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Inflation Persistence in the G7: The Effects of the Covid-19 Pandemic and of the Russia-Ukraine War

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ABSTRACT

This note analyses how shocks caused by the Covid-19 and the Russia-Ukraine crisis impact on inflation persistence G7 countries. Using data ending at December-2019, high estimates of the persistence parameter *d* indicate a strong persistence of inflation. The unit root hypothesis could not be refuted for Germany, Japan, and the United States, while this hypothesis is rejected in favour of higher orders of integration in the remaining cases. Expanding the dataset to include the pandemic and the Russia-Ukraine crisis reveal that d-values remain significantly elevated across all countries, reinforcing the persistence of inflation. Interestingly, Canada, previously excluded from the group, now aligns with Germany, Japan, and the United States. This suggests a change in inflation dynamics for Canada during these extraordinary periods. Additionally, employing a recursive estimate reveals a slight increase in inflation persistence for most countries, except Japan, which exhibits an almost flat trend in the evolution of the differencing parameter.

JEL Classification: C22, E31

1 | Introduction

One of the most telling indicators of economic growth and overall prosperity is the inflation rate. It is therefore one of the most interesting theoretical and empirical fields in macroeconomics. The basic focus of monetary policy is to keep inflation rates low and stable. Therefore, in order to develop the most efficient monetary policy feasible, monetary authorities monitor inflation persistence, which displays their potential to re-establish price stability following a shock.[1]

The persistence of high inflation may arise due to factors such as inflexibility in prices and wages, as suggested by Galí and Gertler (1999), or due to insufficient transparency in the implementation of monetary policy, as posited by Walsh (2007). Numerous studies have endeavoured to empirically evaluate the significant persistence of inflation, with the objective of examining the enduring impact of shocks and ultimately enhancing the accuracy of forecasting. However, these studies have yielded varying and incongruous outcomes. Initially, the body of literature exploring whether inflation exhibits a unit root or stationary process does not present a unanimous agreement. The presence of a unit root in the inflation rate has been documented by Nelson and Schwert (1977), Ball and Cecchetti (1990), Kim (1993), Banerjee, Cockerell, and Russell (2001), and Banerjee and Russell (2001) among others. According to Grier and Perry (1998), the inflation rate exhibits stationarity. However, the findings of Kirchgässner and Wolters (1993) and Bos, Franses, and Ooms (1999) were inconclusive.

There are several indications that suggest a substantial level of persistence in inflation across most G7 nations following World

War II. However, a matter of equivalent importance relates to the change in its degree of persistence over time, possibly attributable to the adoption of different monetary policy frameworks, such as inflation targeting.[2] Research by Pivetta and Reis (2007) and Stock and Watson (2007, 2010), suggests that there were no significant changes in the United States during the post-World War II period, assuming that the uncertainty surrounding point estimates is considered, and a differentiation is made between persistent and transitory modifications in inflation. Caporale, Gil-Alana, and Trani (2022b) arrived at a comparable inference, contending that the extent of inflation persistence in the United Kingdom throughout the twentieth century was relatively lower than that of preceding centuries.

The global economy and inflation have been significantly impacted by two significant external shocks, namely the Covid-19 Pandemic and the war between Russia and Ukraine.[3] These shocks severely disrupted global supply chains, resulting in substantial inflationary pressures. Supply chain disruptions are particularly relevant in the context of inflation persistence because they exacerbate price stickiness (See Ball and Mankiw 2002; Nakamura and Steinsson 2013).

During the Covid-19 Pandemic, supply chain disruptions also created bottlenecks that increased the cost of manufacturing many goods (Guerrieri et al. 2022). As a result, firms were often slow to adjust prices downward when these pressures eased. This slow adjustment occurs for several reasons. First, menu costs—the costs associated with changing prices—discourage frequent price changes (Mankiw 1985). Firms also hesitated to reduce prices too quickly due to uncertainty about the future course of supply chain recovery and the potential for further disruptions. Furthermore, companies may have factored in a future with higher input prices, resulting in a longer return to price stability even when supply chain conditions improve. The pandemic's supply chain shocks increased inflation persistence by making price cuts less frequent and instilling stronger inflation expectations amongst firms and consumers. In this sense, pandemic-related supply chain disruptions not only generated an initial increase in prices, but also ensured that inflation continued as firms responded to these shocks with sticky pricing adjustments (Cascaldi-Garcia, Loria, and López-Salido 2022). The relationship between supply chain constraints, price stickiness, and inflation persistence is an important mechanism by which exogenous shocks influence inflation dynamics over time.

Consequently, the objective of this paper is to offer a comprehensive analysis of the stochastic nature of inflation across all G7 nations and investigate the impact of the COVID-19 pandemic and the Russia-Ukraine Crisis on inflation persistence within the G7. This will be achieved by utilising a long memory technique, specifically fractional integration.[4] Furthermore, to investigate any potential variations in persistence, we use a recursive approach to capture different types of time variation in inflation persistence. The utilisation of the fractional integration method confers an advantage in its capacity to effectively capture the prolonged dynamics inherent in inflation and thus manage the nonstationary nature of the data.

The layout of the remainder of the paper is as follows. Section 2 outlines the methodology, while Section 3 describes the data. Section 4 discusses the results. Finally, Section 5 offers some concluding remarks.

2 | Methodology

The estimated model is as follows:

$$y_t = \beta_0 + \beta_1\, t + x_t, (1 - L)^d\, x_t = u_t, t = 1, 2, ..., \qquad (1)$$

where y_t refers to the observed time series; β_0 and β_1 are the coefficients corresponding respectively to the intercept and a linear time trend, and x_t is supposed to be I(d) where d is a real value; finally, u_t is I(0) and we allow for a weak dependence structure throughout the model of Bloomfield (1973).[5]

On the basis of its binomial expansion, the polynomial $(1 - L)^d$ in Equation (1) can be formulated such that for all real d,

$$(1 - L)^d = \sum_{j=0}^{\infty} \psi_j L^j = \sum_{j=0}^{\infty} \binom{d}{j} (-1)^j L^j = 1 - dL + \frac{d(d-1)}{2} L^2 - ..., \qquad (2)$$

Therefore, letting π_t to be the inflation rate, Equation (3)

$$(1 - L)^d \pi_t = \pi_t - d\pi_{t-1} + \frac{d(d-1)}{2} \pi_{t-2} - ... \qquad (3)$$

The significance of the degree of inflation persistence can be determined by including the variable 'd' in Equation (3), as it characterises the level of dependence of the inflation series. A higher value of d indicates stronger association and persistence between the observations. The advantage of this model is its flexibility since it incorporates classical stationary models and nonstationary ones as particular cases of interest with $d = 0$ and 1 respectively. However, we can also consider nonstationary cases with mean reverting behaviour if d belongs to the interval [0.5, 1). In particular, based on the real nature of d, we can consider the following cases:

i. anti-persistence (if $d > 0$. See, e.g., Veenstra 2013),
ii. short memory (if $d = 0$),
iii. stationary long memory (if $0 < d < 0.5$),
iv. $1/f_{1/2}$ noise (if $d = 0.25$)
v. 1/f noise (if $d = 0.5$. Johnson 1925)
vi. nonstationary mean reverting processes (if $d \le 0.5 < 1$),
vii. I(1) processes (if $d = 1$),
viii. I(2) behaviour (if $d = 2$), among many other processes.

We report the estimates of d (and its confidence bands) by using a standard method based on the likelihood function (Robinson,

1994) and widely used in empirical applications. This method relies on the Lagrange Multiplier (LM) principle and test the null hypothesis:

$$H_0 : d = d_o, \tag{4}$$

for any real d_o, in the model given by Equation (1). Under the null Equation (4), the model becomes stationary I(0) and the test statistic has a standard null and local limit distributions. Moreover, this asymptotic standard behaviour holds for any value d_o, including those outside the stationary region, that is, $d_o \geq 0.5$. The functional form for the version of the test used in this application can be found in L. Gil-Alana and Robinson (1997).

In the final part of the empirical application we present a recursive approach, displaying the estimates of d first in a sample ending at December 2019, and then adding one observation each time until the end of the sample in May 2023.

3 | The Dataset

We use monthly data from the Organisation for Economic Cooperation and Development (OECD) on headline inflation rates in the G7 countries from January 1971 to May 2023. Table 1 provides a summary statistics of G7 inflation rates. The mean values indicate higher average inflation in Italy and the UK, with Japan exhibiting the lowest. Standard deviations show significant volatility in Italy, the UK, and Japan, whereas Germany experiences more stable inflation. Skewness is positive across all countries, with Japan and the UK showing the highest, suggesting a greater occurrence of large inflationary spikes. Kurtosis is notably elevated in Japan, reflecting more frequent extreme inflationary events, while Germany's kurtosis is close to zero, indicating a more normally distributed inflation pattern.

As can be observed from Figure 1, inflation was highly unstable in the 1970s due to oil price shocks, wage-price spirals, and expansionary monetary policies. The oil crises led to increased energy costs, wage increases outpaced productivity growth, and loose monetary policies fuelled inflationary pressures, contributing to economic instability. However, the lower inflation rates in G7 countries since the 1980s can be attributed to disciplined and independent monetary policies, prudent fiscal measures, and structural reforms that enhanced productivity and competition. Additionally, globalisation, technological advancements, and global economic factors have played a role in containing inflationary pressures.

Nevertheless, the COVID-19 pandemic & the Russia-Ukraine crisis have led to inflation pressures similar to those in the 1970s due to supply chain disruptions and commodity price volatility as can be observed from Figure 1. These factors have contributed to higher input costs and potential supply shortage, which can exert upward pressure on prices. All of these factors play a role in shaping the approaches taken in the empirical analyses outlined in Section 4.

4 | Empirical Results

Across Tables 2–4 we report the estimates of d (obtained by using the Whittle function in the frequency domain), along with their associated 95% confidence bands for the three classical cases examined in the unit root literature, and corresponding to the cases of i) no deterministic terms, that is, with $\beta_0 = \beta_1 = 0$ in Equation (1) (results reported in column 2); ii) with an intercept (i.e., with $\beta_1 = 0$. Results given in column 3); and iii) with an intercept and a linear time trend. Column 4).

The results in Table 2 refer to the case of data ending at December 2019, that is, two months before the beginning of the Covid-19 pandemic. We observe that the estimates of d are large in all cases, and the unit root null hypothesis cannot be rejected in the cases of Germany, Japan and the US.[6] Note that for these three countries the confidence intervals include the value $d = 1$ under the three specifications. For the rest of the countries under consideration, including the G7, the estimates of d are significantly higher than 1, with all values in the intervals above this number.

Next we focus on the results for the data ending at March 2023 which are presented in Table 3. Again the values of d are relatively high in all cases. For Germany, the US and Japan, the unit root null ($d = 1$) is not rejected as with the pre-pandemic data. However, Canada is now also included in this group. Comparing the results in the two cases (see Table 4), we see that for all countries except Canada and Japan, there is an increase in the value of d. For these two countries, however, there is no change in persistence.

TABLE 1 | Summary statistics.

Statistic	Canada	France	Germany	Italy	Japan	UK	USA	G7
Mean	4.0	4.1	2.7	6.1	2.4	5.4	4.0	3.9
Standard deviation	3.2	4.0	2.0	6.0	4.3	5.3	3.0	3.2
Skewness	1.1	1.2	0.8	1.2	2.8	1.8	1.4	1.3
Kurtosis	0.2	0.3	−0.1	0.5	9.6	3.0	1.8	1.1
No. of observations	627	627	627	627	627	627	627	627

Source: Author's calculations.

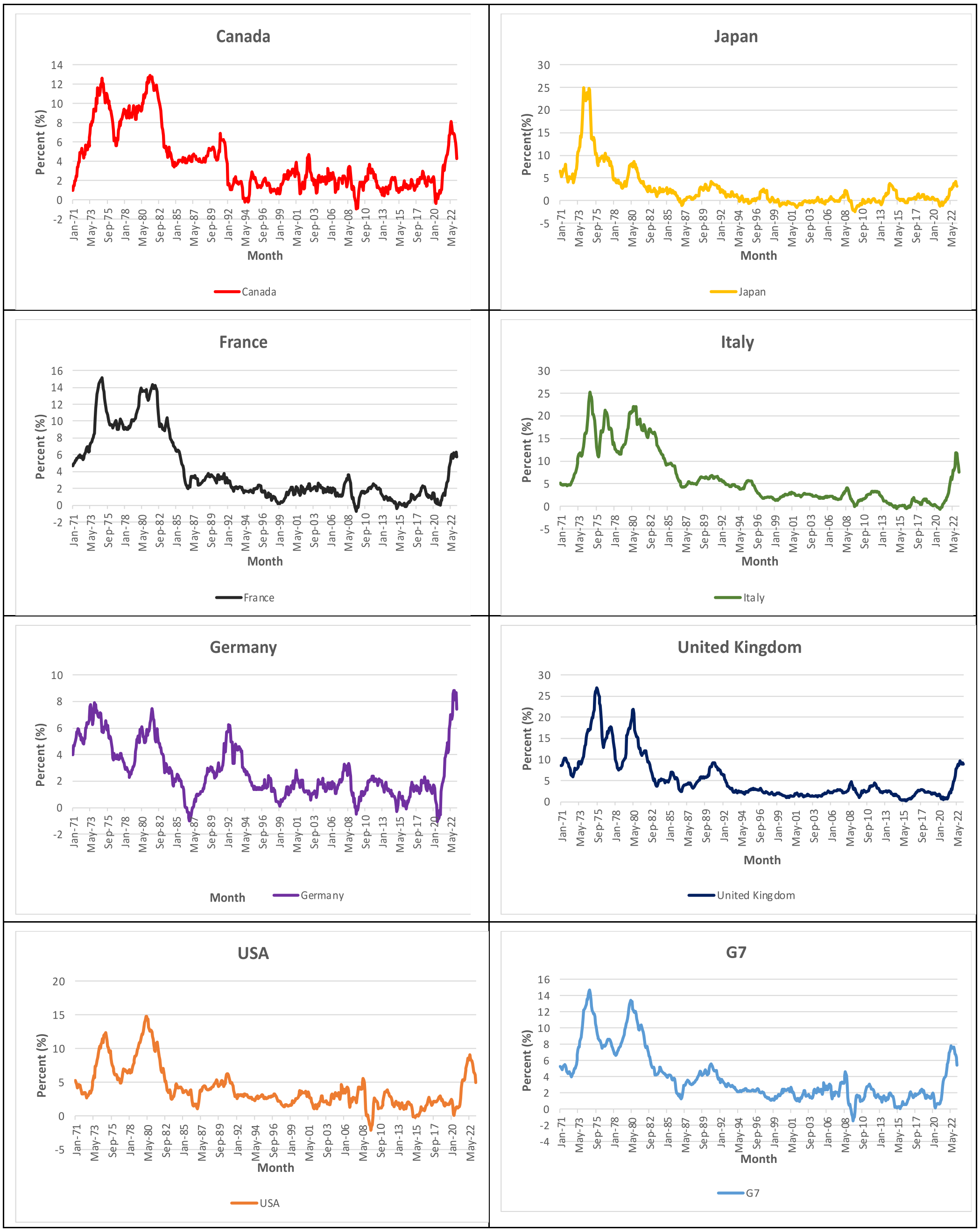

FIGURE 1 | Inflation in the G7. [Colour figure can be viewed at wileyonlinelibrary.com]

Nevertheless, these results may be obscuring the evolution of *d* during the last 2 years. Thus, in what follows, we employ a recursive approach in the estimation of the differencing parameter *d*. Starting with a sample that ends at December 2019, we incrementally incorporate new observations to our prior parameter estimate of *d* to investigate the influence of the Covid-19 pandemic and the Russia-Ukraine conflict on inflation persistence across time. Figure 2 displays both the recursive estimates and the 95% confidence intervals. In general, there is a small rise in the level of inflation persistence. Japan is an exception as its estimated value of *d* remains relatively constant at around 1.10 across all samples. Canada experienced a rise in April 2021(overlapping with economic disruptions caused by the COVID-19 pandemic, followed by a more pronounced increase between March and May 2022 (coinciding with effects the impact of ongoing high commodity prices from the Russia-Ukraine conflict). In France, there was a rise in the persistence parameter in April 2021, followed by a sustained increase from February to July 2022, this was linked to period it experienced supply chain bottlenecks and rising energy costs. Germany has shown an upward trend since January 2020, with notable peaks in July and November 2021, as well as May and September 2022. These peaks coincide with periods of increased economic uncertainty and supply chain disruptions, particularly the effects of the global semiconductor shortage.

TABLE 2 | Estimates of *d* based on autocorrelated errors. Data ending at December 2019.

Series	No terms	With an intercept	With an intercept and a time trend
Canada	1.11 (1.02, 1.23)	1.10 (1.01, 1.24)	1.10 (1.01, 1.23)
France	1.15 (1.06, 1.29)	1.17 (1.08, 1.32)	1.17 (1.08, 1.32)
Germany	1.04 (0.95, 1.16)[a]	1.04 (0.96, 1.16)[a]	1.04 (0.96, 1.16)[a]
Italy	1.24 (1.11, 1.39)	1.25 (1.12, 1.40)	1.25 (1.12, 1.40)
Japan	1.10 (0.99, 1.21)[a]	1.10 (1.00, 1.22)[a]	1.10 (1.00, 1.22)[a]
UK	1.27 (1.14, 1.42)	1.31 (1.20, 1.48)	1.31 (1.20, 1.48)
USA	1.05 (0.96, 1.18)[a]	1.06 (0.95, 1.18)[a]	1.06 (0.95, 1.18)[a]
G7	1.12 (1.02, 1.20)	1.14 (1.04, 1.23)	1.14 (1.04, 1.23)

Note: The values in column 2 refers to a model with no deterministic components. Those in column 3 refer to the model incorporating an intercept, while those in the lat column incorporate an intercept and a linear time trend. The numbers indicate the estimators of the differencing parameter, *d*. In brackets, the 95% confidence intervals of the non-rejection values of *d*.
[a]Evidence of unit roots at the 95% level.

TABLE 3 | Estimates of *d* based on autocorrelated errors. Data ending at March 2023.

Series	No terms	With an intercept	With an intercept and a time trend
Canada	1.09 (1.00, 1.21)[a]	1.10 (0.99, 1.20)[a]	1.10 (0.99, 1.20)[a]
France	1.19 (1.11, 1.31)	1.19 (1.10, 1.32)	1.19 (1.10, 1.32)[a]
Germany	1.10 (1.03, 1.19)	1.08 (1.00, 1.18)[a]	1.08 (1.00, 1.18)[a]
Italy	1.24 (1.13, 1.39)	1.28 (1.16, 1.43)	1.28 (1.16, 1.43)
Japan	1.08 (0.99, 1.19)[a]	1.10 (1.00, 1.22)[a]	1.10 (1.00, 1.22)[a]
UK	1.28 (1.16, 1.42)	1.34 (1.20, 1.50)	1.34 (1.20, 1.50)
USA	1.605 (0.96, 1.16)[a]	1.07 (0.97, 1.20)[a]	1.07 (0.97, 1.20)[a]
G7	1.13 (1.04, 1.25)	1.16 (1.06, 1.28)	1.16 (1.06, 1.28)

Note: The values in column 2 refers to a model with no deterministic components. Those in column 3 refer to the model incorporating an intercept, while those in the lat column incorporate an intercept and a linear time trend. The numbers indicate the estimators of the differencing parameter, *d*. In brackets, the 95% confidence intervals of the non-rejection values of *d*.
[a]Evidence of unit roots at the 95% level.

TABLE 4 | Summary results of persistence.

Series	December 2019	March 2023
Canada	1.10 (1.01, 1.24)	1.10 (0.99, 1.20)
France	1.17 (1.08, 1.32)	1.19 (1.10, 1.32)
Germany	1.04 (0.96, 1.16)[a]	1.08 (1.00, 1.18)[a]
Italy	1.25 (1.12, 1.40)	1.28 (1.16, 1.43)
Japan	1.10 (1.00, 1.22)[a]	1.10 (1.00, 1.22)[a]
UK	1.31 (1.20, 1.48)	1.34 (1.20, 1.50)
USA	1.06 (0.95, 1.18)[a]	1.07 (0.97, 1.20)[a]
G7	1.14 (1.04, 1.23)	1.16 (1.06, 1.28)

Note: The values refer to the estimates of *d* along with their associated 95% confidence intervals (in brackets).
[a]Evidence of unit roots at the 95% level.

Furthermore, the persistence parameter in Italy exhibits stability until mid-2021, followed by a subsequent increase towards the end of 2022. The persistence of the samples remains stable for Japan and the United Kingdom. The persistence parameter in the US has remained stable, but began to increase in October 2021. This move is consistent with broader inflationary pressures in the United States, affected by labour market dynamics, and supply chain issues.

The G7 aggregate experiences an increase in the persistence parameter beginning in February-March 2021, with the highest peak observed in July 2022.

5 | Conclusion

This paper focuses on the potential influence of the Covid-19 pandemic and the Russia-Ukraine conflict on inflation persistence in the G7 nations as several studies have shown that external shocks such as pandemics and wars can significantly impact macroeconomic variables (see Salisu, Ebuh, and Usman 2020).

Prior to the onset of the COVID-19 pandemic, it was observed that the estimates of the persistence parameter *d* were substantially high across all countries, and the null hypothesis of a unit root could not be refuted for Germany, Japan, or the

FIGURE 2 | Recursive estimates of *d* as a measure of inflation persistence. The initial estimate, *d*, is derived from a sample that ends in December 2019, and subsequent estimates are obtained by adding one observation at a time in a recursive fashion. Samples ending in January 2020 and March 2023 are represented by observations 1 and 39, respectively. The estimated values of *d* are shown by the red line, while the 95% confidence intervals are depicted by the black lines. [Colour figure can be viewed at wileyonlinelibrary.com]

United States, with this hypothesis being rejected in favour of higher degrees of integration in the remaining cases. Nonetheless, upon expanding the dataset to encompass the COVID-19 pandemic and the Russia-Ukraine crisis, it is observed that the values of *d* remain considerably elevated across all countries. As with the pre-pandemic data, the null hypothesis of a unit root could not be rejected for Germany, the US or Japan. However, Canada is now included in this group.

In addition, we use a recursive estimate to evaluate how the persistence parameter has changed over time. We find there is a small rise in the level of inflation persistence which the exception of Japan which was almost flat.

This note provides insights for policymakers and economists on how major global events and geopolitical tensions affect inflation dynamics.

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Endnotes

[1] Inflation persistence is a crucial factor to be taken into account while formulating a successful monetary policy as it hinders the central bank's ability to attain economic and price stability. This has been highlighted by various scholars such as Rudebusch (2002), Levin and Williams (2003), Amano (2007), Coenen (2007), Zhang, Osborn, and Kim (2008), Noriega and Ramos-Francia (2009), Zhang (2011), Paez-Farrell (2011), Ahmad and Staveley-O'Carroll (2017), Gil-Alana and Gupta (2019), L. A. Gil-Alana and Trani (2019), Ebuh et al. (2021) and Caporale, Gil-Alana, and Poza (2022a,b).

[2] Recent research on the dynamics of inflation persistence has focused on structural persistence, as evidenced by studies conducted by Tule, Salisu, and Ebuh (2020), Salisu and Isah (2018) and Caporale, Gil-Alana, and Poza. (2022a,b).

[3] The occurrence of pandemics can result in inflationary or deflationary forces due to the disturbances caused to supply chains. According to Armantier et al. (2021), the emergence of Covid-19 has resulted in a rise in inflation uncertainty. Furthermore, according to Cavallo (2020), alterations in the spending habits of consumers have led to a distortion in the measurement of inflation. Furthermore, the Russia and Ukraine conflict has resulted in higher food and energy prices with attendant consequences on inflation.

[4] In contrast to the conventional AutoRegressive-Moving Average (AR[I]MA) models that necessitate the imposition of a unit root or a fundamental AR process assumption, the fractional integration technique is considerably more comprehensive and flexible. Fractional integration is a more comprehensive approach compared to the conventional method that relies on the binary classification of I(0) stationarity and I(1) non-stationarity, as it accommodates both fractional and integer degrees of differentiation. The aforementioned characteristic enables it to encompass a significantly wider spectrum of stochastic processes, thereby facilitating an understanding of the persistence or transience of shock effects, the probability of mean reversion, and the speed of the dynamic adjustment process.

[5] The advantage of using the Bloomfield estimator for fractional integration is that it offers robustness to short-range dependence, flexibility without relying on specific models and ease of implementation. It provides accurate estimates with minimal bias and reasonable efficacy making it a practical choice for analysing time series data

[6] This implies that inflation tends to exhibit a high degree of persistence over time. Consequently, inflation shocks or deviations from the average inflation rate are likely to have a long-lasting (permanent) impact.

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