include growth and investment constraints imposed by the country's electricity shortage and rising electricity prices, a deterioration in the terms of trade, and a downturn in global commodity prices involving key South African exports.

definition is the impact of various factors which influence the setting of such policy rates – a study which is made tractable by the use of Taylor Rule analysis. Beyond the scope of the current study are the wider impacts of crises on the roles and responsibilities of monetary policy authorities more generally, such as how the Financial Crisis led to a broadened mandate of monetary authorities from a relatively narrow focus on inflation targeting to one that includes responsibilities for macroprudential monitoring and management (De Nicolò et. al., 2012). Also beyond the scope of the current study is any cataloguing or analysis of the increased use of unconventional monetary policies – and related bond market interventions – by monetary authorities. These unconventional policies were adopted increasingly in developing countries in response to the 2020 COVID-19 Crisis, where before they had been adopted predominantly in developed countries – particularly in the form of quantitative easing – during the low inflation period after the 2008 Crisis (Strohecker, 2020).

3 Theoretical Framework: Taylor Rules

3.1 Taylor (1993) – Original Monetary Policy Rule

A common tool used to evaluate the conduct of monetary policy in the reviewed literature is the monetary rule specified by Taylor (1993) (the "Taylor Rule"), together with adjustments put forth by Taylor (1999), Clarida et. al. (2000) and others. The original Taylor Rule can be specified as follows:

$$i_t = \pi_t + r_t^* + \beta_\pi(\pi_t - \pi_t^*) + \beta_y Gap_t + u_t \tag{1}$$

where i_t is the central bank interest rate, or policy rate; π_t is the inflation rate; r_t^* is the neutral or target real interest rate; π_t^* is the central bank's target inflation rate; Gap_t represents the output gap or deviation of actual output from potential output; and u_t is a disturbance error term that captures exogenous shocks. In the original specification, $\beta_\pi = \beta_y = 0.5$. This assumption implies that central banks place equal weightings on deviations of the price level and output from their target levels when setting the policy rate. In addition, when both the inflation rate and output are at their target levels (or "in equilibrium"), the real interest rate is assumed to be constant at 2 percent (ie: $r_t^* = 2$).

Since the Taylor Rule's inception, the specification has been used to assess the conduct of monetary policy in several countries through time series regression analysis. The sizes of the estimated beta coefficients have been shown to differ among various central banks, as well as change over time for specific central banks. These differences indicate how each central bank reacts to movements in economic variables, through the varied weightings placed on the inflation and output gaps. The cross-country time series analysis that follows in this paper aims to investigate these differences while evaluating the role that global crises play in any parameter or coefficient changes that may occur. To do this, the above rule is adapted based on certain well-established modifications from the relevant literature.

3.2 Taylor (1998) – Stabilising Condition

Five years after his influential paper, Taylor (1998) revised the monetary policy rule to include a stabilising condition on the size of the coefficient of the inflation gap. He concluded that, while the coefficients of inflation and output should both be positive, central banks must react by more than one-to-one to deviations in the inflation rate in order to achieve the desired result of steering the economy back to the desired long-run equilibrium (Taylor, 1998). This condition is now known as the Taylor Principle and can easily be incorporated into equation (1).

Let $\beta_0 = \pi_t + r_t^*$ be the intercept, a constant. Then (1) becomes:

$$i_t = \beta_0 + (1 + \beta_\pi)(\pi_t - \pi_t^*) + \beta_y Gap_t + u_t \tag{2}$$

The Taylor Principle requires that $(1 + \beta_\pi) > 1$ for stability, such that increases in inflation are met with a more than one-to-one response from the policy rate. Furthermore, the Taylor Principle is argued to be an important condition for all central banks who aim for price stabilisation, regardless of the particular policy rule being followed (Greenspan, 2004: Mishkin, 2011).

3.3 Clarida et. al (2000) – Contemporaneous Specification with Interest Rate Smoothing

Clarida et. al. (2000) argued that the original monetary rule did not accurately represent central banks' decision-making processes. Without modifications, the rule does not capture either the possible randomness of the central bank's actions, or the unpredictable movements of interest rates interacting with financial markets. To account for these, Clarida et. al. (2000) built an interest-smoothing parameter, ρ, into the model. This captures the tendency of central banks to adjust their interest rates in a sequence of small adjustments, so as to close the gaps incrementally over time rather than opt for a full interest rate adjustment that could shock financial markets into destabilising the economy. Therefore, the central bank chooses its current policy rate, i_t, according to a weighted function of the previous rate, i_{t-1}, and the gaps observed in the fundamental rule, i_t^*:

$$i_t = \rho i_{t-1} + (1 - \rho) i_t^* \tag{3}$$

where ρ is the degree of interest rate smoothing, typically expected to lie between zero and one (Perruchoud, 2009: Drakos & Kouretas, 2015).

By rewriting (2) in terms of (3) and collecting constants[4]:

$$i_t = \alpha_0 + \rho i_{t-1} + (1 - \rho)\left[\alpha_\pi \pi_t + \alpha_y Gap_t\right] + \nu_t \tag{4}$$

The new monetary rule in equation (4) makes it possible to examine whether a central bank responds instantaneously to deviations from equilibrium (where ρ equals zero), or more inertially (where ρ is closer to one) (Clarida et. al., 2000). Specifically, a decrease in ρ would indicate increasing responsiveness of central banks to changes resulting from the impact of a global crisis, and an increase in ρ would indicate decreasing responsiveness.

3.4 Ball (2000): An Open Economy Taylor Rule

Ball (2000) put forth a new modification of the Taylor Rule that included the real exchange rate as an additional independent variable in the policy rate specification. Ball (2000) argued that exchange rate movements were central to interest rate determination in open economies, and that policymakers must take into account the effect of exchange rate movements on domestic inflation as they seek to achieve long-run price stability (Ball, 2000). Such a modification can be considered particularly important for small open economies (who are price-takers in international markets) because their domestic policies do not greatly impact global prices or output. By accounting for exchange rate changes, central banks are better able to counteract the effects of local currency appreciations or depreciations on local spending and, hence, on inflation (Ball, 2000).

If a real exchange rate variable, RER_t, is included in equation (1) and the same modification processes as outlined in sections 3.2 and 3.3 are followed, some basic algebraic simplifications yield:

$$i_t = \varphi_0 + \varphi_1 i_{t-1} + \varphi_\pi \pi_t + \varphi_y Gap_t + \varphi_R RER_t + \varepsilon_t \tag{5}$$

where the coefficient of the lagged interest rate, φ_1 now represents the interest smoothing parameter.

Interest-rate smoothing implies that central banks aim to close a fraction of the gaps at a time, over several short runs. This means that a central bank's long-run coefficient on inflation can be calculated as $\varphi_\pi/(1 - \varphi_1)$ which, according to the Taylor Principle, must be positive to achieve long-run price stability (Woglom, 2003).

[4] $\alpha_0 = (1 - \rho)[\beta_0 - \beta_\pi \pi_t^*]$.

In the short run, the central bank is also expected to react positively to increases in inflation. That is, when inflation rises, the central bank is expected to respond by increasing the policy rate, a stance reflected in a positive inflation coefficient. When inflation falls, the central bank takes an expansionary stance by lowering the policy rate. Similarly, the coefficient on the output gap is expected to be positive, indicating that the policy rate will be increased when there is a positive output gap, and decreased when there is a negative output gap. Inflation-targeting central banks act in this way to keep inflation in line with the target, thereby maintaining the price stability that encourages savings and investment in the country (Debelle et. al., 1998). While these central banks do not (directly) aim to control the exchange rate, Ball (2000) highlights that the pass-through of exchange rate fluctuations to local prices must be taken into account for price stability. In line with this, the RER included in the Taylor Rule is expected to have a negative coefficient, such that increases in the RER (i.e. a local currency appreciation) are met with a decrease in the policy rate, while decreases in the RER (i.e. a local currency depreciation) are met with an increase in the policy rate (Ball, 2000).

4 Econometric Methodology

In accordance with the literature, this paper makes use of two econometric techniques to check for a change in monetary policy conduct: Structural Break Tests and Markov-switching regressions.

4.1 Structural Break Tests[5]

Structural break tests are used to identify the location of structural changes and non-stationarity in time series data. We employ the procedure developed by Brown et. al. (1975) to test for parameter stability in the monetary policy rules of each country. This procedure is preferred over others, such as the Chow (1960) test, because it allows testing for multiple breaks, the dates of which do not need to be known beforehand. The Brown et. al. (1975) procedure involves two tests: the cumulative sum (CUSUM) test and cumulative sum of squares (CUSUMQ) test. The null hypothesis of both tests is that the regression coefficients and their variances remain constant, while the alternative is that there is at least one structural break over the period. The tests complement each other, in that the CUSUM test is better suited to identifying the location of breaks but often results in Type II errors (i.e. a failure to reject a false null), while the CUSUMQ test is stricter but consequently can fall prey to Type I errors (i.e. an incorrect rejection of a true null) (Tanizaki, 1995).

[5] A combination of Stata's cusum6, estat sbcusum and estat sbsingle commands are used to execute this analysis.

These tests are used to determine whether a structural break occurred during the Financial Crisis, identified by the Federal Reserve Bank of St Louis (2020) to have started in February 2007 and ended in April 2011. If a break is found, regressions of the Taylor Rule (equation (5)) are run for each of the time periods on either side of the break. Differences in the coefficients of the policy rules between the periods indicate if – and how – the conduct of monetary policy has changed: for instance, how the weightings on inflation and the output gap differ between the two periods. Thereafter, Wald tests are conducted on each pair of coefficients to confirm whether the differences are statistically significant and, therefore, whether any structural break is statistically significant. The null hypothesis of the Wald test is that there is no statistically significant difference between the coefficients, while the alternative is that the coefficients are unequal to a statistically significant degree.

The pre- and post-structural break periods are used as approximations for the pre- and post-Crisis periods, respectively. Given that each country was impacted by (and then responded to) the 2008 Financial Crisis at different times, it would not be accurate to select a break date *a priori* and apply it to all countries. Instead, structural break testing is used to identify whether, and when, break dates can be identified for each country based on its own historical data.

4.2 Markov-Switching (MS) Regression[6]

To complement the study's structural break analysis – and in order to check the robustness of the break-test results – MS regression methodology is used to characterise parameter changes in the time series data. As a robustness check, the MS regression methodology can confirm the dates of the structural breaks. Furthermore, since the presence of structural breaks does not necessarily imply that a regime change has occurred, the MS regression allows an assessment of whether identified structural breaks are indeed associated with a change in regime.

The current study uses a methodology outlined by Hamilton (1989) to identify statistical "turning points" in the time series and to split the data into distinct "states" or "regimes." The analysis is probabilistic, in that the regimes themselves cannot be observed but, by examining how the data behave over time, it is possible to determine the probabilities that either an incumbent regime will prevail in the next period, or that a regime switch will occur (Hamilton, 1989). Regime changes are assumed to follow a first-order Markov process, such that the probability of a change depends only on the incumbent regime and not the historic pattern of regimes (Hamilton, 1989). Therefore, in line with the Lucas (1976) critique, any policy change is treated as random and uncertain in both its type

[6] Stata's `mswitch` command is used to execute this analysis, with the `dr` sub command employed as is commonly done for high-frequency data, such as monthly data (Sánchez, 2015).

and timing (Sims & Zha, 2006). The probabilities of regime changes, or regime continuations, are reported in a "transition matrix," P as follows (Hamilton, 1989: Kim, 1994):

$$P = \begin{pmatrix} p_{11} & p_{12} & \cdots & p_{1K} \\ p_{21} & p_{22} & \cdots & p_{2K} \\ \vdots & \vdots & \ddots & \vdots \\ p_{K1} & p_{K2} & \cdots & p_{KK} \end{pmatrix}$$

where p_{ij} is the probability that regime j will follow regime i.

$\sum_{j=1}^{K} p_{ij} = 1 \; for \; all \; i = 1, \dots, K.$ That is, the sum of probabilities in each row equals one.

The results are also reported in graphs showing the probability that a given regime will prevail in each period. Dramatic and sustained swings in probabilities are indicative of probable regime switches. These are either confirmed or repudiated by regression results.

Given an unobserved state variable, S_t with K possible states/regimes, the generalized MS regression model framework can be laid out as follows (Sánchez, 2015):

$$\boldsymbol{y}_t = \boldsymbol{\mu}_{S_t} + \boldsymbol{x}_t \cdot \boldsymbol{\alpha} + \boldsymbol{z}_t \cdot \boldsymbol{\beta}_{S_t} + \boldsymbol{\varepsilon}_{S_t,t} \tag{6}$$

where $\boldsymbol{y}_t$ is the vector of endogenous variables;

$\boldsymbol{\mu}_{S_t}$ is a state-dependent intercept;

$\boldsymbol{x}_t$ is a vector of exogenous variables with state-invariant coefficients, $\boldsymbol{\alpha}$; and

$\boldsymbol{z}_t$ is a vector of exogenous variables with state-dependent coefficients, $\boldsymbol{\beta}_{S_t}$.

The error terms $\varepsilon_{S_t,t}$ are assumed to be independent and identically normally distributed. That is, $\varepsilon_{S_t,t} \sim i.i.d \; N(0, \sigma^2)$ (Sánchez, 2015).

Following Drakos and Kouretas (2015), a two-state MS regression model is estimated, and the parameters are allowed to switch between two states, $S_t = \{1,2\}$. The analysis is extended to an open-economy Taylor Rule, akin to that in equation (5), but now allowing the coefficients to be state-dependent, as in Murray et. al. (2015):

$$i_t = \gamma_{0,S_t} + \gamma_{1,S_t} i_{t-1} + \gamma_{\pi,S_t} \pi_t + \gamma_{y,S_t} Gap_t + \gamma_{R,S_t} RER_t + \varepsilon_{t,S_t} \tag{7}$$

Changes in the coefficients of the policy rule equation are what constitute a regime change (Creel and Hubert, 2010). Therefore, by comparing the coefficient weightings on the inflation and output gaps in each regime, it is possible to evaluate whether the conduct of monetary policy differs between regimes. Once again, Wald tests will measure the significance of the difference between coefficients.

Should the date of a significant regime switch coincide with the structural break identified in the 2008 Financial Crisis period, it will be possible to conclude that the identified structural break is associated with a regime change in the conduct of monetary policy. That is, if the differences in state-dependent coefficients are statistically significant, and the probability of a given state is low before the Crisis, but high during or after the Crisis, this will serve as evidence that a regime switch occurred.

5 Data

5.1 Raw Data

The data collected for this study are monthly data spanning the period January 2000 to June 2020. This period is deemed to be sufficient for the analysis as it covers the period dubbed the Great Moderation (from 2000 to 2008), the Global Financial Crisis (from 2008 to 2011), the period of secular stagnation from 2011 to 2019, as well as the beginning of the COVID-19 Crisis in 2020 (Federal Reserve Bank of St Louis, 2020). The sources for the data are the official central bank websites for each country, as well as the Federal Reserve Bank of St Louis (2020) Economic Research website. Based on which data were readily available in compatible format, the central banks included in the sample are those of South Africa, Brazil, Colombia, Mexico, Peru, Israel, the Republic of Korea, the United Kingdom (UK), the United States (US) and the European Central Bank (ECB) for the Euro Area.[7] Like South Africa, all central banks in the sample (except that of the US) follow an inflation-targeting framework and have done so since the early 2000s or earlier (Jahan, 2017). The US has been included due to its systemic importance in the global economic system.

The variables required for a regression of the Taylor Rule expressed in equation (5) are:

- the central bank monetary policy interest rate;
- the annualised monthly inflation rate;
- the annualised real exchange rate; and
- the monthly output gap.

[7] The raw data required for this study have been obtained for the whole period, with the exceptions of Peru (for which policy rate data could only be obtained from September 2003 onwards), and South Africa (for which CPI and output data were not available after April 2020 at the time of writing this paper).

The latter three macroeconomic variables are seldom directly available. Instead, they must be constructed from underlying raw data, based on acceptable methodologies. The methodologies used in this study are described below, and the following raw data have been utilised:[8]

- the monthly Consumer Price Index (CPI) for all items (or all items in urban areas);
- the monthly real effective exchange rate index; and
- the monthly real total volume of production in manufacturing index.

The relevant central bank monetary policy interest rate has been selected according to the interest rate identified by the Bank for International Settlements (2020) as the *"most widely referenced money market or central bank interest rate."*

The monthly inflation rate is annualised so as to compare it to the annual inflation target set by each central bank. The annualised monthly inflation rate (π_{annual}) has been calculated by finding the month-on-month percentage change in the CPI, and then annualising this monthly rate ($\pi_{monthly}$) using the following conversion formula:

$$\pi_{annual} = \left[\left(1 + \pi_{monthly}\right)^{12} - 1\right] \times 100 \tag{8}$$

In a similar way, the annualised real exchange rate (RER) has been calculated by first finding the month-on-month percentage changes in the Real Effective Exchange Rate (REER), and then annualising the monthly changes.[9]

The monthly output gap is measured as the difference between actual monthly output and potential monthly output. Actual output is measured as the index of monthly manufacturing production volumes in each country, following Woglom (2003). This measure of production has been used because it is readily obtainable and measured on a monthly basis for most countries, including all countries in the sample. Potential output, or the output gap, is calculated using the Hodrick-Prescott (HP) filter which separates a time series into its trend ("potential", Y_t^*) and cyclical ("actual", Y_t) components (Hodrick & Prescott, 1997).[10] A smoothing parameter of 129600 has been used for the HP Filter, as recommended by Ravn and Uhlig (2002) for monthly data. The monthly output gap enters the Taylor Rule as percentage deviations in monthly output from its trend value, calculated as:

[8] All indices have been re-based to December 2016, to match the raw South African CPI data.

[9] The conversion formula for the RER is stated as $RER_{annual} = \left[\left(1 + RER_{monthly}\right)^{12} - 1\right] \times 100$

[10] The accurate calculation of the output gap is a highly contentious issue in macroeconomics. A number of alternatives have been investigated, each of which has its own weaknesses. The HP Filter is used due to its simplicity and ease of comparability to other papers, since it is widely used in the literature.

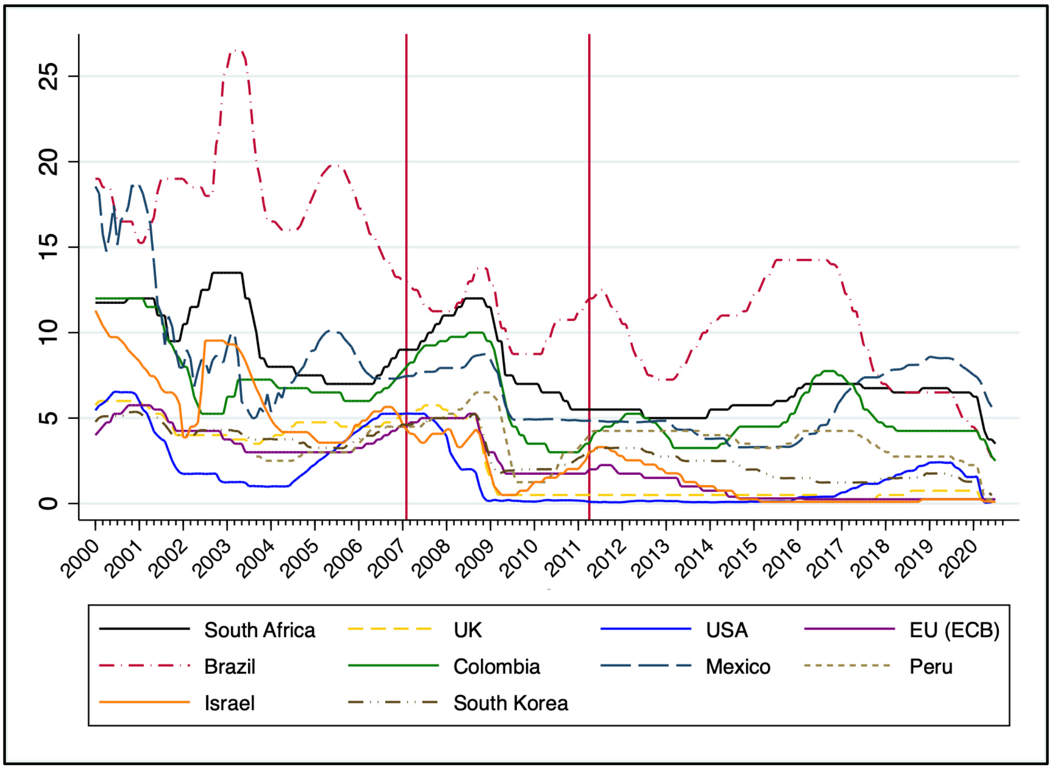
$$Gap_t = \frac{(Y_t - Y_t^*)}{Y_t^*} \times 100 \tag{9}$$

In Appendix 10.1, the mean and standard deviations of the constructed variables are shown for each country, segmented into the pre-Crisis, 2008 Financial Crisis and post-Crisis periods. However, there are a number of key observations from the data and descriptive statistics which are discussed below.

5.2 Presentation and Analysis of the Data

Figure 1 presents the evolution of the ten central bank policy rates over the sample period. The two red vertical lines indicate the start (February 2007) and end (April 2011) of the Crisis.[11] All ten central banks decreased their policy rates during the Financial Crisis, with the US Federal Reserve being the first to do so, beginning in August 2007. Thereafter, the drops in policy rates are staggered over time. Outside of the US, the first central banks to respond are those of Israel, the UK, South Korea and the EU in mid 2008. The developing countries, namely South Africa and the South American countries, responded later, with their central banks lowering rates in late 2008 and early 2009.

Figure 1: Central Bank Policy Interest Rates, 2000 – 2020



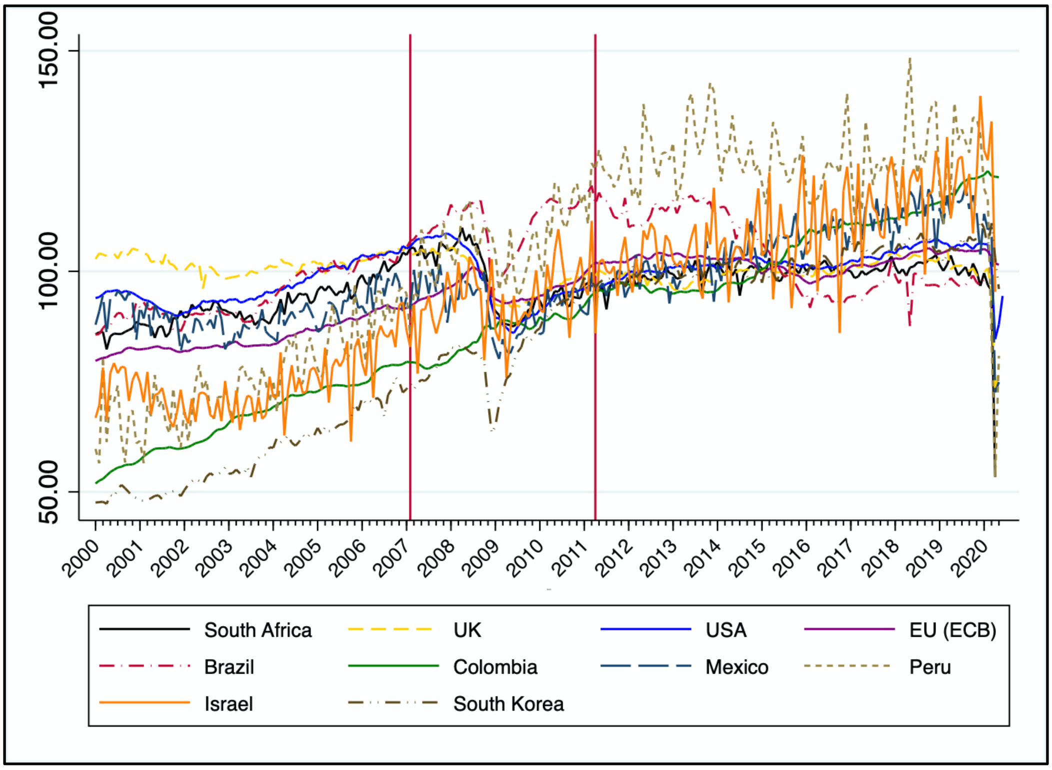
Data Source: Central Bank websites and the St Louis Federal Reserve

[11] For purposes of presenting the relevant descriptive data, the start and end dates of the Crisis used in this study follows the determination on this matter by the Federal Reserve Bank of St Louis (2020).

It is evident from Figure 1 that the developed countries in the sample entered the recession – and their monetary authorities responded – earlier than the developing countries. While developing countries may have seen relatively larger policy rate cuts in a shorter time span, developed countries' rates were generally lower to begin with and the magnitudes of their rate cuts were constrained by the zero lower bound.[12] The data presented in Appendix 10.1 show that, after the 2008 Crisis, policy rates were generally less volatile, with central banks maintaining steady rates at lower levels than before. This could reflect some countries' adoption of unconventional methods, such as quantitative easing (QE), during this period. However, this was not the case for other countries, such as South Africa, which did not engage in QE at that time. South Africa's policy rate, known as the repo rate, had a mean and standard deviation of 9.85% and 2.3%, respectively, before the crisis, which fell to 6.04% and 0.73%, respectively, after the Crisis. Such differences call for a more in-depth, individualised examination of the impact of the Financial Crisis on each central bank's monetary policy conduct.

Figure 2 presents the real monthly manufacturing output index for the ten countries. The figure shows that most countries were experiencing sustained output growth in the years leading up to 2007, a feature consistent with the growth characteristics of the period known as the Great Moderation. With the exception of Colombia, all countries experienced a dramatic drop in output during 2008.

Figure 2: Monthly Output, 2000 – 2020



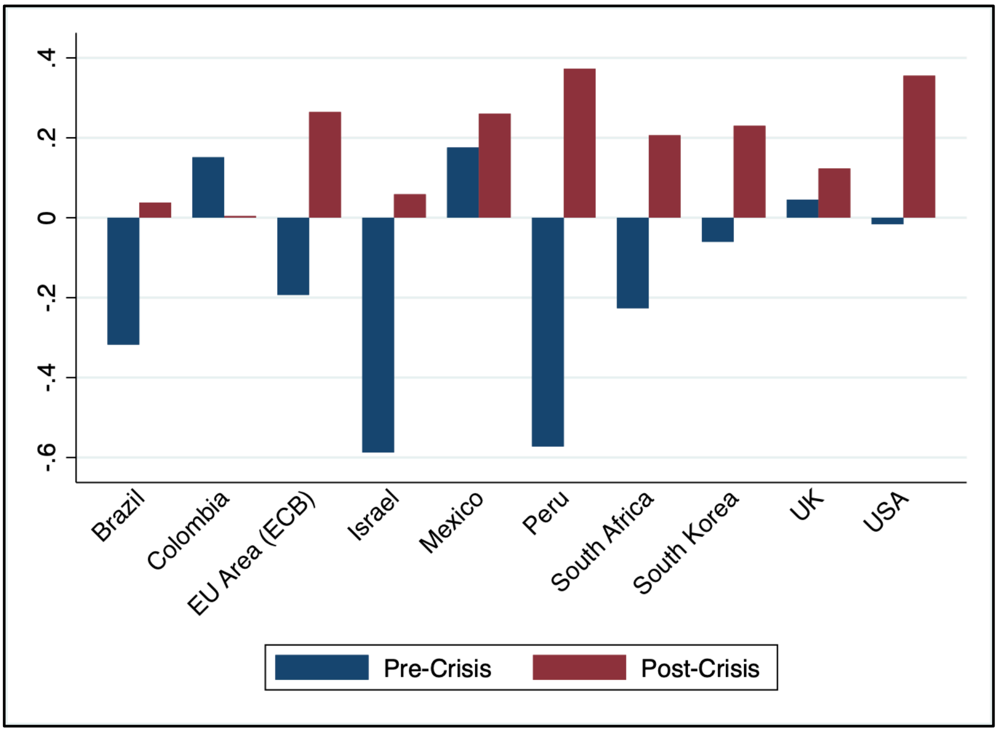
Data Source: Central Bank websites and the St Louis Federal Reserve

[12] Although some central banks – not included in the current study – implemented negative nominal rates.

Notably, after recovering from the recession, the sample countries entered a prolonged period of output stagnation, or secular stagnation, until experiencing the drop in output resulting from the COVID-19 Crisis starting in March/April 2020. The data in Figure 2 were used to construct the output gap variable for the Taylor Rule.

Figure 3 shows the mean output gap for each country, pre-Crisis (January 2000 – January 2007) and post-Crisis (May 2011 – June 2020). Most countries in the sample – with the exceptions of Colombia, Mexico and the UK – see a change from having a negative average output gap in the pre-Crisis period to having a positive average output gap in the post-Crisis period. This means that pre-Crisis, actual output was below its potential value on average, while, post-Crisis, actual output was above its potential value on average in these countries. Negative output gaps are typically associated with recessions, while positive output gaps are typically associated with expansions. The observations in Figure 3 (a mean negative output gap during the 2000 – 2007 expansionary period) therefore seem, at first, to be counterintuitive. However, the result is an artefact, or consequence, of the decline in potential output resulting from the 2008 Crisis and the lengthy period of stagnation that followed it.

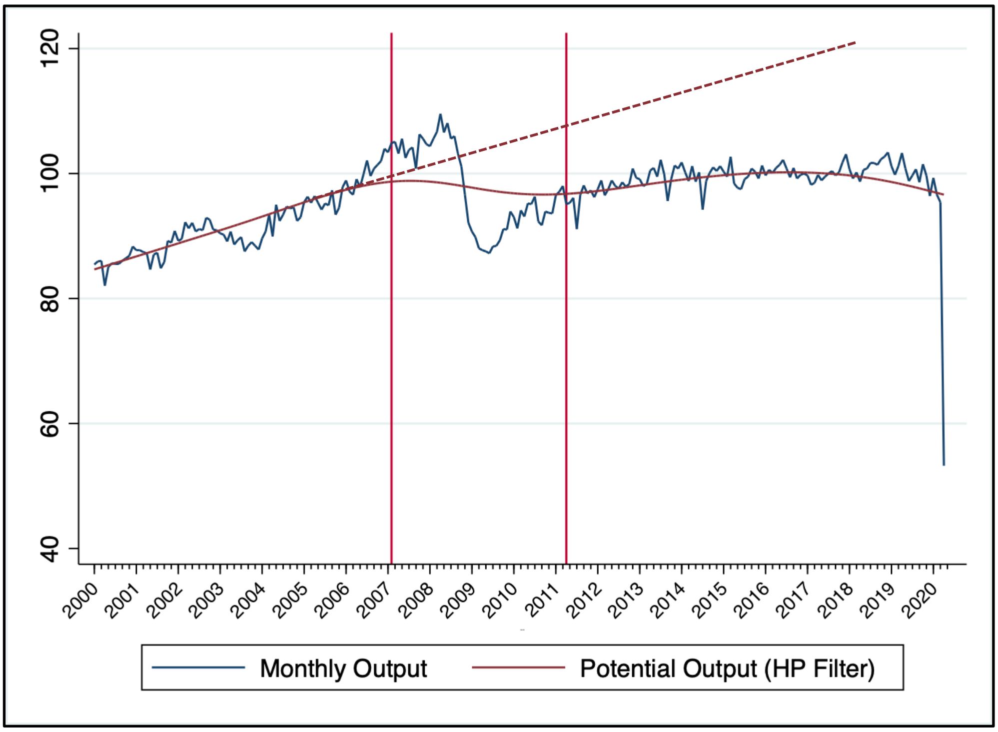
Figure 3: Mean Output Gap, Pre- and Post-Financial Crisis



Data Source: Central Bank websites and the St Louis Federal Reserve

This is clearly indicated in the diagrammatic representation of South Africa's output gap over the whole 20-year period, which is shown in Figure 4. The smooth dark red line shows South Africa's trend potential output, and the blue jagged line shows the country's actual monthly output. The difference between actual output and potential output is the output gap.

Figure 4: Monthly Output and Potential Output for South Africa, 2000 – 2020



Data Source: South African Reserve Bank

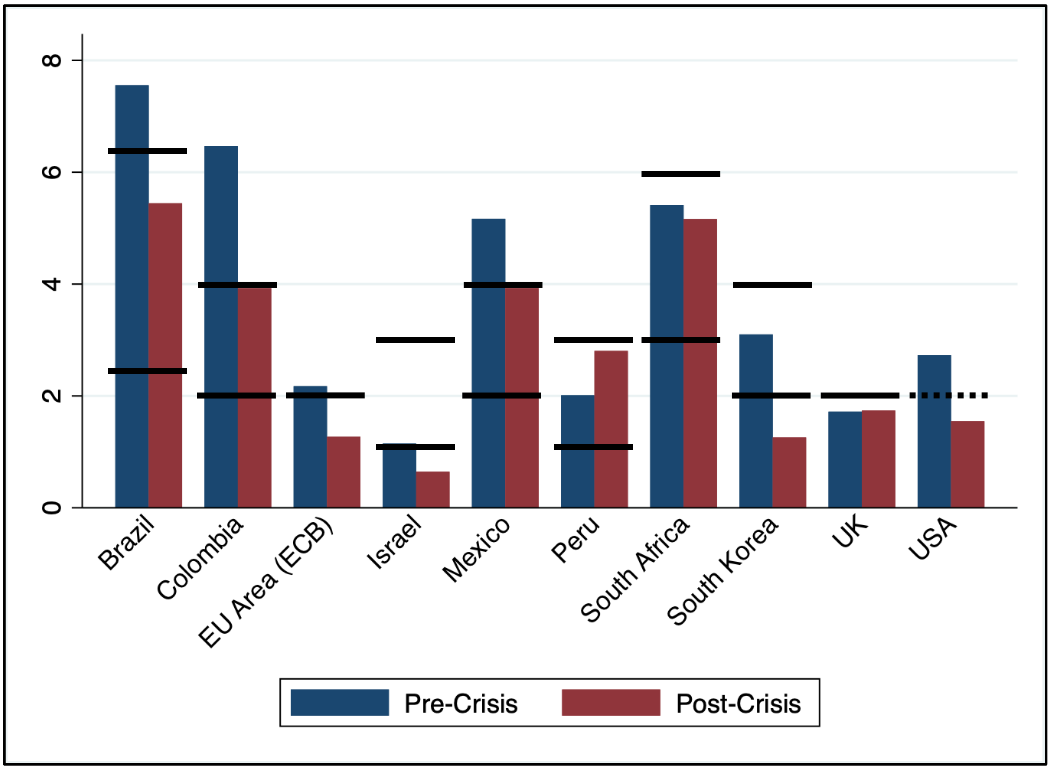
Figure 4 shows that, on average, actual output was indeed below its potential level during the early 2000s, despite the overall economic growth and rising potential output. According to the diagram, the economy began to "overheat" in 2006 when output rose well above its potential level and continued to rise until the "crash" in 2008/9. Figure 4 also clearly illustrates the secular stagnation in the post-Crisis period, as well as the dramatic drop in March/April 2020. The average positive output gap after the 2008 Crisis reported in Figure 3 is mainly a result of the reduction of potential output in the post-Crisis period. Put differently, the average positive output gaps post-Crisis are primarily related to comparatively lower levels of potential output, rather than output growth, which itself was minimal. The loss of potential output is illustrated by the dark red dashed line in Figure 4, which represents the long-term trend of potential output that the economy had followed in the years leading up to 2008, compared to the trend actually followed (i.e. the smooth dark red line). Similar patterns can be seen for the other countries, the diagrams for which are presented in Appendix 10.2.

Figure 5 shows the mean monthly inflation for each country, pre-Crisis (January 2000 – January 2007) and post-Crisis (May 2011 – June 2020). The black horizontal lines in Figure 5 indicate the upper and lower bounds of each country's inflation target (a single line indicates a point target).[13] With the exceptions of the UK and Peru, all countries see lower average inflation rates in the post-

[13] Although the US Federal Reserve is not an inflation-targeting central bank, it does aim to keep inflation at 2% over the long term, indicated by the dashed black line in Figure 5 (Federal Reserve Bank of St Louis, 2020).

Crisis period than in the pre-Crisis period. Moreover, while only five countries maintain an average inflation rate in line with their target before the 2008 Crisis, eight countries do so in the post-Crisis period. South Africa and Peru are the only countries to keep their average inflation rate within their target both pre- and post-Crisis (although, in both cases, average inflation rose above the target range during the Crisis). Furthermore, as seen in Appendix 10.1, inflation rates are less volatile in the post-Crisis period, with many countries displaying standard deviations on inflation below 1%.

Figure 5: Mean Monthly Inflation, Pre- and Post-Financial Crisis



Data Source: Central Bank websites and the St Louis Federal Reserve, and Jahan (2017).

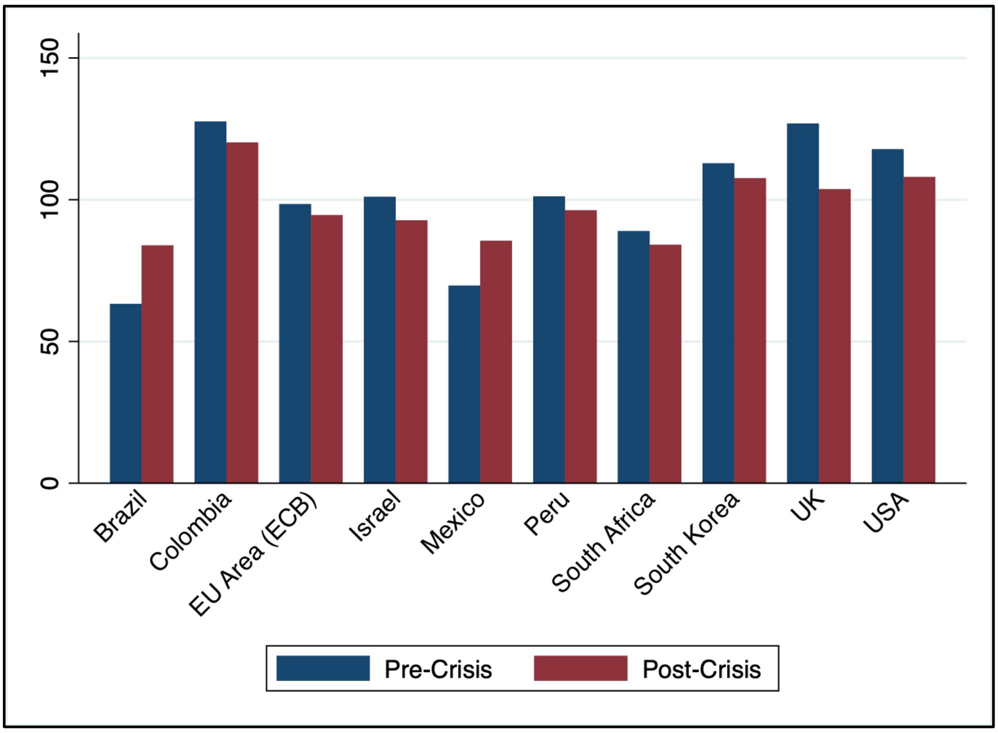
Finally, Figure 6 shows the mean REER for each country, pre-Crisis and post-Crisis. The REER is a measure of trade competitiveness, as it measures the value of the local currency relative to a weighted average of foreign currencies. An increase (decrease) in the REER indicates a local currency appreciation (depreciation), such that local exports become less (more) competitive. Figure 6 indicates that the currencies of Brazil and Mexico have been stronger on average since the 2008 Crisis, while the other currencies have been, on average, relatively weaker.

Changes in the REER are captured by the RER, which is the variable that enters the Taylor Rule.[14] Figure 7 shows the mean RER for each country, pre-Crisis and post-Crisis. Notably, Figure 7 shows that the South African Rand saw more appreciation, on average, before the Crisis than afterwards.

[14] Recall that an increase in RER is an appreciation of the local currency.

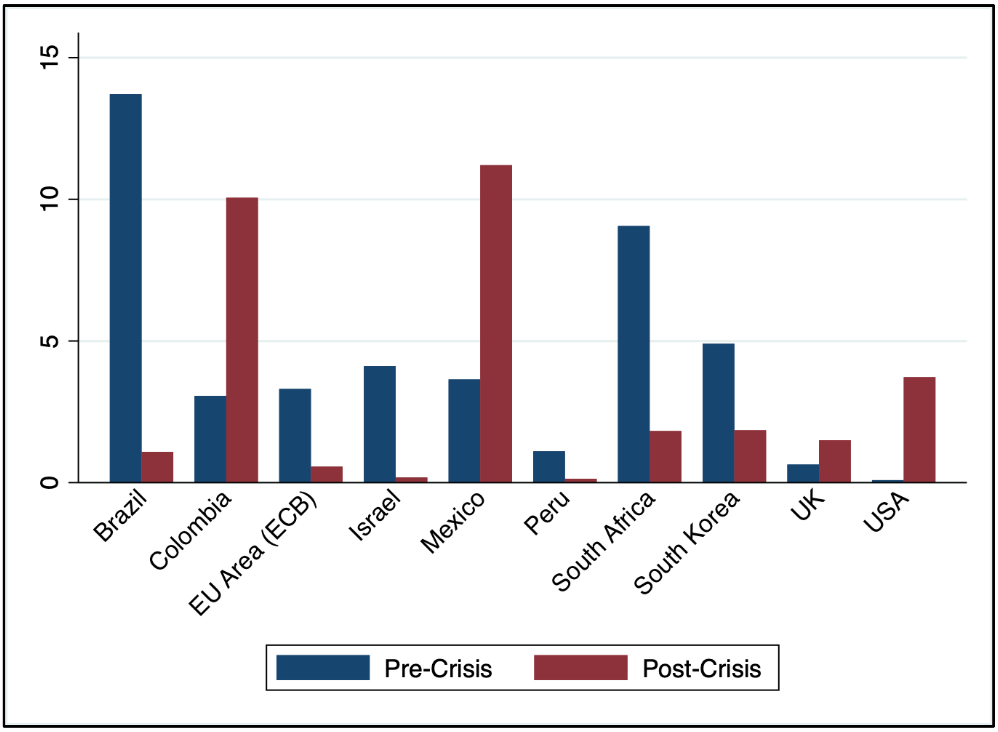
The RER is included so as to account for the inflationary effects of exchange rate changes, for which central banks must account when trying to achieve long-run local price stability (Ball, 2000).

Figure 6: Mean Real Effective Exchange Rate, Pre- and Post-Financial Crisis



Data Source: Central Bank websites and the St Louis Federal Reserve.

Figure 7: Mean Real Exchange Rate Changes, Pre- and Post-Financial Crisis



Data Source: Central Bank websites and the St Louis Federal Reserve.

6 Discussion of Results

This section presents and discusses the empirical results of the methodologies laid out in Section 4. Section 6.1 first discusses the outcomes of the structural break tests. Thereafter, the regression results for South Africa are presented in Section 6.1.1 and the other countries' results are presented in Section 6.1.2. Similarly, the MS regression results are presented in Section 6.2, first for South Africa (in Section 6.2.1) and then for the other countries (in Section 6.2.2).

6.1 Structural Break Tests

The graphical results of the CUSUM and CUSUMQ tests conducted over the January 2000 to June 2020 period for each country are presented in Appendix 10.3. The two vertical red lines in each graph indicate the start (February 2007) and end (April 2011) of the Crisis, as determined by the Federal Reserve Bank of St Louis (2020). For both the CUSUM test and the CUSUMQ tests, the upper and lower limits demarcate a 95% confidence interval. That is, a drifting of the CUSUM or CUSUMQ measure outside of these limits indicates a rejection of the null hypothesis (of no structural break) at the 95% confidence level. The significance of the break can also be evaluated by a Wald test that has a null hypothesis of no structural break at that date.

Notably, all ten countries in the sample exhibit at least one structural break during the twenty-year period, and seven of the countries exhibit statistically significant structural breaks during the Financial Crisis. Mexico, Israel and Brazil do not appear to experience structural breaks during the Crisis, but do experience a structural break in 2001, 2002 and 2003, respectively. These results corroborate those of de Medeiros et. al. (2016), who identified Brazil's most significant structural break to have occurred in 2003. However, unlike a finding of the de Medeiros et. al. (2016) paper, the current study does not find that Brazil experienced a structural break in 2008.

In order to check the robustness of the break dates found during the Crisis, a second set of CUMSUM and CUSUMQ tests were conducted for the shortened time period January 2004 to June 2020.[15] The graphical results for the second set of structural break tests are presented in Appendix 10.4. The second tests corroborate the results of the first tests, in that the seven central banks[16] that exhibited structural breaks in the first tests show the same results in the second tests, significant at the 5% level.

[15] The CUSUM and CUSUMQ tests operate relative to the starting date of the time series regression and, therefore, the results are sensitive to the start date. The second set of structural break tests excludes the significant breaks found before the Financial Crisis in the early 2000s. By conducting a second set of tests, relative to a different starting date, we are able to check the robustness any breaks found during the Crisis.

[16] These are the central banks of South Africa, the US, UK, the ECB (Euro Area), Colombia, Peru, and South Korea.

The second tests also reveal a Crisis break for Israel, although further tests suggest that this break is of weak statistical significance.[17] Additionally, there is insufficient evidence to reject the null hypothesis of no structural break during the Crisis for Brazil and Mexico. Once again, these results contradict the findings of de Medeiros et. al. (2016). However, de Medeiros et. al. (2016) used a nonlinear optimal monetary policy rule in place of the Taylor Rule. Given the sensitivity of the CUSUM and CUSUMQ tests to the regression specification, this could be the reason for the difference in results.

For accuracy and good measure, the statistical significance of the structural breaks identified by the CUSUM and CUSUMQ tests were then checked using a Wald test. Table 1 presents the results of the Wald tests for the structural break dates of each country. With the exceptions of Brazil and Mexico, the Wald statistic is significant at the 10% level or lower at each date, confirming the presence of structural breaks in each case.

The structural break dates seem broadly to correspond with the moments of responses by the central banks. That is, the structural break dates coincide with the rapid reduction in central bank policy rates, an action initiated in response to the Crisis. This would be the reason for the changes in parameter values that caused the structural breaks, as they mark the point at which each country moved from having a relatively high and volatile interest rate environment to one in which interest rates were relatively low and more stable.

An application of the same methodology to analyse the initial impact of the 2020 COVID-19 Crisis shows that five out of the ten countries display signs of an impending structural break, with the CUSUM and CUSUMQ plots spiking in the early months of 2020.[18] Of course, while it is too early to analyse fully the changes in monetary policy conduct before and after the 2020 Crisis, this study provides an initial indication that there are clear, early signs of structural breaks in the monetary rules of a number of economies as a result of the 2020 COVID-19 Crisis. It will be interesting in future research to see the full impact of the COVID-19 Crisis on the setting of policy interest rates, and to compare the changes during this period to those observed after the 2008 Global Financial Crisis.

For now, in order to analyse the impact of the 2008 Global Financial Crisis, this study makes use of the dates identified for the structural breaks in each country (as listed in Table 1) to compare the conduct of monetary policy before and after the Financial Crisis. This is done by conducting two separate regressions for each country on either side of the dates of the identified structural breaks.

[17] The break date located during the Crisis is only weakly significant at the 10% level, according to the Wald test.
[18] These countries are South Africa, the US, the UK, Peru, and South Korea.

Table 1: Statistical significance of estimated break dates

	January 2000 to June 2020 Estimated break date	Wald test Prob > chi2	January 2004 to June 2020 Estimated break date	Wald test Prob > chi2
South Africa	June 2009	0.0283**	June 2009	0.0253**
United States	January 2008	0.0116**	June 2008	0.0000***
United Kingdom	November 2008	0.0000***	November 2008	0.0000***
Euro Area	September 2008	0.0086***	September 2008	0.0167**
Brazil	February 2009	0.1960	September 2006	0.3039
Mexico	February 2009	0.2122	January 2006	0.7192
Peru	February 2009	0.0002***	February 2009	0.0001***
Colombia	February 2009	0.0030***	February 2009	0.0000***
South Korea	October 2008	0.0001***	October 2008	0.0000***
Israel	October 2008	0.0779*	October 2008	0.0916*

*** p<0.01, ** p<0.05, * p<0.1

6.1.1 Regression results for South Africa

Table 2 presents a summary of the results of the Taylor Rule regressions for all ten countries, for both the pre- and post-Crisis (structural break) periods. The complete econometric results for each country are presented in Appendix 10.5. As the focus of the paper, South Africa's results are discussed first.

As shown in Table 1, the structural break for South Africa is located in June 2009 and is significant at the 5% level. As reported in Table 2, for South Africa, the Taylor Rule's coefficients for inflation and the output gap have the expected signs both pre- and post-crisis. This is not the case for the coefficient on the RER, which is positive (while its expected sign was negative) although statistically insignificant. Moreover, the full results in Appendix 10.5 show that the joint explanatory power of the independent variables is consistent throughout, shown by the highly significant F-statistic in both the pre- and post-Crisis periods. In addition, the high R-squared values also indicate that the chosen specification of the Taylor Rule fit the data well.

South Africa's smoothing parameter is positive in both periods but is slightly larger in the post-Crisis period, after the structural break, although the difference is not significant according to the Wald test. The high weighting on the previous period's policy rate suggests that the SARB acts somewhat more inertially in the post-Crisis period, choosing to respond to inflation, output and exchange rate changes more slowly over time. This more long-run-focused approach is also captured in the positive value of the long run response to inflation, which increased dramatically post-Crisis from 0.325 to 7.261.[19] Therefore, the Taylor Principle holds throughout, suggesting that the SARB has made managing long-term inflationary expectations and economic stability the focus of its policy decisions, and even more so after the Financial Crisis.

The coefficient on inflation is statistically insignificant in the pre-Crisis period, but doubles in magnitude and becomes highly significant at the 1% level in the post-Crisis period. At the same time, the coefficient on the output gap decreases post-Crisis but remains statistically significant at the 1% level in both periods. This result aligns with those of Coco and Viegi (2020) and confirms the *a priori* expectation that the central bank has placed a greater focus on inflation and a lesser focus on the output gap since 2009. Indeed, the lower volatility of the inflation rate may reflect the SARB's efforts to keep inflation stable post-Crisis. This falls in line with the SARB's inflation-targeting mandate, although the absence of price shocks in this period would also have played a role. However, the difference in pre- and post-Crisis coefficients is only significant for the output gap, with the Wald test being significant at the 1% level. This suggests that the change in monetary policy conduct evident in the results is primarily rooted in the SARB's changed response to the output gap.

These results provide evidence that the change in monetary policy transmission for output observed by Kabundi and Rapapali (2019) occurs simultaneously with changes in monetary policy conduct. That is, the reduced impact of monetary policy on output after the Crisis appears to take place at the same time as the central bank placing a reduced weighting on the output gap in its post-Crisis monetary rule. However, as noted, there are numerous supply-side factors that have also contributed to the persistently low growth of output since the 2008 Financial Crisis. During this period of secular stagnation, the SARB has been less assertive in using the policy interest rate instrument to stimulate demand, represented by the smaller coefficient on the output gap (even as the output gap has been reported as being positive, on average, primarily due to the fall in potential output post-Crisis).

With regard to inflation, the study shows that the SARB reacts relatively more strongly to inflation post-Crisis – a result which does not, at first glance, align with the statistically insignificant impact of monetary policy on inflation observed by Kabundi and Rapapali (2019) in the post-Crisis period. That is, the current study's finding of an increased conduct-related responsiveness to inflation by the SARB post-Crisis coincides with a non-significant transmission-related responsiveness of inflation to the policy rate as reported by Kabundi and Rapapali (2019).

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[19] Recall that the long run response to inflation is calculated as $\frac{\varphi_\pi}{1-\varphi_1}$. The long-run response coefficients are shown for all countries in Appendix 10.5.

Despite the SARB's increased focus on inflation since the 2008 Crisis, Kabundi and Rapapali's (2019) results suggest that South Africa's inflation rate is not primarily being driven by the demand-side. Like output, price changes could also be heavily influenced by supply-side factors that drive cost-push (rather than demand-pull) inflation, including exchange rate movements and changes in electricity prices. Future research could investigate the drivers of inflation in South Africa, from both the demand and supply side, to better understand the transmission of the SARB's monetary policy to local prices.

Finally, the coefficient on the RER is not significant in either period, which is unsurprising given that South Africa has adopted an explicit inflation targeting framework and not an exchange rate targeting framework, allowing its exchange rate to float relatively freely.

6.1.2 Inter-country comparisons

The results for South Africa acquire more meaning when compared to the results of other countries. As such, it is useful to identify a few interesting commonalities – and differences – in the results of the pre- and post-2008 Financial Crisis Taylor Rule regressions among the various countries in the study. The summarized results in Table 2 allow for easy comparison, but the complete econometric output for each country is available in Appendix 10.5.

The magnitudes and signs of the coefficients in Table 2 differ from country to country, and not all coefficients have the expected signs. This reinforces the notion that aggregated results cannot sufficiently capture the experiences of each country. Thus, an examination of individual central bank results is important for the kind of granular monetary policy analysis that has been the objective of this study. The results in Appendix 10.5 show that the chosen specification of the Taylor Rule fits the data well for every country. This is evidenced by the highly significant F-statistic in both periods, as well as the high R-squared values. Therefore, the chosen specification of the Taylor Rule offers strong explanatory power and excellent goodness of fit for all of the sample countries.

Table 1 showed that the structural break dates for each country are spread out across the tumultuous years of the Financial Crisis. Unsurprisingly, as its financial system was the epicentre of the 2008 Financial Crisis, the US exhibits the earliest structural break in January 2008. Interestingly, however, the results of the first CUSUM test shown in Appendix 10.3 indicate that there may have been a break in the US regression even before the Financial Crisis started – a foreshadowing of the Crisis in mid to late 2006.

Markedly, all the developed countries in the sample (US, UK, EU, South Korea and Israel) exhibit structural breaks earlier than the developing countries (South Africa, Brazil, Mexico, Peru, Colombia).[20] This observation speaks to the highly integrated nature of developed countries – spanning finance, banking and trade – while developing countries seem to be relatively less closely integrated into the global financial and economic system. An advantageous consequence of this is that developing countries may have more time to prepare for global shocks.

Moving to the Taylor Rule regressions themselves, it is found that there are only three countries, namely South Africa, Brazil and Mexico, whose smoothing parameters are larger in the post-Crisis period than in the pre-Crisis period. The other countries display smaller smoothing parameters post-Crisis, with the changes in UK, Colombia and Peru being the most significant according to the Wald test. In particular, the smoothing parameter in the UK falls from 0.955 pre-Crisis to 0.652 post-Crisis, a difference that is statistically significant at the 0.1% level of the Wald test. This illustrates a change in the Bank of England's monetary policy conduct toward being more responsive after the Crisis, so as to close the output and inflation gaps over shorter periods of time. Indeed, the Bank of England is also found to exhibit a more short-run-focused approach, with the long-run response to inflation being negative in both periods, indicating that the Taylor Principle of inflation stabilisation does not hold for the UK. In fact, the UK exhibits a negative coefficient on inflation throughout, against *a priori* expectations – although the coefficient loses significance post-Crisis. The negative sign implies that the Bank of England lowers the policy rate in response to increases in inflation.

Typically, a negative long-run response to inflation like that for the UK is associated with a "destabilizing" Taylor Rule, while a positive long-run response to inflation is associated with a "stabilizing" Taylor Rule (Drakos & Kouretas, 2015). However, the fact that UK inflation has remained relatively stable (with a mean of 1.7 both pre- and post-Crisis) suggests that the central bank is able to manage inflation expectations and must enjoy considerable credibility of its decisions. That being said, the actions of the Bank of England could also have been influenced by a number of other factors, including the limitations of the zero-lower bound, the adoption of unconventional monetary policy, and the British government's decision to implement fiscal austerity in the years following the 2008 Crisis. On top of the COVID-19 pandemic, Brexit will deliver yet another shock

[20] Despite there being no statistically significant structural break found for Brazil or Mexico, pre- and post-Crisis regressions for the two countries have nonetheless been included in Appendix 10.5 for the sake of comparison. Ultimately, the somewhat arbitrary structural break date of February 2009 was selected for Brazil and Mexico as this date reflects the timing of a regime switch identified through the Markov-switching regressions and, conveniently, February 2009 also matches the structural break dates of the other two South American countries in the sample, namely Colombia and Peru.

to the UK; the impact that these events have on the conduct of monetary policy presents another opportunity for future research.

Unlike the UK, most countries in the sample exhibit a stabilizing Taylor Rule in both periods pre- and post- the Financial Crisis, as would be expected in countries where monetary policy is guided by the inflation targeting framework. However, there are three countries that experience a switch, namely Peru, South Korea and Brazil. Peru and South Korea have a destabilizing Taylor Rule pre-Crisis and a stabilizing Rule post-Crisis, however the source of the switch is different in each case. For Peru, the smoothing parameter is greater than one pre-Crisis, suggesting that the Central Reserve Bank of Peru was placing too little weight on the current inflation and output gaps to stabilize them in the long run. Post-Crisis, this parameter for Peru fell to 0.95 and long-run inflation stabilization is targeted. For South Korea, the negative (but insignificant) inflation coefficient is the source of the destabilization pre-Crisis. Post-Crisis, the coefficient on inflation for South Korea becomes positive but remains insignificant. The third country, Brazil, sees the opposite of Peru, with a smoothing parameter greater than one post-Crisis.

In terms of the changed weightings on inflation and the output gap, the results tend to be specific to each country but there are some common threads. Four out of the ten countries (the UK, Brazil, Mexico and Israel) place a lower weight on inflation post-Crisis, while six place a greater weighting. The change in the inflation coefficient for Israel is not significant according to the Wald test, while the change for the UK is weakly significant at the 10% level. Interestingly, despite showing insufficient evidence of a structural break, Brazil and Mexico also see a statistically significant change in their inflation coefficients pre- and post-Crisis. This suggests that a change in monetary policy conduct can, in certain circumstances, be found to occur, even if there is no clear evidence of a structural break. It is possible that the conduct in Brazil and Mexico changed more gradually over time, and that a methodology such as time-varying parameters may be more suited to capturing this movement. Recall that South Africa is one of the six countries that increased its weighting on inflation after the 2008 Crisis, although the change is not statistically significant. However, the same change of an increased weighting on inflation is found to be statistically significant for the US, Colombia and Peru, suggesting that their changes in monetary policy conduct may be rooted in this reweighting.

Six central banks reduce their weighting on the output gap after the Crisis, with three (South Africa, the US and the ECB) experiencing statistically significant changes. While this does indicate a change in monetary policy conduct, the decrease in coefficient magnitudes could also have been exacerbated by other factors. Particularly in the developed countries that entered the 2008 Crisis with low interest rates, the zero lower bound problem would have limited central banks' ability to respond to falling output with lower policy rates – hence the smaller coefficient on output post-Crisis. The global economic environment of secular stagnation would also have contributed, as even those countries that saw statistically significant increases in the magnitude of their coefficients on the output gap, namely Peru and South Korea, did not realise their pre-Crisis levels of growth.

The structural break tests, together with the subsequent pre- and post-Crisis regressions, have revealed statistically significant changes in monetary policy conduct for nine out of the ten sample countries. Israel, although having experienced at least one structural break during the 2000 to 2020 period, has not seen a change in monetary policy conduct between the pre- and post-Crisis periods. This reiterates that structural breaks and policy conduct changes are not synonymous. To investigate the monetary policy conduct of each country further, the next section presents results of MS regressions over the January 2000 to June 2020 period.

Table 2: Summary Table of Structural Break Regression Results

Country	Variable	Coefficient	Pre-Crisis	Post-Crisis	Wald test significance
South Africa	L1.Policy Rate	φ_1	.9671383***	.9970334***	0.1879
	Inflation	φ_π	.0106729	.0215419***	0.2507
	Output gap	φ_y	.053618***	.014775***	0.0035***
	RER	φ_R	.0004907	.0001348	0.6997
US	L1.Policy Rate	φ_1	.9474221***	.9122644***	0.2691
	Inflation	φ_π	.0025884	.0147883***	0.0721*
	Output gap	φ_y	.0346115**	.0071386**	0.0591*
	RER	φ_R	.0011108	-.0016814	0.1219
UK	L1.Policy Rate	φ_1	.9552287***	.6525278***	0.0000***
	Inflation	φ_π	-.0076069**	-.0013355	0.0995*
	Output gap	φ_y	.0185034*	.009624***	0.2830
	RER	φ_R	.0014463**	.0005963	0.2907
EU (ECB)	L1.Policy Rate	φ_1	.9609398***	.9257484***	0.2875
	Inflation	φ_π	.000164	.0019763	0.6042
	Output gap	φ_y	.0293766**	.0030214	0.0521*
	RER	φ_R	.0000246	-.0009895	0.4769
Brazil	L1.Policy Rate	φ_1	.9793538***	1.015366***	0.1220
	Inflation	φ_π	.0559246***	.019378**	0.0543*
	Output gap	φ_y	.0365384*	.0264829**	0.6525
	RER	φ_R	-.0019518	.0000499	0.2234
Mexico	L1.Policy Rate	φ_1	.9428638***	.9789207***	0.1738
	Inflation	φ_π	.0383046**	.0053877*	0.0710*
	Output gap	φ_y	.0100597	.0152826***	0.7079
	RER	φ_R	.0034225	-.0002246	0.1389
Colombia	L1.Policy Rate	φ_1	.9766548***	.9037843***	0.0105**
	Inflation	φ_π	.0056756	.0255075***	0.0647*
	Output gap	φ_y	.0121006	.0276831**	0.4669
	RER	φ_R	.0005457	-.0002664	0.2894
Peru	L1.Policy Rate	φ_1	1.017516***	.9506393***	0.0053***
	Inflation	φ_π	.0042534	.0200203***	0.0465**
	Output gap	φ_y	-.0012242	.0122898***	0.0007***
	RER	φ_R	.000132	.0018205	0.3737
South Korea	L1.Policy Rate	φ_1	.9717699***	.9478325***	0.2543
	Inflation	φ_π	-.0008648	.0029507	0.1352
	Output gap	φ_y	.0125853***	.0227425***	0.0233**
	RER	φ_R	-.0001847	.0010767***	0.0655*
Israel	L1.Policy Rate	φ_1	.9604163***	.9580104***	0.9125
	Inflation	φ_π	.0125402	.0022845	0.3667
	Output gap	φ_y	.0020595	.0006616	0.7493
	RER	φ_R	-.0066124*	-.0026649**	0.2924

*** p<0.01, ** p<0.05, * p<0.1

6.2 Markov-switching Regressions

Just as a structural break does not necessarily constitute a change in monetary policy conduct, so too does a structural break not necessarily constitute a regime switch. That is, the presence of a structural break does not necessarily imply that a regime change has occurred. The results of the MS regressions allow an assessment of whether or not the identified structural breaks are indeed associated with a change in regime. In addition, this methodology checks the robustness of the structural break dates.

To conduct this analysis, the literature suggests the estimation of a two-state MS regression, allowing the parameters to switch between two states. For each state, the predicted value of the policy rate is obtained, as well as the probability that the state will prevail in each period. These values are depicted in the graphical output presented in Appendix 10.6. Each country has two graphs, where the left-hand graph represents State 1, and the right-hand graph represents State 2. Each graph has three components: the blue line is the predicted policy rate for that state; the green line is the probability that the state will prevail in each period; and the grey shaded area demarcates the Crisis period.

There is evidence of a regime switch when the probability of a given state swings suddenly from being near zero to being near one (and vice-versa). Nine out of the ten countries experience a regime switch during the Financial Crisis, shown by the dramatic swings in state probabilities.[21] The regime switches that occur during the Crisis coincide with the moment of response by central banks, just as was the case in the structural break analysis. This result confirms the robustness of the structural break dates identified in Table 1 above. In addition, six countries[22] display a regime switch in early 2020, signalling an impending change for monetary policy due to the impact of the COVID-19 Crisis.

Table 3 presents a summary of the results of the MS Taylor Rule regressions for all ten countries, for both State 1 and State 2. The complete econometric results for each country are presented in Appendix 10.5. Separate regression results have been obtained for State 1 and State 2, and they are accompanied by the Wald test results for differences between the two states' coefficients.

Although the *a priori* expectation was to see one regime prevail before the Crisis and another after the Crisis, this is not the ultimate result. Instead, central banks seem to have switched regimes only during a portion of the Crisis itself and then returned to their original regime afterwards. This result suggests that a three-state MS regression could be more appropriate because it could capture differences between pre-Crisis, Crisis and post-Crisis regimes, should such differences exist.

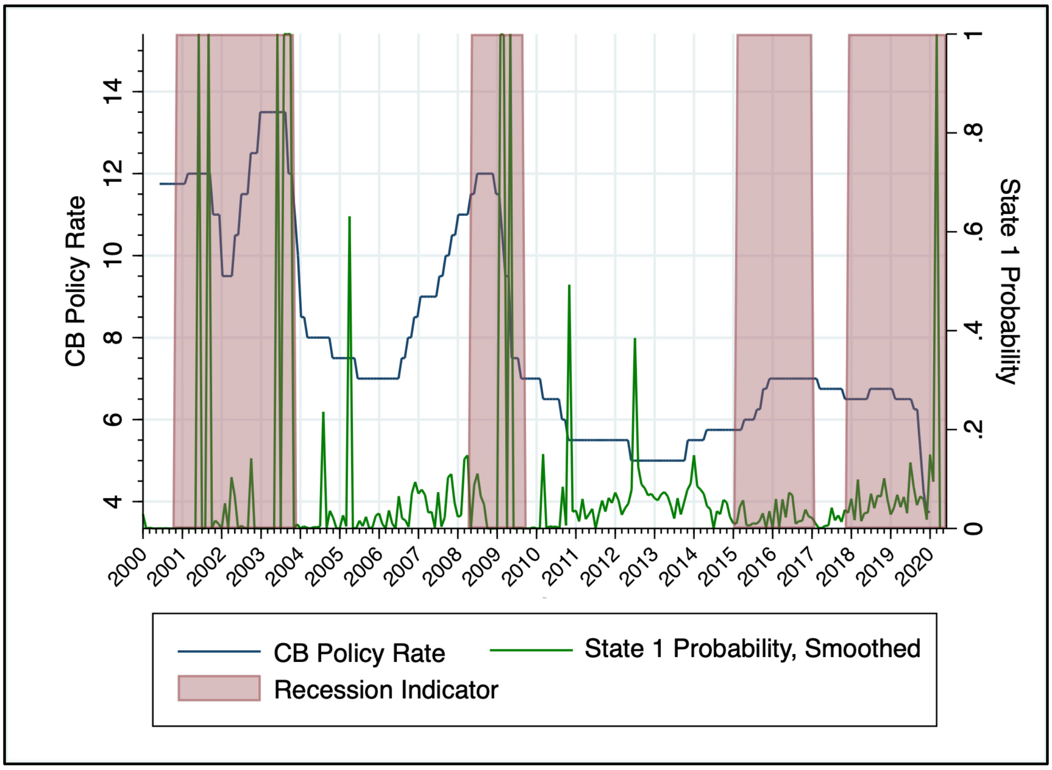
[21] Only Israel does not appear to experience a regime switch during the Financial Crisis.
[22] These are South Africa, the US, the UK, Peru, Colombia, and South Korea.

However, the results obtained are nonetheless useful because they enable a comparison of how central banks conduct themselves during a crisis to how they conduct themselves in "normal" times. The MS regression results are interpreted in this way, first for South Africa and then for the other countries.

6.2.1 South Africa

The probability graphs for South Africa in Appendix 10.6 show that there have been several regime switches over the sample period, clustered during mid 2001, mid 2003, early 2009 and early 2020. These are all times during which the SARB underwent dramatic policy rate cuts in response to economic downturns. Figure 8 takes a more in-depth look at these switches by showing the actual SARB policy rate and State 1 probabilities together with a recession indicator for South Africa.[23] Figure 8 confirms that a regime switch to State 1 is more likely to occur when the economy is in a recession than when the economy expanding.

Figure 8: OECD-based Recession Indicator for South Africa



Data Source: South African Reserve Bank and the St Louis Federal Reserve

In line with this, we interpret South Africa's regression results for State 1 as the monetary policy conduct followed during a recession or crisis, and State 2 as the monetary policy conduct followed

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[23] The OECD-based recession indicator measures a recession as the time between the peak and trough turning points of an economy's growth cycle (Federal Reserve Bank of St Louis, 2020). The indicator is constructed as a dummy variable with a value of one for a recession and zero for an expansion (Federal Reserve Bank of St Louis, 2020). The recession indicator in Figure 3 shows recessionary periods for South Africa, as defined by the OECD.

during an expansion. In particular, State 1 is characterised by swift and dramatic reductions in the policy rate, while State 2 is characterised by a policy rate path that is relatively more stable or rising.

While differences in South Africa's State 1 and State 2 coefficients for inflation and the RER are not significant, the Wald tests identify statistically significant differences between the coefficients on the lagged policy rate (i.e. the smoothing parameter), as well as between the coefficients on the output gap. This implies that the regime switches are rooted in the latter two macroeconomic variables.

The smoothing parameter is smaller during State 1 (the "recession" state) than during State 2 (the "expansion" state). This implies that the SARB acts more rapidly during a recession than during an expansion. Coupled with the structural break regression results, this suggests that the SARB acted somewhat inertially pre-Crisis, acted rapidly during the Crisis to respond to movements in the output gap and inflation, and then, post-Crisis, returned to acting more inertially. Indeed, the weighting on inflation is three times larger during State 1 than during State 2. Similarly, the coefficient on the output gap is almost eight times larger during State 1 than during State 2. However, the influence of inflation on the policy rate is insignificant during State 1, while the influence of the output gap is highly significant at the 0.1% level in both states. This indicates that emphasis is placed on growth and recovery, highlighting the central bank's focus on steering the economy back on track during a recession. That is, the SARB responds asymmetrically – it reduces the policy rate faster during a recession and increases it more slowly during an expansion. However, between 2015 and 2017, the SARB raised the policy rate during a recession. During this period, the SARB may have acted inappropriately by increasing the policy rate in response to a positive output gap, which, as discussed in Section 5, was likely an artefact of the high average positive output gap brought about by a decrease in potential output after the Crisis. To understand this further, future research can investigate these changes to the SARB's conduct in greater detail, possibly using a three-state MS model.

The expected durations and transitional probabilities of each state also speak to the SARB's responsiveness during a crisis. The expected duration of State 1 (the "recession" state) is 1.28 months, while the expected duration of State 2 (the "expansion" state) is 15.03 months. In addition, the probability that State 1 will be followed by State 2 is 77.7%, while the probability that State 2 will be followed by State 2 is 93.3%. Together, these results imply that State 1 is likely to be short-lived, while State 2 is more persistent. This suggests that the SARB acts quickly and decisively when choosing to lower its policy rate during a crisis, and then commits to its decision over the months that follow. However, the greater-than-one smoothing parameter and negative long-run response to inflation in State 2 suggest that the SARB may respond too slowly outside of a recession, by taking actions that are not strong enough to stabilize prices in the long run.

6.2.2 Inter-country comparisons

South Africa is not alone in experiencing a mid-Crisis regime switch. In fact, nine out of the ten sample countries experience a regime switch during the Crisis, shown by the dramatic swings in state probabilities presented by the diagrams in Appendix 10.6. The tenth country, Israel, shows no evidence of a regime switch during the Crisis. Together with Israel's weakly significant structural break and insignificant differences between pre- and post-Crisis coefficients, this result implies that the Bank of Israel has not changed the conduct of its monetary policy significantly over the sample period. Brazil, on the other hand, presents more frequent regime switches, indicating a relatively more erratic monetary policy stance.

Turning to an analysis of the regimes themselves, we see similar results for all nine countries, in that they all switch to State 1 at some point during the Financial Crisis, only to return to State 2 afterwards. Therefore, as for South Africa, State 1 is interpreted as being the monetary policy conduct followed in response to a recession or crisis, and State 2 is interpreted as the monetary policy conduct followed during an expansion.

As seen in Table 3, along with South Africa, seven other countries see a reduction in the size of the smoothing parameter during State 1, six of which are statistically significant according to the Wald test. These decreases in the smoothing parameter reflect the tendency of central banks to be more reactive during a Crisis, in an effort to support and ultimately reignite the economy as quickly as possible. Only the US and Mexico see increases in their smoothing parameters, albeit small and insignificant ones.

Still, the US behaves more inertially during State 1 than State 2. The coefficients on the output gap and inflation for the US drop dramatically in State 1 (though they are insignificant throughout); it seems that the Federal Reserve neglects output and inflation during a recession, in favour of its currency. The coefficient on the RER is larger and significant at the 0.1% level in State 1, while it is smaller and insignificant in State 2. Therefore, the RER has a greater influence on monetary policy during a crisis than during normal times. The negative sign implies that the Federal Reserve lowers its policy rate in response to real currency appreciations – an action possibly taken to devalue the US dollar and maintain the competitiveness of US exports. This can ultimately (indirectly) boost local output through an increase in foreign demand for local goods and services.

The US is not the only country to target its exchange rate in this way – the EU, Peru and Israel also exhibit negative and significant RER coefficients in State 1 – but there are other countries that seem to have the opposite response. Brazil, for example, switches from having a significant negative RER coefficient in State 2, to having a significant positive RER coefficient in State 1 that is double in size. This goes against *a priori* expectations, implying that the Central Bank of Brazil increases the policy rate in response to an appreciation of its currency. At the same time, Brazil's coefficient on inflation changes sign and becomes negative, against *a priori* expectations, implying that decreases in inflation are also met with increases in the policy rate. As seen in Appendix 10.6, Brazil experiences a regime switch to State 1 in the latter half of the Crisis and this change is sustained until approximately 2015 when State 2 prevails. In State 2, Brazil's coefficients all have the expected signs. This change in Brazil's monetary policy conduct during the 2008 Crisis suggests that a balancing act was performed, likely in an effort to keep the local currency strong amidst uncertainty, with both local currency appreciation and disinflation being met with a policy interest rate rise.

Instead of the RER, the SARB prioritises the output gap and inflation during a recession. The UK, Brazil, Mexico, Peru and South Korea also each have significant output gap coefficients during State 1, the magnitudes of which are all greater than in State 2. The UK, Mexico, Colombia and South Korea complement their response to the output gap with larger and significant weightings on inflation in State 1. It is noted, however, that the output gap coefficients for Mexico and Colombia become negative in State 1, implying that these central banks respond to increases in output by lowering the policy rate. At the same time, Mexico's and Colombia's coefficients on inflation rises considerably, implying that the central bank goes to great lengths to stimulate output while also controlling prices during a recession. The reverse occurs in Peru, with the sign on inflation becoming negative during State 1, and its coefficient on the output gap increases substantially. The sign change on the short-run inflation coefficient leads to the long run response to inflation falling below zero and, as a result, it is possible to conclude that in Peru the Taylor Principle has not been followed during State 1. Accordingly, the Central Reserve Bank of Peru seems to follow a destabilizing Taylor Rule during recessions, prioritising short-run recovery over long term price stabilization.

The expected durations of each state vary across the different countries, along with their transitional probabilities. Similarly, there are mixed results when it comes to how central banks prioritise or even respond to inflation during a crisis. This reinforces the notion that aggregated results cannot sufficiently capture the experiences of each country and that a granular examination of individual central bank results is important for accurate monetary policy analysis. While an in-depth analysis of every countries' experience is outside the scope of this paper, the analysis herein is intended to open up avenues for future monetary policy research, aimed at better understanding how central banks respond when their economies are experiencing a crisis.

Table 3: Summary Table of Markov-switching Regression Results

Country	Variable	Coefficient	State 1	State 2	Wald test significance
South Africa	L1.Policy Rate	γ_{1,S_t}	.9066523***	1.004197***	0.0272**
	Inflation	γ_{π,S_t}	.0343435	.0119154***	0.3636
	Output gap	γ_{y,S_t}	.0891239***	.0166032***	0.0098***
	RER	γ_{R,S_t}	.0019279	-.0001591	0.5211
US	L1.Policy Rate	γ_{1,S_t}	1.023986***	1.013094***	0.6574
	Inflation	γ_{π,S_t}	-.0009	.002185	0.6632
	Output gap	γ_{y,S_t}	.0004182	.0010996	0.9274
	RER	γ_{R,S_t}	-.0053736***	-.0003538	0.0006***
UK	L1.Policy Rate	γ_{1,S_t}	.8029554***	.9982149***	0.0000***
	Inflation	γ_{π,S_t}	-.0657388***	-.0044156**	0.0000***
	Output gap	γ_{y,S_t}	.0699562***	.0035137**	0.0039***
	RER	γ_{R,S_t}	.0121048***	.0005337**	0.0000***
EU (ECB)	L1.Policy Rate	γ_{1,S_t}	.9109344***	1.007502***	0.0139**
	Inflation	γ_{π,S_t}	.0059949	-4.51e-06	0.6823
	Output gap	γ_{y,S_t}	-.0199777	.0025949	0.4058
	RER	γ_{R,S_t}	-.0025451***	-6.79e-06	0.0101**
Brazil	L1.Policy Rate	γ_{1,S_t}	.9203594***	1.016016***	0.0000***
	Inflation	γ_{π,S_t}	-.0302629**	.0431871***	0.0000***
	Output gap	γ_{y,S_t}	.1015134***	.0135178	0.0000***
	RER	γ_{R,S_t}	.0041849***	-.0021629**	0.0004***
Mexico	L1.Policy Rate	γ_{1,S_t}	1.020309***	1.0201**	0.9948
	Inflation	γ_{π,S_t}	.1105393***	.0094456*	0.0000***
	Output gap	γ_{y,S_t}	-.116538***	.0076263	0.0000***
	RER	γ_{R,S_t}	.0013007	.000212	0.7812
Colombia	L1.Policy Rate	γ_{1,S_t}	.9176357***	.9866532***	0.0000***
	Inflation	γ_{π,S_t}	.0190047**	.0064159	0.3108
	Output gap	γ_{y,S_t}	-.0575296**	.0104878	0.0466**
	RER	γ_{R,S_t}	.0001375	-.0000565	0.8399
Peru	L1.Policy Rate	γ_{1,S_t}	.9359181***	.9921834***	0.0261**
	Inflation	γ_{π,S_t}	-.0063033**	.0069986**	0.0017***
	Output gap	γ_{y,S_t}	.0065842**	.0000125	0.0339**
	RER	γ_{R,S_t}	-.0027774*	.0002445	0.0742*
South Korea	L1.Policy Rate	γ_{1,S_t}	.9729864***	1.005276***	0.1063
	Inflation	γ_{π,S_t}	.0195481***	-.0004797	0.0001***
	Output gap	γ_{y,S_t}	.0276135***	.0067261***	0.0000***
	RER	γ_{R,S_t}	.0012062	.000497**	0.6237
Israel	L1.Policy Rate	γ_{1,S_t}	.9751117***	1.004035***	0.6772
	Inflation	γ_{π,S_t}	.0038049	.1283229***	0.0000***
	Output gap	γ_{y,S_t}	.0007566	.1073845***	0.0000***
	RER	γ_{R,S_t}	-.0024483***	-.0518848***	0.0000***

*** p<0.01, ** p<0.05, * p<0.1

7 Conclusion

This paper uses an open-economy Taylor Rule to examine the monetary policy conduct of ten central banks over the period from January 2000 to June 2020. In particular, this study seeks to investigate how monetary policy conduct in South Africa differed before and after the 2008 Financial Crisis. The behaviour of the South African Reserve Bank (SARB) was then compared to that of the other central banks in the sample.

Through a combination of structural break tests and Markov-switching Regressions, the study presents evidence of Crisis-related changes in monetary policy conduct in South Africa, as well as in the US, the UK, the Euro Area (the ECB), Colombia, Peru and South Korea. On the other hand, the results for Brazil, Mexico and Israel do not show conclusive differences in monetary policy conduct between the pre-Crisis and post-Crisis periods. Moreover, the Markov-switching regressions with two-states reveal that central bank conduct could be further dissected into that undertaken before, during and after a crisis or, alternatively, that undertaken during a recession and during an expansion.

As hypothesised, the 2008 Crisis resulted in changes in the coefficients or weightings within the Taylor Rules for each country. While the change in monetary conduct in each country is quite unique, there are some common threads and interesting differences. The empirical results show that the SARB acted somewhat more inertially post-Crisis, with a larger smoothing parameter in that period. In addition, there is evidence to suggest that the SARB has placed a greater focus on inflation and a lesser focus on the output gap since 2009. However, at times during the post-Crisis period, the SARB may have acted inappropriately by increasing the policy rate in response to a positive output gap, which was likely an artefact of the high average positive output gap brought about by a decrease in potential output after the Financial Crisis.

Along with South Africa, there are only two other countries, namely Brazil and Mexico, whose smoothing parameters are larger in the post-Crisis period. The other sample countries display smaller smoothing parameters post-Crisis, with the change in UK being the most significant. The UK also exhibits a destabilizing Taylor Rule, with a negative long-run coefficient on inflation throughout the 20-year time frame. This is in contrast to Peru, which has a negative long-run coefficient on inflation pre-Crisis but a positive one post-Crisis. Unlike the UK and Peru, most countries in the sample exhibit a stabilizing Taylor Rule both pre- and post- the Financial Crisis, as would be expected in countries where monetary policy is guided by the inflation targeting framework.

Four out of the ten countries place a lower weight on inflation post-Crisis, while six place a greater weighting. Six central banks reduce their weighting on the output gap after the Crisis. It is noted that, while this does indicate a change in monetary policy conduct, the changes in coefficient magnitudes could have been exacerbated by a number of other factors. Across all the countries, the coefficient on the real exchange rate is statistically insignificant in most cases, both pre- and post-Crisis.

Conversely, the real exchange rate does seem to play a significant role in the decisions made by central banks during a crisis, or recession. The Markov-switching regressions reveal that the US, EU Area (under the European Central Bank), Peru and Israel targeted changes in their exchange rates during the 2008 Crisis, likely in an effort to maintain trade competitiveness and boost local output through this channel. In terms of responsiveness, eight countries (including South Africa) saw a reduction in the size of the smoothing parameter during the 2008 Crisis. These decreases in the smoothing parameter reflect the tendency of central banks to be more reactive during a crisis, in an effort to support – and ultimately reignite – the economy as effectively and rapidly as possible. In line with this, six countries (including South Africa) prioritised the output gap during the 2008 Crisis and four countries (including South Africa) had larger, significant weightings on inflation.

Finally, the study has identified initial signals of impending structural breaks and regime switches in the monetary policy conduct of six countries in response to the 2020 COVID-19 Crisis. Future research could compare how monetary policy conduct changes in response to a financial crisis (as in 2008), to a real economic crisis (as in 2020). Such research should include a variety of econometric methods so as to ascertain whether the changes are gradual or abrupt. Structural break tests would help to identify points at which monetary policy conduct may have changed but it would be important to recall that the presence of a structural break is neither a sufficient nor a necessary condition for determining whether monetary policy conduct has changed. It would be through undertaking MS Regressions with more than two states that would likely be a more appropriate approach for capturing the responses of central banks before, during and after a crisis.

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10 Appendix

10.1 Descriptive Statistics

South Africa

	Pre-Crisis (January 2000 – January 2007)		Crisis (February 2007 – April 2011)		Post-Crisis (May 2011 – April 2020)	
Variable	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Policy Rate	9.85	2.305273	8.686275	2.295563	6.037037	.7305218
Inflation	5.412743	5.397905	7.078072	5.249494	5.162965	3.015496
Output Gap	-.2265512	2.285991	-.151492	6.282276	.2063431	4.724293
RER	9.059289	43.1755	12.39798	51.42297	1.821509	34.95087

US

	Pre-Crisis (January 2000 – January 2007)		Crisis (February 2007 – April 2011)		Post-Crisis (May 2011 – June 2020)	
Variable	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Policy Rate	3.230353	1.915344	1.621569	1.997674	.6807273	.7897319
Inflation	2.728639	3.505919	2.430643	5.022521	1.548228	2.578257
Output Gap	-.0165132	2.333941	-.8958894	6.487579	.3554681	2.814078
RER	.0882462	13.11558	-1.710551	20.53178	3.722081	14.23251

UK

	Pre-Crisis (January 2000 – January 2007)		Crisis (February 2007 – April 2011)		Post-Crisis (May 2011 – June 2020)	
Variable	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Policy Rate	4.641176	.7563689	2.588235	2.347245	.4959091	.1563828
Inflation	1.719113	3.658235	3.129698	3.945471	1.739084	3.122814
Output Gap	.0456235	1.72546	-.3879831	3.798469	.118306	3.770686
RER	.6383454	14.31246	-3.166246	23.98561	1.494438	17.55719

EU (ECB)

	Pre-Crisis (January 2000 – January 2007)		Crisis (February 2007 – April 2011)		Post-Crisis (May 2011 – June 2020)	
Variable	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Policy Rate	3.944118	.9380962	3.205882	1.525374	.6645455	.627334
Inflation	2.174904	3.294256	2.50266	5.392008	1.269669	6.372447
Output Gap	-.1931498	1.030479	-.2586037	2.930466	.2621873	1.697661
RER	3.305925	19.35075	1.467679	21.81292	.5645318	15.71669

Brazil

	Pre-Crisis (January 2000 – January 2007)		Crisis (February 2007 – April 2011)		Post-Crisis (May 2011 – June 2020)	
Variable	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Policy Rate	18.26765	3.079499	11.10784	1.529097	9.587091	3.200744
Inflation	7.555731	6.885711	5.547213	2.819254	5.444737	4.20347
Output Gap	-.3069133	2.168624	.3053126	5.075772	.0514857	4.507655
RER	13.71475	54.89594	14.59934	33.14827	1.086909	41.37905

Mexico

	Pre-Crisis (January 2000 – January 2007)		Crisis (February 2007 – April 2011)		Post-Crisis (May 2011 – June 2020)	
Variable	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Policy Rate	9.843059	3.880322	6.53549	1.55127	5.487636	1.833268
Inflation	5.16777	4.086587	4.503767	4.317338	3.929559	4.834
Output Gap	.1761721	3.876407	-.8621197	6.058075	.2532546	5.731304
RER	3.642204	30.50341	9.174627	55.04132	11.20545	65.22355

Peru

	Pre-Crisis (September 2003 – January 2007)		Crisis (February 2007 – April 2011)		Post-Crisis (May 2011 – May 2020)	
Variable	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Policy Rate	3.286585	.7553165	3.941176	1.812863	3.568807	.8276693
Inflation	2.253179	3.831445	3.585469	3.525399	2.859942	3.393293
Output Gap	-1.265586	5.616165	-.1878497	6.782167	.372943	9.14204
RER	1.630015	12.24373	.7315229	14.95077	-.3005445	13.33016

Colombia

	Pre-Crisis (January 2000 – January 2007)		Crisis (February 2007 – April 2011)		Post-Crisis (May 2011 – June 2020)	
Variable	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Policy Rate	7.891176	2.304062	6.583333	2.943496	4.734091	1.208379
Inflation	6.465839	4.804309	4.954376	3.715618	3.928335	3.05436
Output Gap	.1515853	1.228014	-.2331246	1.941299	.004766	1.90925
RER	3.061235	27.49321	6.431176	54.48759	10.05588	41.16808

Israel

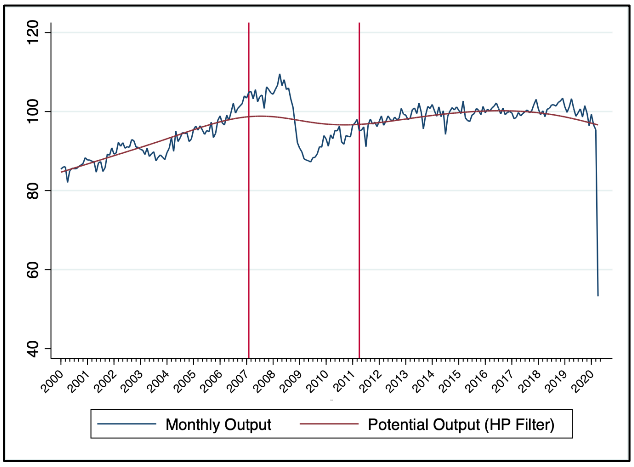
	Pre-Crisis (January 2000 – January 2007)		Crisis (February 2007 – April 2011)		Post-Crisis (May 2011 – June 2020)	
Variable	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Policy Rate	6.398353	2.296599	2.49	1.370155	.794	1.006945
Inflation	1.148715	5.850211	3.600551	5.532145	.6451477	3.87874
Output Gap	-.5880224	6.490173	.5938623	7.729294	.0578006	7.101086
RER	4.113243	19.5838	-1.702443	20.82091	.1804284	15.7192

South Korea

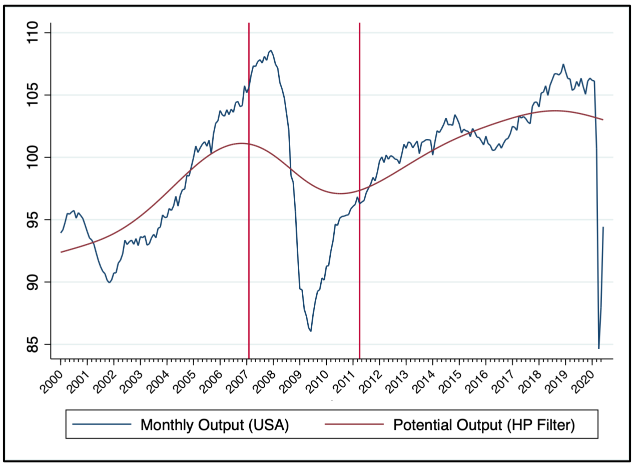
	Pre-Crisis (January 2000 – January 2007)		Crisis (February 2007 – April 2011)		Post-Crisis (May 2011 – June 2020)	
Variable	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Policy Rate	4.172235	.6215119	3.353725	1.35951	1.958545	.7367382
Inflation	3.100525	5.251543	3.802839	4.319905	1.258254	3.968329
Output Gap	-.0601509	2.842765	-.4842423	6.741684	.2276638	2.423764
RER	4.901059	17.42998	-.2625321	34.25999	1.847424	17.28348

10.2 Output Gaps: Monthly Output and Potential Output

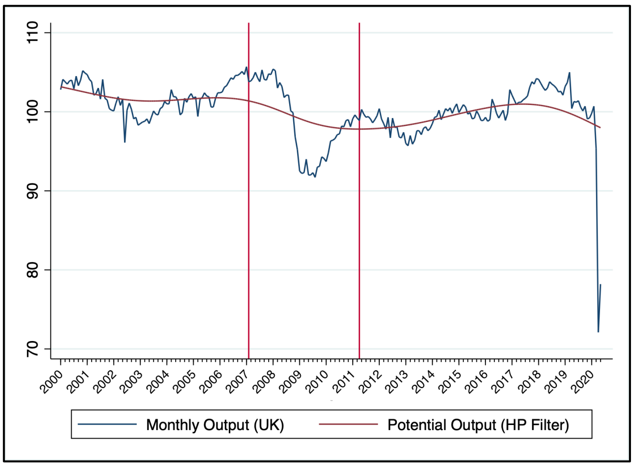
South Africa



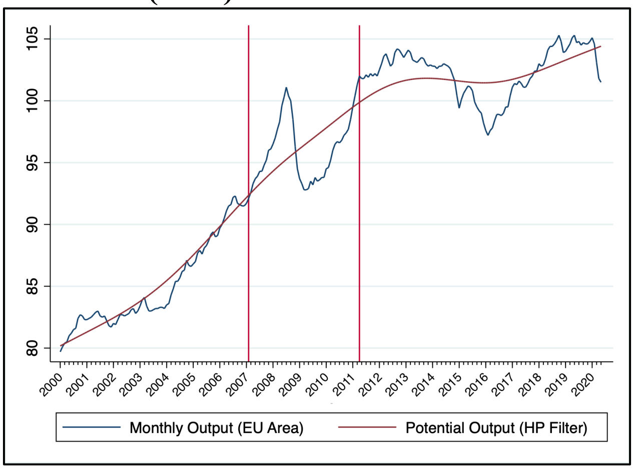
US



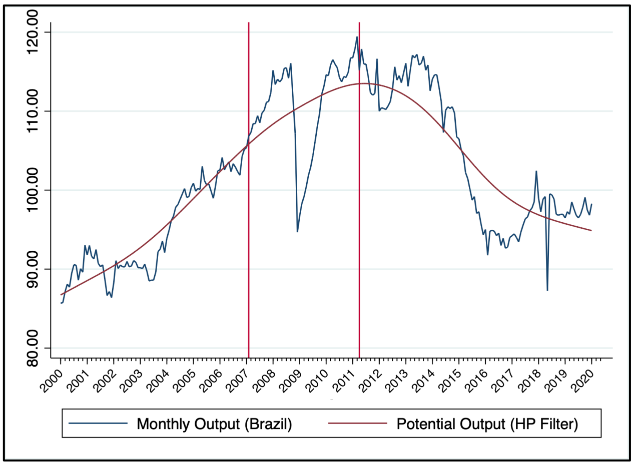
UK



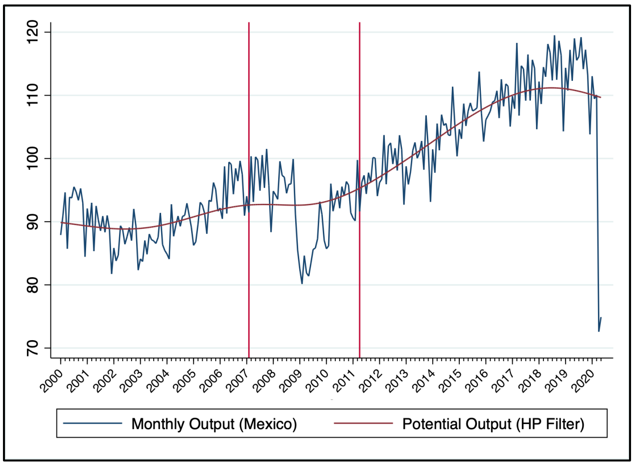
EU Area (ECB)



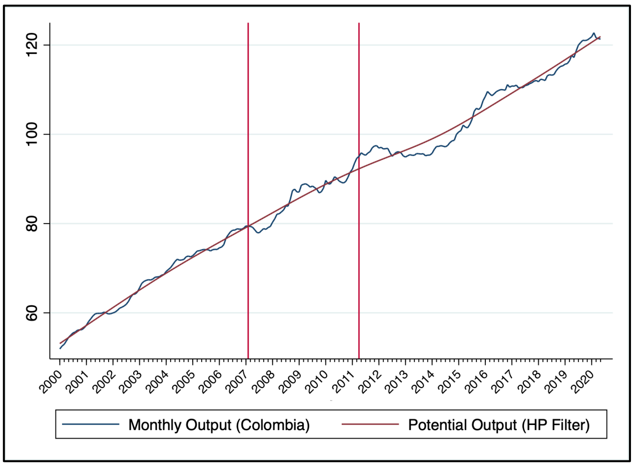
Brazil



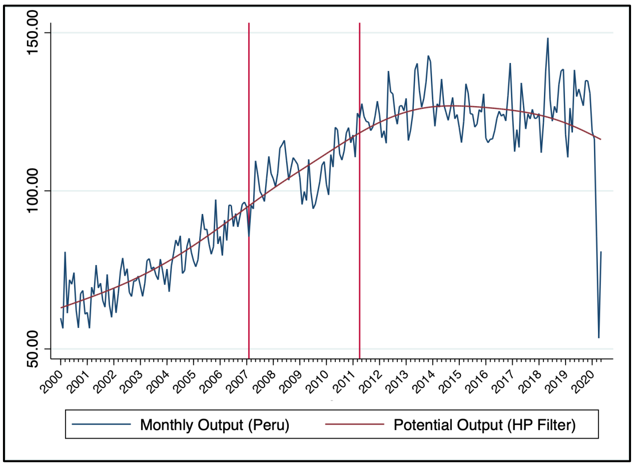
Mexico



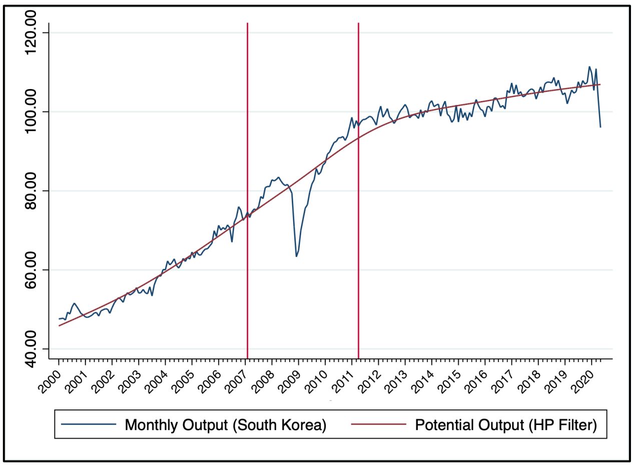
Colombia



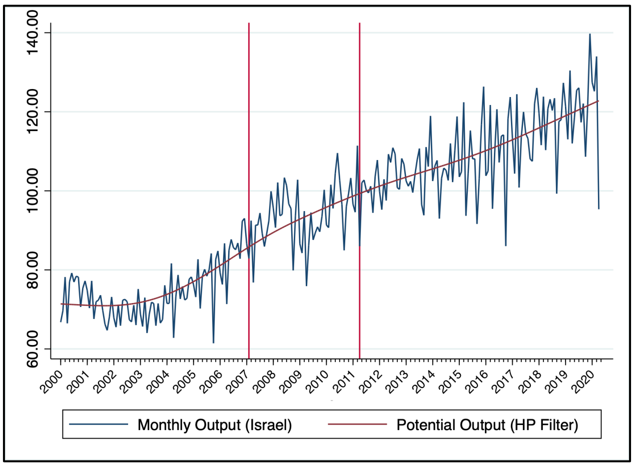
Peru



South Korea

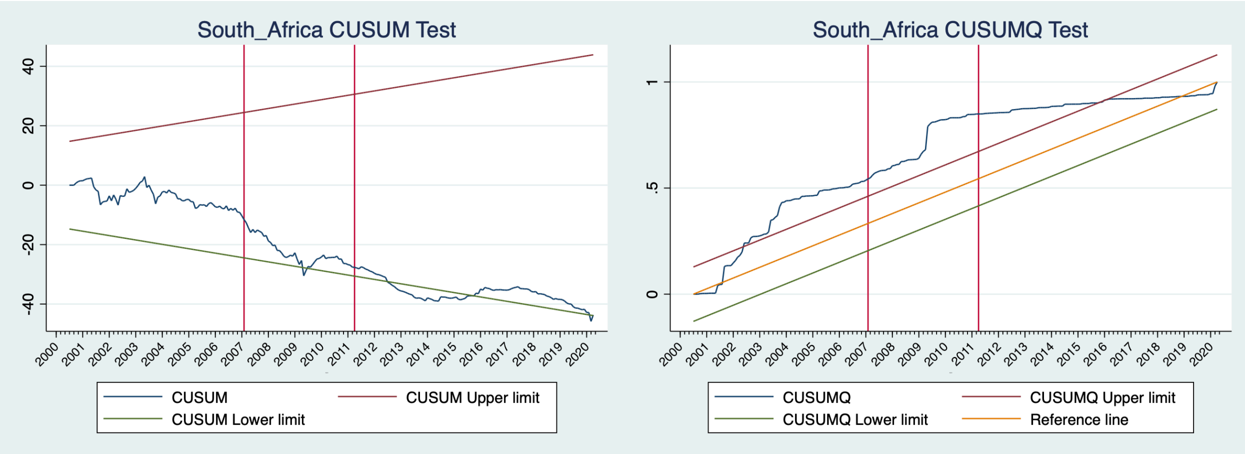


Israel

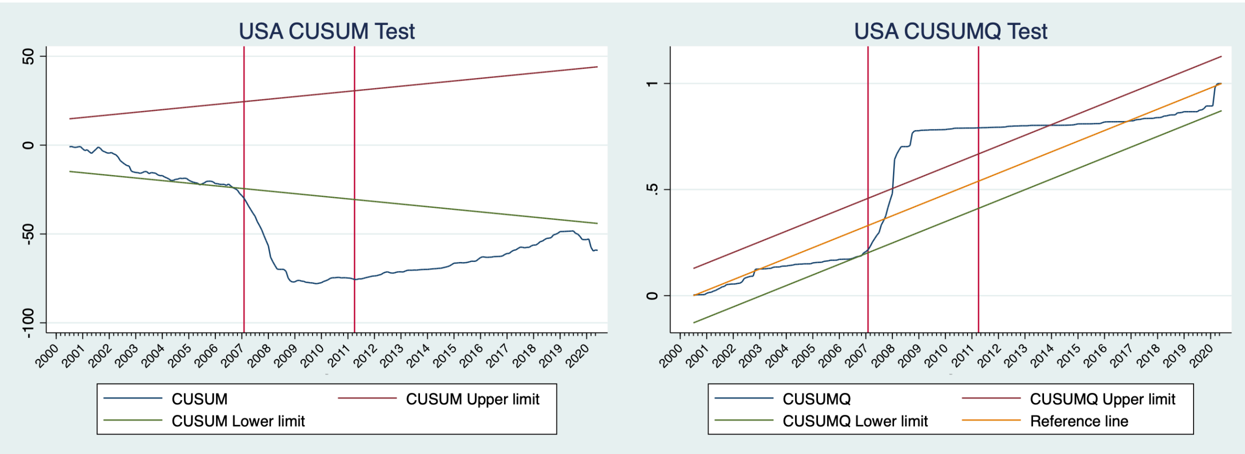


10.3 Structural Break Tests: January 2000 – June 2020

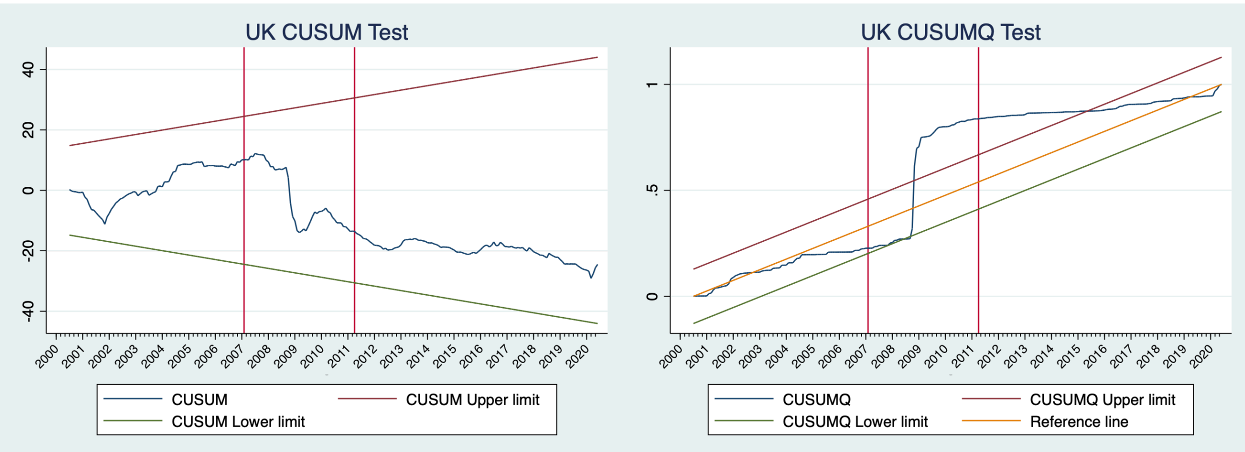
South Africa



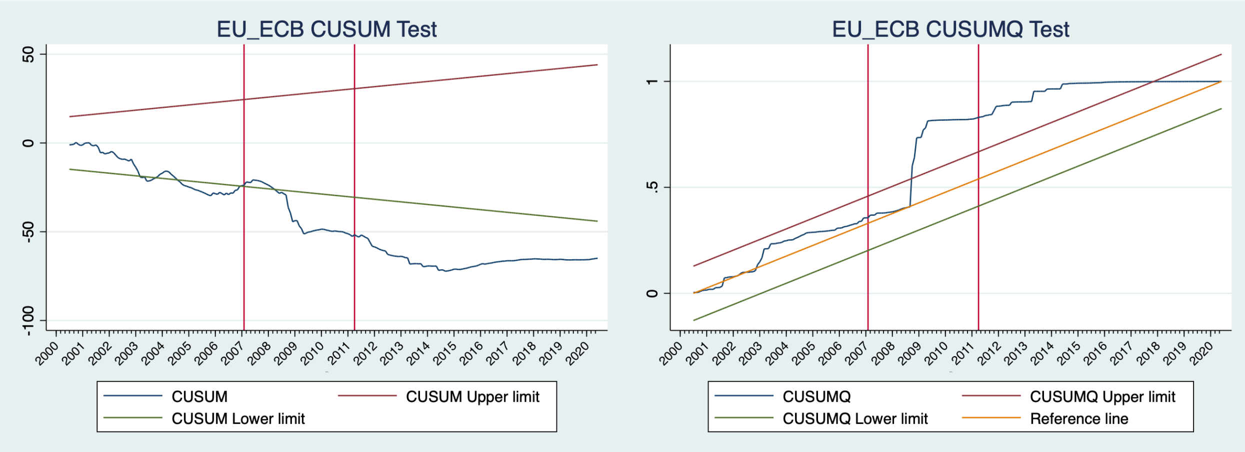
US



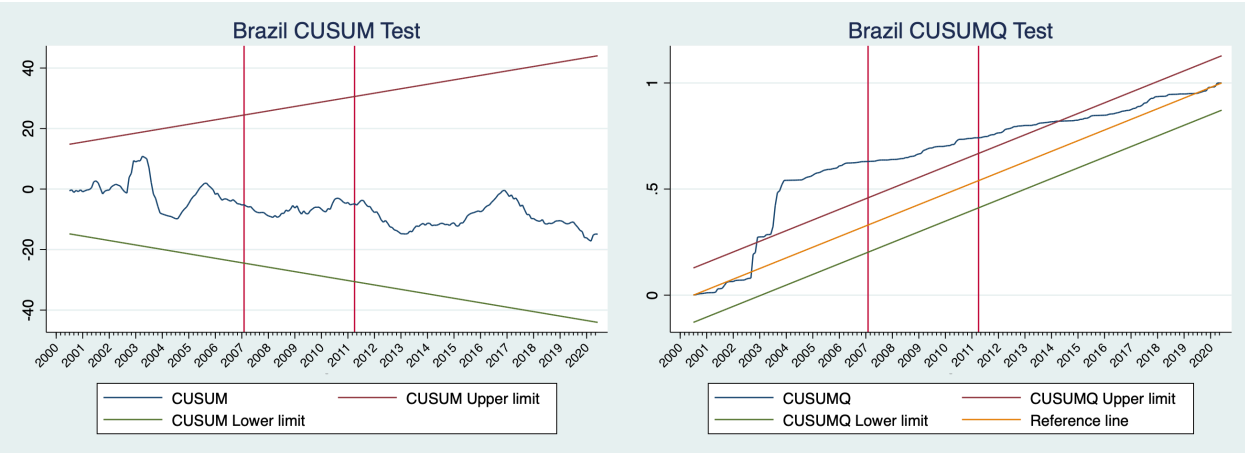
UK



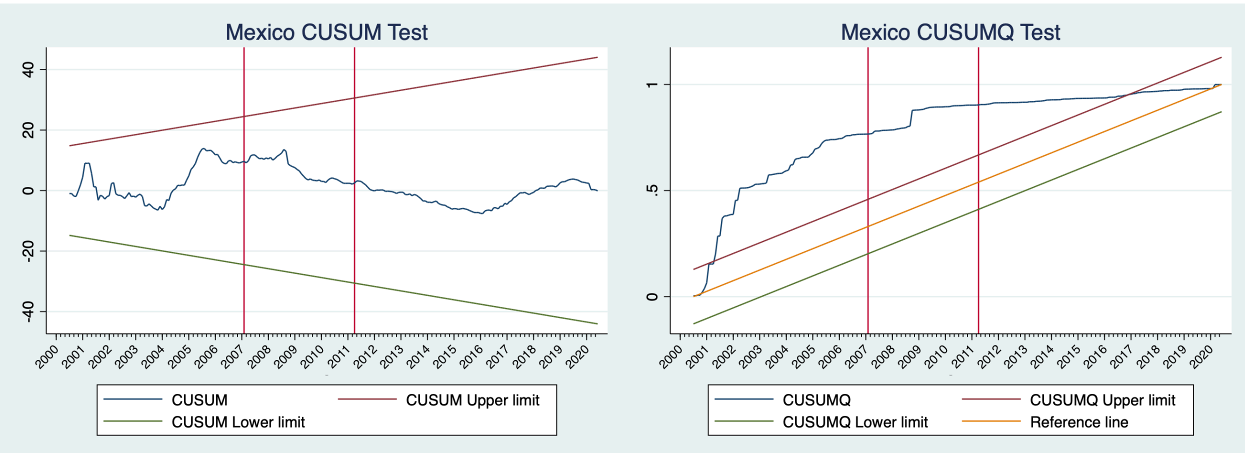
EU (ECB)



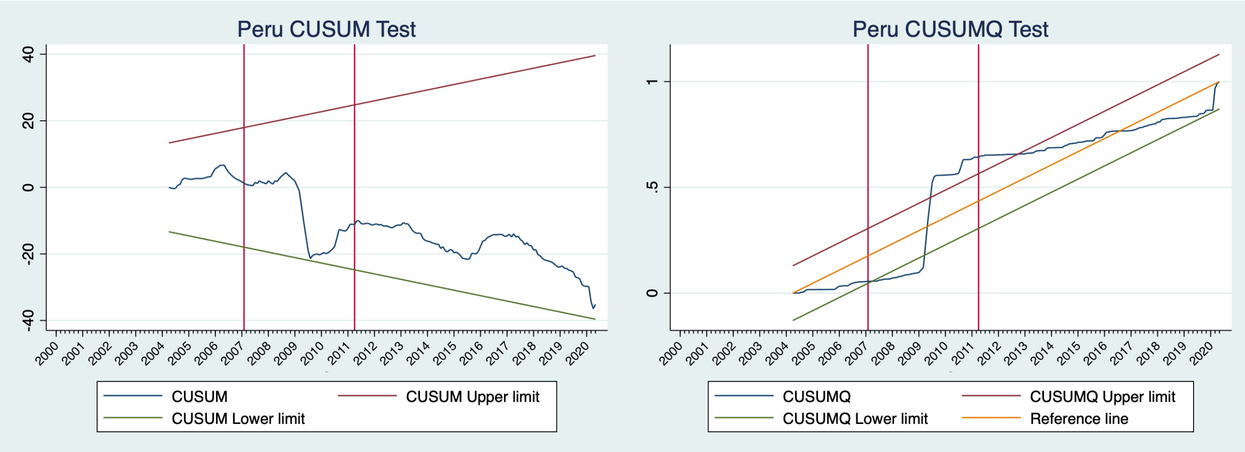
Brazil



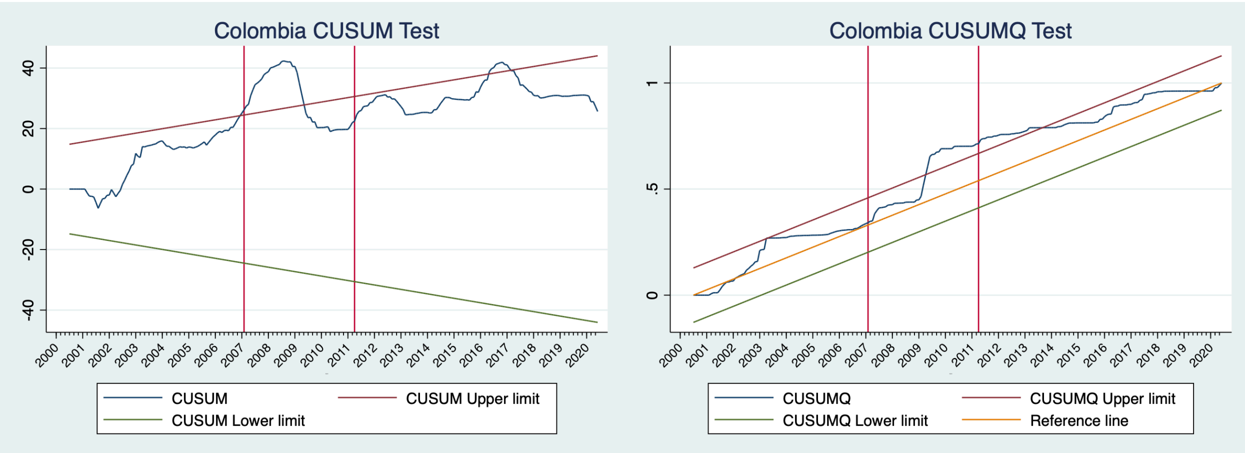
Mexico



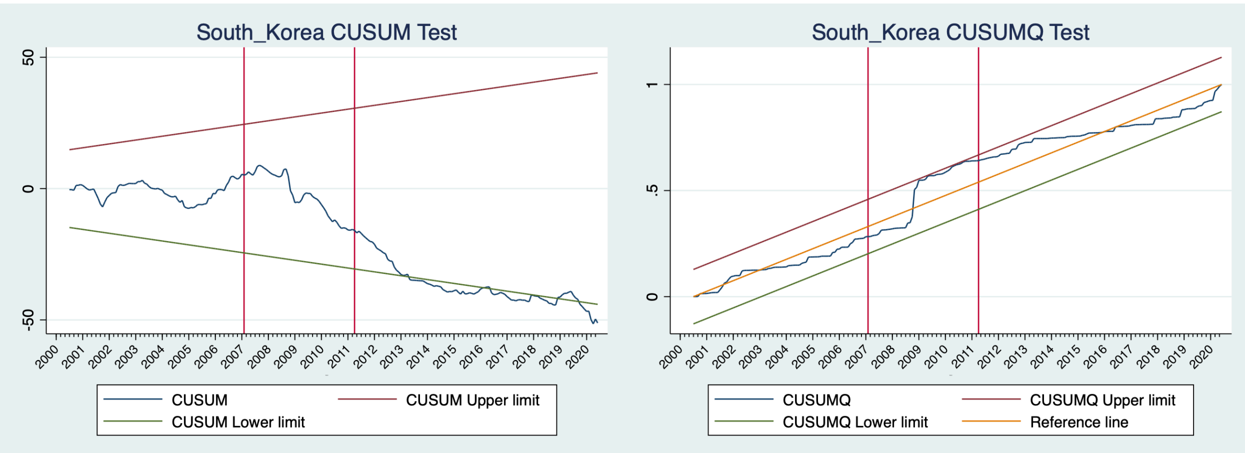
Peru



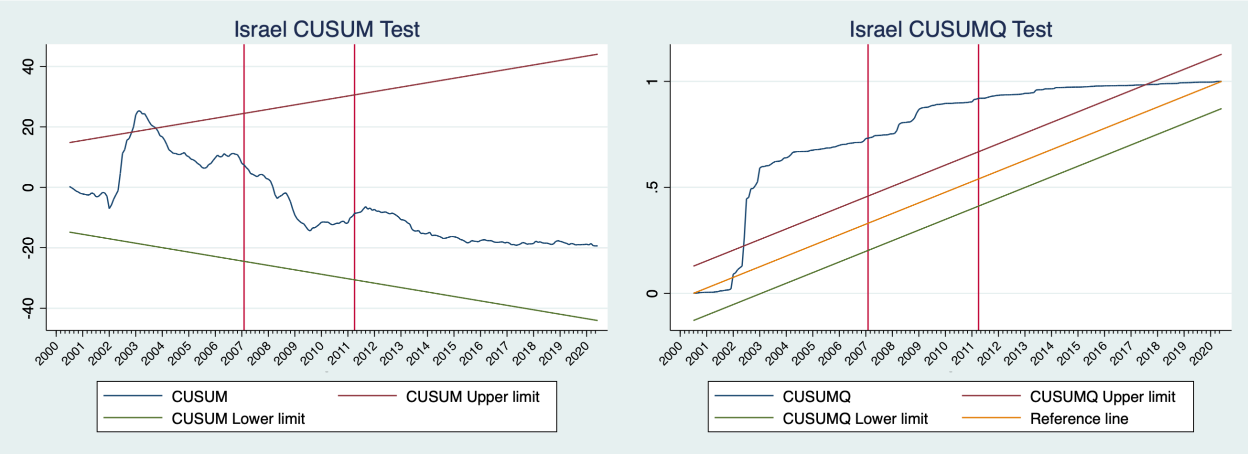
Colombia



South Korea



Israel



Israel CUSUM Test
40
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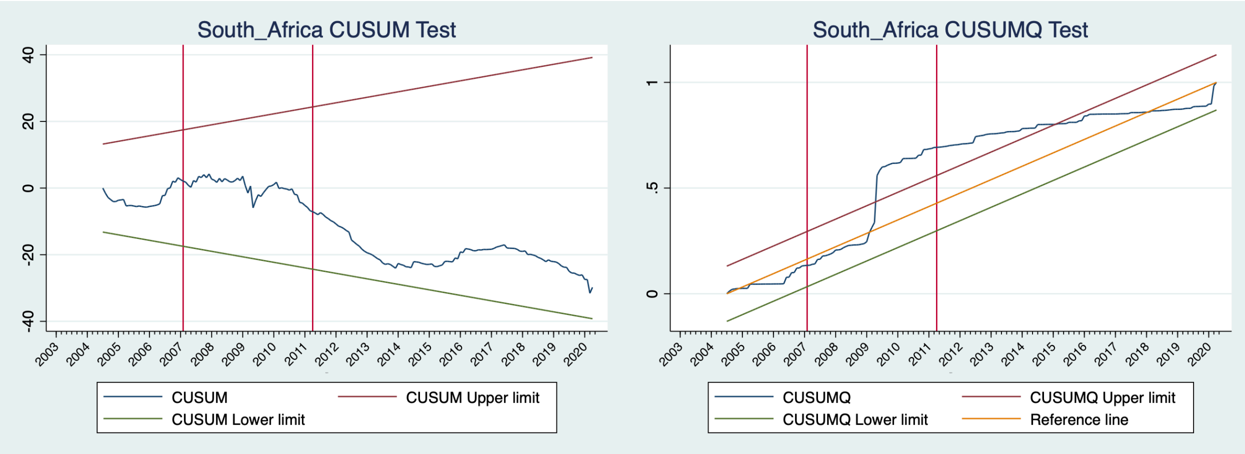
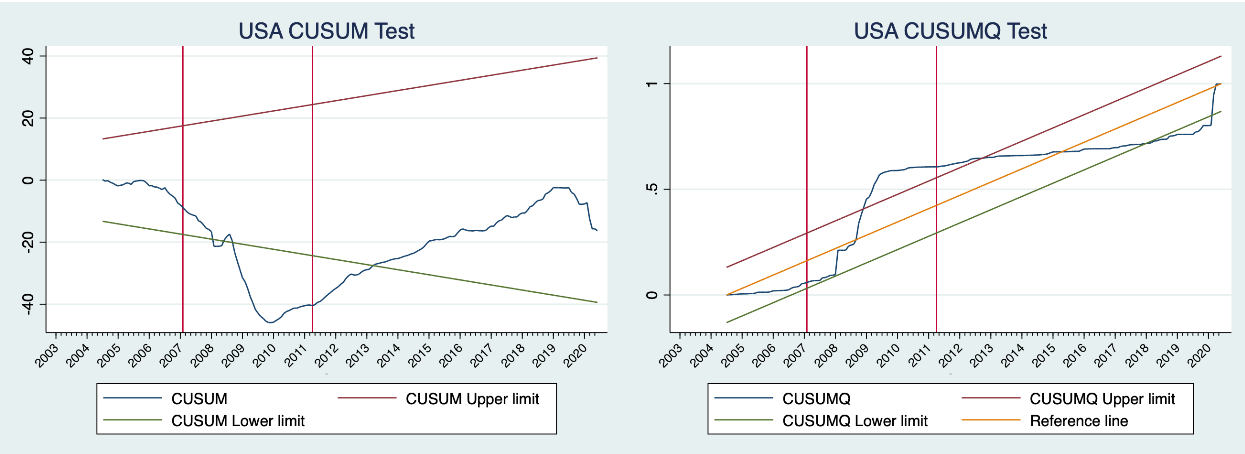
2019
2020
CUSUM
CUSUM Upper limit
CUSUM Lower limit
Israel CUSUMQ Test
1
.5
0
CUSUMQ
CUSUMQ Upper limit
CUSUMQ Lower limit
Reference line

10.4 Structural Break Tests: January 2004 – June 2020

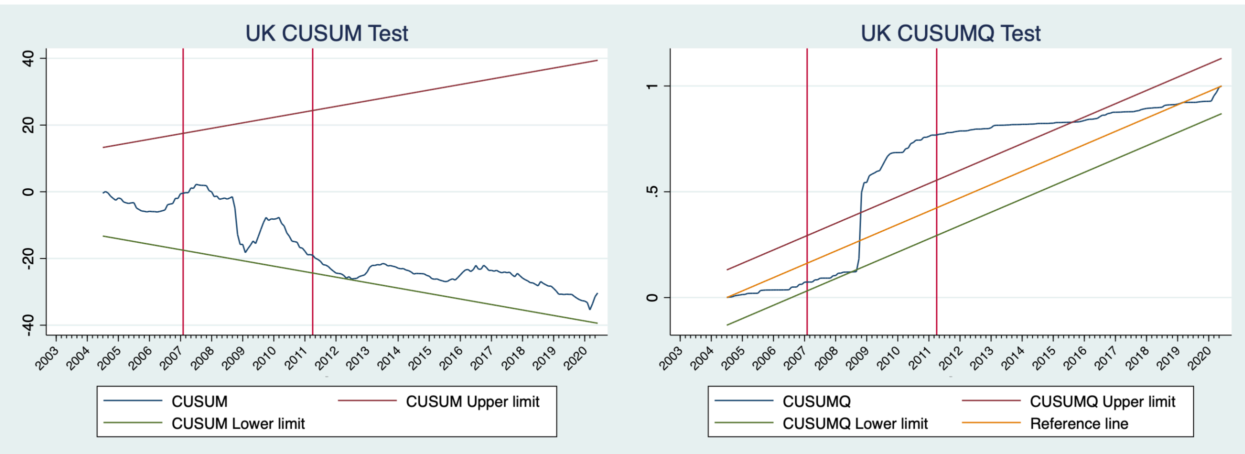
South Africa



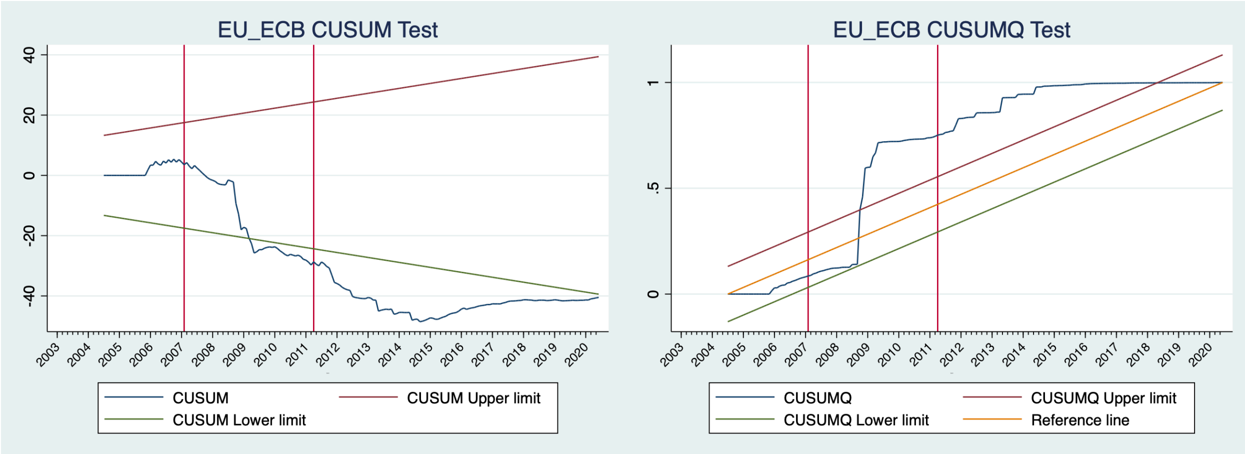
US



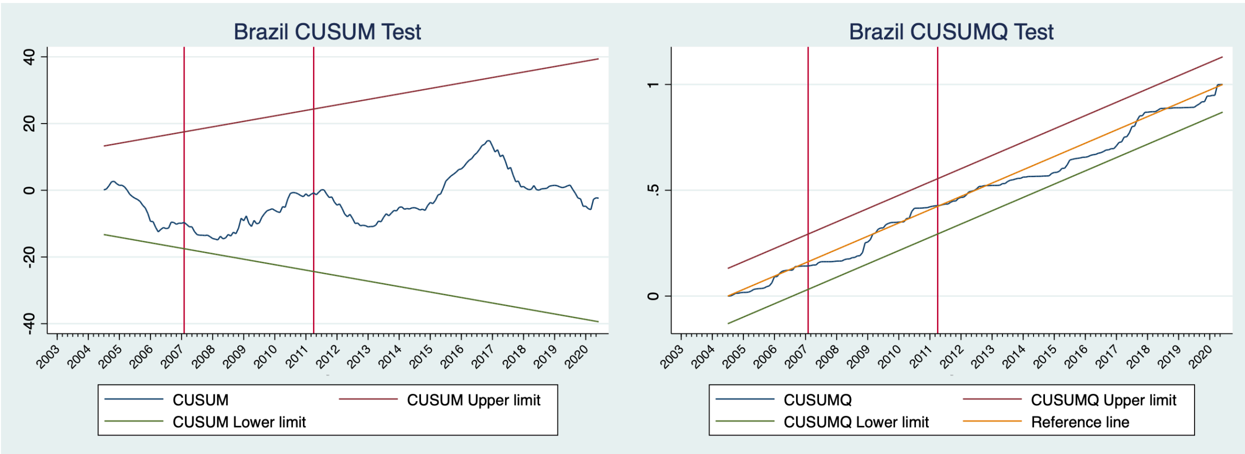
UK



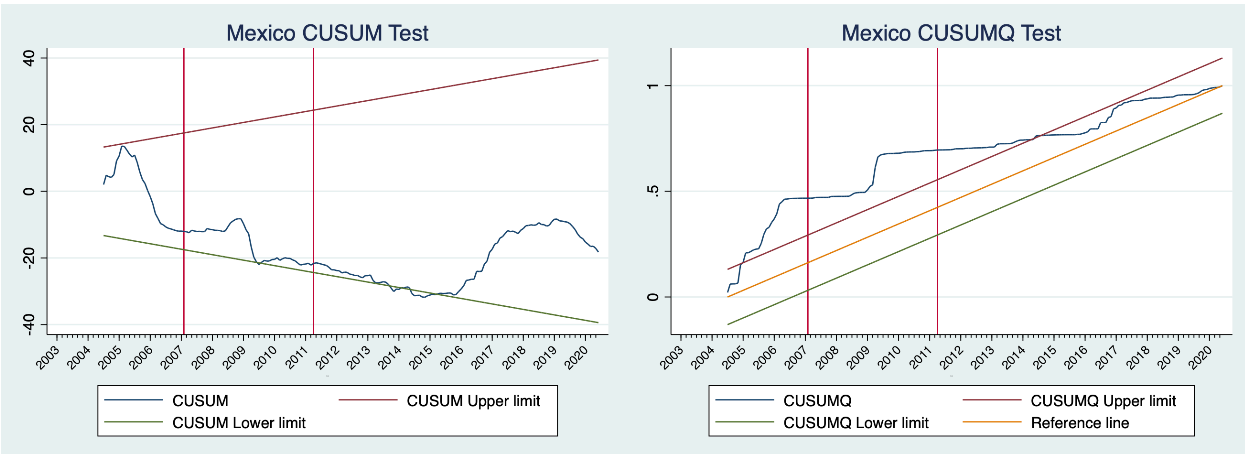
EU (ECB)



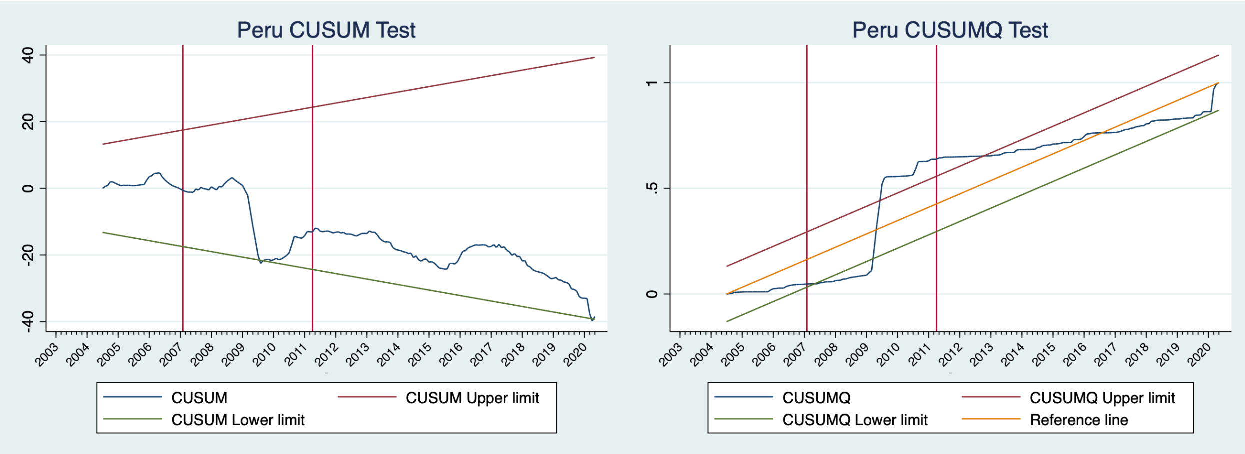
Brazil



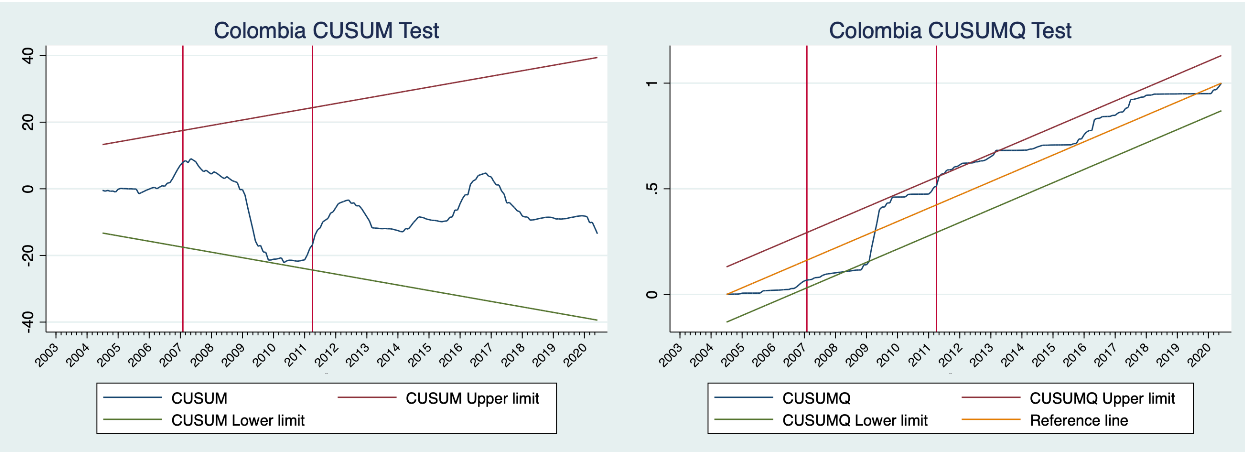
Mexico



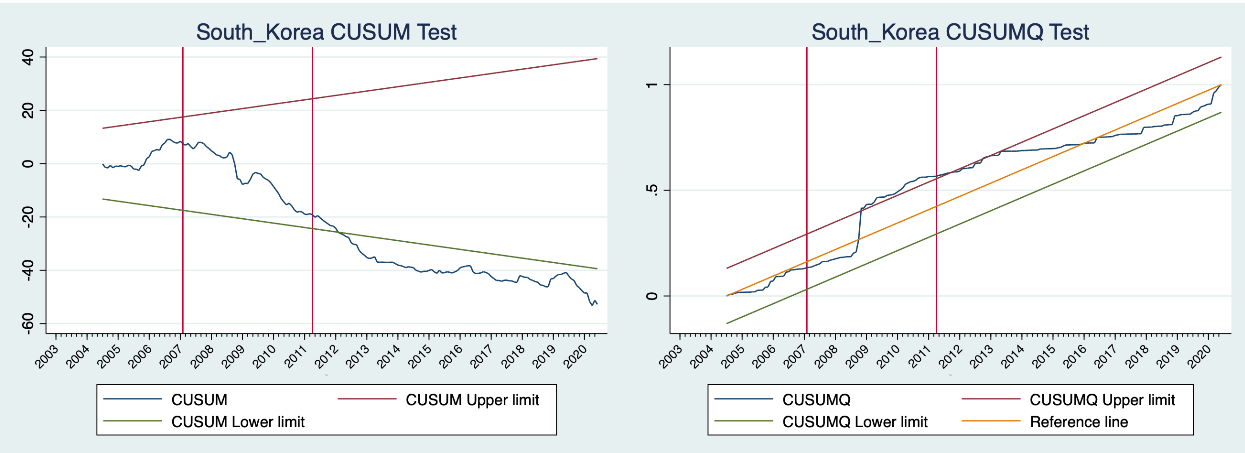
Peru



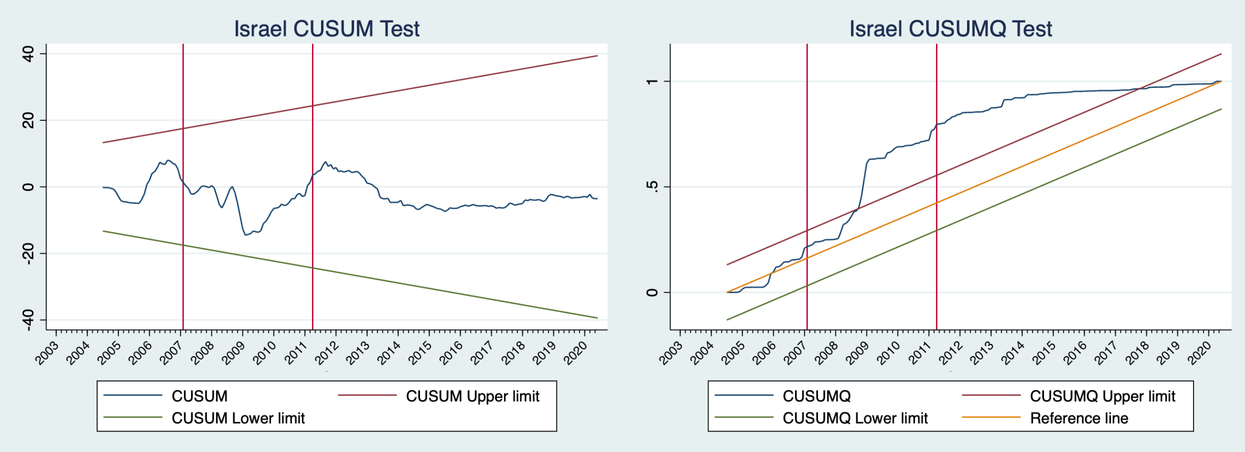
Colombia



South Korea



Israel


Israel CUSUM Test
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2020
CUSUM
CUSUM Upper limit
CUSUM Lower limit
Israel CUSUMQ Test
1
.5
0
CUSUMQ
CUSUMQ Upper limit
CUSUMQ Lower limit
Reference line

10.5 Empirical Results: Structural Break Regressions and Markov-switching Regression

South Africa Pre-and-Post Financial Crisis Regressions

	Pre-Break (January 2000 – May 2009)				Post-Break (June 2009 – April 2020)				Wald Test
Policy Rate	**Coefficient**	**Robust St. Err**	**OLS P > |t|**	**NW P > |t|**	**Coefficient**	**Robust St. Err**	**OLS P > |t|**	**NW P > |t|**	**Prob > chi2**
L1.Policy Rate	.9671383***	.0161098	0.000	0.000	.9970334***	.0163212	0.000	0.000	0.1879
Inflation	.0106729	.0075824	0.162	0.125	.0215419***	.0058614	0.000	0.001	0.2507
Output Gap	.053618***	.0133898	0.000	0.000	.014775***	.002185	0.000	0.000	0.0035***
RER	.0004907	.0007513	0.515	0.514	.0001348	.0005566	0.812	0.818	0.6997
Constant	.1878623	.1357463	0.169	0.146	-.1079608	.1035062	0.307	0.272	
Long run response to inflation	.32478265				7.2616153				
Number of observations	113				131				
R-squared	0.9672				0.9609				
F-test	1307.26				1399.06				
Prob > F	0.0000				0.0000				

*** p<0.01, ** p<0.05, * p<0.1

South Africa Markov-switching Regressions

	State 1			State 2			Wald Test
Policy Rate	**Coefficient**	**Robust St. Err**	**P > |z|**	**Coefficient**	**Robust St. Err**	**P > |z|**	**Prob > chi2**
L1.Policy Rate	.9066523***	.043101	0.000	1.004197***	.0052395	0.000	0.0272**
Inflation	.0343435	.0239426	0.151	.0119154***	.0041095	0.004	0.3636
Output Gap	.0891239***	.0278996	0.001	.0166032***	.0026843	0.000	0.0098***
RER	.0019279	.0032223	0.550	-.0001591	.0003009	0.597	0.5211
Constant	.1341157	.4996329	0.788	-.0777629*	.0473047	0.100	
Long run response to inflation	.367909			-2.839028			
p11	.2232879						
p21				.0665428			
Expected duration	1.287478			15.02793			
Number of observations	244						
sigma	.1958952						

*** p<0.01, ** p<0.05, * p<0.1

US Pre-and-Post Financial Crisis Regressions

	Pre-Break (January 2000 – December 2007)				Post-Break (January 2008 – June 2020)				Wald Test
Policy Rate	**Coefficient**	**Robust St. Err**	**OLS P > |t|**	**NW P > |t|**	**Coefficient**	**Robust St. Err**	**OLS P > |t|**	**NW P > |t|**	**Prob > chi2**
L1.Policy Rate	.9474221***	.0196065	0.000	0.000	.9122644***	.0258048	0.000	0.000	0.2691
Inflation	.0025884	.005871	0.660	0.608	.0147883***	.0036911	0.000	0.003	0.0721*
Output Gap	.0346115**	.0145866	0.020	0.158	.0071386**	.0030944	0.022	0.064	0.0591*
RER	.0011108	.0013499	0.413	0.365	-.0016814	.0012532	0.182	0.175	0.1219
Constant	.137232**	.0618049	0.029	0.138	.0188178	.0123273	0.129	0.269	
Long run response to inflation	.04922981				.16855549				
Number of observations	96				150				
R-squared	0.9910				0.9743				
F-test	3465.48				405.70				
Prob > F	0.0000				0.0000				

*** p<0.01, ** p<0.05, * p<0.1

US Markov-switching Regression

	State 1			State 2			Wald Test
Policy Rate	**Coefficient**	**Robust St. Err**	**P > |z|**	**Coefficient**	**Robust St. Err**	**P > |z|**	**Prob > chi2**
L1.Policy Rate	1.023986***	.0241664	0.000	1.013094***	.0046199	0.000	0.6574
Inflation	-.0009	.0070185	0.898	.002185	.0018449	0.236	0.6632
Output Gap	.0004182	.0074899	0.955	.0010996	.0013548	0.417	0.9274
RER	-.0053736***	.001449	0.000	-.0003538	.0004121	0.391	0.0006***
Constant	-.4587712***	.1016549	0.000	.006498	.0071942	0.366	
Long run response to inflation	.0375219			-.16687032			
p11	.80118						
p21				.0271871			
Expected duration	5.029676			36.78216			
Number of observations	246						
sigma	.0951715						

*** p<0.01, ** p<0.05, * p<0.1

UK Pre-and-Post Financial Crisis Regressions

	Pre-Break (January 2000 – October 2008)				Post-Break (November 2008 – June 2020)				Wald Test
Policy Rate	**Coefficient**	**Robust St. Err**	**OLS P > |t|**	**NW P > |t|**	**Coefficient**	**Robust St. Err**	**OLS P > |t|**	**NW P > |t|**	**Prob > chi2**
L1.Policy Rate	.9552287***	.0209696	0.000	0.000	.6525278***	.013165	0.000	0.000	0.0000***
Inflation	-.0076069**	.0035729	0.036	0.043	-.0013355	.0015341	0.386	0.402	0.0995*
Output Gap	.0185034*	.0083411	0.029	0.081	.009624***	.0013837	0.000	0.000	0.2830
RER	.0014463**	.0007236	0.048	0.029	.0005963	.0003889	0.128	0.105	0.2907
Constant	.2107556*	.0960437	0.031	0.097	.1723985***	.0095855	0.000	0.000	
Long run response to inflation	-.16990658				-.00384336				
Number of observations	106				140				
R-squared	0.9692				0.9507				
F-test	1092.50				768.00				
Prob > F	0.0000				0.0000				

*** p<0.01, ** p<0.05, * p<0.1

UK Markov-switching Regression

	State 1			State 2			Wald Test
Policy Rate	**Coefficient**	**Robust St. Err**	**P > |z|**	**Coefficient**	**Robust St. Err**	**P > |z|**	**Prob > chi2**
L1.Policy Rate	.8029554***	.0326986	0.000	.9982149***	.0028273	0.000	0.0000***
Inflation	-.0657388***	.0135159	0.000	-.0044156**	.001888	0.019	0.0000***
Output Gap	.0699562***	.0230517	0.002	.0035137**	.0016237	0.030	0.0039***
RER	.0121048***	.0018408	0.000	.0005337**	.0002649	0.044	0.0000***
Constant	.3305878**	.153548	0.031	.0132108**	.0053118	0.013	
Long run response to inflation	-.33362396			-2.47358691			
p11	.5901559						
p21				.0160064			
Expected duration	2.439952			62.47504			
Number of observations	246						
sigma	.0834673						

*** p<0.01, ** p<0.05, * p<0.1

EU (ECB) Pre-and-Post Financial Crisis Regressions

	Pre-Break (January 2000 – August 2008)				Post-Break (September 2008 – June 2020)				Wald Test
Policy Rate	**Coefficient**	**Robust St. Err**	**OLS P > |t|**	**NW P > |t|**	**Coefficient**	**Robust St. Err**	**OLS P > |t|**	**NW P > |t|**	**Prob > chi2**
L1.Policy Rate	.9609398***	.0209433	0.000	0.000	.9257484***	.0264076	0.000	0.000	0.2875
Inflation	.000164	.0031793	0.959	0.960	.0019763	.0016257	0.226	0.179	0.6042
Output Gap	.0293766**	.0123654	0.019	0.035	.0030214	.0062612	0.630	0.659	0.0521*
RER	.0000246	.0009739	0.980	0.973	-.0009895	.0010779	0.360	0.321	0.4769
Constant	.1643703**	.0773769	0.036	0.092	.0402889**	.0199525	0.045	0.036	
Long run response to inflation	.00419761				.02661673				
Number of observations	104				142				
R-squared	0.9760				0.9821				
F-test	1569.80				378.02				
Prob > F	0.0000				0.0000				

*** p<0.01, ** p<0.05, * p<0.1

EU (ECB) Markov-switching Regression

	State 1			State 2			Wald Test
Policy Rate	**Coefficient**	**Robust St. Err**	**P > |z|**	**Coefficient**	**Robust St. Err**	**P > |z|**	**Prob > chi2**
L1.Policy Rate	.9109344***	.0392485	0.000	1.007502***	.0034241	0.000	0.0139**
Inflation	.0059949	.0147281	0.684	-4.51e-06	.0007741	0.995	0.6823
Output Gap	-.0199777	.0270418	0.460	.0025949	.0022958	0.258	0.4058
RER	-.0025451***	.000901	0.005	-6.79e-06	.00049	0.989	0.0101**
Constant	-.1964629*	.1168683	0.093	-.0021685	.0051968	0.676	
Long run response to inflation	.06730882			.0006012			
p11	.3089793						
p21				.0472466			
Expected duration	1.447135			21.16555			
Number of observations	246						
sigma	.0820463						

*** p<0.01, ** p<0.05, * p<0.1

Brazil Pre-and-Post Financial Crisis Regressions

	Pre-Break (January 2000 – January 2009)				Post-Break (February 2009 – June 2020)				Wald Test
Policy Rate	**Coefficient**	**Robust St. Err**	**OLS P > |t|**	**NW P > |t|**	**Coefficient**	**Robust St. Err**	**OLS P > |t|**	**NW P > |t|**	**Prob > chi2**
L1.Policy Rate	.9793538***	.0190343	0.000	0.000	1.015366***	.0142063	0.000	0.000	0.1220
Inflation	.0559246***	.0172853	0.002	0.000	.019378**	.008774	0.029	0.068	0.0543*
Output Gap	.0365384*	.0195213	0.064	0.058	.0264829**	.0117537	0.026	0.044	0.6525
RER	-.0019518	.001526	0.204	0.295	.0000499	.0006987	0.943	0.944	0.2234
Constant	-.0816996	.282874	0.773	0.802	-.3262621**	.1284481	0.012	0.018	
Long run response to inflation	2.7087102				-1.2610931				
Number of observations	109				137				
R-squared	0.9739				0.9854				
F-test	923.77				3068.07				
Prob > F	0.0000				0.0000				

*** p<0.01, ** p<0.05, * p<0.1

Brazil Markov-switching Regression

	State 1			State 2			Wald Test
Policy Rate	**Coefficient**	**Robust St. Err**	**P > |z|**	**Coefficient**	**Robust St. Err**	**P > |z|**	**Prob > chi2**
L1.Policy Rate	.9203594***	.0176052	0.000	1.016016***	.0071742	0.000	0.0000***
Inflation	-.0302629**	.0131217	0.021	.0431871***	.0111353	0.000	0.0000***
Output Gap	.1015134***	.0128865	0.000	.0135178	.0091704	0.140	0.0000***
RER	.0041849***	.0015806	0.008	-.0021629**	.0008947	0.016	0.0004***
Constant	.8711478***	.2281743	0.000	-.4540354***	.1094748	0.000	
Long run response to inflation	-.37999337			-2.69649725			
p11	.9063416						
p21				.036588			
Expected duration	10.6771			27.33136			
Number of observations	246						
sigma	.3798271						

*** p<0.01, ** p<0.05, * p<0.1

Mexico Pre-and-Post Financial Crisis Regressions

	Pre-Break (January 2000 – January 2009)				Post-Break (February 2009 – June 2020)				Wald Test
Policy Rate	**Coefficient**	**Robust St. Err**	**OLS P > |t|**	**NW P > |t|**	**Coefficient**	**Robust St. Err**	**OLS P > |t|**	**NW P > |t|**	**Prob > chi2**
L1.Policy Rate	.9428638***	.0256179	0.000	0.000	.9789207***	.0087473	0.000	0.000	0.1738
Inflation	.0383046**	.0184068	0.040	0.069	.0053877*	.0028561	0.061	0.125	0.0710*
Output Gap	.0100597	.0138836	0.470	0.422	.0152826***	.0031607	0.000	0.002	0.7079
RER	.0034225	.0025075	0.175	0.202	-.0002246	.0002305	0.332	0.297	0.1389
Constant	.2196789	.222844	0.327	0.400	.0845098*	.0439787	0.057	0.187	
Long run response to inflation	.67040914				.25559325				
Number of observations	109				137				
R-squared	0.9578				0.9901				
F-test	570.48				5109.19				
Prob > F	0.0000				0.0000				

*** p<0.01, ** p<0.05, * p<0.1

Mexico Markov-switching Regression

	State 1			State 2			Wald Test
Policy Rate	**Coefficient**	**Robust St. Err**	**P > |z|**	**Coefficient**	**Robust St. Err**	**P > |z|**	**Prob > chi2**
L1.Policy Rate	1.020309***	.0232281	0.000	1.0201***	.0192199	0.000	0.9948
Inflation	.1105393***	.0172641	0.000	.0094456*	.0050116	0.059	0.0000***
Output Gap	-.116538***	.0120776	0.000	.0076263	.0056607	0.178	0.0000***
RER	.0013007	.0038883	0.738	.000212	.0005062	0.675	0.7812
Constant	-2.388178***	.246567	0.000	-.1248669	.1184473	0.292	
Long run response to inflation	-5.44287262			-.46993035			
p11	.5763172						
p21				.0394687			
Expected duration	2.360257			25.33654			
Number of observations	246						
sigma	.3241544						

*** p<0.01, ** p<0.05, * p<0.1

Colombia Pre-and-Post Financial Crisis Regressions

	Pre-Break (January 2000 – January 2009)				Post-Break (February 2009 – June 2020)				Wald Test
Policy Rate	**Coefficient**	**Robust St. Err**	**OLS P > |t|**	**NW P > |t|**	**Coefficient**	**Robust St. Err**	**OLS P > |t|**	**NW P > |t|**	**Prob > chi2**
L1.Policy Rate	.9766548***	.0138266	0.000	0.000	.9037843***	.0250559	0.000	0.000	0.0105**
Inflation	.0056756	.0077881	0.468	0.496	.0255075***	.0075609	0.001	0.014	0.0647*
Output Gap	.0121006	.0185827	0.516	0.681	.0276831**	.0113101	0.017	0.107	0.4669
RER	.0005457	.000495	0.273	0.286	-.0002664	.0005939	0.660	0.681	0.2894
Constant	.1315875	.0935276	0.162	0.288	.2995537***	.098269	0.003	0.065	
Long run response to inflation	.24311836				.26510719				
Number of observations	109				137				
R-squared	0.9842				0.9654				
F-test	2413.92				502.09				
Prob > F	0.0000				0.0000				

*** p<0.01, ** p<0.05, * p<0.1

Colombia Markov-switching Regression

	State 1			State 2			Wald Test
Policy Rate	**Coefficient**	**Robust St. Err**	**P > |z|**	**Coefficient**	**Robust St. Err**	**P > |z|**	**Prob > chi2**
L1.Policy Rate	.9176357***	.0157525	0.000	.9866532***	.0066737	0.000	0.0000***
Inflation	.0190047**	.0129334	0.041	.0064159	.0070462	0.363	0.3108
Output Gap	-.0575296**	.0332902	0.013	.0104878	.0080585	0.193	0.0466**
RER	.0001375	.0008461	0.836	-.0000565	.0004516	0.900	0.8399
Constant	.0431959	.1025186	0.645	.0991672***	.038073	0.009	
Long run response to inflation	.23074395			.48070699			
p11	.9117584						
p21				.0299596			
Expected duration	11.33252			33.37826			
Number of observations	246						
sigma	.1993931						

*** p<0.01, ** p<0.05, * p<0.1

Peru Pre-and-Post Financial Crisis Regressions

	Pre-Break (January 2000 – January 2009)				Post-Break (February 2009 – June 2020)				Wald Test
Policy Rate	**Coefficient**	**Robust St. Err**	**OLS P > |t|**	**NW P > |t|**	**Coefficient**	**Robust St. Err**	**OLS P > |t|**	**NW P > |t|**	**Prob > chi2**
L1.Policy Rate	1.017516***	.0112808	0.000	0.000	.9506393***	.0217273	0.000	0.000	0.0053***
Inflation	.0042534	.0043831	0.336	0.367	.0200203***	.0068104	0.004	0.027	0.0465**
Output Gap	-.0012242	.0022759	0.593	0.613	.0122898***	.0033982	0.000	0.005	0.0007***
RER	.000132	.0011915	0.912	0.862	.0018205	.001537	0.238	0.141	0.3737
Constant	-.0254309	.0478883	0.597	0.674	.0747598	.0687337	0.279	0.376	
Long run response to inflation	-.2428249				.40559247				
Number of observations	64				136				
R-squared	0.9921				0.9576				
F-test	2038.68				709.52				
Prob > F	0.0000				0.0000				

*** p<0.01, ** p<0.05, * p<0.1

Peru Markov-switching Regression

	State 1			State 2			Wald Test
Policy Rate	**Coefficient**	**Robust St. Err**	**P > |z|**	**Coefficient**	**Robust St. Err**	**P > |z|**	**Prob > chi2**
L1.Policy Rate	.9359181***	.0236246	0.000	.9921834***	.0090486	0.000	0.0261**
Inflation	-.0063033**	.0031377	0.045	.0069986**	.0028548	0.014	0.0017***
Output Gap	.0065842**	.0028215	0.020	.0000125	.001279	0.992	0.0339**
RER	-.0027774*	.0015189	0.067	.0002445	.0007471	0.743	0.0742*
Constant	-.647643***	.1196898	0.000	.0294056	.0339802	0.387	
Long run response to inflation	-.09836319			.89535092			
p11	.7108116						
p21				.0102404			
Expected duration	3.457953			97.65207			
Number of observations	200						
sigma	.1224452						

*** p<0.01, ** p<0.05, * p<0.1

South Korea Pre-and-Post Financial Crisis Regressions

	Pre-Break (January 2000 – X)				Post-Break (X – X)				Wald Test
Policy Rate	**Coefficient**	**Robust St. Err**	**OLS P > |t|**	**NW P > |t|**	**Coefficient**	**Robust St. Err**	**OLS P > |t|**	**NW P > |t|**	**Prob > chi2**
L1.Policy Rate	.9717699***	.0154824	0.000	0.000	.9478325***	.0147841	0.000	0.000	0.2543
Inflation	-.0008648	.0017658	0.625	0.599	.0029507	.0019126	0.125	0.108	0.1352
Output Gap	.0125853***	.0031779	0.000	0.003	.0227425***	.003277	0.000	0.000	0.0233**
RER	-.0001847	.0005921	0.756	0.773	.0010767***	.0003718	0.004	0.005	0.0655*
Constant	.1231013*	.0660414	0.065	0.099	.0752392**	.0320123	0.020	0.060	
Long run response to inflation	-.0306343				.05656122				
Number of observations	105				141				
R-squared	0.9778				0.9833				
F-test	1497.30				1536.13				
Prob > F	0.0000				0.0000				

*** p<0.01, ** p<0.05, * p<0.1

South Korea Markov-switching Regression

	State 1			State 2			Wald Test
Policy Rate	**Coefficient**	**Robust St. Err**	**P > |z|**	**Coefficient**	**Robust St. Err**	**P > |z|**	**Prob > chi2**
L1.Policy Rate	.9729864***	.0186226	0.000	1.005276***	.004785	0.000	0.1063
Inflation	.0195481***	.0049707	0.000	-.0004797	.0010545	0.649	0.0001***
Output Gap	.0276135***	.0036192	0.000	.0067261***	.002119	0.002	0.0000***
RER	.0012062	.0014054	0.391	.000497**	.0002169	0.022	0.6237
Constant	-.085409	.0850979	0.316	-.009717	.0148608	0.513	
Long run response to inflation	.72363920			.09092115			
p11	.6172064						
p21				.0472409			
Expected duration	2.612374			21.16808			
Number of observations	246						
sigma	.0748382						

*** p<0.01, ** p<0.05, * p<0.1

Israel Pre-and-Post Financial Crisis Regressions

	Pre-Break (January 2000 – X)				Post-Break (X – X)				Wald Test
Policy Rate	**Coefficient**	**Robust St. Err**	**OLS P > |t|**	**NW P > |t|**	**Coefficient**	**Robust St. Err**	**OLS P > |t|**	**NW P > |t|**	**Prob > chi2**
L1.Policy Rate	.9604163***	.0123217	0.000	0.000	.9580104***	.0185658	0.000	0.000	0.9125
Inflation	.0125402	.0109996	0.257	0.364	.0022845	.0037139	0.540	0.539	0.3667
Output Gap	.0020595	.0039105	0.600	0.596	.0006616	.002157	0.760	0.715	0.7493
RER	-.0066124*	.0036525	0.073	0.059	-.0026649**	.0011593	0.023	0.054	0.2924
Constant	.1586545**	.0681939	0.022	0.118	.0098942	.0124537	0.428	0.543	
Long run response to inflation	.3168028				.05440627				
Number of observations	105				141				
R-squared	0.9647				0.9765				
F-test	1893.18				718.08				
Prob > F	0.0000				0.0000				

*** p<0.01, ** p<0.05, * p<0.1

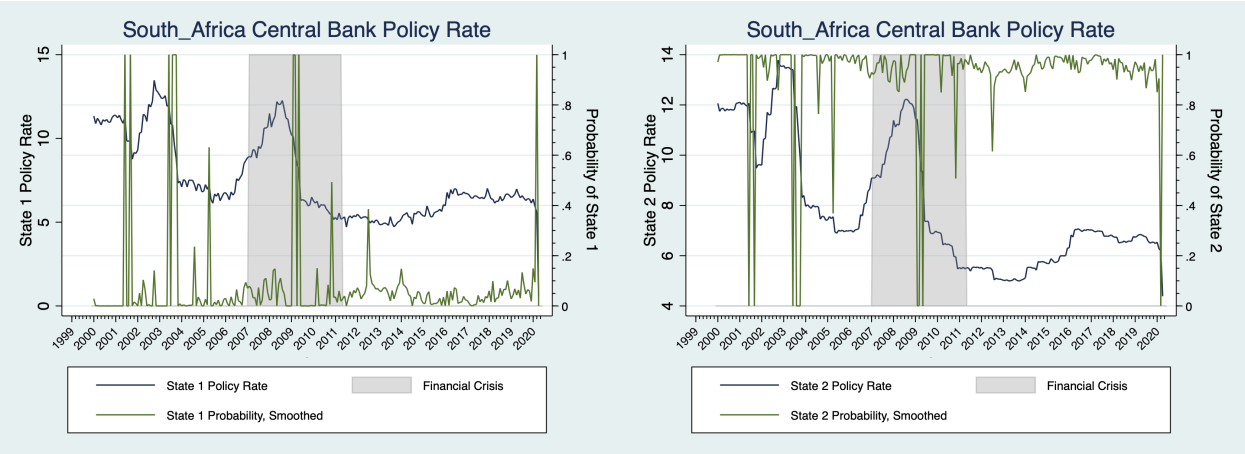
Israel Markov-switching Regression

	State 1			State 2			Wald Test
Policy Rate	**Coefficient**	**Robust St. Err**	**P > |z|**	**Coefficient**	**Robust St. Err**	**P > |z|**	**Prob > chi2**
L1.Policy Rate	.9751117***	.0037713	0.000	1.004035***	.0693816	0.000	0.6772
Inflation	.0038049	.003174	0.231	.1283229***	.0240469	0.000	0.0000***
Output Gap	.0007566	.0019271	0.695	.1073845***	.0161325	0.000	0.0000***
RER	-.0024483***	.000793	0.002	-.0518848***	.0024479	0.000	0.0000***
Constant	.0084028	.0128049	0.512	.4591046	.6065367	0.449	
Long run response to inflation	.15287906			-31.8024535			
p11	.9955769						
p21				.1427436			
Expected duration	226.0859			7.005569			
Number of observations	246						
sigma	.1836147						

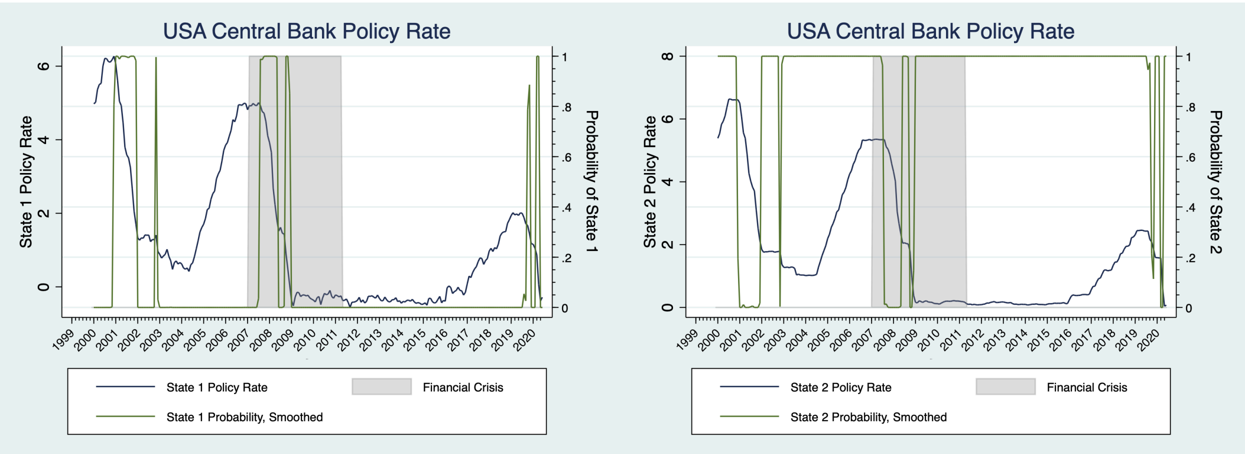
*** p<0.01, ** p<0.05, * p<0.1

10.6 Markov-switching Regressions Graphical Output

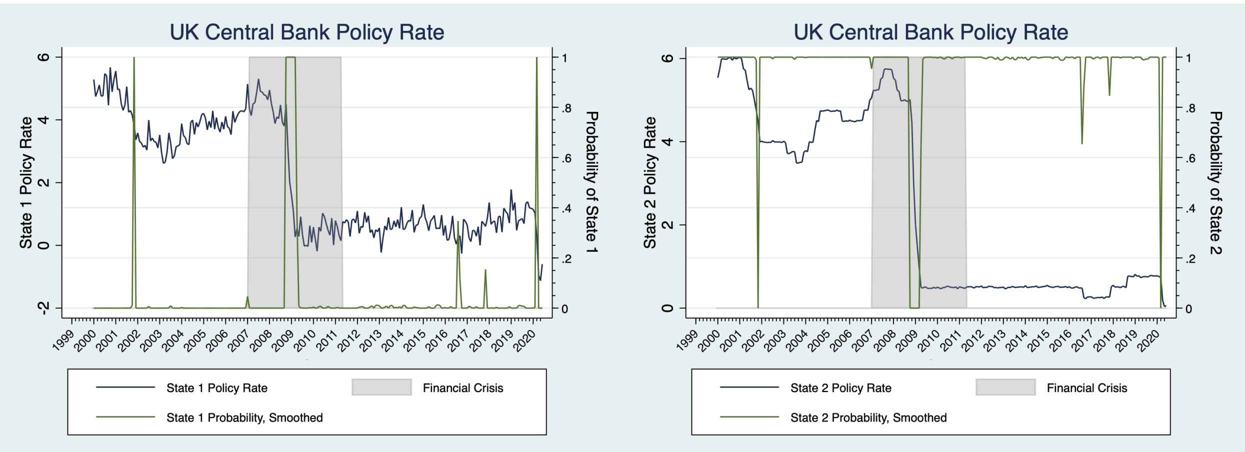
South Africa



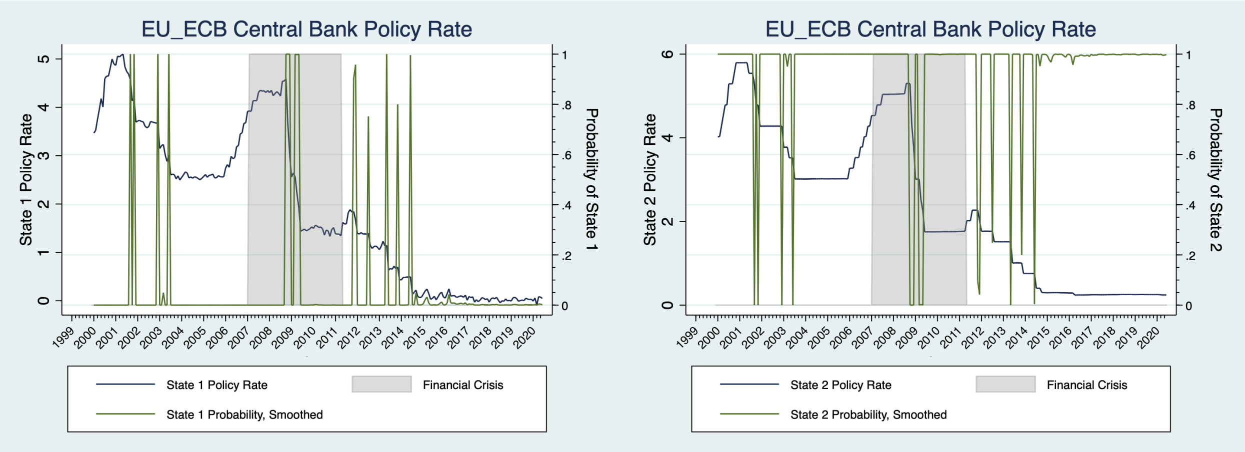
US



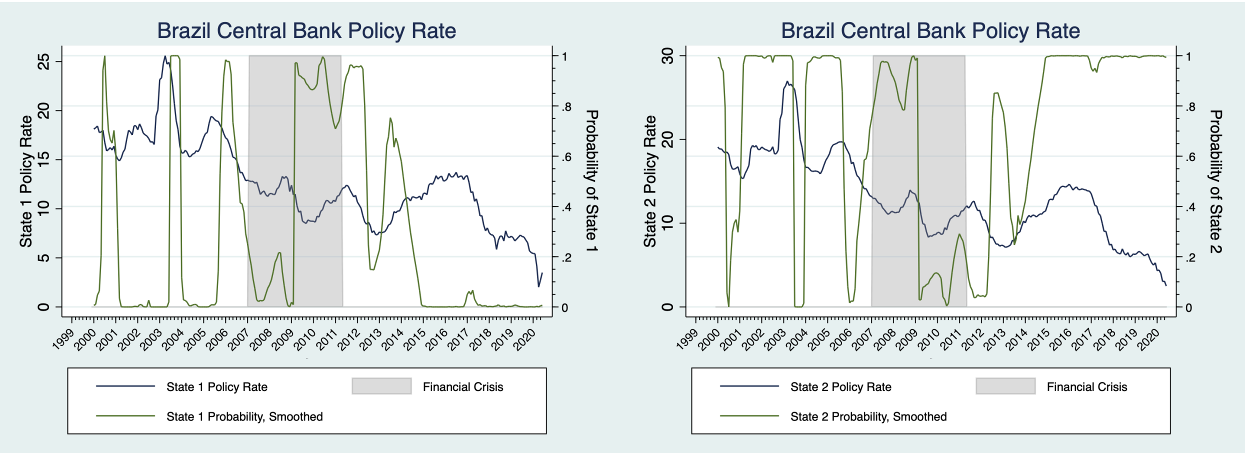
UK



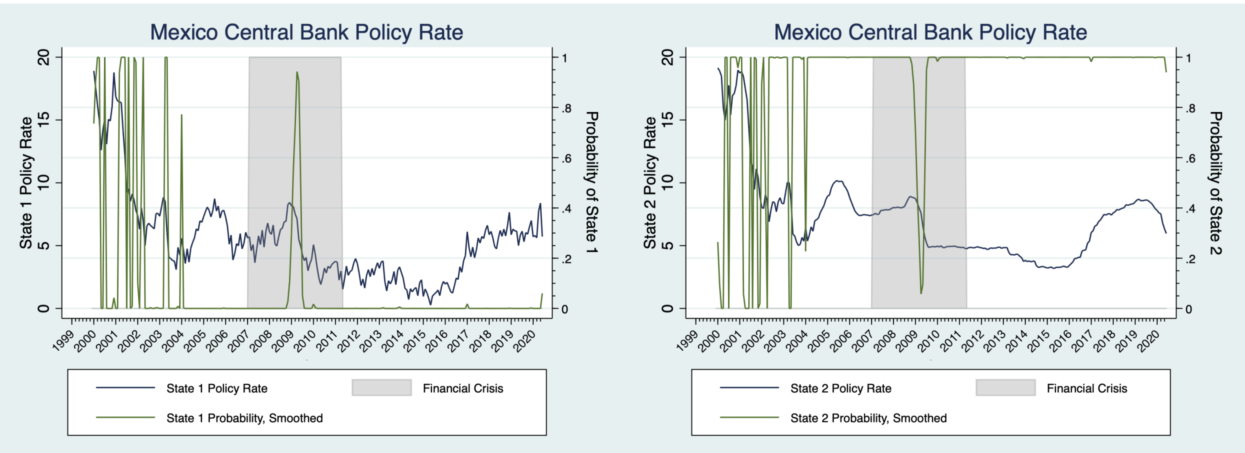
EU (ECB)



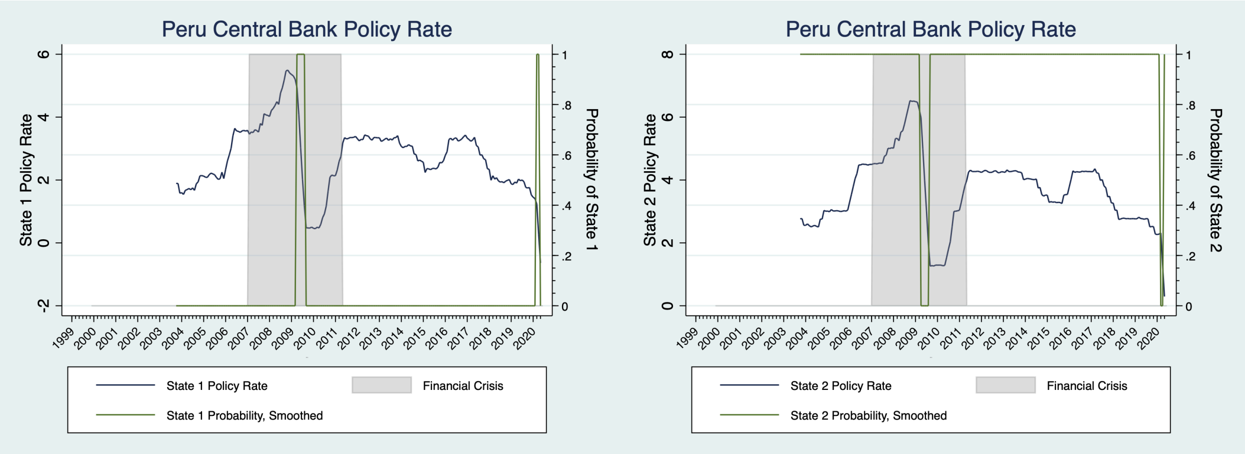
Brazil



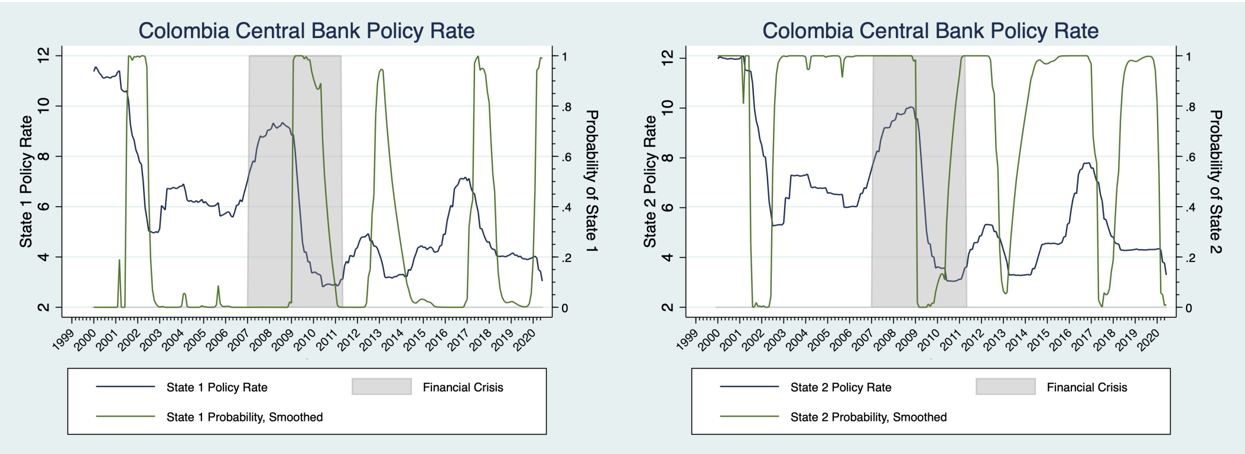
Mexico



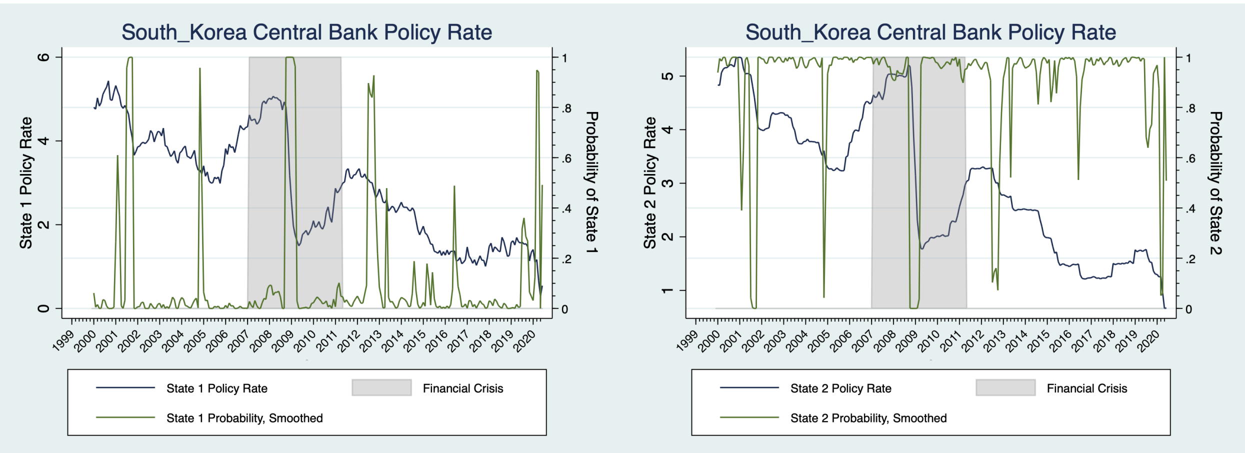
Peru



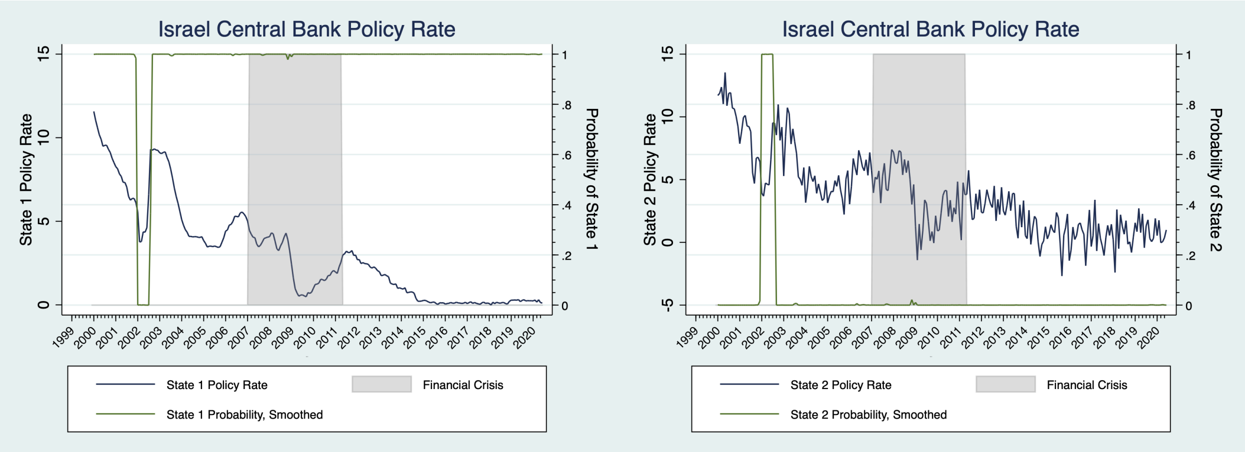
Colombia



South Korea



Israel


Israel Central Bank Policy Rate
State 1 Policy Rate
Probability of State 1
State 1 Policy Rate
Financial Crisis
State 1 Probability, Smoothed
Israel Central Bank Policy Rate
State 2 Policy Rate
Probability of State 2
State 2 Policy Rate
Financial Crisis
State 2 Probability, Smoothed