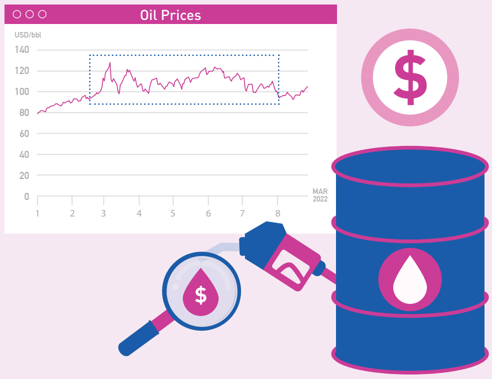
Feature Article

ANALYSIS OF RETAIL PETROL PRICES IN SINGAPORE

OVERVIEW



Following the start of the war in Ukraine on 20 February 2022, Brent crude oil prices surged amidst global supply concerns, peaking at US$133 per barrel (/bbl) in March 2022. They remained elevated and volatile in 2022 and only dipped below US$100/bbl in August 2022, before gradually declining further in end-2022 and 2023. Following the surge in oil prices in 2022, retail petrol prices in Singapore, as well as some developed economies such as the UK, rose sharply. Amidst elevated retail petrol prices, questions have been raised in Singapore as to whether petrol retailers pass through oil price increases to a greater extent than decreases (i.e., the "rocket and feather" effect). For example, while oil prices receded for the most part in June 2022 from its peak in March 2022, retail petrol prices in Singapore climbed to even higher levels in June 2022 and exceeded their March 2022 levels. At the same time, there were questions on whether retail pricing behaviour might have changed given the higher volatility in oil prices following the war.

FINDINGS

We analyse the magnitude and latency of the passthrough from oil price changes to retail petrol price movements, including whether there is evidence of the passthrough of oil price increases to retail petrol price being greater compared to that of decreases (i.e., the "rocket and feather" effect).

Finding 1:

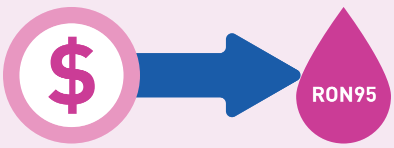
From 1 January 2016 to 30 September 2023, the cumulative passthrough to retail petrol prices of different grades from a S$1 increase in oil price was S$0.68 to S$0.71, with a latency of more than a week.

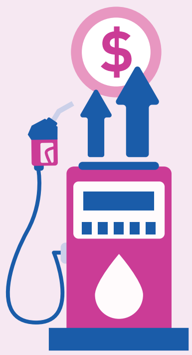
Finding 2:

We examine the relationship between oil prices and retail petrol prices before and after the Ukraine war began on 20 February 2022 and find no statistically significant differences in passthrough rates between the two periods.

Finding 3:

Petrol price adjustments are more likely to occur when there are larger oil price changes, whether increases or decreases. The increase in volatility of oil prices following the outbreak of the war in Ukraine resulted in more frequent retail petrol price changes.





EXECUTIVE SUMMARY

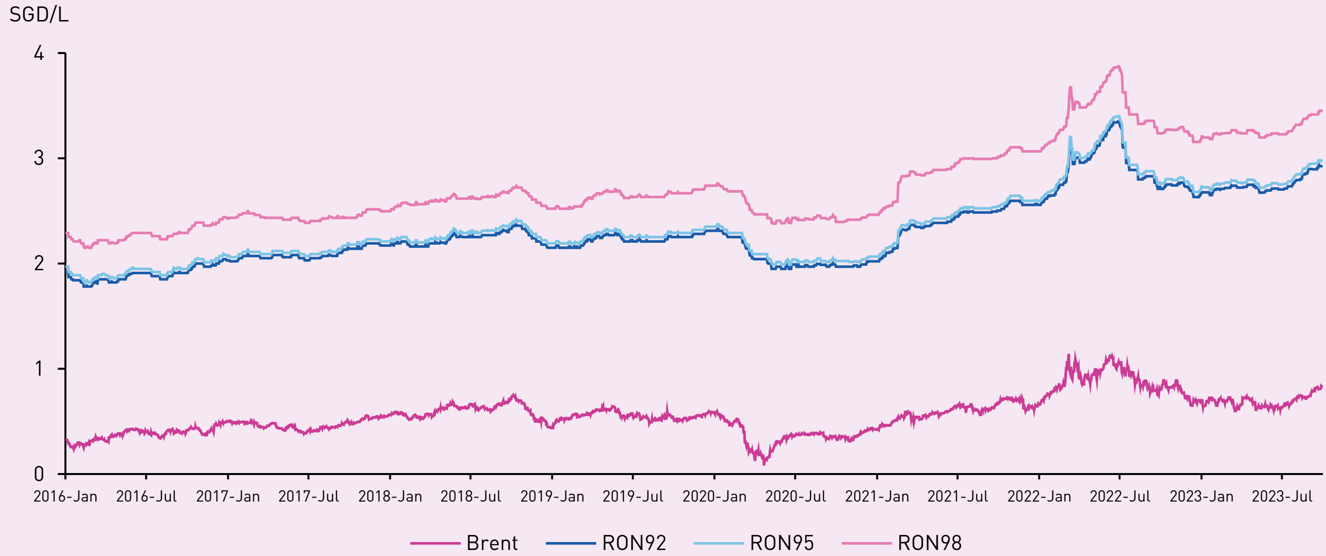
- This article examines the passthrough of oil prices to retail petrol prices in Singapore using daily data from 1 January 2016 to 30 September 2023.
- We analyse the magnitude and latency of the passthrough from oil price changes to retail petrol price movements, including whether there is evidence of the passthrough of oil price increases to retail petrol price being greater compared to that of decreases (i.e., the "rocket and feather" effect). Our findings show that the cumulative passthrough to retail petrol prices of different grades from a S$1 increase in oil price was S$0.68 to S$0.71, with a latency of more than a week.
- Next, we investigate whether the relationship between oil prices and retail petrol prices was affected by the war in Ukraine. First, we examine the passthrough rates before and after the war began on 20 February 2022 and find no statistically significant differences between the two periods. Second, we examine if petrol price adjustments are more likely to occur when there are larger oil price changes, whether increases or decreases. Our findings show that the increase in volatility of oil prices following the outbreak of the war in Ukraine resulted in more frequent retail petrol price changes.

The views expressed in this paper are solely those of the authors and do not necessarily reflect those of the Ministry of Trade and Industry or the Government of Singapore.[1]

INTRODUCTION

Following the start of the war in Ukraine on 20 February 2022, Brent crude oil prices surged amidst global supply concerns, peaking at US$133 per barrel (/bbl) in March 2022. They remained elevated and volatile in 2022 and only dipped below US$100/bbl in August 2022, before gradually declining further in end-2022 and 2023. Following the surge in oil prices in 2022, retail petrol prices in Singapore, as well as some developed economies such as the UK, rose sharply. Amidst elevated retail petrol prices, questions have been raised in Singapore as to whether petrol retailers pass through oil price increases to a greater extent than decreases (i.e., the "rocket and feather" effect).[2] For example, while oil prices receded for the most part in June 2022 from its peak in March 2022, retail petrol prices in Singapore climbed to even higher levels in June 2022 and exceeded their March 2022 levels [Exhibit 1]. At the same time, there were questions on whether retail pricing behaviour might have changed given the higher volatility in oil prices following the war.

Exhibit 1: Brent Crude Oil and Retail Petrol Prices from 1 January 2016 to 30 September 2023



Source: US Energy Information Administration (EIA), Consumers Association of Singapore (CASE), Monetary Authority of Singapore (MAS)

1 *We would like to thank Ms Yong Yik Wei, Dr Andy Feng and Dr Tan Di Song for their useful suggestions and comments. We are also grateful to the Consumers Association of Singapore (CASE) for providing daily retail petrol price data from the Fuel Kaki website for this study. All errors belong to the authors.*

2 *The question of whether there is a "rocket and feather" effect is of interest in many countries. In Singapore, the Competition and Consumer Commission of Singapore (CCCS) conducted a 2017 market inquiry into the retail petrol market, following a 2011 Economic Survey of Singapore Feature Article on the same issue. Both studies were unable to find statistically significant empirical evidence for a "rocket and feather" effect.*

This article examines the relationship between crude oil prices and retail petrol prices, and whether this relationship changed after the start of the war in Ukraine. Using daily data on crude oil prices and retail petrol prices from 1 January 2016 to 30 September 2023, we analyse (i) the magnitude and latency of the passthrough from oil price changes to retail petrol price movements, (ii) whether there is evidence of a "rocket and feather" effect, and (iii) whether there has been a change in the relationship between oil and retail petrol price movements following the onset of the war in Ukraine.

LITERATURE REVIEW

Internationally, several empirical studies have analysed the relationship between crude oil prices and retail petrol prices and some have found asymmetric price adjustments in various markets (e.g., Bacon (1991), Reilly & Witt (1998) for the UK market, Borenstein et al. (1997) for the US market).

In Singapore, a 2017 market inquiry by the Competition and Consumer Commission of Singapore (CCCS) examined the pricing behaviour of petrol retailers using daily data on wholesale petrol prices (Mean of Platts Singapore (MOPS)[3]) and retail petrol prices from January 2010 to December 2016. The study found that wholesale petrol price changes did not pass through to retail petrol prices completely and immediately: the cumulative passthrough for a S$1 increase (decrease) in MOPS was around S$0.64 (S$0.66), with price adjustments taking place over eight (six) days. In addition, the difference in the cumulative passthrough for an increase and decrease in oil prices was not statistically significant (i.e., no empirical evidence of a "rocket and feather" effect). The same market inquiry also found that wholesale petrol cost as a share of retail petrol prices decreased from 2010 to 2015 while non-fuel cost components (e.g., operating costs, levy & taxes, land costs, and discounts & rebates) increased.

Similarly, Liu et al. (2015) found no evidence to reject the hypothesis that passthrough estimates were symmetric for an increase and decrease in oil prices using weekly data in Singapore from November 2006 to March 2015. The study found that there was a complete passthrough from crude oil price changes to retail petrol price movements in the long run. Furthermore, the study hypothesised that increased smartphone usage, which enabled consumers to search for the best price, contributed to faster retail petrol price adjustments in response to crude oil price decreases but had no effect on retailers' adjustments to crude oil price increases.

DATA AND METHODOLOGY

(i) Passthrough for the Full Sample Period

To examine how retail petrol prices respond to oil price changes over the period of 1 January 2016 to 30 September 2023, we use a dynamic autoregressive distributed lag model (ADLM) of retail petrol prices against changes in Brent crude oil prices, with a momentum term for petrol price changes (i.e., lag term ΔR_{t-1} as an independent variable) to reflect persistence in retail petrol pricing.[4]

Our main regression specification is as follows:

$$\Delta R_t = \kappa \Delta R_{t-1} + \sum_{i=0}^{p} \beta_i \Delta O^{+}_{t-i} + \sum_{j=0}^{q} \gamma_j \Delta O^{-}_{t-j} + u_t$$

where:

- ΔR_t = change in average listed retail petrol price[5] for a particular octane grade (we studied RON92, RON95 and RON98 prices), of all petrol retailers in Singapore, between time t and t-1;
- ΔO^{+}_{t-i} = increase in Brent crude oil prices[6,7] between time $t-i$ and $t-i-1$, 0 if oil prices did not increase;
- ΔO^{-}_{t-j} = decrease in Brent crude oil prices between time $t-j$ and $t-j-1$, 0 if oil prices did not decrease;
- u_t = error term.

3 *MOPS is a price index for refined petroleum products in Southeast Asia.*

4 *When using an ADLM without the momentum term, the residuals were autocorrelated. On the other hand, the residuals of our dynamic model are not statistically significantly autocorrelated. The autocorrelation (ACF) plots of ΔR_t and univariate ARIMA models also indicate that an AR(1) term should be included in the specification. When we run unit root tests on the retail petrol price changes data, we are unable to conclude that there are unit roots.*

5 *As Fung et al. have noted, retail petrol prices across the five different petrol retailers in Singapore are quite similar for the same octane and tend to move in the same direction. We use the average price because not every retailer offers every octane.*

6 *We use European spot Brent crude oil prices as reported by the US Energy Information Administration (EIA). Crude oil prices in USD per barrel are converted to SGD per litre using the same-day USD to SGD exchange rate as reported by the Monetary Authority of Singapore (MAS).*

7 *A similar regression was performed using available MOPS data instead of Brent crude oil prices over a shorter time period, with similar results. Brent crude oil prices, which are available over a longer time, are therefore used as a proxy for MOPS in this study.*

We use the Bayesian Information Criteria (BIC) to choose the number of lags for oil price increases (p) and decreases (q) in the regression specification.[8] The procedure identified seven lags for oil price increases and ten lags for oil price decreases.

Our estimates suggest that $\kappa \in [0,1)$, which in turn implies that (i) our model passes the unit root test, and (ii) petrol price changes in the present period are positively correlated with petrol price changes in the previous period (i.e., price momentum). Given this, the cumulative impact on R_t from a S$1 change in ΔO_t^+ and ΔO_t^- at time t (i.e., the total passthrough) are given by $\frac{\sum_{i=0}^{p}\beta_i}{1-\kappa}$ and $\frac{\sum_{i=0}^{q}\gamma_i}{1-\kappa}$ respectively.[9]

To determine whether there is evidence of asymmetry in the passthrough estimates through the relationship between ΔR_t and $\Delta O_t^{\pm}$, we use the following linear test under the null hypothesis that there is no "rocket and feather" effect. Hence, a rejection of the null hypothesis implies the statistically significant presence of asymmetries in the effects of oil price increases and decreases on retail petrol prices.

$$H_0 : \sum_{i=0}^{p}\beta_i = \sum_{j=0}^{q}\gamma_j \qquad\qquad H_A : \sum_{i=0}^{p}\beta_i \neq \sum_{j=0}^{q}\gamma_j$$

(ii) Sub-Sample Period and Structural Break Analysis

As both oil and petrol prices were elevated and volatile after the outbreak of the war in Ukraine, we study two sub-sample periods separately: (i) 1 January 2016 to 19 February 2022 (before the war), and (ii) 20 February 2022 to 30 September 2023.

We conduct a Chow test to determine if the average passthrough estimate changed after 20 February 2022 in the post-war period. To do so, we estimate a regression of the following form:

$$\Delta R_t = \kappa\Delta R_{t-1} + \sum_{i=0}^{p}\beta_i\Delta O_{t-i}^{+} + \sum_{j=0}^{q}\gamma_j\Delta O_{t-j}^{-} + \sum_{i=0}^{p}\delta_{\geq 2022}\,\rho_i\Delta O_{t-i}^{+} + \sum_{j=0}^{q}\delta_{\geq 2022}\,\sigma_j\Delta O_{t-j}^{-} + u_t$$

where:

- $\delta_{\geq 2022}$ = a dummy indicator for whether the time period is after 20 February 2022.[10]

The coefficients of interest are ρ_i and σ_j. We test for the presence of a structural break for the cumulative price increase passthrough and the cumulative price decrease passthrough separately, under the null hypotheses that there are no structural breaks. Hence, a rejection of either null hypothesis implies that there is a statistically significant change in the passthrough rate for either oil price increases or decreases.

$$H_0 : \sum_{i=0}^{p}\rho_i = 0 \qquad H_A : \sum_{i=0}^{p}\rho_i \neq 0$$

$$H_0 : \sum_{j=0}^{q}\sigma_j = 0 \qquad H_A : \sum_{j=0}^{q}\sigma_j \neq 0$$

(iii) Retail Price Adjustments in Response to Magnitude of Oil Price Changes

As daily oil prices frequently exhibit mean-reverting behaviour (e.g., daily fluctuations around a certain price level), we hypothesise that petrol retailers may choose to hold back on petrol price adjustments in response to small oil price movements, and only make adjustments when oil price changes are large.

We use a logistic regression to test this hypothesis:

$$Prob\left(\Delta R_t \neq 0\right) = f\left(\kappa I_{>0}\left\{\left|R_{t-1}\right|\right\} + \sum_{k=0}^{max(p,q)}\delta_k I_{>0}\{|\Delta O_{t-k}|\} + \sum_{i=0}^{p}\beta_i|\Delta O_{t-i}^{+}| + \sum_{j=0}^{q}\gamma_j|\Delta O_{t-j}^{-}| + u_t\right)$$

8 For completeness, we also use the Akaike Information Criteria (AIC) to calibrate the number of lags in oil price changes. The results are similar, with the AIC identifying 10 lags for both oil price increases and decreases. We prefer the BIC for its tendency towards simpler models.
9 Refer to the Annex for a derivation of this expression.
10 As robustness checks, we explored a range of possible break points from the fourth quarter of 2021 to the end of the first quarter of 2022. The results were similar.

where:

- $I_{>0}\{|R_{t-1}|\}$ = a dummy indicator for whether retail petrol price changed between time $t-1$ and $t-2$;
- $I_{>0}\{|\Delta O_{t-k}|\}$ = a dummy indicator for whether oil price changed between time $t-k$ and $t-k-1$;
- $|\Delta O^{+}_{t-i}|$ = absolute change in Brent crude oil prices between time $t-i$ and $t-i-1$ if oil prices increased;
- $|\Delta O^{-}_{t-j}|$ = absolute change in Brent crude oil prices between time $t-j$ and $t-j-1$ if oil prices decreased.

If the magnitude of oil price movements has a bearing on the probability of petrol price changes, the β_i and γ_j coefficients in the specification would be statistically significant. In particular, positive coefficients would imply that petrol prices are more likely to change when oil price movements, either increases or decreases, are larger in magnitude. Given that oil price volatility increased following the outbreak of the war in Ukraine, this would further imply that petrol prices would change more frequently in the post-war period.

RESULTS

(i) Passthrough Estimates for the Full Sample Period

For the entire period from 1 January 2016 to 30 September 2023, the cumulative passthrough to petrol prices of different grades (i.e., RON92, RON95 and RON98) from a S$1 increase in oil price was S$0.68 to S$0.71. In other words, petrol prices increased by S$0.68 to S$0.71 in total for a S$1 increase in oil price. For a S$1 decrease in oil price, the cumulative passthrough to petrol prices of different grades was S$0.65 to S$0.68, i.e., petrol prices fell by S$0.65 to S$0.68 in total for a S$1 decline in oil price. All cumulative passthroughs were statistically significant at the 5% level [Exhibit 2]. However, the difference in the passthrough estimates between an oil price increase and an oil price decrease was not statistically significant. In other words, we do not find evidence of a "rocket and feather" effect as the passthrough estimates are symmetric for an oil price increase and decrease.

The estimated period over which petrol prices adjust to oil price changes was largely similar for a S$1 increase in oil price and a S$1 decrease in oil price, at seven days and ten days respectively.[11]

Exhibit 2: Estimates of Passthrough from Oil Price to Petrol Price from 1 January 2016 to 30 September 2023

	RON92	RON95	RON98
Cumulative passthrough to petrol price from S$1 oil price increase (S$)	0.678	0.704	0.714
Cumulative passthrough to petrol price from S$1 oil price decrease (S$)	0.649	0.683	0.679
Any statistically discernible difference between the passthrough from a price increase vs decrease? (p-value)	No (0.771)	No (0.833)	No (0.736)

(ii) Sub-Sample Period Passthrough Estimates and Structural Break Analysis

The estimated cumulative passthrough to petrol prices from a S$1 increase in oil price for the post-Ukraine war sub-sample period of 20 February 2022 to 30 September 2023 (i.e., S$0.79 to S$0.87) was slightly higher than that for the earlier period of 1 January 2016 to 19 February 2022 (i.e., S$0.56 to S$0.58) [Exhibit 3]. Similarly, for a S$1 decrease in oil price, the estimated cumulative passthrough for the post-war period (i.e., S$0.79 to S$0.86) was slightly higher than that for the earlier period (i.e., S$0.53 to S$0.54). All cumulative passthroughs were statistically significant at the 5% level.

For both sub-periods, the difference in cumulative passthrough rates for oil price increases and decreases was not statistically significant, indicating that there is no evidence of a "rocket and feather" effect. The Chow test found that the difference in estimated cumulative passthroughs between the two periods was not statistically significant, suggesting that there was no structural change in retailers' passthrough of oil price changes to retail petrol prices following the onset of the war.

11 The estimated passthrough rates and adjustment periods are broadly similar to that found in the 2017 CCCS market inquiry.

Exhibit 3: Estimates of Passthrough from Oil Price to Petrol Price, 1 January 2016 to 19 February 2022 and 20 February 2022 to 30 September 2023

<table>
<tr><th colspan="2" rowspan="2"></th><th colspan="2">RON92</th><th colspan="2">RON95</th><th colspan="2">RON98</th></tr>
<tr><th>1 Jan 2016 – 19 Feb 2022</th><th>20 Feb 2022 – 30 Sep 2023</th><th>1 Jan 2016 – 19 Feb 2022</th><th>20 Feb 2022 – 30 Sep 2023</th><th>Jan 2016 – 19 Feb 2022</th><th>20 Feb 2022 – 30 Sep 2023</th></tr>
<tr><td colspan="2">Cumulative passthrough to petrol price from S$1 oil price increase (S$)</td><td>0.558</td><td>0.792</td><td>0.571</td><td>0.855</td><td>0.582</td><td>0.866</td></tr>
<tr><td colspan="2">Cumulative passthrough to petrol price from S$1 oil price decrease (S$)</td><td>0.527</td><td>0.786</td><td>0.540</td><td>0.864</td><td>0.540</td><td>0.856</td></tr>
<tr><td colspan="2">Any statistically discernible difference between the passthrough from a price increase vs decrease? (p-value)</td><td>No
(0.542)</td><td>No
(0.977)</td><td>No
(0.551)</td><td>No
(0.964)</td><td>No
(0.385)</td><td>No
(0.961)</td></tr>
<tr><td rowspan="2">Was there a statistically significant structural break on 20 Feb 2022? (p-value)</td><td>Price Increase</td><td colspan="2">No
(0.173)</td><td colspan="2">No
(0.122)</td><td colspan="2">No
(0.160)</td></tr>
<tr><td>Price Decrease</td><td colspan="2">No
(0.220)</td><td colspan="2">No
(0.143)</td><td colspan="2">No
(0.149)</td></tr>
</table>

(iv) Estimates of Retail Price Adjustments in Response to Magnitude of Oil Price Changes

Daily oil price movements were more volatile after the war in Ukraine began on 20 February 2022 compared to the pre-war period. Specifically, the standard deviation in oil price changes from 20 February 2022 to 30 September 2023 was 2.63, higher than the 1.30 observed from 1 January 2016 to 19 February 2022.[12] Petrol price changes also became more frequent after the war started (0.22 to 0.30 changes per month from 20 February 2022 to 30 September 2023) compared to the earlier period (0.17 to 0.21 changes per month from 1 January 2016 to 19 February 2022).

Our logistic regression yields positive and statistically significant coefficients on the size of oil price increases and decreases (i.e., β_i and γ_j), suggesting that petrol retailers are more responsive towards large oil price changes (i.e., both increases and decreases) compared to smaller ones. Given that daily oil price movements were more volatile after the outbreak of the war in Ukraine, with both price increases and decreases being larger, this resulted in the higher frequency of retail petrol price changes that was observed.

CONCLUSION

Our findings show that the cumulative passthrough to retail petrol prices of different grades from a S$1 increase in oil price was S$0.68 to S$0.71, with a latency of more than a week. We did not find empirical evidence of a "rocket and feather" effect. We also investigated if the relationship between oil prices and retail petrol prices was affected by the onset of the war in Ukraine. We did not find statistically significant differences in the passthrough rates in the post-war period, compared to the earlier period. Nonetheless, the increased volatility in oil price movements after the war began resulted in more frequent retail petrol price changes.

12 Oil prices are measured in USD per barrel (rather than in SGD per litre) to capture the volatility in oil prices only.

Contributed by:

Mr Andrew Chia
Senior Economist
Economics Division
Ministry of Trade and Industry

Ms Sarah Liu
Economist
Economics Division
Ministry of Trade and Industry

Mr Herbert Fung
Senior Director
Data and Digital Division
Competition and Consumer Commission of Singapore

Mr Kong Weng Loong
Deputy Director
Business and Economics Division
Competition and Consumer Commission of Singapore

Ms Vilasni Pandian
Competition Analyst
Policy and Markets Division
Competition and Consumer Commission of Singapore

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ANNEX

Proposition: The cumulative impact on R_t from a 1-unit change in ΔO_t^+ and ΔO_t^- at time t is given by $\frac{\sum_{i=0}^{p}\beta_i}{1-\kappa}$ and $\frac{\sum_{i=0}^{q}\gamma_i}{1-\kappa}$ respectively

Proof of Proposition: Consider the case where $p = q = 1$, where we look at a shock on ΔO_t^+ at time t. In the first period, the impact on ΔR_t would be β_0, and in the second period the impact would be κ times the first period impact plus β_1 so we have $\kappa\beta_0 + \beta_1$. Thereafter, the impact would be κ times the previous period. Denoting the cumulative impact as ΔR (dropping the t subscript as we are considering the cumulative impact), it can be written as:

$$\Delta R = \beta_0 + \sum_{h=0}^{\infty}\kappa^h(\kappa\beta_0 + \beta_1) = \beta_0 + \frac{(\kappa\beta_0 + \beta_1)}{(1\text{-}\kappa)} = \frac{(\beta_0 + \beta_1)}{(1\text{-}\kappa)}$$

where the second equality is by the properties of a geometric series.

For the general, consider the cumulative impact being the sum of p geometric series, one for each lag of ΔO_t^+. At time t, the shock results in a ΔR_t increase of β_0 through ΔO_t^+. This is then propagated throughout the rest of the time periods $t + h$ for $h = 1, 2, \ldots$ at a declining rate determined by κ, cumulatively forming the geometric series $\sum_{h=0}^{\infty}\kappa^h\beta_0$.

At time $t + 1$, the shock results in an ΔR_t increase of β_1 through ΔO_{t+1}^+. This is then propagated throughout the rest of the time periods in a similar fashion forming the geometric series $\sum_{h=0}^{\infty}\kappa^h\beta_1$.

The above process continues for all p lag terms on ΔO_t^+ that are included in the model. Because the model only accounts for the dynamics of ΔR_t and not ΔO_t, each shock and its propagation are independent of the others. Therefore, the cumulative impact can be written as:

$$\Delta R = \sum_{i=0}^{p}\sum_{h=0}^{\infty}\kappa^h\beta_i = \sum_{h=0}^{\infty}\kappa^h\sum_{i=0}^{p}\beta_i = \frac{\sum_{i=0}^{p}\beta_i}{(1\text{-}\kappa)}$$