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Homogenous inflation persistence in the EA and its monetary-policy relevance: Evidence from local whittle estimates

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Abstract

In the context of growing macroeconomic uncertainty, understanding inflation dynamics is essential for monetary policy analysis. This study examines inflation persistence in the EA across four macroeconomic periods: the pre-crisis period (January 2001 – December 2008), the financial crisis (January 2009 – March 2015), the stabilisation period (April 2015 – July 2021), and the period of sharp inflation increase (August 2021 – April 2023). The analysis was conducted using monthly data and applied the local Whittle estimator to estimate the parameter *d* – an indicator of long-run (long-memory) persistence. The results show that inflation persistence in the EA is relatively low and homogeneous across member states, which is relevant for interpreting inflation dynamics in the euro area's monetary policy environment. However, national-level fiscal measures can influence the duration of inflationary pressures.

Keywords: Inflation, persistence, local Whittle estimator, euro area

JEL Classification: E31, E52, E62

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1. Introduction

Obtaining quantitative insights into the nature of inflation is crucial for policymakers, and empirical evidence on inflation enables a better-informed understanding of inflation dynamics (Škare, Gavurova and Sinkovic, 2023). Inflation, as a key macroeconomic indicator, affects economic stability and living standards, while its persistence – a key characteristic of inflation – refers to the speed at which inflation returns to its equilibrium level following a shock (Angeloni *et al.*, 2006). This notion is particularly important for monetary policy because it shapes not only the intensity of stabilisation measures required after a shock but also the time profile (*i.e.*, the timing and speed of the policy response) of the policy response. From a conceptual perspective, unconventional measures such as quantitative easing, are often discussed in the literature as being associated with changes in inflation persistence, for example through their interaction with financial conditions and inflation expectations. Against this background, it is therefore crucial to empirically assess how inflation persistence behaves across different monetary policy regimes and within the heterogeneous euro area (EA). Examining inflation persistence both across individual euro area countries and within the entire monetary bloc represents a valuable contribution to a deeper understanding of inflationary processes and their implications for the effectiveness of the European Central Bank's (ECB) monetary policy.

In this study, we test inflation persistence in the euro area, considering the role of quantitative easing (QE) only indirectly through the sub-period design. We estimate inflation persistence (long memory) via the local Whittle estimator for monthly y/y HICP inflation in the euro area and its member states, compare persistence across four macroeconomic sub-periods, and evaluate cross-country homogeneity as a descriptive feature, with any policy implications discussed only indirectly. Accordingly, we examine how inflation persistence evolves across sub-periods that differ in macroeconomic conditions and the broader policy environment, including the QE era. Given that QE is not modelled as an explicit quantitative variable, any link to QE is discussed only indirectly on the basis of the sub-period comparison. From the standpoint of optimal monetary policy functioning, lower inflation persistence is desirable – meaning that after a shock-induced increase, such as that triggered by quantitative easing, inflation should return to its equilibrium level as quickly as possible. Lower persistence would ensure a more flexible adjustment of economies to changes and would contribute to the effectiveness of monetary policy in stabilising the euro area economy.

Our research therefore analyses four time periods that reflect key turning points in inflation dynamics. These periods capture significant structural changes in inflation and economic development: (i) the pre-crisis period from January 2001 to December 2008 (iden-

tified by the Bai and Perron structural break test), (ii) the financial crisis and subsequent recovery from January 2009 to March 2015, (iii) the stabilisation period from April 2015 to July 2021 (with the aim of analysing inflation behaviour following the ECB's Asset Purchase Programme), and finally (iv) the sharp rise in inflation from August 2021 to April 2023, associated with post-pandemic fluctuations. This approach allows for a detailed analysis of inflation across different periods characterised by significant economic shifts, and places these developments in the context of the ECB's monetary policy environment. At the same time, it offers insights into the process of inflation returning to its equilibrium level over time, without implying a causal effect of specific ECB interventions.

The findings of this analysis will provide a deeper understanding of the mechanisms of inflation persistence in the euro area and offer a basis for interpreting inflation dynamics in a single monetary policy setting. This research is relevant not only from the perspective of theoretical understanding of inflation but also as a policy-relevant contribution, as it may inform how persistence is taken into account when discussing inflation developments during periods of elevated inflationary pressures.

2. Literature Review

The effectiveness of monetary policy can be defined as the central bank's ability to achieve its objectives (*e.g.*, maintaining price stability, supporting economic growth, and ensuring low unemployment) through standard or non-standard instruments, such as the Asset Purchase Programme. Effective monetary policy helps to sustain low and stable inflation. High inflation may lead to economic instability, while deflation can hinder economic growth. In practice, despite a significant number of studies, it remains unclear to what extent such policy can influence inflation and macroeconomic conditions in environments where financial markets are not in a state of severe disarray. According to Reichlin (2021), *the effectiveness of monetary policy can be enhanced* through good coordination with fiscal measures, *i.e.*, synchronisation of fiscal and monetary policy. Coordinated monetary and fiscal policy can strengthen confidence in the ability of governments and central banks to manage the economy. Such confidence is essential for inflation expectations, which may contribute to inflation persistence. If a variable is persistent, it implies that – under unchanged conditions – it tends to remain close to its recent value unless acted upon by other economic forces. In the case of inflation, the rate of change in the price level tends to remain constant (*i.e.*, inflation is persistent) in the absence of such forces (Fuhrer, 2010). This cycle may be difficult to break. However, coordination of monetary and fiscal policy can help to interrupt this cycle of persistent inflation. When the central bank and government synchronise their policies to control inflation, it can shift inflation expectations.

There are several types of inflation persistence, including intrinsic and inherited persistence. Intrinsic persistence implies that current inflation is largely dependent on its own lagged values. Inherited persistence means that inflation inherits part of its persistence from other variables. Other classifications include reduced-form and structural persistence. Reduced-form persistence refers to the empirical characteristic of observed inflation rates, while structural persistence stems from identified economic sources. Although estimating reduced-form inflation persistence is a useful step, it offers limited value for policymakers. When designing policy, it is crucial to determine whether inflation persistence is structural – *i.e.*, a stable feature of the economic environment – or instead the outcome of policy responses captured by the reduced form (Fuhrer, 2010).

Inflation persistence (long memory) remains a central topic in economic research. A number of studies have highlighted the importance of inflation expectations, which significantly influence inflation's persistence. For example, Łyziak and Paloviita (2017), as well as Bems *et al*. (2021), examined how expectations shape the duration of inflationary episodes. More recent studies – such as those by Oloko *et al*. (2021), Kato *et al*. (2021), and Caporale *et al*. (2022) – have focused on inflation persistence in the context of structural changes, market concentration, and oil price shocks.

The euro area is one of the most studied regions in terms of inflation and its persistence. Batini (2006) analyses the euro area from 1970 to 2002 and finds that the effects of monetary policy on inflation manifest with a lag exceeding one year, with Germany exhibiting a significant decline in inflation persistence. The importance of monetary policy transparency in reducing persistence is emphasised by Oikonomou, Papadamou, and Spyromitros (2021), who examine 19 euro area countries from 2002 to 2016. Their findings suggest that transparent monetary policy has a statistically significant negative effect on inflation inertia, which is key for effective price stabilisation. Similarly, Kanellopoulos and Koutroulis (2016) analyse 11 euro area countries during 1997–2015 and report that inflation persistence is nonlinear—at higher inflation levels, persistence is substantially greater. Malta emerges as a specific case in the study by Micallef and Ellul (2020), who analyse the period from 1996 to 2019. Their findings show that inflation persistence in Malta was lower than the euro area average before 2012 but increased thereafter, aligning more closely with the euro area norm. This transition may reflect shifts in economic dynamics or structural changes within the euro area's monetary regime. The authors offer valuable insights into how small, open economies respond to global and regional inflationary pressures, highlighting how economic transformations can significantly affect inflation inertia even in countries with historically low persistence.

Research on the United States focuses on long-term structural changes in monetary policy and their effects on inflation. Chin (2022) examines the period from 1955 to 2021 and finds that inflation persistence was significantly reduced as a result of aggressive monetary policy implementation in the 1980s. Kato, Okuda, and Tsuruga (2021) study sectoral inflation persistence from 1976 to 2020 and show that in sectors with higher market concentration, inflation persistence is lower due to the greater price-stabilising capacity of large firms. Lovcha and Perez-Laborda (2018) examine the effects of unconventional monetary policy on inflation between 1954 and 2007, finding that such measures can paradoxically increase inflation persistence, suggesting the need for caution in their use.

Research on emerging markets – such as those in Latin America, Central and Eastern Europe, and Asia – highlights region-specific inflation dynamics. Darvas and Varga (2014) examine Central and Eastern Europe and report varying levels of persistence across countries; inflation persistence remained relatively stable in the Czech Republic, Slovakia, and Slovenia, while it declined in others. Leszczyńska-Paczesna (2020) focuses on Poland from 1999 to 2017 and identifies significant differences in price rigidity across sectors, with food and energy sectors showing the highest persistence and other sectors displaying lower price inertia. Franta, Saxa and Šmídková (2007) show that estimated differences in inflation persistence between the euro area and new EU Member States are highly sensitive to methodological assumptions, particularly the treatment of structural breaks. Using detailed product-level data for the Czech Republic, Babecký, Coricelli and Horváth (2009) document the presence of aggregation bias, showing that aggregate inflation appears more persistent than its underlying components. This suggests that estimates based on aggregate inflation measures, such as HICP, should be interpreted with caution, highlighting the importance of methodological choices when analysing inflation dynamics across countries.

Oloko *et al*. (2021) study ten oil-exporting and importing countries, concluding that oil price shocks have limited influence on inflation persistence, indicating effective monetary policy adaptation.

Several studies compare advanced and emerging economies. Bems *et al*., (2021) examine 24 advanced and 21 emerging economies (1989–2009) and find that temporary inflation shocks have fewer lasting effects when inflation expectations are well anchored, underlining the importance of public trust in central banks. Wu and Wu (2018) demonstrate that in industrial economies, flexible exchange rates are associated with greater inflation persistence due to the more adaptable nature of monetary policy. Inflation targeting, however, helps reduce this persistence – a conclusion also supported by Bratsiotis, Madsen, and Martin (2015), who identify a notable drop in persistence following the adoption of inflation targeting in a sample of seven countries, including euro area members.

Overall, the findings of these studies underscore that inflation persistence is influenced by a combination of factors, including market structure, monetary policy transparency, exchange rate regimes, and central banks' capacity to respond to shocks. For advanced economies such as the euro area and the United States, long-term structural changes are particularly influential, while emerging economies face unique challenges due to external inflationary pressures.

Despite the growing body of research, gaps remain in understanding inflation persistence across euro area countries, especially concerning its behaviour during key turning points in economic development. The post-pandemic period – characterised by elevated inflation resulting from extensive quantitative easing – remains relatively underexplored. One of the crucial questions still insufficiently addressed is the persistence of inflation in the euro area during the period of unconventional monetary policy measures, including QE. Lower inflation persistence is desirable, as it allows economies to respond more flexibly to shocks – such as QE – and return more swiftly to equilibrium, thereby improving economic stabilisation across the euro area. While much research examines key historical episodes reflecting major shifts in inflation trends, this particular issue remains insufficiently addressed in the existing literature.

3. Methodology

This study aims to test the following hypothesis:

- Inflation in the euro area exhibits high persistence over time.

From the perspective of the effective implementation of a unified monetary policy, it would be desirable for inflation in the euro area to be as little persistent as possible, allowing it to return swiftly to its equilibrium level after an increase caused, for instance, by a quantitative easing shock (Kočenda and Varga, 2017; Angeloni *et al*., 2006). Given the still relatively high asymmetry of macroeconomic shocks and the considerable heterogeneity among euro area member states (Sapir, 2016), we also expect inflation to demonstrate a high degree of persistence.

3.1 Data

The data used to estimate inflation persistence will consist of monthly time series, with inflation measured as the year-on-year (y/y)[1] percentage change of the Harmonised Index of Consumer Prices (HICP). The data will be seasonally adjusted, allowing for more accurate analysis by eliminating the influence of seasonal fluctuations. Inflation persistence will be estimated using the local Whittle estimator, a method commonly applied to estimate the long memory parameter *d.*

The analysis will include time series data for all euro area countries, as well as the aggregated average for the euro area as a whole. Specifically, the study will focus on the following euro area countries: Belgium (BE), Cyprus (CY), Estonia (EE), Finland (FI), France (FR), Greece (GR), the Netherlands (NL), Ireland (IE), Lithuania (LT), Latvia (LV), Luxembourg (LU), Malta (MT), Germany (GE), Portugal (PT), Austria (AT), Slovakia (SK), Slovenia (SI), Spain (ES), and Italy (IT). Data for the respective variables will be obtained from Eurostat, national central banks of the Eurosystem, and the World Bank. Descriptive statistics for the variable under study are presented in Table 2.

Table 1: The variable included in the model

Variable	Abbreviation	Included in the study	Source
Inflation [M – HICP, %]	INF	Živkov *et al*. (2020), De Haan a End (2018), Zhu a Yang (2013)	Eurostat (M)

Note: M – monthly.

Source: Authors' own calculations

The dataset is divided into four main time periods, reflecting major macroeconomic events and structural breaks in the evolution of inflation:

1. pre-crisis period (January 2001 – December 2008), identified using the Bai and Perron structural break test,
2. financial crisis and subsequent recovery (January 2009 – March 2015), allowing for an analysis of the impact of crisis-related events on inflation,

1 Although year-on-year inflation rates may exhibit mechanical base effects at a 12-month horizon following large shocks, these effects are short-term in nature and primarily reflect the construction of the year-on-year indicator. Since the local Whittle estimator focuses exclusively on low-frequency components of the time series in order to capture long-run persistence, such short-term mechanical fluctuations do not materially affect the estimation of the long-memory parameter *d*.

3. tabilisation period (April 2015 – July 2021), during which the ECB introduced the Asset Purchase Programme – a key moment for analysing inflation behaviour,
4. period of sharp inflation increase (August 2021 – April 2023), associated with post-pandemic disruptions and resulting upward pressure on the price level (inflationary pressures may also have been driven by supply shocks related to Russia's invasion of Ukraine).

This approach enables a detailed assessment of inflation dynamics and ECB monetary policy responses across different phases of the economic cycle. It also allows for the tracking of inflation persistence both across individual euro area countries and within the monetary union as a whole.

Table 2 presents detailed descriptive statistics for inflation across the four time periods (pre-crisis, financial crisis and recovery, stabilisation, and sharp inflation increase), which facilitates a more nuanced understanding of the variable's development over time. Extreme values are indicated in parentheses by country. The results show that inflation exhibited significant variation across periods. The lowest value was recorded in Lithuania (– 1.86 %) during the pre-crisis period (January 2001 – December 2008), while the highest inflation rate (25.27 %) was observed in Estonia during the most recent period (August 2021 – April 2023), characterised by a sharp surge in inflation. This final period also displays the highest values across all statistical measures, reflecting the exceptional nature of inflation developments compared to previous phases. These findings also indicate that small open economies—such as the Baltic states – are particularly vulnerable to fluctuations in certain macroeconomic indicators, especially inflation. The ECB's single monetary policy should take this into account when implementing both standard and non-standard measures, as it represents a significant challenge to the effective functioning of monetary policy in an environment of heterogeneous national economies.

Table 2: Descriptive statistics of inflation by sub-periods

	INF			
	January 2001 – December 2008	**January 2009 – March 2015**	**April 2015 – July 2021**	**August 2021 – April 2023**
Min	−1.86 (LT)	−4.27 (LV)	−3.05 (CY)	0.30 (MT)
1st Quartile	1.92	0.39	0.20	5.42
Median	2.68	1.56	1.02	7.87
Mean	3.20	1.58	0.99	8.59
3rd Quartile	3.82	2.73	1.78	10.40
Max	17.56 (LV)	9.72 (LV)	4.79 (EE)	25.27 (EE)

Notes: Inflation is measured as the year-on-year (y/y) percentage change of the Harmonised Index of Consumer Prices (HICP), based on monthly data. The reported minimum and maximum values represent extreme values observed across all monthly observations and all euro area countries within each sub-period; the corresponding country is indicated in parentheses.

Source: Authors' own calculations

3.2 Local Whittle estimation

In recent decades, persistence has often been modelled using integrated ARMA models (ARIMA), which assume that the effect of a shock to a time series does not dissipate but rather persists for a prolonged period. However, this assumption presents a conceptual challenge: for many economic time series – such as inflation – it is theoretically difficult to justify the notion that the effect of a shock should persist indefinitely. As a result, researchers have increasingly turned to alternative approaches that capture persistence more realistically, without assuming infinite-duration effects. These newer approaches include long-memory models, which are considered a more appropriate alternative to ARIMA models[2] (Balcilar, 2004).

2 The empirical literature on inflation persistence includes various univariate (e.g., AR, ARMA, ARIMA) and multivariate (e.g., VAR, SVAR, VECM, GMM) methodological approaches to its measurement (Kanellopoulos and Koutroulis, 2016). ARIMA models capture persistence through finite-order lag dynamics, long-memory models quantify persistence directly via the fractional parameter d, and multivariate frameworks are typically used when persistence is analysed jointly with other determinants; since our aim is a comparable country- and period-level measure of persistence, we estimate d using the local Whittle estimator.

The Local Whittle estimator is used to estimate the long-memory parameter *d* in time series data. It is a method for estimating the degree of long-range dependence and persistence within a dataset. The estimation of the long-memory parameter using the local Whittle function was proposed by Baum, Hurn, and Lindsay (2020). This function is a semi-parametric technique that allows for a more precise and efficient estimation of the long-memory parameter compared to traditional methods such as ARFIMA (Škare, Gavurova and Sinkovic, 2023).

The motivation for using the local Whittle estimator is that the core of our research question is not to identify specific determinants of inflation, but to quantify the degree of persistence – namely, how long inflation continues to bear the imprint of past shocks across different macroeconomic periods.

We use the local Whittle estimator to estimate the long-memory parameter *d* in the inflation time series (Baum, Hurn and Lindsay, 2020; Robinson, 1995). The method is based on the idea that information about long-run persistence is contained mainly in slow, long-run movements in inflation (long "waves"), rather than in short-term monthly fluctuations (Granger and Joyeux, 1980). Technically, it therefore works with so-called low frequencies (the neighbourhood of "zero frequency"), which in practice means focusing on inflation behaviour over a long horizon (Baum, Hurn and Lindsay, 2020). The estimator uses the periodogram, *i.e.*, a frequency-domain description of the time series that indicates how strongly long versus short fluctuations are present in the data (Baum, Hurn and Lindsay, 2020). Subsequently, the value of *d* is chosen to best match the observed behaviour in this long-run (low-frequency) part—specifically by minimising a suitably defined criterion / objective function based on the periodogram (Robinson, 1995; Baum, Hurn and Lindsay, 2020).

Formally, following Robinson (1995), let $I(\lambda_j)$ denote the periodogram of the inflation time series evaluated at the Fourier frequencies $\lambda_j = 2\pi j/T$, for $j = 1, \ldots, m$, where T denotes the sample size and m is the number of lowest frequencies included in the estimation. The local Whittle estimator of the long-memory parameter *d* is obtained by minimising the following objective function:

$$Q(d) = \log\left(\frac{1}{m}\sum_{j=1}^{m}\lambda_j^{2d} I(\lambda_j)\right) - \frac{2d}{m}\sum_{j=1}^{m}\log\lambda_j \qquad (1)$$

with respect to *d* over an appropriate parameter space. The logarithmic form of the objective function follows from the Whittle likelihood approximation in the frequency domain and is standard in semi-parametric long-memory estimation (Robinson, 1995). The objective function is constructed using only low-frequency components of the periodogram, reflecting the idea that information about long-run persistence is primarily contained in slow-moving fluctuations of the inflation series. The parameter *d* captures the degree of long-memory behaviour by governing the rate at which the spectral density diverges near the zero

frequency. Minimisation of $Q(d)$ therefore selects the value of d that best matches the observed low-frequency behaviour of inflation. The bandwidth parameter m determines the number of low-frequency ordinates included in the estimation and represents a trade-off between bias and variance. In this study, we follow the standard choice implied by the employed implementation and focus on relative comparisons of persistence across sub-periods rather than on precise point estimates. In the empirical implementation, the bandwidth parameter m is selected according to the default rule of the employed software, which sets m as a function of the sample size. This choice is kept constant across countries and sub-periods to ensure comparability of the persistence estimates.

The local Whittle estimator does not require explicit modelling of short-run dynamics or deterministic components, as it focuses exclusively on the low-frequency behaviour of the series. As a practical consideration, this is an approximate frequency-domain approach, so its finite-sample performance may depend on the particular spectral characteristics of the series. We therefore interpret d conservatively – via the standard long-memory ranges – and complement the estimates with sub-period analysis to reduce potential distortions from major regime changes (Baum, Hurn and Lindsay, 2020; Robinson, 1995).

The use of the local Whittle estimator assumes that the series is observed at regular intervals without missing observations and that it is not dominated by a strong deterministic trend that could distort the low-frequency behaviour relevant for long memory (Robinson, 1995; Baum, Hurn and Lindsay, 2020). Since regime shifts and structural breaks may affect persistence estimates, it is appropriate to estimate d over relatively homogeneous time segments (Baum, Hurn and Lindsay, 2020). In our application, these assumptions are addressed by using monthly HICP series (regular spacing) and estimating d separately for four macroeconomic sub-periods.

In the empirical application, the local Whittle estimator is applied separately to each country-level inflation series and to the euro area aggregate, and is estimated independently for each of the four macroeconomic sub-periods.

According to Balcilar (2004), the parameter d can take fractional values and is not restricted to integers:

- if $-0.5 < d < 0.5$, the time series is *stationary*, meaning its values tend to stabilise over time,
    - if $0 < d < 0.5$, the process exhibits *long memory* (long-term persistence), implying that the effects of shocks decay slowly but eventually vanish[3].

3 In the context of inflation persistence, it is ideal for the value of the parameter d to lie within the interval $0 < d < 0.5$, where the time series exhibits long memory but still shows a tendency to return to its equilibrium level.

  - if $-0.5 < d < 0$, the process is *antipersistent*[4], indicating that values stabilise more rapidly following a shock,
- if $d = 1$, the time series has a *unit root*, meaning it is *non-stationary with permanent persistence*, where shocks have a lasting impact,
- if $d \geq 0.5$, the time series is *non-stationary with infinite variance* and does not show a tendency to return to its mean.

In the context of inflation, these ranges have a clear economic interpretation. Values of the long-memory parameter d within $0 < d < 0.5$ – which is the range obtained in our estimates – indicate the presence of long-run persistence while inflation remains covariance-stationary. In practical terms, inflation shocks can have a prolonged influence, but their impact gradually fades and inflation tends to return towards its equilibrium level. Higher values of d within this interval imply a slower decay of shocks and hence a more inertial inflation process, which may require stabilisation policy to remain in place for longer; lower values point to a more flexible adjustment of inflation. From a monetary-policy perspective, estimates of d close to (but still below) 0.5 can therefore be read as a signal of elevated persistence rather than as evidence of non-stationary or permanently self-reinforcing inflation dynamics.

As a robustness check, we also estimate d using the Geweke and Porter-Hudak (GPH) estimator (Geweke and Porter-Hudak, 1983), which provides an alternative semi-parametric approach based on a log-periodogram regression. Although GPH point estimates can be higher and more variable – particularly in shorter sub-samples – the qualitative conclusions regarding long-run inflation persistence remain unchanged; we therefore report 95% confidence intervals (see Appendix A: Table 4, Table 5, Table 6).

4. Results

Persistence is often measured using time series with finer temporal frequency (*e.g.*, quarterly or monthly data), as such series allow for better identification of the persistence of effects. Annual data may sometimes smooth out short-term fluctuations and reduce the accuracy of the estimation. In contrast, monthly data offer a more precise view of how inflation evolves in response to short-term shocks. These higher-frequency intervals can provide a more detailed picture of the immediate response of inflation to shocks, while annual data tend to reflect broader, long-term trends.

4 Within this interval, the values of the time series display a tendency toward "excessive" stabilisation. This means that when a shock occurs, the series tends to return rapidly to its mean, sometimes even overshooting in the opposite direction.

Based on the long-memory parameter, it is possible to analyse how inflation dynamics evolved across key macroeconomic periods in the euro area. Each of these periods has specific characteristics and has been shaped by major events that left a clear imprint on inflation developments[5].

Relative stability of the estimated long-memory parameter reported in Table 3 across countries and periods reflects the fact that the local Whittle estimator captures a structural, low-frequency property of the inflation process rather than short-run volatility. The method is designed to focus on long-run persistence and to abstract from temporary shocks and high-frequency fluctuations. Differences in persistence are therefore naturally smoother and less pronounced than differences in the level of inflation or in inflation volatility. The stability of the estimated values thus does not imply an absence of economic heterogeneity; instead, it points to broadly similar long-run inflation dynamics across euro area countries.

Since the local Whittle estimator captures long-run, low-frequency inflation persistence, the values of the parameter *d* reported in Table 3 do not reflect short-term fluctuations or episodic shocks, but rather the structural inertia of the inflation process.

- **Pre-Crisis Period (January 2001 – December 2008)**

During the pre-crisis period (2001–2008), inflation was relatively stable, which corresponds to the moderate levels of inflation persistence observed during this interval. This period was characterised by relatively steady economic growth within the euro area, with no major external economic shocks. It was also marked by ongoing economic development, the accession of new countries to the European Union, and increasing globalisation – all of which contributed to keeping inflation under control.

The values of the parameter *d* presented in Table 3 show that most euro area countries had estimates within the range of 0.48–0.49, indicating elevated long-term inflation persistence ($0 < d < 0.5$). Because the local Whittle estimator focuses on low-frequency movements, these estimates describe persistence over longer horizons rather than short-term fluctuations. This implies that inflationary shocks decayed slowly over time, but not permanent, reflecting a stable inflationary framework. These values point to a relatively stable inflation environment, in which shocks did not have lasting long-term consequences.

5 The estimated values of the parameter *d* hovered around 0.49, which is very close to the upper bound of the stationary long-memory range (i.e., $-0.5 < d < 0.5$), a range that is preferable from a monetary-policy perspective because shocks eventually decay rather than having permanent effects. While values in this range do not pose a fundamental problem, they may indicate the need for a mild policy adjustment to facilitate a faster return of inflation to its target level. Nevertheless, with values remaining below 0.5, the situation can still be considered relatively stable and does not warrant immediate corrective action.

- **Financial Crisis and Recovery Period (January 2009 – March 2015)**

The financial crisis that erupted in 2008 had a profound impact on inflation and economic growth in the euro area. The period from 2009 to 2015 was marked by a sharp decline in economic activity, rising unemployment, and weakened demand – all of which exerted a natural dampening effect on inflation.

The estimated values of the parameter *d* for this period are slightly higher than in the preceding one, with values ranging from about 0.49 to 0.495, indicating elevated long-run inflation persistence. Within the local Whittle framework, this increase in d implies a slower decay of inflationary shocks at low frequencies. The increased persistence may reflect the slower pace of economic recovery and the need for longer-term policy measures to stimulate growth. During this period, inflation tended to remain at lower levels for longer, suggesting that economic shocks – such as the crisis – had more prolonged effects on inflation, although these effects gradually diminished over time.

- **Stabilisation Period and ECB Asset Purchase Programme (April 2015 – July 2021)**

Following the recovery from the financial crisis and a prolonged phase of low inflation growth, the ECB launched its Asset Purchase Programme during this period with the aim of supporting economic activity and inflation. The years 2015 to 2021 are characterised by low and stable inflation, during which the ECB actively sought to stimulate demand in an effort to reach its inflation target.

During this period, the estimated values of the long-memory parameter *d* show a slight decline, ranging between 0.47 and 0.49 for most countries, suggesting a mild reduction in long-run inflation persistence. Within the local Whittle framework, this decline in *d* implies that inflationary shocks dissipated more quickly at low frequencies than in the preceding period. It indicates that although inflation still exhibited long-term persistence, demand stimulation and ECB interventions helped to reduce the long-term impact of shocks on inflation dynamics.

- **Period of Sharp Inflation Increase (August 2021 – April 2023)**

The most recent period (2021–2023) was characterised by a sharp increase in inflation, driven by a series of shocks following the COVID-19 pandemic and subsequent disruptions in global supply chains. These were further exacerbated by rising energy prices and geopolitical tensions – most notably the war in Ukraine – which created strong inflationary pressures (Zimková *et al.*, 2023). This period represents one of the most significant inflationary surges in recent decades.

During this period, a slight decline in the values of the parameter *d* can be observed, settling around 0.48 to 0.482. Despite the sharp rise in inflation, these estimates still indicate elevated long-term persistence. Within the local Whittle framework, the fact that *d* remains below 0.5 implies that inflationary shocks were persistent but ultimately mean-reverting, *i.e.* their effects dissipated gradually at low frequencies rather than becoming permanent. Overall, this suggests that the inflation surge was associated with substantial short-run volatility, while the long-run persistence of inflation did not increase further.

Across these four periods, it is evident that the euro area has undergone distinct phases that have influenced the dynamics and persistence of inflation:

- **The pre-crisis period** was marked by stability and lower persistence, during which the euro area economy did not face significant inflationary shocks.
- **The financial crisis period** brought about higher inflation persistence, associated with a prolonged recovery following major shocks.
- **The stabilisation period** shows a slight decline in inflation persistence, reflecting the effects of monetary stimulus and a return to more stable economic growth.
- **The period of sharp inflation increase** reflects a renewed surge in inflation; however, the slight decline in persistence suggests that inflationary shocks may have only a temporary impact, with inflation showing a tendency to gradually stabilise over time.

The relatively small differences between the estimated inflation persistence coefficients across the various periods may be attributed to the fact that inflation was more strongly influenced by its own past developments than by specific monetary policy interventions, which maintained a stable level of persistence.

In addition, fiscal policy may have had a stabilising effect, preventing larger deviations between periods. For instance, if governments maintained similar deficit levels and public debt ratios over time, this may have helped to avoid excessive inflation expectations. As a result, expectations could have remained well anchored, thereby contributing to the limited variation in inflation persistence across periods.

Table 3: Analysis of inflation persistence in the euro area using the long-memory parameter across different periods

	Long-memory parameter			
Country	**January 2001 – December 2008**	**January 2009 – March 2015**	**April 2015 – July 2021**	**August 2021 – April 2023**
AT	0.492727	0.495077	0.4896833	0.483824
BE	0.493848	0.494897	0.4791825	0.470365
CY	0.488821	0.493196	0.4908942	0.473314
EE	0.496853	0.495356	0.4939977	0.479193
ES	0.491803	0.494223	0.4930604	0.462835
FI	0.495850	0.494588	0.4905584	0.481763
FR	0.491438	0.495399	0.4930926	0.483004
GE	0.490285	0.492995	0.4872836	0.476263
GR	0.479906	0.495758	0.4908445	0.478843
IE	0.494467	0.495280	0.4895935	0.475135
IT	0.491132	0.495515	0.4889661	0.480565
LT	0.497488	0.495181	0.4939975	0.481709
LU	0.489863	0.493918	0.4902020	0.466313
LV	0.497528	0.495229	0.4938780	0.482779
MT	0.493821	0.491197	0.4929570	0.483632
NL	0.497296	0.494784	0.4882763	0.462781
PT	0.493062	0.495469	0.4645998	0.483723
SI	0.496163	0.490954	0.4923625	0.480870
SK	0.495780	0.496076	0.4958691	0.485548
EA	0.492462	0.495543	0.4925910	0.482004

Source: Authors' own calculations based on Eurostat (2024)

Inflation persistence in the euro area as a whole

- **Pre-Crisis Period (January 2001 – December 2008)**

Inflation in the euro area exhibited low persistence in long-run (low-frequency) terms, meaning that it returned to its equilibrium level relatively quickly following shocks. Within the local Whittle framework, this interpretation relates to persistence embedded in low-frequency movements rather than short-term fluctuations. The euro had been introduced as an accounting currency in 1999 and began circulating in physical form in 2002. At that point, the euro area was already benefiting from the advantages of a single currency, including simplified trade, harmonised interest rates, and a unified monetary policy under the ECB.

This period was also marked by economic growth and stable demand, supported by globalisation and expanding international trade. Energy prices remained relatively stable, enabling the ECB to keep inflation low and manage price stability effectively. Thanks to the ECB's effective policy measures and the overall stability of the euro area, both consumers and businesses maintained well-anchored inflation expectations, which helped to contain inflationary pressures and contributed to lower inflation persistence. During this time, inflation returned to equilibrium levels rapidly after minor shocks, reflecting the ECB's ability to control inflation efficiently and the benefits of a unified monetary policy.

- **Financial Crisis and Recovery Period (January 2009 – March 2015)**

During the financial crisis and the subsequent recovery period, inflation in the euro area exhibited a slightly higher degree of long-run (low-frequency) persistence compared to the pre-crisis period. The value of the long-memory parameter d, estimated at 0.495, indicates that inflation tended to remain at low levels for extended periods, reflecting the slow pace of economic recovery and weak demand. The European Central Bank faced significant challenges during this time, including deflationary pressures and uneven recovery across euro area member states.

Nonetheless, the persistence of inflation suggests that the crisis had a deep and lasting impact on inflation dynamics across the euro area and contributed to a delayed return of inflation to target levels.

- **Stabilisation Period and ECB Asset Purchase Programme (April 2015 – July 2021)**

This period witnessed a stabilisation of inflation in the euro area. The estimated values of the parameter d, ranging from 0.47 to 0.49, indicate a slight reduction in inflation persistence compared to the previous period. This development coincided with the implementation

of the ECB's Asset Purchase Programme, which was introduced to support economic activity and aggregate demand.

Within the local Whittle framework, lower values of *d* imply a faster decay of inflationary shocks in the long-run (low-frequency) sense, which is *consistent with* a more stable inflation environment during this period.

- **Period of Sharp Inflation Increase (August 2021 – April 2023)**

The most recent period was marked by a sharp surge in inflation, while the estimated log-memory parameter *d* declined slightly to around 0.482. This implies a somewhat faster decay of shocks in the long-run (low-frequency) sense than in the preceding period. This slight decrease suggests that the shocks which triggered the inflation increase – such as the COVID-19 pandemic, supply chain disruptions, rising energy prices, and geopolitical tensions – still had long-term effects, but their impact was gradually diminishing.

Despite the sharp rise in inflation during this period, inflation dynamics in the euro area appear to be gradually returning to a more stable path.

5. Discussion

The analysis showed that inflation in the euro area exhibits a certain long-term persistence; however, this persistence is not so significant as to represent a fundamental obstacle to the return of inflation to the target level. The hypothesis of high inflation persistence was therefore not fully confirmed. Such an assessment of inflation persistence may help policymakers to better understand how different structural changes affect inflation and may provide a basis for future measures aimed at stabilising the price level in the euro area.

In contrast to some views suggesting that inflation persistence may differ significantly between euro area countries, our results indicate that long-run (low-frequency) inflation persistence in the EA countries as captured by the local Whittle estimator, exhibits relatively limited cross-country variation, even in the presence of major shocks such as the financial crisis, the COVID-19 pandemic, or the energy crisis. This finding does not preclude substantial heterogeneity in short-run inflation dynamics across countries. Low and homogeneous persistence in most euro area countries may be associated with confidence in the common monetary policy framework and its role in maintaining price stability over the long run.

Comparison with other authors

Our results suggest that inflation persistence in the euro area exhibits some variability depending on the economic period. During the period of sharp inflation increase, we observed a slight decline in persistence, which may indicate the ability of inflation to gradually stabilise. This trend supports the conclusions of Batini (2006), who argues that inflation persistence can decrease over a longer horizon, especially when monetary policy responds effectively to external shocks.

During the financial crisis and the subsequent recovery period (2009–2015), we observed a modest increase in inflation persistence in the euro area compared to the previous period. This development aligns with the findings of Kanellopoulos and Koutroulis (2016), who claim that inflation persistence varies with the level of inflation and can increase under certain economic conditions.

In the stabilisation period, a decline in estimated inflation persistence is observed, which contrasts with the findings of Micallef and Ellul (2020), who observed an increase in persistence in some EU countries after 2012. However, our results are consistent with a stabilisation of inflation dynamics across the euro area as a whole.

During the most recent inflation surge, we again recorded a slight decline in inflation persistence. This can be partially linked to the findings of Oikonomou, Papadamou, and Spyromitros (2021), who emphasise that monetary policy transparency has a negative and statistically significant effect on inflation persistence. Our findings may suggest that the increased transparency of the ECB's monetary policy during this period contributed to more effective inflation management, even under conditions of elevated inflation.

Although the studies employ different methodological approaches, the comparison is meaningful at the level of identifying and interpreting economic mechanisms rather than at the level of direct numerical estimates. Different methods measure persistence in different ways, yet all aim to capture the same underlying economic phenomenon: how quickly and to what extent inflation returns to equilibrium following a shock. If crisis episodes are associated with an increase in inflation inertia, or if institutional and communication-related factors are linked to its reduction, such directional effects are expected to be observable across a range of methodological frameworks.

Implications for current and prospective euro area members

The homogeneous inflation persistence across euro area countries represents an important factor for the further functioning of the monetary union. For prospective euro area members

–particularly Central and Eastern European countries – this consistency is a positive signal. If these countries succeed in reducing their inflation persistence to euro area levels, they could integrate into the monetary union smoothly and without significant risks related to inflation differentials. Moreover, our findings may suggest that inflationary shocks in the euro area tend to be absorbed over time, although the present analysis does not allow for a direct assessment of monetary policy effectiveness. For current euro area members, the results highlight the presence of broadly coordinated monetary conditions over the sample period. The relatively low persistence of inflation in recent periods – particularly despite major shocks such as the post-pandemic inflation surge – may suggests that these shocks have had a temporary character and that the ECB has been able to maintain price stability even under difficult conditions. This capacity to preserve homogeneous inflation persistence across countries strengthens confidence in the single monetary policy.

Policy recommendations to reduce inflation persistence

The ECB could further optimise its monetary policy decisions through several targeted approaches that would help reduce inflation persistence and support a more efficient return to the inflation target after economic shocks. These recommendations are based on our analysis of inflation persistence and inflation dynamics during the four key periods examined. Implementing these measures would enhance the ECB's flexibility in managing inflation and stabilising the euro area.

The proposed measures to reduce inflation persistence are as follows:

1. More flexible quantitative easing

One such approach is more flexible quantitative easing. The results indicate that there are only small differences in inflation persistence across euro area countries. This relatively low regional dispersion may be partly due to structural differences and variations in the response to monetary policy. If the ECB were able to tailor quantitative easing to the specific needs of individual countries, it could respond more effectively to local inflation fluctuations and reduce long-term inflation persistence more efficiently. Such a targeted approach to QE would be particularly useful in the period following the financial crisis (2009–2015), when individual countries were recovering at different paces.

In principle, differences in inflation persistence may be relevant when discussing how unconventional policy tools interact with inflation dynamics across countries. Precisely targeted asset purchases enable better control of inflation across different parts of the euro area, reducing the need for broad-based interventions. A more flexible QE approach could

reduce the risk that a 'one-size-fits-all' solution may not be appropriate for all countries, which could increase the overall effectiveness of monetary policy.

2. Closer cooperation with national governments

Another important step is for the ECB to cooperate more closely with national governments by combining monetary instruments with fiscal measures such as fiscal stimulus (*e.g.* tax relief, tax cuts, social benefits) and public investment (*e.g.* in infrastructure, healthcare, and education). The combination of monetary and fiscal policy would be particularly effective in situations such as the financial crisis or the COVID-19 pandemic, where monetary policy alone may not be sufficient to revive demand. The post-crisis recovery period and the stabilisation phase after 2015 clearly highlight the need to combine stimulus measures in order to reduce inflation persistence, boost consumption, and support growth. Fiscal stimulus and public investment can help ease long-term persistence by directly stimulating economic activity and reducing the need for prolonged inflationary shocks to take hold.

3. Accounting for structural differences

The ECB could also place greater emphasis on structural differences between individual euro area economies and adapt its decisions according to how different countries respond to inflationary pressures. Since countries in the EA exhibit varying degrees of inflation persistence (due, for example, to structural factors or greater sensitivity to external shocks), it is important for the ECB to tailor its monetary policy to the specific needs of individual economies. For instance, when setting interest rates or introducing credit stimulus measures, the ECB could take into account differences in inflation persistence across economies, which would allow for more effective targeted interventions. If the ECB identified that certain countries required stronger support for economic activity due to high inflation persistence, it could focus on providing greater stimulus or adjust conditions to increase lending volumes in those countries. This approach would have been particularly useful during the period of sharp inflation growth between 2021 and 2023, when some countries may have required more intensive interventions.

4. More effective communication with financial markets

Inflation is largely influenced by market expectations. In this context, more effective communication with financial markets could serve as a key tool. Clear and precise communication by the ECB regarding its planned monetary policy actions can help shape expectations in the markets, particularly with respect to inflation. If markets and economic agents expect inflation to fall, they tend to adjust their behaviour accordingly, which can accelerate

the return of inflation to the ECB's target and reduce its persistence. This step is especially important during periods of high inflation (such as the post-pandemic period from 2021 to 2023), when clear communication on inflation targets and anticipated measures could help to speed up inflation stabilisation and reduce persistence.

5. Greater flexibility in inflation targeting

Another option is to introduce greater flexibility in the inflation target. During periods of elevated inflation, the ECB could consider a temporary adjustment of its inflation objective to better reflect prevailing macroeconomic conditions. This would allow for a quicker return of inflation to target without the need for excessively harsh interventions that could jeopardise economic growth. Such an approach would be particularly useful when strict adherence to a fixed inflation target risks triggering overly aggressive measures that may undermine economic stability. Greater flexibility in inflation targeting would have been especially beneficial during the sharp rise in inflation after 2021, when a temporary adjustment to the target could have eased pressure on the economy and allowed for a smoother alignment of inflation with the desired level.

6. Conclusions

As the euro area has experienced a prolonged period of unconventional monetary policy – particularly since 2015, including the extensive use of quantitative easing, especially during the COVID-19 pandemic, which may have affected inflation – the primary objective of this study was to examine long-run inflation persistence in the euro area in this policy environment, using a long-memory (local Whittle) approach.

Monthly data were used to analyse inflation persistence, covering four key macroeconomic periods – the pre-crisis period, the financial crisis, the stabilisation period, and the period of sharply rising inflation. Given this data frequency, the local Whittle estimator was applied to assess inflation persistence. Examining persistence across different periods allowed for a more nuanced understanding of how inflationary pressures evolve during crises and economic recovery. The findings indicate that inflation persistence was lowest in the pre-crisis period and slightly increased during the financial crisis and the subsequent recovery. The stabilisation period saw a decline in persistence, which continued during the period of surging inflation, suggesting that the shocks in the most recent period were largely transitory in nature.

The findings of the study further show that inflation persistence, in a long-run (low-frequency) sense, is relatively homogeneous across euro area countries over different periods.

However, differences in national fiscal environments may be relevant when interpreting observed inflation persistence, although fiscal policy is not explicitly modelled in the present analysis. While fiscal policy remains the responsibility of individual member states, the results may provide contextual information that can be considered alongside other evidence when assessing inflation developments in the euro area. In practice, such considerations are typically addressed within broader macroeconomic frameworks, which lie beyond the scope of the present study. Accounting for fiscal context may be useful for broader discussions of inflation dynamics, although the present analysis does not assess the effectiveness or calibration of monetary policy measures. The relatively low and homogeneous persistence may suggests that a common monetary policy framework can, in principle, be consistent with maintaining price stability, even in a shock-prone environment.

As with most empirical studies, this research has its limitations. Macroeconomic data, particularly from the post-pandemic period, may be subject to revisions, meaning that the results of the analysis could change slightly if statistical offices or the ECB later update the data. In addition, our empirical approach is intentionally univariate and focuses on long-run (low-frequency) inflation persistence. Therefore, the findings should be interpreted as descriptive and correlational rather than causal. We also acknowledge that an inherent limitation of the univariate framework is that it does not allow one to disentangle whether the observed level of inflation persistence reflects dynamics intrinsic to the inflation process itself or the stabilising response of monetary policy to inflationary shocks; addressing this distinction is a natural avenue for future research within a multivariate framework with explicit policy and macroeconomic variables. Monetary policy is captured only indirectly through the division of the sample into macroeconomic sub-periods, and the analysis does not identify the direct effects of specific policy instruments or other macroeconomic determinants (such as fiscal policy, energy prices, exchange rates, or wage dynamics).

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Conflicts of interest: The authors hereby declare that this article was neither submitted nor published elsewhere.

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Appendix

As a robustness check, we re-estimated the long-memory parameter *d* using the GPH (log-periodogram) estimator. The results (Table 4) confirm the main conclusions regarding long-run inflation persistence across sub-periods and the limited cross-country dispersion of estimates.

Table 4: Robustness check – GPH estimates of long-memory parameter *d*

Country	January 2001 – December 2008	January 2009 – March 2015	April 2015 – July 2021	August 2021 – April 2023
AT	0.528653	0.589320	0.339450	0.703948
BE	0.498757	0.546573	0.390440	0.796198
CY	0.307240	0.448647	0.331400	0.663176
EE	0.699570	0.524030	0.539707	0.758220
ES	0.166859	0.577102	0.461604	0.519208
FI	0.563208	0.376055	0.411215	0.680908
FR	0.287965	0.543955	0.568094	0.649840
GE	0.411780	0.529391	0.567955	0.701663
GR	0.320184	0.721445	0.555957	0.980009
IE	0.416877	0.653903	0.553630	0.666147
IT	0.433800	0.531513	0.464252	0.676005
LT	0.624998	0.307723	0.443835	0.740993
LU	0.367711	0.760949	0.388489	0.567770
LV	0.621128	0.329761	0.495361	0.798293
MT	0.375046	0.650703	0.489547	0.545769
NL	0.476164	0.519816	0.410468	0.652925
PT	0.264120	0.704110	0.315115	0.711158
SI	0.275390	0.484457	0.318745	0.454974
SK	0.612369	0.526112	0.476447	0.632931
EA	0.389296	0.444422	0.474318	0.862563

Source: Authors' own calculations based on Eurostat (2024)

Table 5: Local Whittle estimates – 95% confidence intervals

Country	January 2001 – December 2008	January 2009 – March 2015	April 2015 – July 2021	August 2021 – April 2023
AT	[0.350, 0.636]	[0.332, 0.658]	[0.329, 0.651]	[0.157, 0.810]
BE	[0.351, 0.637]	[0.332, 0.658]	[0.318, 0.640]	[0.144, 0.797]
CY	[0.346, 0.632]	[0.330, 0.657]	[0.330, 0.652]	[0.147, 0.800]
EE	[0.354, 0.640]	[0.332, 0.659]	[0.333, 0.655]	[0.153, 0.806]
ES	[0.349, 0.635]	[0.331, 0.658]	[0.332, 0.654]	[0.136, 0.790]
FI	[0.353, 0.639]	[0.331, 0.658]	[0.329, 0.652]	[0.155, 0.808]
FR	[0.348, 0.634]	[0.332, 0.659]	[0.332, 0.654]	[0.156, 0.810]
GE	[0.347, 0.633]	[0.330, 0.656]	[0.326, 0.648]	[0.150, 0.803]
GR	[0.337, 0.623]	[0.332, 0.659]	[0.330, 0.652]	[0.152, 0.806]
IE	[0.352, 0.637]	[0.332, 0.659]	[0.328, 0.651]	[0.148, 0.802]
IT	[0.348, 0.634]	[0.332, 0.659]	[0.328, 0.650]	[0.154, 0.807]
LT	[0.355, 0.640]	[0.332, 0.659]	[0.333, 0.655]	[0.155, 0.808]
LU	[0.347, 0.633]	[0.331, 0.657]	[0.329, 0.651]	[0.140, 0.793]
LV	[0.355, 0.640]	[0.332, 0.659]	[0.333, 0.655]	[0.156, 0.809]
MT	[0.351, 0.637]	[0.328, 0.655]	[0.332, 0.654]	[0.157, 0.810]
NL	[0.354, 0.640]	[0.331, 0.658]	[0.327, 0.649]	[0.136, 0.789]
PT	[0.350, 0.636]	[0.332, 0.659]	[0.303, 0.626]	[0.157, 0.810]
SI	[0.353, 0.639]	[0.328, 0.654]	[0.331, 0.653]	[0.154, 0.808]
SK	[0.353, 0.639]	[0.333, 0.659]	[0.335, 0.657]	[0.159, 0.812]
EA	[0.350, 0.635]	[0.332, 0.659]	[0.331, 0.654]	[0.155, 0.809]

Note: The final sub-period is short, hence intervals are naturally wider.

Source: Authors' own calculations based on Eurostat (2024)

Table 6: GPH estimates (robustness) – 95% confidence intervals

Country	January 2001 – December 2008	January 2009 – March 2015	April 2015 – July 2021	August 2021 – April 2023
AT	[0.338, 0.720]	[0.454, 0.725]	[0.201, 0.478]	[0.540, 0.868]
BE	[0.356, 0.641]	[0.397, 0.696]	[0.184, 0.596]	[0.386, 1.206]
CY	[0.038, 0.577]	[0.187, 0.710]	[0.120, 0.543]	[-0.001, 1.328]
EE	[0.496, 0.904]	[0.321, 0.727]	[0.362, 0.717]	[0.274, 1.242]
ES	[-0.085, 0.418]	[0.390, 0.764]	[0.313, 0.610]	[0.033, 1.005]
FI	[0.396, 0.731]	[0.185, 0.567]	[0.180, 0.643]	[0.504, 0.857]
FR	[0.070, 0.506]	[0.377, 0.711]	[0.314, 0.823]	[0.361, 0.938]
GE	[0.249, 0.575]	[0.320, 0.739]	[0.352, 0.784]	[0.063, 1.341]
GR	[0.141, 0.499]	[0.358, 1.084]	[0.300, 0.811]	[0.156, 1.804]
IE	[0.145, 0.689]	[0.496, 0.812]	[0.092, 1.015]	[0.162, 1.170]
IT	[0.249, 0.619]	[0.320, 0.743]	[0.307, 0.622]	[0.117, 1.235]
LT	[0.514, 0.736]	[0.223, 0.392]	[0.311, 0.576]	[0.568, 0.914]
LU	[0.187, 0.549]	[0.441, 1.081]	[0.208, 0.569]	[0.175, 0.960]
LV	[0.513, 0.729]	[0.161, 0.498]	[0.255, 0.736]	[0.494, 1.102]
MT	[0.154, 0.596]	[0.343, 0.959]	[0.332, 0.647]	[0.474, 0.618]
NL	[0.339, 0.614]	[0.294, 0.746]	[0.068, 0.753]	[0.429, 0.877]
PT	[0.065, 0.463]	[0.344, 1.064]	[0.099, 0.531]	[0.432, 0.990]
SI	[0.052, 0.499]	[0.276, 0.693]	[0.024, 0.613]	[0.187, 0.723]
SK	[0.340, 0.885]	[0.370, 0.682]	[0.381, 0.572]	[0.539, 0.727]
EA	[0.232, 0.547]	[0.263, 0.626]	[0.313, 0.636]	[0.506, 1.219]

Source: Authors' own calculations based on Eurostat (2024)

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