Special Feature A

50 Years of Inflation Experience in Singapore

1 Introduction

This Special Feature provides a review of Singapore's inflation experience since the establishment of MAS in 1971.[1] It identifies the historical drivers of inflation outcomes and monetary policy responses over the course of the past five decades. Several econometric approaches are taken to assess how the exchange rate-centred monetary policy has been formulated to address inflation during the economy's major cyclical phases. The Feature concludes with some observations on the medium-term outlook for inflation in Singapore in light of ongoing structural changes in the global economy.

2 Six Main Phases of Singapore's Historical Inflation Experience

The history of Singapore's headline inflation over the past 50 years can be broadly divided into six time periods, with breakpoints between the phases marked by shifts in the dynamics of inflation. Using a rolling autoregressive model for headline inflation, Singapore's CPI-All Items inflation from Q1 1971 to Q4 2020 can be analysed in terms of its long-term expectation and idiosyncratic components.[2] The long-term expectation is estimated as the model-implied unconditional mean for inflation, which in turn is a function of structural and persistence parameters derived from the time series characteristics of headline inflation. The idiosyncratic component is the deviation of inflation outturns from the expected value, capturing the effects of shocks from events such as global oil price movements or recessions. Long-term expected inflation volatility can also be derived as the unconditional variance of inflation in the model. The estimates of the long-term expected levels and volatility of headline inflation, so derived, are used as the basis to categorise Singapore's inflation experience into the six distinct periods **(Chart 1)**.

The tumultuous seventies (1971 to 1980) saw Singapore facing high long-term expected inflation levels and volatility, with the former averaging 5.8% and the latter, 8.6% points.[3] The subsequent period from 1981 to 1987 saw significant declines in both measures. Long-term expectations for headline inflation were relatively low and stable from 1988 to 1996, then fell

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1 This Special Feature has benefitted from useful discussions and comments from Professor Ramkishen S. Rajan of the Lee Kuan Yew School of Public Policy.

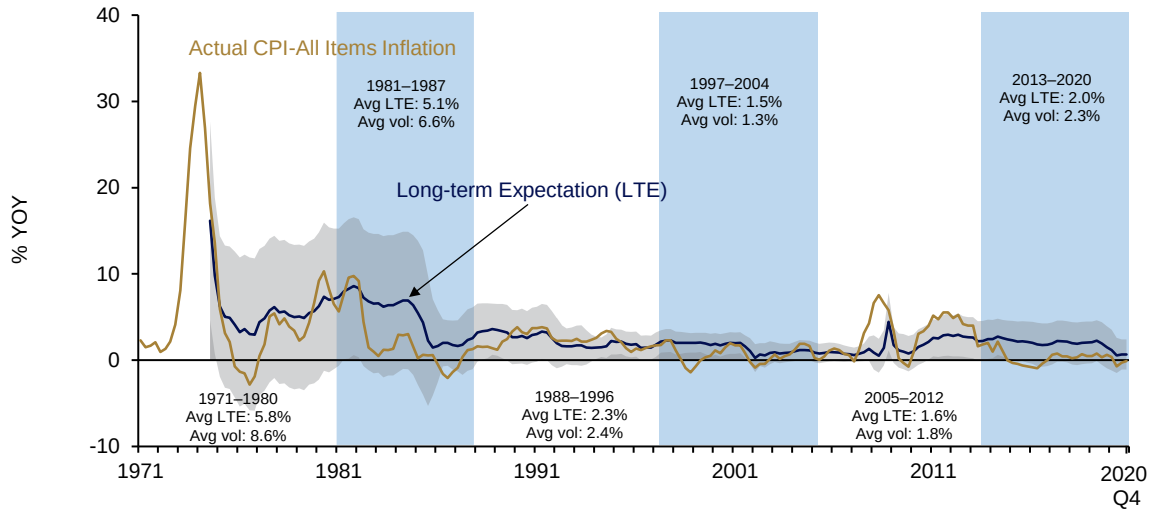
2 The inflation dynamics are parsed into structural (α), persistence (β) and shock components (ε) using a first order autoregression model as in Aziz (2021), with a 12-year rolling window, given by the following equation: $\pi_t = \alpha + \beta\pi_{t-1} + \varepsilon_t$, where π_t represents headline inflation at time t and ε_t is an idiosyncratic error term. Under this framework, the unconditional mean of CPI-All Items inflation is given by $\frac{\alpha}{1-\beta}$. Meanwhile, the unconditional standard error or volatility of CPI-All Items inflation is given by $\frac{\sigma}{\sqrt{(1-\beta^2)}}$,where σ is the standard error of the idiosyncratic component, ε_t, as estimated by the standard error of regression.

3 The headline inflation series is only available from Q1 1962. With a 12-year rolling regression window, the first estimate starts from 1974.

further during the period 1997 to 2004 and reached a low of 0.2% in Q1 2002 after successive economic shocks. Both the expected level and volatility of inflation subsequently rose from 2005 to 2012, peaking at 4.5% and 3.3% points respectively in Q4 2008, during the GFC. Since 2013, long-term expectations for headline inflation have declined gradually, although volatility has remained somewhat elevated. During the recent COVID-19 pandemic, the long-term expected level of inflation dipped further to around 0.6% in Q2–Q4 2020.

From a long-term perspective, the expected levels and volatility of headline inflation in Singapore have been trending down since the mid-1970s, reflecting structural factors such as the secular decline in external inflation due to the effects of globalisation, the impact of liberalisation of some domestic industries on consumer prices, lower currency volatility, and more diversified import sources. The following section takes a closer look at Singapore's inflation experience in each of the six periods identified in **Chart 1** in the context of shifting global macroeconomic currents, and of changes in MAS' monetary policy framework. The **Box** within this Special Feature further examines trends in Singapore's real effective exchange rate (S$REER) against the backdrop of relative inflation and nominal effective exchange rate (S$NEER) movements.

Chart 1 CPI-All Items inflation and long-term expectation (LTE) of headline inflation for Singapore by the six main phases from Q1 1971 to Q4 2020



Source: DOS and EPG, MAS estimates

Note: The headline inflation series is only available from Q1 1962. With a 12-year rolling regression window, the first estimate is for Q1 1974. However, the LTE series only starts from Q3 1974 as headline inflation was non-stationary for the 12-year rolling windows ending in Q1 and Q2 1974. The persistence measure for Q1 to Q3 2008 was interpolated for these quarters as headline inflation was non-stationary. The long-term volatility of headline inflation (vol) is marked out by the grey bands.

3 Review of Inflation and Singapore's Monetary Policy Regime

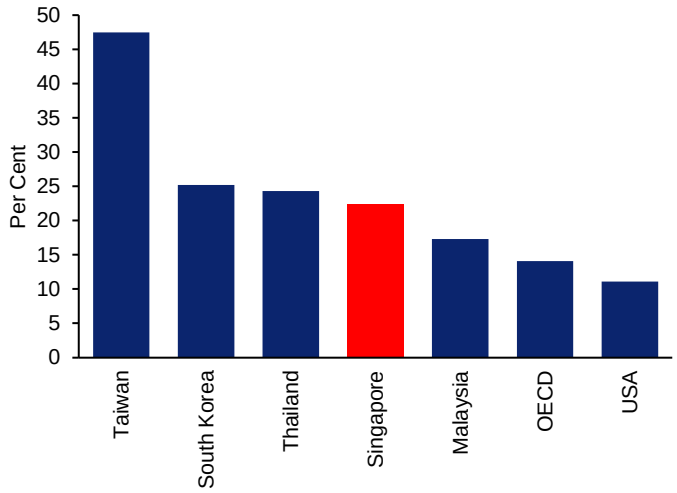
1971–1980: The swinging seventies

The seventies proved to be a tumultuous decade that saw high and volatile inflation in Singapore. Barely one year after MAS was established in January 1971, strains on the Bretton Woods system of fixed exchange rates emerged. Amid the turmoil in foreign exchange

markets over the next two years, the OPEC cartel of oil-producing countries engineered an embargo in October 1973 that led to a quadrupling in oil prices.

Higher oil prices led to cost-push inflation and drove Singapore's headline inflation to 20% in 1973 and around 30% y-o-y in the first half of 1974. These inflation outcomes were much higher than those in the advanced economies but were similar to some of the Asian economies **(Chart 2)**. In response to high imported inflation and surging domestic liquidity, MAS implemented an eclectic mix of monetary tightening measures, including raising banks' statutory reserve requirement from 5% to 9%, imposing credit ceilings and guidelines, and hiking interest rates by 2% points in October 1974 (see MAS, 2011a).

Chart 2 Peak annual average headline inflation in Singapore and comparators during the oil shock of 1973 to 1975



Source: DOS, Haver Analytics, OECD, World Bank and EPG, MAS estimates

Note: Inflation peaked in 1974 for all regions, except South Korea (peaked in 1975).

Domestic inflation quickly dropped to −1.9% in 1976. The monetary framework continued to evolve during this period. By 1975, while still utilising an eclectic monetary policy toolkit including influencing bank interest rates and adjusting reserve requirements, MAS had also begun to monitor the level of the S$NEER within an exchange rate policy band. The second oil price shock in the late 1970s caused Singapore's headline inflation to surge again, although this time to a lower peak of close to 10% in Q4 1980. The step-up in Singapore's inflation was again much larger than that in the advanced economies, but more modest than in many of the Asian economies.

1981–1987: A new exchange rate-centred policy framework

In the 1980s, headline inflation was significantly less volatile and long-term expected inflation declined **(Chart 1)**. Headline inflation in Singapore moderated to an average of around 2% p.a. between 1981 and 1987, from close to 7% in the 1970s **(Table 1)**. As oil prices fell sharply in the middle of the decade, inflation in Singapore declined in tandem with the global trend. Indeed, average inflation in Singapore was lower than that of most advanced and regional economies during this period.

Lower inflation in this period followed MAS' move towards formalising an exchange rate-centred regime as the country's monetary policy framework in 1981. From 1981 to 1985, the S$NEER appreciated by 22%, helping to filter out still-strong inflationary pressures in many of Singapore's major trading partners. Another factor driving inflation lower in this period was the country's first post-independence economic recession in 1985, which led to headline inflation briefly dipping into the negative domain in the following year. The decline in consumer prices was exacerbated by a slump in the global oil market, which generated sharp falls in the prices of oil-related items in the CPI basket (see MAS, 2003). In the face of the severe drop in aggregate demand and rising unemployment, MAS guided the S$NEER to a lower path. In addition, the government introduced several labour cost reduction measures in 1986, including lowering the employers' Central Provident Fund (CPF) contribution rate by 15% points, and imposing a two-year wage-restraint policy in the public sector. After a period of relatively strong unit labour cost (ULC) growth in the early 1980s[4], ULC contracted by 9% in 1986, further dampening inflationary pressures **(Chart 3)**.

Table 1 Headline inflation in Singapore and comparators by phases (mean and standard deviation)

Economies	1971 to 1980	1981 to 1987	1988 to 1996	1997 to 2004	2005 to 2012	2013 to 2020
Singapore	6.6	2.2	2.4	0.7	2.9	0.5
	(8.0)	(3.1)	(0.8)	(0.9)	(2.3)	(0.9)
Advanced Economies						
OECD	10.0	9.4	6.3	3.5	2.4	1.7
	(3.2)	(1.8)	(1.6)	(0.9)	(0.9)	(0.6)
USA	7.9	4.7	3.7	2.4	2.5	1.5
	(3.3)	(2.8)	(1.0)	(0.6)	(1.3)	(0.7)
Asian Economies						
South Korea	16.5	6.1	6.4	3.6	3.0	1.1
	(7.8)	(6.9)	(1.7)	(1.9)	(0.9)	(0.5)
Malaysia	6.0	3.5	3.5	2.2	2.6	1.7
	(4.7)	(3.5)	(0.8)	(1.4)	(1.5)	(1.6)
Taiwan	11.1	3.1	3.5	0.6	1.5	0.7
	(13.7)	(5.9)	(1.0)	(0.8)	(1.3)	(0.7)
Thailand	10.0	4.2	5.0	2.8	3.3	0.6
	(7.5)	(4.0)	(1.0)	(2.7)	(2.0)	(1.1)

Source: DOS, Haver Analytics, OECD, World Bank and EPG, MAS estimates

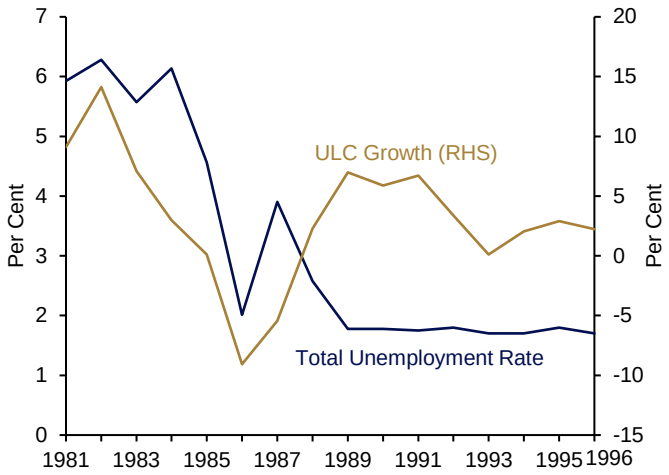
Note: These are period averages of headline inflation in %, with standard deviations in % point, in parentheses.

1988–1996: The boom years

A period of strong and sustained economic growth after the 1985 recession drove an acceleration in domestic headline inflation over 1988–1996. Average real GDP growth in Singapore stepped up to 9.1% during these boom years, from 6.7% in the previous period. At the same time, the total unemployment rate in the country fell to an average of 1.8%, significantly lower than in the early 1980s. Reflecting the strong growth and tighter labour market conditions, Singapore's headline inflation averaged 2.4% over this period, slightly higher than 2.2% in the previous period, but remained significantly lower than in comparator economies **(Table 1)**. In response, MAS allowed the currency to appreciate steadily during this phase, which helped to contain overall domestic inflationary pressures.

[4] High ULC growth in the early eighties partially reflected the government's high-wage policy during that period and was also driven by a steady increase in the employers' contribution rate to the CPF to 25% in July 1984.

Chart 3 Singapore's total unemployment rate and ULC growth, 1981 to 1996



Source: DOS, Haver Analytics, IMF and EPG, MAS estimates

Note: Total unemployment rate data prior to 1986 excludes non-residents.

1997–2004: The crisis years

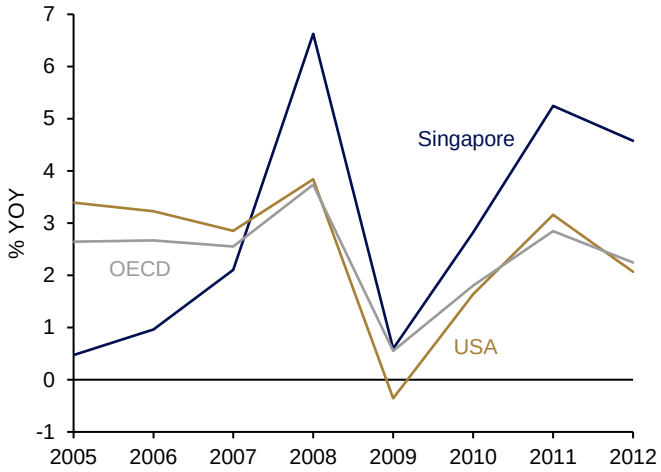
From 1997 to 2004, Singapore experienced successive negative shocks—the AFC in 1997, the 2001 IT Downturn, and the Severe Acute Respiratory Syndrome (SARS) epidemic in 2003—that caused headline inflation to turn briefly negative. Weakness in domestic economic activity and elevated resident unemployment weighed on consumer prices (see MAS, 2003). In addition, this period coincided with the government's moves to liberalise various industries (such as the telecommunications sector), leading to additional downward pressure on prices. Headline inflation for Singapore averaged 0.7% during these years—significantly lower than the previous period and weaker than most comparators—although long-term expected inflation declined by less **(Table 1 and Chart 1)**. The volatility of inflation fell to its lowest level among the phases. Accordingly, the S$NEER was guided to a lower path to mitigate the effects of these sizeable macroeconomic shocks.

2005–2012: Domestic constraints and the GFC

In the latter half of the 2000s, exchange rate policy was generally tightened as Singapore's headline inflation rose rapidly, from 0.5% in 2005 to a peak of 6.6% in 2008 **(Chart 4)**. This increase occurred against a backdrop of strong global commodity prices, driven in part by rapid economic growth in China and other emerging market economies. Besides external cost pressures, higher headline inflation in Singapore also reflected stronger domestic output growth as the economy recovered from the shocks of the previous period. At the same time, rising business costs (import, wage and rental costs) passed through to consumer prices (see MAS, 2007b) while the GST hike in mid-2007 further added to domestic price pressures.[5]

[5] GST was raised from 5% to 7% in July 2007. This was estimated to add around 0.4–0.6% point to headline inflation each year in 2007 and 2008 (see MAS, 2007a).

Chart 4 Singapore's headline inflation vis-à-vis advanced economies, 2005–2012



Source: OECD, Haver Analytics, DOS and EPG, MAS estimates

The uptrend in domestic inflation, however, ended in 2009 with the onset of the GFC. Singapore once again entered recession, which was followed by a decline in headline inflation. In the wake of the GFC, Singapore's headline inflation recovered and stayed relatively high at 4.2% p.a. on average during the early 2010s, reflecting both cost-push and demand-pull price pressures. Domestic cost pressures gradually rose alongside a tighter labour market as foreign worker policies became more binding[6] (see MAS, 2011c). Meanwhile, on the external front, commodity prices picked up sharply. The robust economic recovery from the GFC and resilient domestic demand gave firms more leeway to pass on cost increases to consumers. Concurrently, the low global interest rate environment post-GFC underpinned strong demand for private transport and accommodation. This fed through to headline inflation as COE premiums were driven up by the strength of car demand relative to quota supply, while tightness in the housing rental market lifted rental costs (see MAS, 2011b).

2013–2020: Slower growth and a pandemic

Between 2013 and the onset of the COVID-19 pandemic, persistent weakness in global and domestic inflation allowed for a more accommodative exchange rate policy. Global inflation fell to a low of 1.4% in 2015 alongside the decline in commodity prices.[7] Singapore's headline inflation was still lower than other comparators, reflecting the added effect of weak domestic accommodation inflation **(Table 1)**. The accommodation component exerted an average drag of 0.6% point p.a. on headline inflation in 2015–19, as earlier domestic supply constraints in the housing rental market began to ease and reverse (see MAS, 2014a). In addition, car loan restrictions introduced in 2013, as part of a broader set of macroprudential measures, helped to moderate demand for cars and rein in excessive increases in COE premiums, thus suppressing private transport inflation (see MAS, 2014b). Reflecting a combination of muted global inflation as well as a weak domestic rental market, headline

6 Foreign worker measures were tightened successively in 2010–12, including the raising of qualifying salaries for Employment and S Pass holders as well as increases in foreign worker levies for S Pass and Work Permit Holders.

7 Source: IMF International Financial Statistics. World CPI data is available from 1981 to 2020.

inflation stepped down from an average of 2.9% p.a. in the previous phase to 0.5% p.a. in this phase **(Table 1)**.

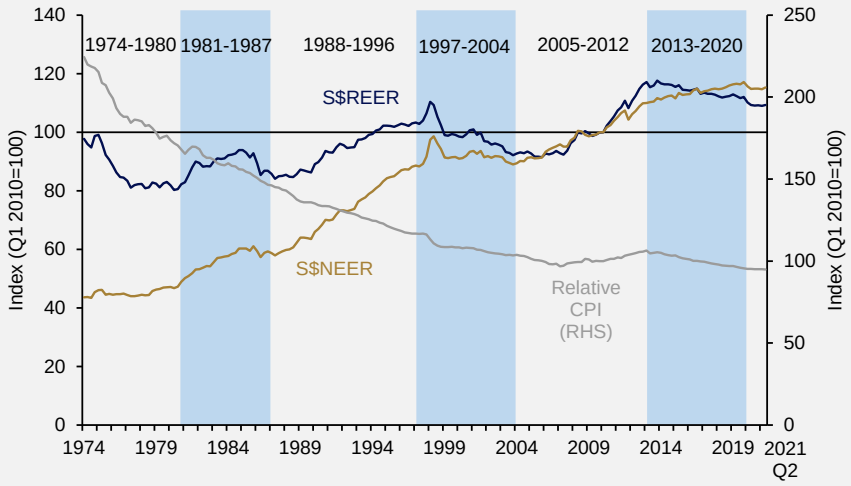
More recently, the outbreak of the COVID-19 pandemic led to a sharp drop in inflation, with headline inflation dipping into negative territory (averaging −0.2%) in 2020. However, this has been more than reversed as demand has recovered more rapidly than supply, amid severe pandemic-related disruptions to global supply chains. The pandemic will likely lead to structural changes in economic behaviour on many fronts, although it is too early to characterise the overall long-run effect on the inflation process, and to tell whether the trend of subdued global inflation during 2013–2020 will continue.

Box: Trends in Singapore's Real Effective Exchange Rate

This Box examines the trends in Singapore's S$REER over the past five decades and discusses the key factors underlying its broad movements. EPG adopts the neoclassical view that the long-run equilibrium path of the S$REER is determined by real supply-side factors, such as trends in productivity in Singapore relative to those abroad, and therefore cannot be influenced by the central bank. Prices and wages will adjust over time to remove any deviation of the S$REER from equilibrium. MAS' S$NEER policy settings can only affect the level of the S$REER temporarily due to the presence of short-term wage and price rigidities. Empirical analysis of MAS' policy actions suggests that the associated nominal exchange rate movements are consistent with the aim of stabilising output around potential over the business cycle and ensuring medium-term price stability.

The S$REER has trended up over the past 47 years, rising by about 12% over the period and driven fundamentally by the economy's rapid development and high productivity growth. The trend increase in the S$REER is the result of a steady rise in the S$NEER that was partly offset by falling relative prices, as the domestic price level was rising more slowly than prices in Singapore's key trading partners **(Chart 5)**. In the interim, however, there have been recurrent fluctuations around the long-term appreciation path, mainly reflecting the impact of economic shocks. For instance, the S$REER depreciated in the wake of the 1985 recession and the AFC.

Chart 5 S$REER, S$NEER and relative CPI, Q1 1974 – Q2 2021



Source: Haver Analytics and EPG, MAS estimates

Note: Relative CPI is computed as the ratio of consumer prices in Singapore vis-à-vis that in trading partners.

Following the six-phase classification described in the main text of this Special Feature, the S$REER depreciated in the first phase over 1974–1980[1], as the price level in Singapore

[1] Data on Singapore's S$REER and S$NEER are only available from 1974 onwards.

rose at a slower pace relative to those in its trading partners on average.[2] The S$NEER only appreciated modestly as MAS then had a mandate to keep the Singapore dollar stable, with the decision made in 1975 to keep the currency on a managed float as opposed to a free float. However, MAS had yet to shift formally to an exchange rate-centred policy framework, and Singapore had exchange controls in place until many of these were liberalised in 1978.

In the second phase from 1981 to 1987, the S$REER initially strengthened after the shift to an exchange rate-centred regime in 1981, as domestic cost pressures rose and MAS appreciated the S$NEER significantly to curb import price inflation originating from the second oil price shock. In 1985, Singapore faced its first recession post-independence, precipitated by both a fall-off in external demand and weaker construction activity as the infrastructure boom of the early 1980s faded. In response, the S$NEER was allowed to weaken, while policies to lower business costs (such as reductions in employers' CPF contribution rate) were implemented, resulting in a decline of the S$REER.

The recovery from recession was followed by the boom years of 1988–1996, when both the S$REER and the S$NEER strengthened steadily. As inflationary pressures built up alongside robust global growth, MAS allowed the S$NEER to appreciate. The strengthening in the S$NEER helped to contain inflationary pressures and prevented overheating of the domestic economy in the first half of the 1990s, when GDP growth averaged around 9% p.a. During the AFC of 1997–1998, MAS shifted to a looser policy stance, while adopting greater flexibility in the management of the S$NEER to accommodate the attendant financial market volatility. However, the S$NEER, and consequently the S$REER, rose in 1998 before falling, reflecting the widened policy band and the sharper depreciation of some regional currencies against the US dollar, notwithstanding some weakening of the S$/US$ bilateral exchange rate. As the Singapore economy began to rebound in 2000, MAS embarked on a gradual, modest appreciation path for the policy band. Faced soon after with recessionary shocks—the IT Downturn in 2001 and SARS in 2003—MAS again switched to a more accommodative policy, flattening the slope of the policy band in July 2001 and re-centring it downwards twice, in January 2002 and July 2003. The decline in the S$NEER, together with a continued fall in Singapore's prices relative to foreign prices, resulted in a broad depreciation in the S$REER over this period.

The S$REER experienced an appreciation phase in the period spanning the late 2000s to early 2010s, reflecting the combination of an uptrend in the S$NEER and rising relative prices. Apart from a brief period during the GFC, MAS set the S$NEER on an appreciation path over most of this period to contain domestic inflation. The relative strength of inflation can be attributed to robust aggregate demand and binding supply constraints, both before and after the GFC, with a hike in the GST rate in mid-2007 imparting a further one-off increase in prices. MAS therefore shifted to a modest and gradual appreciation path and re-centred the policy band upwards twice over 2010–11, while macroprudential measures were deployed to dampen increases in property and car prices. This had the effect of lowering inflation, even as it helped to secure financial stability. MAS recognised that some shifts in relative prices had to occur in order to facilitate economic restructuring, and had calibrated policy such that it would only "temper, but not fully offset" the inflationary impact of restructuring.

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[2] The decline in relative prices over 1974–1980 in part reflects a smaller rise in Singapore's price level vis-à-vis some regional countries in the immediate aftermath of the two oil price shocks. As a small open economy, economic activity in Singapore was also more severely affected by the global slowdown that ensued, which led to a sharper decline in inflation relative to trading partners.

After peaking in 2013, the S$REER has been on a mild declining trend, even as the S$NEER appreciated modestly. Relative prices in Singapore fell and more than offset the increases in the S$NEER. In April 2016, MAS flattened the slope of the S$NEER policy band as global and domestic developments led to a persistent downdrift in Singapore's growth and inflation outlook. After reverting to an appreciation path in April 2018, the S$NEER policy band was recentred at its lower prevailing level and flattened in April 2020 in response to the outbreak of the COVID-19 pandemic.

4 Characterising Singapore's Headline Inflation Drivers with an SVAR

Over the past 50 years, a number of factors—oil price shocks, global inflation movements, domestic economic factors and MAS' exchange rate policy decisions—have been important drivers of inflation dynamics in Singapore. Given this, a structural vector autoregression (SVAR) model is used to decompose headline inflation movements into these fundamental drivers for the period Q1 1975 to Q4 2020, and to empirically estimate the effects of shocks to each of them on domestic inflation.[8]

$$\begin{pmatrix} \Delta Oil_t \\ \pi_t^F \\ \Delta GDP_t \\ \pi_t \\ \Delta NEER_t \end{pmatrix} = \alpha + \sum_{s=0}^{\infty} A_{t-s} \begin{pmatrix} \epsilon_{t-s}^{OIL} \\ \epsilon_{t-s}^{EXT} \\ \epsilon_{t-s}^{SUPPLY} \\ \epsilon_{t-s}^{DEMAND} \\ \epsilon_{t-s}^{MP} \end{pmatrix}$$

The SVAR contains five endogenous variables—the change in oil prices ΔOil_t, weighted headline CPI inflation of several of Singapore's key trading partners π_t^F, Singapore's GDP growth ΔGDP_t, domestic CPI-All Items inflation π_t and changes in the S$NEER, $\Delta NEER_t$. These variables depend on contemporaneous and past values of the five drivers, or "structural shocks"—oil shocks ϵ_{t-s}^{OIL}, external CPI shocks ϵ_{t-s}^{EXT}, domestic aggregate supply shocks ϵ_{t-s}^{SUPPLY}, domestic aggregate demand shocks ϵ_{t-s}^{DEMAND} and exchange rate policy shocks ϵ_{t-s}^{MP}. Estimation of the SVAR is effected using quarterly data on the annualised values of the five endogenous variables.

To identify the effects of the five structural shocks on macroeconomic variables, the following restrictions were applied, drawing from established results in the SVAR literature.

1) Oil prices depend only on oil shocks, a common identification assumption for SVARs (e.g., Bjornland, 2001), reflecting the low statistical correlation between oil prices and global economic variables.

2) External CPI inflation only depends on oil shocks and other external shocks, reflecting Singapore's status as a small open economy with negligible influence on global economic outcomes.

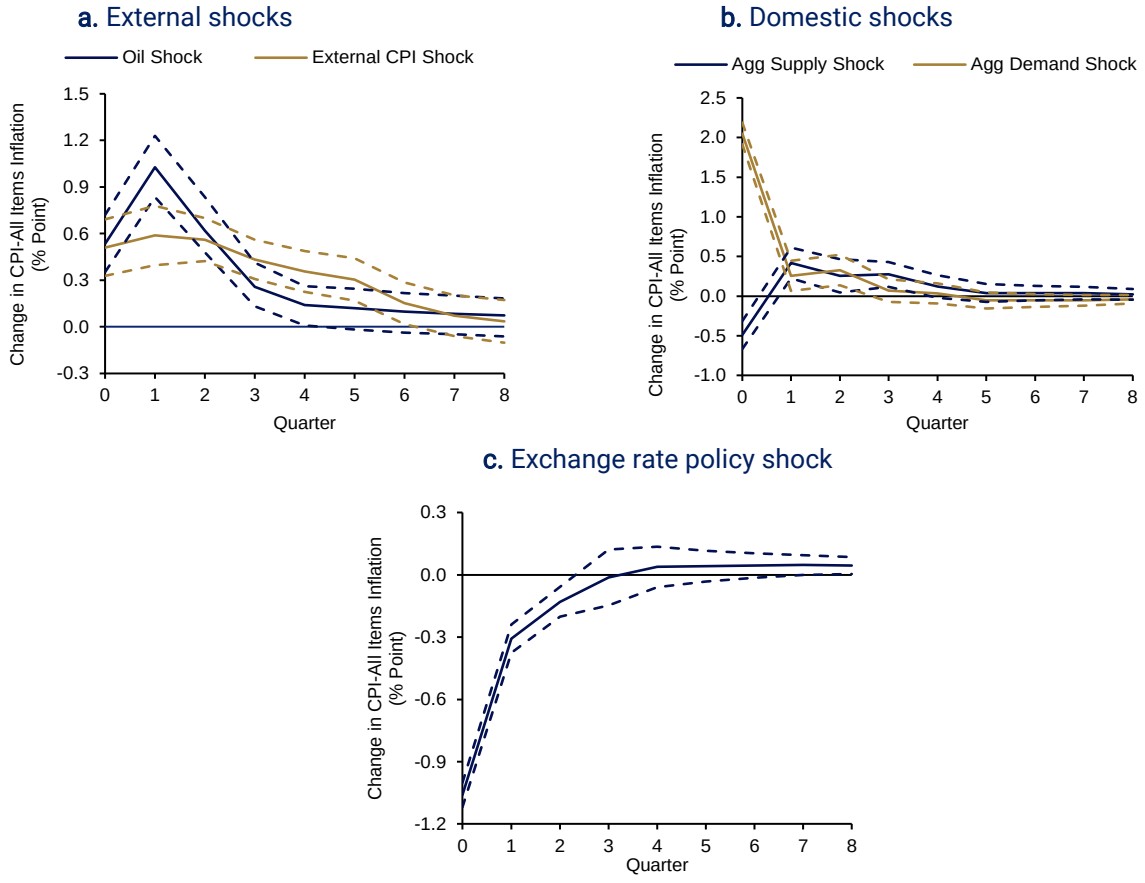
3) Domestic aggregate demand shocks and exchange rate policy shocks have no long-run impact on GDP growth. This reflects the assumption that the Phillips Curve is vertical in the long run; neither monetary shocks nor cyclical demand shocks can have a permanent impact on the output gap. This assumption was introduced by Blanchard and Quah (1989), and variants of it have been commonly used in the estimation of SVARs.

4) Exchange rate policy shocks have no contemporaneous effect on Singapore's GDP growth, reflecting the lagged effects of monetary policy on output, a short-run restriction that originates from the seminal paper of Sims (1980) and applied to the SVAR context in Gali (1992).

[8] The SVAR analysis starts from 1975, rather than 1971, due to limitations in data availability for a number of variables in the model specification.

The estimated effects of one standard deviation positive innovations in the five structural shocks on CPI All-Items inflation, for eight quarters, are presented in **Chart 6**.[9]

Chart 6 Impulse response functions of structural shocks on CPI All-Items inflation



Source: EPG, MAS estimates

Note: The effect of a one-time, one standard deviation positive innovation to each structural shock on CPI All-Items inflation is plotted on each panel of the chart. The bands represent 95% confidence intervals for asymptotic standard errors.

The top left panel illustrates the effects of oil and foreign CPI shocks on domestic headline inflation. Both shocks lead to a temporary rise in inflation. The effects peak one quarter after the initial shock, with headline inflation rising by about 1% point and 0.6% point in response to an oil shock and a foreign CPI shock respectively. The higher initial pass-through from oil shocks to headline inflation compared to foreign CPI shocks reflects the greater direct exposure of domestic CPI components to global oil prices than to (general) foreign prices. However, oil shocks have less persistent effects on domestic inflation, with the impact fading after four quarters, compared to six quarters for foreign CPI shocks. Oil shocks typically dissipate quickly as unexpected changes in oil prices usually induce mitigating supply-side responses from international producers, and as domestic users adjust behaviour.

The effects of domestic aggregate supply shocks and aggregate demand shocks on inflation are depicted in the top right panel. A positive aggregate supply shock raises potential

[9] When restricting the sample to the more recent period, the estimated impulse response functions generally have the same shapes as those presented on Chart 6, although the magnitudes of the effects vary slightly for some variables.

output in Singapore, inducing deflationary pressures upon impact as aggregate supply temporarily exceeds aggregate demand. After one quarter, the positive effect of the aggregate supply shock on domestic GDP growth translates to a temporary and small rise in inflation, which dissipates after a further two quarters. A positive shock to aggregate demand, for example in the form of an unexpected tax cut, leads to a rise in inflation by around 2% points within the same quarter. In line with predictions from a Keynesian macroeconomic model, in which demand shocks should generate a one-time permanent increase in the price level, the SVAR results show that the inflation effect is short-lived and fades after around two quarters.

An exchange rate policy shock that causes the S$NEER to appreciate lowers headline inflation by around 1% point in the same quarter. The negative impact on inflation is largest during the contemporaneous quarter, with the effect petering out thereafter and vanishing after two quarters. The results suggest that a positive shock to the S$NEER can effectively lower domestic inflationary pressures by filtering out foreign import prices and reducing factor prices.

Next, separate econometric analysis of MAS' monetary policy reaction function suggests that the central bank's actions are consistent with a forward-looking rule that has the S$NEER as the intermediate target, with the objectives of stabilising expected changes in MAS Core Inflation and minimising deviations from potential output. The estimates show that a 1% point rise in expected inflation engenders a response of a 1.7% point appreciation in the S$NEER, while a 1% point increase in the output gap induces a 0.9% point appreciation in the S$NEER. The larger size of the coefficient for inflation vis-à-vis the output gap suggests that monetary policy in Singapore has placed a relatively high degree of importance on maintaining low and stable inflation. For details on the estimation of a Taylor-type Rule for Singapore, refer to the **Technical Appendix**.[10]

5 Conclusion

Overall, since the formalisation of MAS' new framework in 1981, exchange rate-centred monetary policy has been very effective in attaining price stability, by reducing the level and volatility of domestic inflation, and contributing to low and stable inflation expectations. Over the past five decades, Singapore has generally kept inflation lower than most advanced and regional economies, while avoiding extended deflationary episodes that can undermine confidence in the economy.

Nevertheless, the ongoing COVID-19 pandemic, in causing simultaneous demand and supply shocks that are difficult to disentangle, has presented renewed challenges to monetary policy. Disruptions to global supply chains and labour markets have led to marked inflationary pressures in the major advanced economies and in some regional economies, while it remains unclear if the pandemic has led to scarring and a permanent loss in potential output. Continuing uncertainties over both inflation and economic growth during the recovery phase of the pandemic have complicated central banks' path to monetary policy normalisation. Even as central banks in the advanced economies have generally taken a patient approach to the withdrawal of policy accommodation, there remains a risk that COVID-19 may have induced longer-term shifts in inflation trends. A transitory shock could

[10] A similar estimation of Singapore's monetary policy rule was done in IMF (2018).

lead to rising inflation expectations, and the slippage of the expectations anchor may result in more persistent inflationary pressures.

Climate risks present another set of challenges to medium-term price stability. More frequent extreme weather events wrought by climate change may impact price formation via a few channels, including through supply-side shocks to food production. Yet, the complex relationships between climate change, relative prices and inflation expectations remain poorly understood, presenting challenges for central banks with inflation mandates, including MAS. The emerging priority for MAS and other central banks is therefore to quantify the frequency, likelihood and size of climate change effects, as well as to incorporate climate risk into their analytical toolkits. These efforts will better equip monetary policy to respond to the threats posed by climate change to core price stability objectives.

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Technical Appendix: MAS' Implied Policy Reaction Function

This appendix presents an econometric analysis to show that over the past three decades, MAS' policy actions are consistent with a forward-looking rule that employs the S$NEER as the intermediate target, with the aim of stabilising expected inflation and minimising the output gap.

As noted by McCallum (2006), MAS' implementation of monetary policy is very similar to that of other central banks, except that its policy management involves periodic adjustments in the exchange rate, rather than a short-term nominal interest rate.[11] Parrado (2004) followed up on this insight by deriving an analogous form of the usual Taylor Rule to accommodate MAS' unique monetary policy framework.[12] This rule sets the y-o-y changes in the S$NEER at a level consistent with stabilising expected inflation over the medium term and maintaining output at potential, and can be represented by the following reduced form equation:

$$\Delta NEER_t = \delta + \beta(E[\pi_{t+n}] - \pi^*) + \gamma(E[y_{t+m}]) + \varepsilon_t$$
$$= \alpha + \beta(E[\pi_{t+n}]) + \gamma(E[y_{t+m}]) + \varepsilon_t$$

where $\Delta NEER_t$ is the y-o-y change in the S$NEER, π is the y-o-y MAS Core Inflation rate, π^* is the inflation target, α is the constant and y is the output gap. $E[\cdot]$ denotes the expectations of a variable at time $t+n$ or $t+m$. The equation is estimated using the Generalised Method of Moments (GMM) on quarterly data over the period Q2 1992 – Q4 2019.[13] Lags of MAS Core Inflation, the output gap, the S$NEER and the 3-month S$ SIBOR are utilised as instruments. The forward-looking horizon for expected core inflation is 6 quarters ($n = 6$) in the equation above and the output gap enters contemporaneously ($m = 0$). All the estimated coefficients are highly significant and of the correct sign, except for the constant α (Table 2).

Table 2 MAS reaction function, Q2 1992 – Q4 2019

	Coefficient	Standard Error	P-value
Constant (α)	−0.927	1.016	0.364
Expected Inflation (β)	1.692	0.689	0.016
Output Gap (γ)	0.873	0.180	0.000

Source: EPG, MAS estimates

Note: Based on the Hansen test, the J-statistic (p-value = 0.231) shows that the over-identifying restrictions are valid. The Durbin-Wu-Hausman test also does not reject the null hypothesis that there is no endogeneity among the regressors (p-value = 0.464).

The results show that a 1% point rise in expected inflation induces a 1.7% point appreciation in the S$NEER, implying that the real exchange rate is temporarily altered to affect aggregate demand, and consequently, core inflation. The estimates suggest that MAS also responds to deviations from potential output, with a 1% point increase in the output gap

11 McCallum, B (2006), "Singapore's Exchange Rate-Centred Monetary Policy Regime and its Relevance For China", MAS Staff Paper, No. 43.

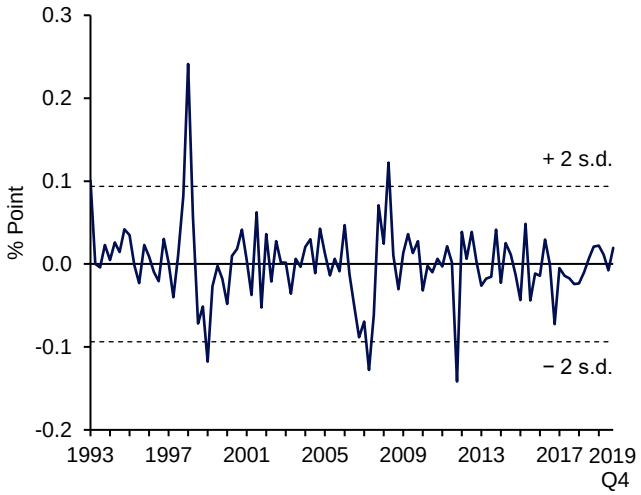
12 Parrado, E (2004), "Singapore's Unique Monetary Policy: How Does It Work?", MAS Staff Paper, No. 31.

13 The sample period is limited by the availability of potential GDP estimates, which start only in Q3 1991. The time period of estimation is further reduced due to the use of lagged variables.

engendering a 0.9% point appreciation in the S$NEER. Additionally, the relative size of the coefficient for inflation vis-à-vis the coefficient for output suggests that monetary policy in Singapore has placed a relatively high degree of importance on maintaining low and stable inflation.

The policy prescribed by the estimated Taylor rule tracks actual policy fairly well. Forecast errors have mostly remained within two-standard error bands over the past 28 years **(Chart 7)**. Significant deviations from the estimated policy rule occurred on only four occasions, and for only one or two quarters, in 1993, 1998–1999, 2007–2008 and 2011, mainly during periods of significant volatility in the global financial system such as the AFC and the Eurozone sovereign debt crisis of 2011.

Chart 7 Deviations of the S$NEER from the estimated Taylor rule



Source: EPG, MAS estimates