IDB WORKING PAPER SERIES Nº IDB-WP-1482

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Eric Parrado

Inter-American Development Bank
Department of Research and Chief Economist

December 2023

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Cataloging-in-Publication data provided by the
Inter-American Development Bank
Felipe Herrera Library

Parrado, Eric.

An exchange rate policy rule / Eric Parrado.
p. cm. — (IDB Working Paper Series ; 1482)
Includes bibliographical references.
1. Foreign exchange rates-Singapore. 2. Inflation (Finance)-Singapore. 3. Monetary policy-Singapore. I. Inter-American Development Bank. Department of Research and Chief Economist. II. Title. III. Series.
IDB-WP-1482

http://www.iadb.org

Abstract

This paper introduces a novel monetary policy framework where the exchange rate becomes the central instrument. Using Singapore as a case study, it explores the Monetary Authority's adoption of the exchange rate as the primary tool since 1981, diverging from conventional approaches centered on interest rates or monetary aggregates. The estimated exchange rate reaction function aligns well with actual deviations, supporting the hypothesis that Singapore's forward-looking policy rule effectively responds to inflation and output volatility, especially during economic crises. This framework offers a promising alternative for countries with open economies and challenges in implementing traditional interest rate instruments.

JEL classifications: E31, E52, E58, F41
Keywords: exchange rate, inflation, monetary policy rules, Singapore

1. Introduction

Increasing globalization and growing international capital flows have presented significant challenges in implementing effective monetary policy and selecting appropriate policy instruments. These challenges are particularly pronounced for small, open economies that strive to control inflation despite constant foreign shocks. Singapore, recognizing these challenges, adopted a monetary policy framework centered on managing the exchange rate, with the primary objective of promoting price stability as the foundation for sustainable economic growth. Consequently, traditional approaches such as the Taylor rule (Taylor, 1993) or the McCallum rule (McCallum, 1988), which use interest rates or monetary aggregates, respectively, as policy instruments, are inadequate for characterizing Singapore's monetary policy.

In this paper, I build upon Parrado (2004) by introducing a novel policy rule that places the exchange rate at the core of the monetary policy toolkit. Focusing on Singapore as a case study, I establish and evaluate a new reaction function to explore how changes in the trade-weighted nominal exchange rate respond to deviations in inflation and output deviations from their respective targets. The estimated reaction function reveals a forward-looking approach aimed at achieving stability in both inflation and output. The strong historical alignment indicates that this novel reaction function could serve as a valuable benchmark for characterizing monetary policy in Singapore.

Since 1981, the Monetary Authority of Singapore (MAS) has actively managed the Singapore dollar's exchange rate against a trade-weighted basket of currencies representing Singapore's major trading partners. The composition of this basket is periodically revised to accommodate changes in trade patterns, although specific details regarding the index and target-band boundaries remain undisclosed. The MAS guides the exchange rate to appreciate or depreciate through direct sales or purchases of the U.S. dollar in the foreign exchange market,[1] primarily influenced by the strength or weakness of expected inflationary pressures. In essence, the monetary policy pursued by the MAS follows an unconventional inflation targeting regime.[2]

As the MAS states, "The primary objective has been to promote price stability as a sound basis for sustainable economic growth. The exchange rate represents an ideal intermediate target of monetary policy in the context of the small and open Singapore economy. It is relatively

[1] Changes in international reserves Granger-cause changes in the exchange rate.
[2] See Parrado (2004) and McCallum (2014) for further details on monetary policy in Singapore.

controllable through direct interventions in the foreign exchange markets and bears a stable and predictable relationship with the price stability as the final target of policy over the medium-term."[3]

The paper is organized as follows. Section 2 provides a summary of Singapore's monetary/exchange rate policy framework, and its operation during the past four decades. Section 3 specifies and estimates a policy reaction function for Singapore. In addition, it provides robustness checks to test the stability of the exchange rate policy rule's coefficients. Section 4 summarizes the results and derives implications for monetary policy.

2. Background of Singapore's Monetary Framework

Singapore's exchange-rate-centered monetary policy framework has helped achieve a track record of low inflation with prolonged economic growth (see Figure 1). Taking advantage of Singapore's high saving rate, prudent fiscal policy,[4,5] and substantial foreign reserves, monetary policy has offset inflation pressures by guiding the exchange rate along an appreciating path. At first sight, a stable rate of inflation has been associated with an appreciating exchange rate. For instance, in the early 1980s a combination of oil price shocks and high capital flows intensified inflation pressures in the economy. However, by appreciating the trade-weighted exchange rate index (TWI) by 30 percent during 1981-1985 (averaging about 5 percent per year), inflationary pressures were contained.[6]

In 1985, Singapore suffered its first recession, caused largely by the deterioration in export competitiveness, a cyclical downturn in electronics, and the collapse of the construction boom. To regain competitiveness, a real depreciation was implemented through a reduction in business costs from a cut in employer pension contributions, and a depreciation of the nominal exchange rate. The TWI depreciated only by about 16 percent during the 1985-1988 period even though it depreciated sharply against the Japanese yen and German mark during the period of U.S. dollar strength following the Plaza Accord. After the economy recovered from the 1985 recession, fear of renewed inflation prompted the MAS to allow the TWI to appreciate from 1988 through 1997.

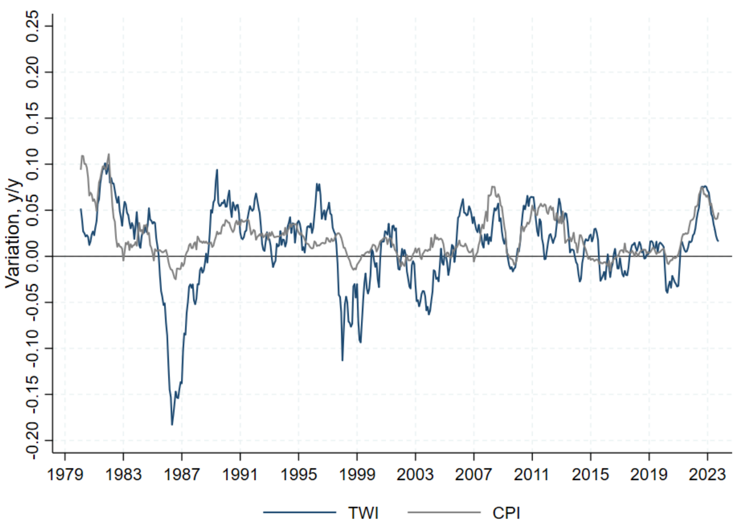
[3] Monetary Authority of Singapore (2012).
[4] Continued fiscal surpluses since 1980, except for 1987 and 2001/02, has released the MAS of the need to finance the government, allowing it to focus on its primarily responsibility of maintaining price stability.
[5] Nadal De Simone (2000) finds that in about 70 percent of the fiscal years between 1967 and 1995, the actual policy mix in Singapore was a contractionary fiscal policy accompanied by a contractionary monetary policy.
[6] Inflation in Singapore ended around 6 percent annually in the period 1981-82, which contrasts with the OECD average of nearly 11 percent.

This policy action limited inflationary pressures and precluded an overheated economy during the first half of the 1990s, when real GDP growth averaged almost 8 percent each year.

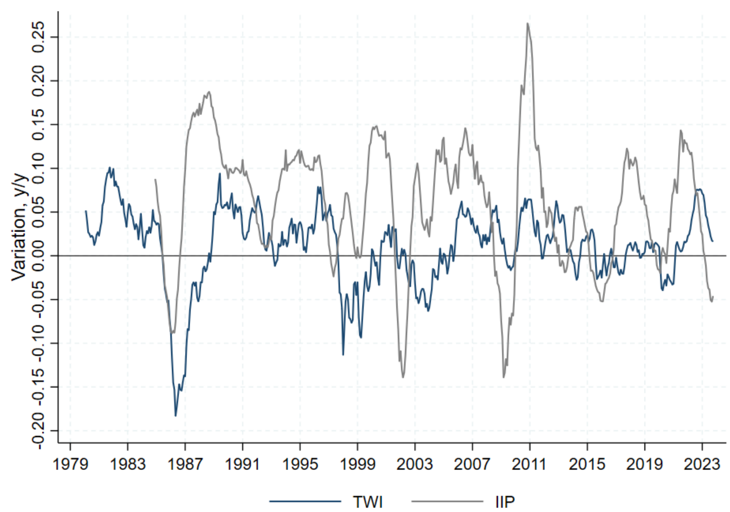
With the onset of the Asian crisis, the economy was buffeted by a strengthening of the Singapore dollar in effective terms, owing to the sharp depreciation of the regional currencies. Although the Singapore dollar weakened against the U.S. dollar, it strengthened significantly against the Indonesian rupiah, Thai baht, and Malaysian ringgit. As inflation eased and real GDP growth stalled, MAS ended its decade-long trend appreciation of the TWI, by easing policy and guiding the exchange rate to fluctuate within a zero-appreciation exchange rate band. The MAS also conducted monetary operations to ensure adequate liquidity in the money market, allowing domestic interest rates to decline.

Figure 1. Evolution of CPI, TWI, and IIP

A. CPI vs TWI



B. IIP vs TWI



In early 2000, against the backdrop of a favorable external environment and a strong rebound in the Singapore economy, monetary policy was tightened by inducing a gradual appreciation of the Singapore dollar on a trade-weighted basis. MAS announced in January 2001 that it would maintain this policy stance to limit inflation pressures, but economic conditions subsequently deteriorated by more than expected. Against the backdrop of a weak external economic environment, a protracted global electronics downturn, and subsiding inflationary pressures, the MAS eased the policy stance to a neutral setting in July 2001, with a policy band centered on a zero percent appreciation of the exchange rate.

During the global crisis of 2008, Singapore's economy experienced a widespread decline, shrinking by 16.4 percent in the fourth quarter of 2008 on a seasonally adjusted annualized basis compared to the previous quarter. This downturn was driven by a significant drop in global demand, leading to a rapid slowdown in sectors linked to trade, including manufacturing, wholesale trade, and transportation services. Additionally, the financial sector faced severe challenges due to instability in international financial markets. As a result, the MAS shifted its policy stance to zero appreciation in April of 2009 and returned to modest appreciation in October of 2010, when the economy rebounded considerably, and inflation rose to levels above 3 percent.

The outbreak of the COVID-19 pandemic hit the global economy, including Singapore. Most sectors were affected by the crisis, especially tourism, aviation, retail, and construction. That year, Singapore's economy fell 3.9 percent, and inflation was 0 percent, with deflation for 9 consecutive months. MAS opted for a zero-appreciation monetary policy, and the TWI fell nearly 3 percent in 2020.

During 2021 and 2022, Singapore's economy recovered, largely due to the easing of some COVID-19 restrictions, robust fiscal stimuli, and monetary policy easing. This recovery also brought with it demand pressures, which combined with persistent global supply chain disruptions and the onset of the war in Ukraine, contributed to a substantial rise in inflation. Price increases peaked in August of 2022, reaching 7.4 percent. In response to these inflationary pressures, the Monetary Authority of Singapore (MAS) tightened monetary policy by re-centering the mid-point of the Singapore dollar nominal effective exchange rate policy band and slightly increasing the rate of appreciation of the policy band.

With this background, the next sections analyze the determinants of inflation as a basis for specifying a policy reaction function that could reproduce these historical shifts in the policy stance. The impact of the direct effects of the exchange rate on inflation and its indirect effects through output changes will shed light on the transmission channels of monetary policy. The estimated reaction function would be used to gauge how changes in economic fundamentals influence changes in the monetary policy stance, as reflected in the changes in the TWI.

3. Exchange Rate Policy: A Proposal

3.1 Specification

Here, the conventional empirical policy reaction functions, in which a domestic interest rate or monetary aggregate is the policy variable, are modified to allow the monetary policy stance to be characterized by changes in the trade-weighted exchange rate index (TWI) or the Singapore dollar's nominal effective exchange rate.

The policy reaction function works as follows: Assume that within each operating period the MAS has a target for the change in the TWI, Δe_t^*, that is based on the state of the economy. Also assume that the MAS cares about stabilizing inflation and output, while allowing for the possibility that it adjusts its policy response to anticipated inflation and output. Specifically:

$$\Delta e_t^* = \bar{\Delta e} + \beta\left(E\left[\pi_{t+n} \mid \Omega_t\right] - \pi^*\right) + \gamma\left(E\left[y_{t+m} \mid \Omega_t\right] - y^*\right), \tag{1}$$

where $\bar{\Delta e}$ is the long-run equilibrium change in the TWI, π_{t+n} is the rate of inflation between periods *t* and *t+n*, y_{t+m} is real output (or industrial production) between periods *t* and *t+m*, and π^* and y^* are the targets for inflation and output, respectively. In particular, y^* is defined as the equilibrium level of output that would arise if wages and prices were perfectly flexible. *E* is the expectation operator, and Ω_t is the information available to the policymaker.

To capture concerns about potentially disruptive shifts in the exchange rate, I assume that the exchange rate is adjusted only partially to its target level:

$$\Delta e_t = (1-\rho)\Delta e_t^* + \rho\Delta e_{t-1} + \upsilon_t. \tag{2}$$

Here, the parameter $\rho \in [0,1]$ captures the degree of exchange rate smoothing. The exogenous random shock to the exchange rate, υ_t, is assumed to be *i.i.d.*

To define an estimable equation, let $\alpha = \bar{\Delta e} - \beta\pi^*$ and $x_t = y_t - y^*$. Then equation (1) can be rewritten as follows:

$$\Delta e_t^* = \alpha + \beta E\left[\pi_{t+n} \mid \Omega_t\right] + \gamma E\left[x_{t+m} \mid \Omega_t\right]. \tag{3}$$

Combining equation (3) with the partial adjustment mechanism (2) and eliminating the unobserved forecast variables yields the following:

$$\Delta e_t = (1-\rho)\alpha + (1-\rho)\beta\pi_{t+n} + (1-\rho)\gamma x_{t+m} + \rho\Delta e_{t-1} + \varepsilon_t \ . \tag{4}$$

The error term ε_t is a linear combination of the forecast errors of inflation and output and the exogenous disturbance υ_t.

This new policy rule deviates from the conventional Taylor and McCallum rules, which typically rely on short-term interest rates or monetary aggregates as monetary policy instruments. Parrado (2004) proposed a novel approach in which the change in the exchange rate serves as the key monetary policy instrument in a forward-looking inflation targeting context. This innovative perspective opened new avenues for research. Subsequently, several other scholars have incorporated this distinctive exchange rate rule into their own analyses.[7]

Let u_t be a vector of variables (a set of instruments) within the policymaker's information set (i.e., $u_t \in \Omega_t$) that are orthogonal to ε_t. Possible elements of u_t include any lagged variables that help forecast inflation and output and any contemporaneous variables that are uncorrelated with the current exchange rate shock υ_t. In particular, the choice of instruments used in this paper includes 1 to 12 lags of the Consumer Price Index (CPI) inflation, industrial production gap, the TWI, the World Commodity Index, and the nominal federal funds rate. Contemporaneous CPI inflation and TWI are also included as instruments.

Thus, since $E[\varepsilon_t \mid u_t] = 0$, the following equation can be estimated using the Generalized Method of Moments (GMM) with an optimal weighting matrix:[8]

$$E\left[\Delta e_t - (1-\rho)\alpha - (1-\rho)\beta\pi_{t+n} - (1-\rho)\gamma x_{t+m} - \rho\Delta e_{t-1} \mid u_t\right] = 0 \ . \tag{5}$$

3.2 Estimation

Equation (5) is estimated over the sample period from 1985:01 to 2023:04 with year-on-year CPI, year-on-year industrial production, and the year-on-year change in the TWI. The elements of u_t are lagged values of CPI inflation, output, the TWI, the International Monetary Fund's World

[7] See Gerlach-Kristen (2006), Gerlach and Gerlach-Kristen (2006), McCallum (2007), Khor et al. (2007), MAS (2013), Mihov (2013), Santacreu (2015), Benes et al. (2015), Corbacho and Peiris (2018), Heipertz et al. (2022), and Cavoli et al (2023), among others.

[8] The use of an optimal weighting matrix implies that GMM estimates are robust to heteroskedasticity and autocorrelation of unknown form.

Commodity Price Index, and the nominal federal funds rate.[9] The forward-looking horizons are varied to assess the policy horizon.

Assuming a forward-looking horizon of nine months (n = 9)—at which the standard error of the regression is the smallest and the R^2 is the largest—the coefficients associated with expected inflation are positive and significant (see Table 1). They indicate that, in response to a 1 percent rise in *expected* inflation, the TWI is appreciated by 1.8 percent, implying a real exchange rate appreciation of 0.8 percent, *ceteris paribus*. In other words, the real exchange rate is temporarily altered to affect aggregate demand, and thus, inflation. The coefficient associated with the industrial output gap is also positive and significant, suggesting that the monetary authority reacts by appreciating the exchange rate by 0.48 percent when domestic output is 1 percent above potential. Finally, the coefficient that captures policy inertia is high ($\rho \cong 0.93$), indicating that monetary policy slowly adjusts the exchange rate to its projected target level.[10,11]

Table 1. The MAS Reaction Function

Baseline Case

Alternative Inflation Target Horizons	α	β	γ	ρ	R^2	*p-value*	*J-test*
Current inflation (n=0)	0.0010 (0.074)	0.784** (2.158)	0.695*** (4.436)	0.929*** (81.307)	0.930	0.533	58.449
Expected inflation (n=3)	-0.0100 (-1.288)	1.356*** (4.052)	0.539*** (3.929)	0.923*** (85.828)	0.931	0.547	58.059
Expected inflation (n=6)	-0.0120 (-1.372)	1.473*** (3.529)	0.523*** (3.459)	0.927*** (86.544)	0.931	0.531	58.505
Expected inflation (n=9)	-0.019* (-1.804)	1.813*** (3.702)	0.479*** (3.263)	0.927*** (87.095)	0.931	0.508	59.113
Expected inflation (n=12)	-0.025** (-2.07)	2.078*** (3.746)	0.513*** (3.928)	0.927*** (87.081)	0.930	0.494	59.501

(1) * p<0.10; ** p<0.05; *** p<0.01.
(2) *t* statistics are in parentheses.
(3) The set of instruments includes 1 to 12 lags of CPI inflation, the industrial production gap, the TWI, the World Commodity Index, and the nominal federal funds rate. Contemporaneous CPI inflation and TWI are also included as instruments.
(4) Data range from January 1985 to April of 2023.
Source: Author's estimates.

[9] Sargan-Hansen J-test is also performed to avoid overidentification.
[10] Additional estimates confirm that a standard Taylor rule is not observationally equivalent.
[11] The estimated coefficients associated with inflation are stable for several specifications and combinations of different target horizons for the output gap (m=3,6,9,12).

These results are corroborated by two additional exercises that test the hypothesis that Singapore's monetary policy reacts mainly to large shocks. Table 2 includes only large fluctuations (larger than half a standard deviation) in CPI inflation. The results confirm that monetary policy reacts to large changes in inflation, as the beta coefficient continues to be significant. Conversely, regressions (not reported here) suggest that monetary policy hardly responds to small shocks.

Table 2. The MAS Reaction Function

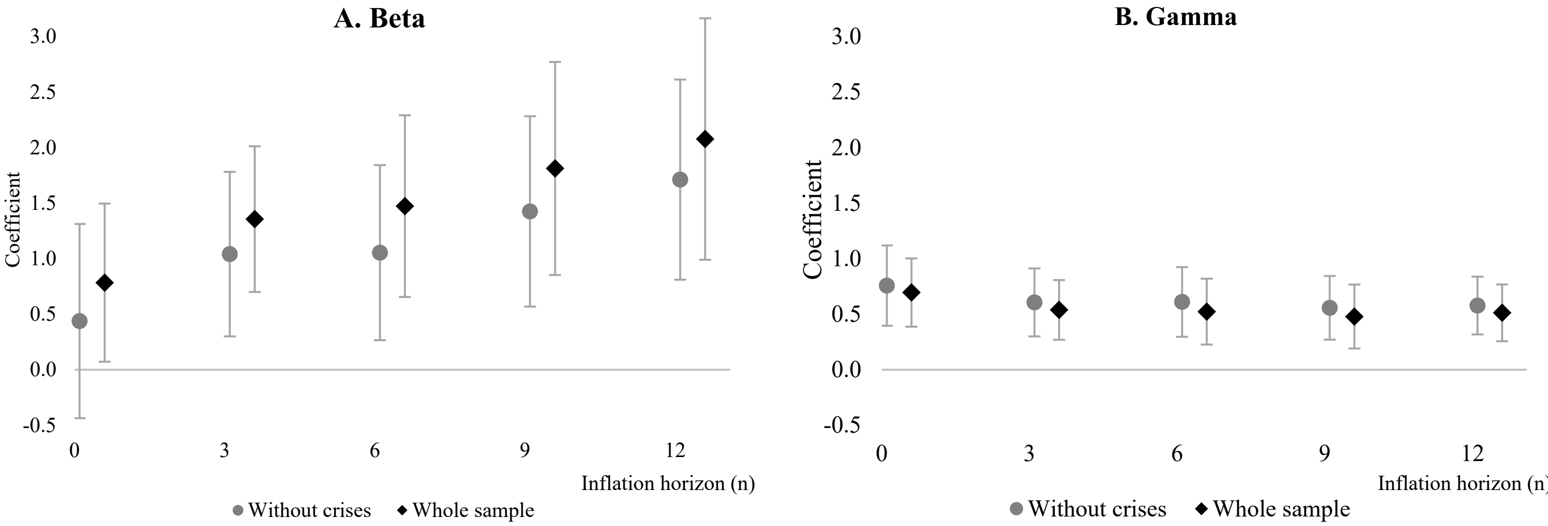
High Inflation Volatility

Alternative Inflation Target Horizons	α	β	γ	ρ	R^2	*p-value*	*J-test*
Current inflation (n=0)	-0.0050 (0.009)	0.816** (0.326)	0.646*** (0.168)	0.944*** (0.011)	0.947	0.849	48.805
Expected inflation (n=3)	-0.023*** (0.007)	1.461*** (0.261)	0.356*** (0.097)	0.923*** (0.011)	0.943	0.943	43.719
Expected inflation (n=6)	-0.0170 (0.012)	1.51*** (0.453)	0.503*** (0.152)	0.944*** (0.009)	0.937	0.933	44.461
Expected inflation (n=9)	-0.044** (0.017)	2.325*** (0.635)	0.452** (0.192)	0.953*** (0.011)	0.926	0.928	44.809
Expected inflation (n=12)	-0.0140 (0.011)	1.365*** (0.387)	0.705*** (0.182)	0.93*** (0.014)	0.917	0.911	45.853

(1) * p<0.10; ** p<0.05; *** p<0.01.
(2) *t* statistics are in parentheses.
(3) The set of instruments includes 1 to 12 lags of CPI inflation, the industrial production gap, the TWI, the World Commodity Index, and the nominal federal funds rate. Contemporaneous CPI inflation and TWI are also included as instruments.
(4) Data range from January 1985 to April of 2023.
Source: Author's estimates.

In addition to assessing the MAS's reaction to significant shocks, I estimate the coefficients using a sample that excludes the 2008-09 financial crisis and the COVID-19 pandemic. These estimations are then compared with the coefficients obtained from the analysis of the entire sample. When the crises are considered, the beta coefficients exhibited higher values, indicating a more substantial policy response when the economy faces a recession (see Figure 2). At the same time, the gamma coefficients (associated with the output gap) are slightly lower. These findings shed light on the MAS's dynamic policy approach during economic downturns.

Figure 2. Estimated Coefficients of Inflation Gap (Beta) and Output Gap (Gamma)
Different samples (whole sample vs w/o crises)



(1) The set of instruments includes 1 to 12 lags of CPI inflation, the industrial production gap, the TWI, the World Commodity Index, and the nominal federal funds rate. Contemporaneous CPI inflation and TWI are also included as instruments.
(2) The data range between 1985:01 – 2007:12 and 2010:01 - 2019:12 when the 2008-09 financial crisis and the COVID-19 crisis are excluded.
Source: Author's calculations.

3.3 Robustness

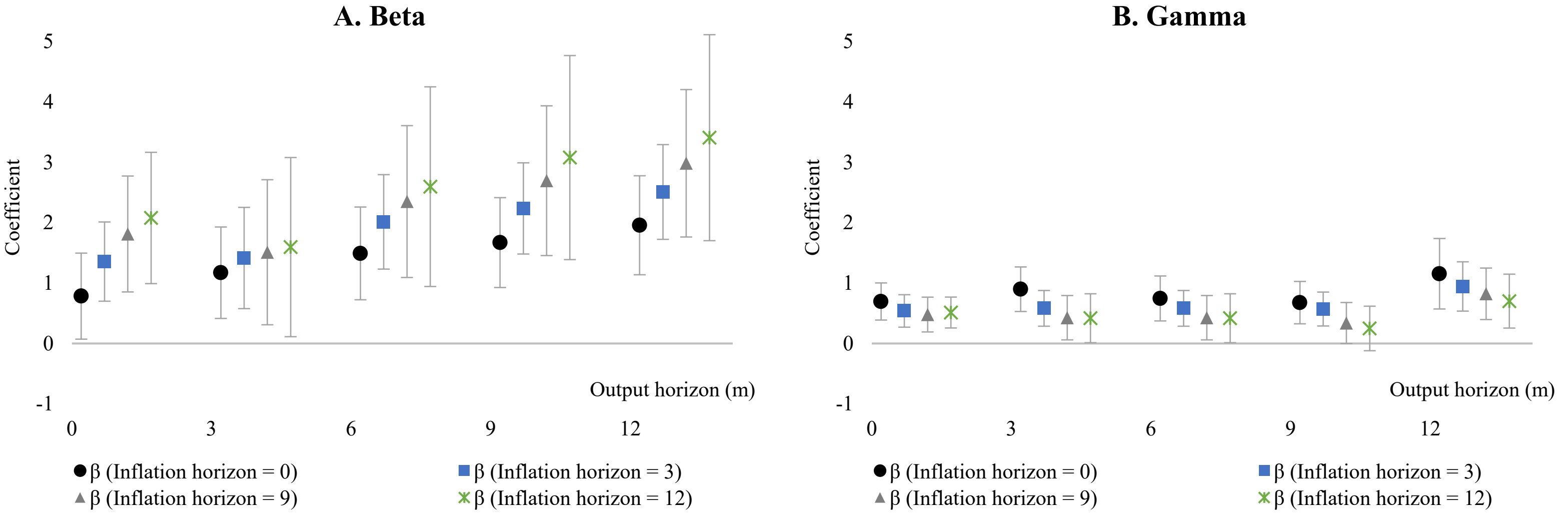
3.3.1 Targets Horizons

The decision to select a fixed target horizon of zero (*m*=0) for the output gap in the analysis was primarily driven by simplicity. Given that the original exercise already incorporates multiple target horizons for the inflation gap, including various combinations with the output gap could introduce confusion. However, it is crucial to examine the stability of the parameter associated with the inflation gap.

Figure 3 illustrates the stability of the estimated coefficient associated with inflation across various specifications. Notably, the statistical analysis reveals that most betas and gammas exhibit strong levels of significance. However, there are a few exceptions: notably, the gamma value does not achieve significance when the inflation horizon (*n*) is set at 12 and the output horizon (*m*) is either 3 or 9.

Figure 3. Estimated Coefficients Inflation Gap (Beta) and Output Gap (Gamma)

Different output horizons



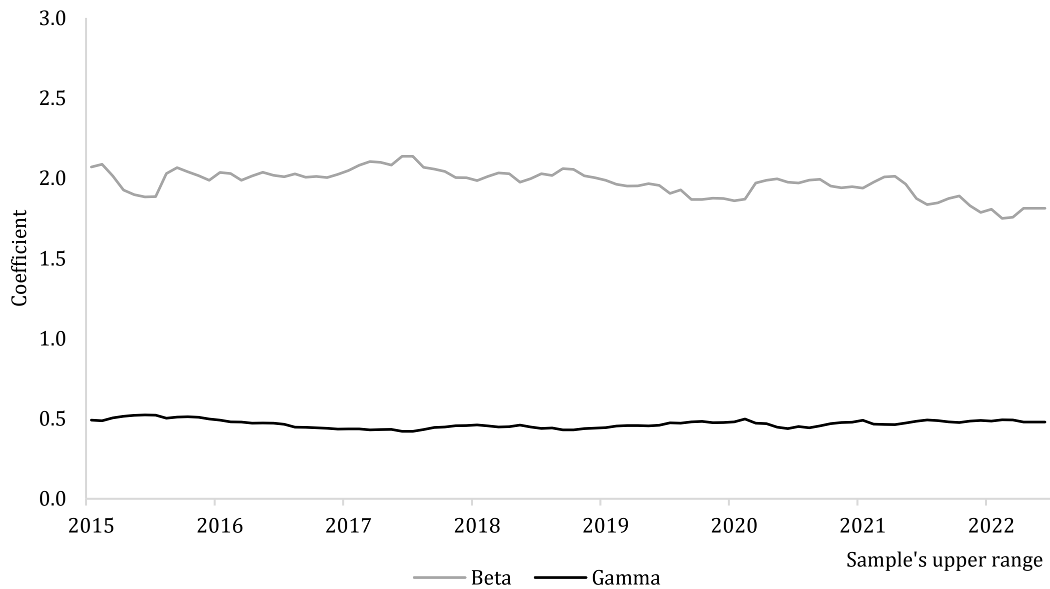
(1) The set of instruments includes 1 to 12 lags of CPI inflation, the industrial production gap, the nominal effective exchange rate, the world commodity price index and the nominal federal funds rate. Contemporaneous CPI inflation and TWI are also included as instruments.

Source: Author's estimates.

3.3.2 Samples

Overall, the estimated parameters exhibit stability when employing various samples, including the rho estimates. This observation is further supported by the findings presented in Figure 4. In this analysis, the sample range is initially restricted to 2014:12, and each subsequent monthly observation is cumulatively added. Importantly, the results demonstrate consistent stability across the entire timeline, and they remain statistically significant.

Figure 4. Beta and Gamma with Different Time Horizons
Expected inflation = 9



(1) All coefficients are statistically significant at the 95 percent level.
(2) The set of instruments includes 1 to 12 lags of CPI inflation, the industrial production gap, the TWI, the World Commodity Index, and the nominal federal funds rate. Contemporaneous CPI inflation and TWI are also included as instruments.
Source: Author's estimates.

3.3.2 Selection of Instruments and Lags

The set of instruments in this study encompasses all the variables within the MAS's information set when changes in the exchange rate—the policy variable—occur. A similar approach is discussed by Favero (2000), who notes that a vector should incorporate all the variables available to the central bank when making decisions on interest rates. Furthermore, to evaluate whether the simple specification of the monetary policy rule overlooks significant variables that are part of the central bank's rule, the standard statistical analysis employs the *J*-test to assess the validity of overidentifying restrictions.

Regarding the inclusion of lags, Clarida, Galí, and Gertler (2000) argue that the instruments used should be based on the information set available when determining the interest rate. They incorporate four lags of inflation, the output gap, the federal funds rate, the short-long spread, and commodity price inflation in estimating the Federal Reserve's policy reaction function.

Similarly, Caputo and Herrera (2017) use lagged values of country-specific output, inflation deviations, the policy rate, exchange rate changes, and contemporaneous and lagged values of common variables such as the fed funds rate and the percentage change in oil prices for each country. Additionally, contemporaneous inflation is included as an instrument.

4. Conclusion

The estimation results from the reaction function analysis provide compelling evidence that controlling inflation has been the primary focus of monetary policy in Singapore. This supports the hypothesis that the monetary policy framework in Singapore can be characterized by a forward-looking policy rule that aims to stabilize expected inflation and maintain output at its potential level. Notably, the estimated reaction function implicitly includes an inflation targeting component, as argued by Clarida, Galí, and Gertler (1998, 1999), highlighting its significance in ensuring effective monetary policy making.

Furthermore, the coefficients associated with CPI inflation and output reveal that monetary policy in Singapore assigns considerable importance to maintaining low and stable inflation. Importantly, the estimations demonstrate stability across samples, suggesting the findings are robust. When crises such as the 2008-9 financial crisis and the COVID-19 pandemic are considered, the coefficient associated with expected inflation is larger. This implies that the policy response is more pronounced during economic downturns, underlining the adaptive nature of monetary policy in addressing recessions.

Given the strong historical fit of the estimated reaction function, this approach presents a promising alternative for countries with high openness to capital markets that face challenges in managing monetary policy effectively using traditional instruments such as interest rates or monetary aggregates. In fact, recent research building upon this framework suggests that when a small and open economy has a trade openness level above 40 percent of GDP, a monetary policy framework centered on an exchange rate instrument is more efficient in stabilizing prices than the traditional interest rate approach (Heresi and Parrado, 2023).

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