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Evidence of Inflation Using Harmonized Consumer Price Indices in Some Euro Countries: France, Germany, Italy, and Spain, along with the Euro Zone

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Abstract: This paper deals with the analysis of the persistence in the Harmonized Indices of Consumer Prices in France, Germany, Italy, and Spain. The degree of persistence is measured through fractional integration or I (d) techniques, using monthly data from January 2010 to February 2023. We first conducted the analysis with data ending in December 2019, that is, with data prior to the COVID-19 pandemic. Then, we extended the sample, first up to December 2021 and finally to February 2023. Our results show that the findings of our series are highly persistent, with values of the differencing parameter about one or higher than one in the majority of cases. In fact, mean reversion is only observed in the case of Germany with pre-pandemic data. Generally, we observed an increase in the degree of persistence of the series as a consequence of both the COVID-19 pandemic and the Russia–Ukraine war, with the only exception being Spain, where we observe a reduction in the order of integration when including 2022–2023 data.

Keywords: Euro area; inflation rates; long memory; fractional integration; time trends

MSC: 28-06; 28-08

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1. Introduction

One of the most critical concerns in contemporary economics is the potential resurgence of persistent inflation, along with the economic and financial ramifications stemming from the prolonged implementation of expansionary fiscal and monetary policies (Cordero et al. [1]; Cole & Ohanian [2]). The primary objective of central banks across the globe is to maintain price stability, which entails preventing significant inflation and prolonged deflation (Sturm & Wollmershäuser [3]). Inflation refers to the overall increase in prices over time, reducing the purchasing power of money, while permanent inflation indicates a persistent rise in prices over an extended period (Cordero et al. [1]). Conversely, deflation represents a sustained decline in the general price level, resulting in increased purchasing power but potentially leading to negative economic consequences (Cole & Ohanian [2]).

Periods characterized by excessive inflation or deflation have well-documented adverse effects on the economy, whereas price stability promotes economic growth, safeguards employment, and instills confidence among citizens that the value of their currency will remain relatively stable over time. This paper aims to analyze the statistical properties of the Monetary Union Index of Consumer Prices (MUICP) and investigate the degree of integration in France, Germany, Italy, and Spain (Herzog-Stein & Horn [4]). The goal is to determine whether shocks in the series have transitory or permanent effects (Cuestas & and Gil-Alana [5]).

Given that Germany, France, Italy, and Spain together constitute a substantial proportion (65%) of European GDP, the data from these four countries are particularly relevant within the European Union (Herzog-Stein & Horn [4]). To measure the degree of dependence in the series, fractional integration methods are employed (Cordero et al. [1]). This approach proves especially valuable, as it surpasses the limitations of traditional econometric models that primarily rely on integer degrees of differentiation, such as I (0) for stationarity and I (1) for non-stationarity cases. Allowing for fractional values of differentiation (d) enhances the model's flexibility and resilience, enabling us to discern whether shocks in the series have lasting or temporary effects. Additionally, the chosen methodology facilitates the direct analysis of (log) prices instead of their first differences (inflation rates), even for values outside the stationary region (Cordero et al. [1]).

The contributions of this study are threefold: firstly, it examines the degree of persistence of the series from a fractional perspective, which offers greater flexibility compared with classical methods employing integer differentiation. Secondly, it investigates whether the degree of dependence has undergone changes over time, particularly in response to significant shocks such as the COVID-19 pandemic and the Russia–Ukraine war (Cordero et al. [1]). Lastly, the study employs a robust methodology based on Robinson (1994), valid even in nonstationary contexts, allowing for the direct analysis of price indices rather than their growth rates.

The objective of this paper is to investigate the property of persistence in the price index series of the four countries mentioned above along with the Euro area, using updated time series techniques. Thus, the hypothesis under examination is that price indices in Europe are very persistent, showing a lack of mean reversion and presenting permanency of shocks.

In conclusion, this paper aims to shed light on the persistence of inflationary pressures and their implications for price stability and economic performance in the Eurozone. By analyzing the statistical properties of price series in key European countries and employing fractional integration techniques, this study provides valuable insights into the nature of shocks and their long-term effects on prices. The findings contribute to the understanding of inflation dynamics and have important implications for policymakers seeking to maintain price stability and promote sustainable economic growth in the Eurozone. Further research can build upon this study by exploring alternative modeling approaches and considering additional factors.

The subsequent sections of this paper are structured as follows: Section 2 defines key concepts, including inflation, permanent inflation, and deflation, to enhance clarity and understanding. Section 3 reviews the relevant literature, providing an overview of the current state of research on inflation dynamics assessed by the general price index. Section 4 introduces the methodology utilized in this study, while Section 5 presents the dataset employed. The empirical results are presented in Sections 6 and 7 concludes the paper, summarizing the findings and outlining potential implications for policy and further research.

2. Concepts and Definitions

The traditional definition of inflation refers to a sustained increase in the prices of goods and services over time. However, measuring inflation involves considering different dimensions of price movements, leading to various categories of price inflation. The U.S. Bureau of Labor Statistics tracks the Consumer Price Index (CPI), which reflects changes in the prices of items typically purchased by households, and the Producer Price Index (PPI), which measures price changes at the production level. Additionally, there are other measures. These include the U.S. Import and Export Price Indices, which monitor price changes of goods and services traded internationally, providing insights into the impact of global trade on domestic inflation. The GDP deflator is another measure that encompasses price changes across all final goods and services produced within an economy, offering a broad perspective on overall price level movements. Lastly, core inflation excludes volatile components, such as food and energy prices, and focuses on underlying inflation trends, providing a more stable measure of long-term price movements. These additional measures enhance our understanding of inflation dynamics and contribute to informed decision-making by policymakers and economists.

In what follows we make a short review of the different definitions of inflation:

According to various academic studies, inflation is traditionally defined as a generalized and sustained increase in the prices of goods and services within a specific period (Mankiw [6]; Blanchard [7]). However, scholars argue that this definition, although easy to understand, has limitations due to its generic nature (Romer [8]). Researchers suggest that multiple measures can be employed to categorize the price level of an economy, leading to different types of price inflation (Fischer [9]).

For instance, the U.S. Bureau of Labor Statistics compiles various types of inflation measures, including the Consumer Price Index (CPI), Producer Price Index (PPI), and Import and Export Price Indices (Bureau of Labor Statistics [10]). These indices provide insights into different aspects of price changes in the economy.

In the Euro area, the academic literature highlights the significance of the Harmonized Index of Consumer Prices (HICP) as the most representative index for the European Union (Eurostat [11]; Draghi [12]). The HICP is considered "harmonized" because it follows standardized rules and methodology, allowing for cross-country comparisons (Darvas [13]).

Academic research also emphasizes the importance of the Monetary Union Index of Consumer Prices (MUICP) within the Euro area for the design of monetary policy (ECB [14]; Smets and Wouters [15]). The MUICP is widely used by institutions such as the European Central Bank as a key indicator in managing monetary policy (Taylor [16]).

Furthermore, the academic literature discusses the complexities and considerations involved in measuring inflation accurately. These include aspects such as coverage of purchases, treatment of special fees and taxes, inclusion of sales taxes and rebates, and exclusion of credit charges and interest (Mankiw [6]; Romer [8]).

3. Literature Review

Several empirical studies analyze inflation and price persistence using different approaches; in the literature, the most typical model is the ARMA—Autoregressive Moving Average (Osborn and Sensier [17], in the UK as an example). A notable exception is Baillie [18], who employed an ARFIMA_GARCH—Autoregressive Fractionally Integrated Moving Average with Generalized Autoregressive Conditional Heteroskedasticity—model to deal with the persistence in inflation with long memory behavior. In a similar, way, Caporale et al. [19] used long memory methods based on fractional integration. In this article, the authors measured inflation persistence in the UK over the period 1660–2016 and found inflation stability since the end of World War I, despite different monetary regimes. The main advantage relies on it not requiring the imposition of any assumption of a unit root or a simple AR process; therefore, it is more generic compared with the much-favored ARMA modeling approach and gives us a variety of possible stochastic behaviors. For the 1210–2016 period, Caporale and Gil-Alana [20] showed that, in general, exchange rate and monetary regime changes do not seem to have a significant impact on the stochastic behavior of prices if a long-term historical perspective is adopted.

Gadea and Mayoral [21] studied the statistical properties of inflation. Its degree of persistence and stability over time are the subject of intense debate; a consensus has not yet been reached. The aim of the paper was to analyze this controversy using a general approach to provide a plausible explanation for the existing contradictory results. They considered the prices of the OECD—Organization for Economic Co-operation and Development—economies that were designed as fractionally integrated (FI) processes. First, they analytically showed that FI could appear in inflation rates after aggregating the individual prices of companies facing the different costs of adjusting their prices. Next, they provided strong empirical evidence supporting the FI hypothesis using classical and Bayesian techniques. They then estimated impulse response functions and other scalar measures of persistence, achieving an accurate picture of that property and its variation across countries. The application of certain typical tools to measure persistence, such as the sum of AR—autoregressive—coefficients, could lead to inaccurate conclusions if fractional integration was present. Finally, they concluded that inflation persistence was not permanent, but has been high in many post-industrial countries and remained stable over the last four decades.

Meller and Nautz [22] offer new evidence on price persistence before and after the European Monetary Union (EMU). Considering the fractional integration of inflation, they confirmed that inflation movements differed significantly across Euro area countries before the start of the EMU. Nevertheless, since 1999, results reached by panel estimation indicate that the degree of long-term inflation inertia usually converges. Consistent with model predictions, they found that the degree of persistence declined significantly in the Euro area. The main reason is the increased effectiveness of the ECB's (European Central Bank's) monetary policy.

4. Methodology

Stationarity is a minimal requirement in time series to make statistical inference. By this we mean that the mean and the variance are constant and the covariance between any two observations only depends on the distance between them and not on their specific locations in time. However, many economic time series are nonstationary, and a standard practice to remove that feature is to take first differences. Nevertheless, this is only one particular case of a more general approach to denominated fractional integration, and that is the approach employed in this work.

We used long memory methods based on fractional integration, which means that the number of differences required in a series to render it stationary I (0) may be a fractional value. If the differencing parameter is positive, the series displays long memory or long-range dependence, which is characterized because the infinite sum of its autocovariances is infinite, or, alternatively, in the frequency domain, because its spectral density function (which is the Fourier transform of the autocovariances) has a pole or singularity at the zero frequency. These types of processes were originally proposed by Granger [23], Granger and Joyeux [24], and Hosking [25] based on the observation that many series that apparently were I (1) and required first differentiation, once they were differenced, became over-differenced (with the estimated spectral density function close to zero at the zero frequency). Thus, there should be something intermediate between the I (0) and I (1) cases. Robinson [26] justified their proposals in terms of the aggregation of heterogeneous processes and other arguments to employ these models; Taqqu et al. [27], Chambers [28], Parke [29], and Souza [30] also used aggregation as their main argument. Baillie [18], Robinson [31], Gil-Alana and Hualde [32], and Hualde and Nielsen [33] included interesting surveys of these models and their applications in economics and finance.

In order to incorporate deterministic terms and following standard practice in unit roots (Bhargava [34]; Schmidt and Phillips [35]), our estimated model is:

$$y_t = \alpha + \beta t + x_t, \qquad (1 - L)^d x_t = u_t, \tag{1}$$

where y_t refers to the observed data (or log-transformed data); α and β are unknown parameters corresponding, respectively, to an intercept and a linear trend; x_t is I (d) where d may be any real value, thus including integers but also potentially fractional numbers; L is the lag operator ($Lx_t = x_{t-1}$); and u_t is I (0) and based on the seasonal nature of the data. We model it in terms of a seasonal (monthly) AR (1) process of the form.

$$u_t = \varphi u_{t-12} + \varepsilon_t, \tag{2}$$

where $|\varphi| < 1$ and ε_t is a white noise with zero mean and constant variance. Thus, apart from the seasonal structure, the rest of the time dependence is exclusively captured by the long memory differencing parameter d.

Note that by allowing the differencing parameter d in the second equality in Equation (1) to be any real value, we can consider a variety of model specifications that include the following: anti-persistence (if $d < 0$); short memory behavior (if $d = 0$); long memory ($d > 0$); covariant stationary long memory with mean reversion ($0 < d < 0.5$); nonstationary and mean reversion ($0.5 \leq d < 1$); unit roots ($d = 1$); and explosive patterns ($d > 1$). Thus, the parameter d plays a crucial role in relation to the nature of exogenous shocks in the series, being transitory if the differencing parameter is smaller than 1, and permanent if d is equal to or higher than 1.

Finally, the estimation was conducted via the Whittle function expressed in the frequency domain (see Dahlhaus [36], and for this purpose we used a simple version of the Lagrange Multiplier test of Robinson [31], which has been widely used in empirical applications on fractional integration (see Gil-Alana and Robinson [37]; Gil-Alana and Moreno [38]; Abbritti et al. [39]; Abbritti et al. [40]; etc.)).

Robinson's method is based on testing the null hypothesis:

$$H_o\text{: } d = d_o, \tag{3}$$

in the set-up given by Equation (1) for any real value d_o. His test has some distinguishing features compared with other methods. In particular, it has a standard N (0, 1) asymptotic distribution (unlike what happens, for example, with the unit root tests), and this standard limit behavior holds independently of the inclusion of deterministic terms in the model and the way of modeling the I (0) error term. More importantly, the test remains valid for any real value do, thus including values belonging to the nonstationary region ($d_o \geq 0.5$). Thus, it does not require preliminary differentiation on the presumption of nonstationary behavior, as is the case with the series analyzed in this paper. Finally, Gaussianity is not a requirement in the data and the test is the most efficient method in the Pitman sense against local departures from the null (see Pitman [41]).

5. Data

The traditional definition of inflation defined, as the generalized and sustained increase in the prices of goods and services existing in the market during a certain period, is, although easy to understand, limited by its very generic terms. This means that there are multiple possible measures for categorizing the price level of an economy and, therefore, many different categories of price inflation. As an example, the U.S. Bureau of Labor Statistics compiles three types of inflation: the Consumer Price Index, the Producer Price Index, and the U.S. Import and Export Price Indices, to which two others should be added, such as the GDP deflator and core inflation.

In the Euro area, although there are different entities that calculate this entire array of price indices at the national level, the index that, due to its construction, is the most representative for the European Union is the Harmonized Index of Consumer Prices (HICP). It is termed "harmonized" because all the countries in the Euro area follow the same rules and methodology. This ensures that the data used for one country can be compared with the data for another. The HICP is compiled and released by Eurostat and the national statistical institutes in accordance with harmonized statistical methods.

There are several types of European HICPs based on the geographic area. The four most relevant ones are:

- the Monetary Union Index of Consumer Prices (MUICP)—an index covering the countries in the Euro area.
- the national HICPs—for each of the EU Member States.
- the European Index of Consumer Prices (EICP)—for the whole European Union, the Euro area, plus the other Member States.
- the European Economic Area Index of Consumer Prices (EEAICP)—which, in addition to the EU, also covers Iceland and Norway.

To isolate the possible effects of appreciation and depreciation of currencies other than the Euro and, more specifically, so that it can be used more concretely for the design of monetary policy in the Euro area, the first indicator was selected.

The Monetary Union Index of Consumer Prices (MUICP) is published monthly by Eurostat using statistics provided by the Member States on price changes and the consumption patterns of consumers within their economic territories. The MUICP is used by, among others, the European Central Bank (ECB) as a main indicator for monetary policy management for the Euro area. It is calculated by taking the weighted average of the Harmonized Indices of Consumer Prices (HICPs) from each country within the Eurozone (also called the Euro area). The HICPs are determined in terms of "household final monetary consumption expenditure.

Some specific issues arise regarding the use of "household final monetary consumption expenditure". These are:

- The coverage is of all purchases by individuals within the territory of a country (the so-called "domestic concept"), including those by both resident and non-resident households.
- The HICPs include prices paid for goods and services in real monetary transactions. Therefore, some special fees and taxes paid in economies, such as licenses, will be removed (there is no equivalent good or service received in return).
- The prices included are those paid by households. They include sales taxes, for example, such as VAT, and they also include rebates and end-of-season sales prices.
- The HICPs exclude credit charges and interest, regarding them as financing charges rather than consumption expenditure.

The HICPs are published monthly following a rapid, strict schedule which is announced, in general, between 17 and 19 days before the month end in question. All the HICPs are accessible through the Eurostat page and the 'Euro-indicators' page. The period chosen begins in January 2010 and ends in February 2023. With this sample, we cover the moments in which inflation and its prospects were very low to the most current moments, where it is already evident that the inflation phenomenon persists.

6. Results

We start by displaying the results for a sample ending in December 2019, that is, two month before the start of the COVID-19 pandemic. Results are displayed across Tables 1 and 2. In Tables 3 and 4, the sample is extended to cover the period until December 2021, while Tables 5 and 6 include the results for the whole sample, that is, ending in February 2023.

Table 1. Estimates of the differencing parameter d: Data ending in December 2019.

Series	No Terms	An Intercept	A Linear Time Trend
Euro	0.98 (0.85, 1.13)	1.00 (0.88, 1.18)	**0.99 (0.88, 1.16)**
Spain	0.98 (0.86, 1.13)	**1.03 (0.90, 1.23)**	1.03 (0.90, 1.21)
France	0.98 (0.85, 1.13)	1.06 (0.92, 1.26)	**1.06 (0.93, 1.25)**
Germany	0.97 (0.85, 1.13)	0.83 (0.76, 0.95)	**0.79 (0.68, 0.94)**
Italy	0.97 (0.85, 1.13)	0.89 (0.79, 1.06)	**0.90 (0.80, 1.06)**

The values in bold in Table 1 refer to the selected specification for each series. In parenthesis, the 95% confidence band of the estimated values of d.

Table 2. Estimated coefficients in the selected models: Data ending in December 2019.

Series	d (95% Band)	Intercept (tv)	Time Trend (tv)	Seasonality
Euro	0.99 (0.88, 1.16)	91.461 (173.33)	0.116 (2.51)	0.893
Spain	1.03 (0.90, 1.23)	91.780 (101.26)	—	0.897
France	1.06 (0.93, 1.25)	92.640 (232.49)	0.112 (2.36)	0.859
Germany	0.79 (0.68, 0.94)	91.703 (196.39)	0.118 (6.60)	0.743
Italy	0.90 (0.80, 1.06)	90.691 (84.48)	0.107 (1.67)	0.954

In parenthesis, in columns 3 and 4, the *t*-values of the estimated coefficients.

Table 3. Estimates of the differencing parameter d: Data ending in December 2021.

Series	No Terms	An Intercept	A Linear Time Trend
Euro	0.99 (0.89, 1.13)	**1.18 (1.08, 1.30)**	1.19 (1.08, 1.31)
Spain	0.98 (0.88, 1.13)	**1.24 (1.11, 1.40)**	1.24 (1.11, 1.40)
France	0.98 (0.87, 1.12)	1.04 (0.94, 1.17)	**1.05 (0.94, 1.17)**
Germany	0.98 (0.89, 1.12)	0.95 (0.85, 1.07)	**0.94 (0.83, 1.07)**
Italy	0.99 (0.88, 1.12)	**1.03 (0.92, 1.16)**	1.03 (0.93, 1.16)

The values in bold in Table 3 refer to the selected specification for each series. In parenthesis, the 95% confidence band of the estimated values of d.

Table 4. Estimated coefficients in the selected models: Data ending in December 2021.

Series	d (95% Band)	Intercept (tv)	Time Trend (tv)	Seasonality
Euro	1.18 (1.08, 1.30)	91.430 (176.94)	—	0.855
Spain	1.24 (1.11, 1.40)	91.676 (102.23)	—	0.876
France	1.05 (0.94, 1.17)	92.641 (240.24)	0.118 (2.93)	0.769
Germany	0.94 (0.83, 1.07)	91.584 (181.97)	0.134 (4.19)	0.613
Italy	1.03 (0.92, 1.16)	90.665 (83.96)	—	0.934

In parenthesis, in columns 3 and 4, the *t*-values of the estimated coefficients.

Table 5. Estimates of the differencing parameter d: Data ending in February 2023.

Series	No Terms	An Intercept	A Linear Time Trend
Euro	0.99 (0.89, 1.12)	**1.23 (1.14, 1.37)**	1.25 (1.15, 1.39)
Spain	0.99 (0.89, 1.12)	**1.07 (0.97, 1.21)**	1.07 (0.97, 1.21)
France	1.00 (0.89, 1.13)	1.12 (1.04, 1.21)	**1.13 (1.05, 1.23)**
Germany	0.99 (0.89, 1.14)	1.09 (1.01, 1.19)	**1.10 (1.02, 1.21)**
Italy	0.98 (0.88, 1.11)	**1.15 (1.04, 1.31)**	1.16 (1.04, 1.33)

The values in bold in Table 5 refer to the selected specification for each series. In parenthesis, the 95% confidence band of the estimated values of d.

Table 6. Estimated coefficients in the selected models: Data ending in February 2023.

Series	d (95% Band)	Intercept (tv)	Time Trend (tv)	Seasonality
Euro	1.23 (1.14, 1.37)	91.411 (165.17)	—	0.818
Spain	1.07 (0.97, 1.21)	91.738 (96.07)	—	0.812
France	1.13 (1.05, 1.23)	92.561 (215.19)	0.1793 (2.84)	0.752
Germany	1.10 (1.02, 1.21)	91.485 (151.61)	0.2144 (2.79)	0.563
Italy	1.15 (1.04, 1.31)	90.587 (79.56)	—	0.891

In parenthesis, in columns 3 and 4, the *t*-values of the estimated coefficients.

Across Tables 1, 3 and 5, we report the estimates of the differencing parameter d (and the 95% confidence intervals) in the model given by Equations (1) and (2) under the three-standard scenarios of (1) no deterministic terms (in column two); (2) including only an intercept (in column three); and (3) including both a constant and a linear time trend (column four). The selected model for each series is marked in bold in the table. This selection is based on the significance of the estimated coefficients for the deterministic terms. Note that filtering the first equation in (1) by (1 − L) d, the two equalities in Equation (1) can be expressed as:

$$\widetilde{y}_t = \alpha \, \widetilde{1}_t + \beta \, \widetilde{t}_t + u_t, \qquad t = 1.2, \ldots \tag{4}$$

where

$$\widetilde{y}_t = (1 - L)^d y_t; \qquad \widetilde{1}_t = (1 - L)^d 1; \qquad \widetilde{t}_t = (1 - L)^d t,$$

and since u_t is I (0) by construction, standard t-values hold in (4). Then, we first look at the model with a linear time trend, and if β is found to be insignificant, we move to the model with only an intercept (column three in Tables 2, 4 and 6); if this parameter is also found to be insignificant, we finally move to the model with no terms (column two).

The estimates of d presented across the tables are based on the Whittle function, which is an approximation of the likelihood function, and the confidence bands are the values of d_o where the null hypothesis in (3) cannot be rejected at the 95% level.

Starting with the sample ending in December 2019, the first thing we observe is that the time trend is statistically significant in all cases except for Spain. This coefficient is positive in the four series. Focusing on the estimated values of d in the selected models (in Table 2), we observe that the unit root null hypothesis is rejected in favor of mean reversion ($d < 1$) in the case of Germany; for the rest of the countries (and for the Euro as a whole), the values of d range from 0.90 in Italy to 1.06 in France, and the unit root null hypothesis ($d = 1$) cannot be rejected in any of the series. Thus, only the prices in Germany present some evidence of reversion to the mean and transitory shocks. The fact that the unit root null is not rejected in any series except for Germany is consistent with the results based on other more classical approaches and based on unit root tests. In fact, we tried with most employed unit root methods (Dickey and Fuller [42]; Phillips and Perron [43]; Elliot et al. [44]; Ng and Perron [45]), and all them provided evidence supporting the I (1) hypothesis. Finally, seasonality seems to be a relevant issue, with values relatively high in all cases and ranging from 0.743 (in Germany) to 0.897 (Spain) and 0.954 (Italy). The large values in the last two economies might be related to the importance of the tourism sector in these two economies.

Extending the sample up to December 2021 in Tables 3 and 4, we see that the time trend coefficient now becomes insignificant, not only for Spain but also for Italy and the Euro as a whole. In general, we observe a sharp increase in the value of d; the unit root hypothesis cannot be rejected in the cases of France, Germany, and Italy, and this hypothesis is now rejected in favor of $d > 1$ in the cases of Euro (1.18) and Spain (1.24). Thus, the most noteworthy detail is the change in the degree of persistence in Germany, moving from mean reversion ($d < 1$) to a lack of it.

The final results in Table 7 refer to the case with data ending in February 2023. As in the previous case, the time trend is statistically significant only for the cases of France and Germany, and the estimates of d are significantly higher than 1 for all cases except for Spain, where $d = 1.07$, and the unit root cannot be rejected. Thus, it seems that the Russia–Ukraine war has produced an increase in the degree of persistence of prices in all cases except for Spain.

According to Caporale et al. [46], the Russia–Ukraine war has caused prices to increase, and it looks like those prices will stay high for a while. In the case of energy prices, influence has been large, but since it is due to supply side inflation, its effect will be temporary as soon as the causes that produce it are resolved. In Spain, prices have been going up since March 2021 due to different factors such as the end of the pandemic, oil prices, and the war in Ukraine. To try to stop the prices from going up, the government has adopted several measures such as capping gas prices and giving discounts to people in need, unlike other European countries (Uxó [47]), and this may explain the reduction in the degree of persistence in the most recent time periods.

Table 7. Summary table.

	Estimates of *d*			**Seasonality**		
	- Dec 2019	**- Dec 2021**	**- Feb 2023**	**- Dec 2019**	**- Dec 2021**	**- Feb 2023**
Euro	0.99 UR	1.18	1.23	0.893	0.855	0.818
Spain	1.03 UR	1.24	1.07 UR	0.897	0.876	0.812
France	1.06 UR	1.05 UR	1.13	0.859	0.769	0.752
Germany	0.79 MRV	0.94 UR	1.10	0.743	0.613	0.563
Italy	0.90 UR	1.03 UR	1.15	0.954	0.934	0.891

UR means evidence of unit roots at the 95% level. MRV indicates evidence of mean reversion.

As a final comment, since the estimated values for the differencing parameter are close to one or significantly higher than one in all cases (except for Germany with data ending in December 2019), this means that there is lack of reversion to the mean, implying that shocks in prices will have a permanent nature requiring strong policies to recover the long-term projection of the data. This is also consistent with other works, which also find high levels of persistence in prices in these economies ([19–22]; Kumar & Okimoto [48]; Canarella & Miller [49]).

7. Conclusions and Discussion

In this paper, we have analyzed the persistence of price indices in Spain, France, Germany, Italy, and the Euro area using fractional integration techniques. The results revealed high values of the differencing parameter, indicating the presence of shocks with long-lasting effects. Importantly, the degree of persistence exhibited variation over the sample period, with a notable increase attributed to the influence of the COVID-19 pandemic and the Russia–Ukraine war. These external events had a substantial impact on the persistence of inflationary pressures. Our findings underscore the significance of considering the evolving nature of shocks and their long-term implications for price dynamics. By understanding the persistence of these shocks, policymakers can make informed decisions to mitigate their effects and promote price stability in the respective economies.

Addressing the urgent need to act swiftly, central banks and national governments emerge as the key actors responsible for avoiding harm to the competitiveness of the Eurozone economy and safeguarding the well-being of pensioners and small savers. Masciandaro and Romelli [50] shed light on how politicians influence central banks' decisions in different situations and the evolving role of central banks over time. The European Central Bank (ECB) has already indicated its intention to raise intervention rates and reduce debt purchases, albeit with some nuances in terms of the timing and extent of these actions. Meanwhile, European leaders, as discussed by Jones [51], face the challenge of making difficult decisions concerning monetary policies and the ongoing conflict in Ukraine.

Relying solely on measures such as asset purchases and negative interest rates may not provide a sustainable solution to address financial issues. It is crucial to take a comprehensive approach and consider a range of policy options to effectively mitigate inflationary pressures. The collaboration and coordination between central banks and national governments is vital in striking the right balance between price stability and supporting economic growth. The implementation of appropriate policies should be based on careful analysis, considering the potential consequences and trade-offs associated with each measure. By adopting a prudent and well-calibrated approach, policymakers can navigate the challenges posed by persistently high inflation and promote a sustainable and robust economic environment in the Eurozone.

National authorities have several options to counter inflation. Implementing price controls may appear tempting, but it carries the risk of creating product shortages and fostering black markets, as explained by Vinod [52]. Alternatively, governments can explore measures such as raising taxes, reducing spending, and controlling prices to combat inflation. However, the impact on national deficits and the broader economy must be carefully evaluated. As highlighted in Uxó [47], the Spanish government has already taken steps to reduce inflation, such as capping gas prices in the electricity market, but the burden has disproportionately fallen on those with lower incomes.

When considering less politically expedient options, reducing public spending emerges as a potential measure to address high inflation, albeit with risks to economic recovery. Another effective approach is to increase competition, particularly in sectors such as hydrocarbons and food, as this can help curb inflation by reducing companies' pricing power and preventing the accumulation of excessive profits. A multifaceted approach is necessary to tackle the complex problem of high inflation. Crucially, calibrating inflation expectations among economic agents is of utmost importance to avoid a scenario where high inflation is coupled with a recession. Reiche and Meiler [53] emphasize the significance of managing expectations, as individuals' age, education, and economic sentiments play a role in shaping their perception of price movements. By adopting a comprehensive strategy that encompasses both supply side measures to promote competition and demand-side measures to manage expectations, policymakers can work towards addressing the challenge of high inflation effectively.

In conclusion, our study underscores the significance of addressing persistently high inflation through appropriate policy measures. Central banks and national governments need to collaborate effectively to strike a balance that ensures price stability, supports economic growth, and safeguards the welfare of individuals and the overall economy. However, the implementation of such policies should be carefully assessed, considering their potential limitations and impact on various economic factors. Further research is warranted to refine modeling techniques and explore additional avenues for addressing the challenges posed by persistent inflation.

Future lines of research should consider alternative modeling approaches that incorporate the long memory feature observed in the data. Thus, for example, structural breaks at known or unknown periods of time may be included in both the deterministic and/or the stochastic components of the model, noting that this issue is very much related with the long-range dependence feature (see, e.g., Sibbertsen [54]). In the same vein, non-linear (again, deterministic or stochastic) trends can also be incorporated in the long memory model studied in the present work. Thus, for example, the linear time trend described by Equation (1) can be substituted by non-linear components such as the Chebyshev polynomials in time, with the errors still displaying a long memory fractionally integrated behavior. This is the approach used, for example, by Cuestas and Gil-Alana [5]. It is argued in that paper that these orthogonal polynomials do not produce the abrupt changes generated by structural breaks and can approximate that behavior in a natural and easy way. Similarly, alternative methods such as the Fourier functions in time and neural networks have also been implemented within the I (d) models by Gil-Alana and Yaya [55] and Yaya et al. [56]. All of these approaches can also be examined in the analysis of price index series in Europe.

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