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THE IMPACT OF THE RUSSIAN-UKRAINIAN WAR ON THE FOOD INFLATION RATE PERSISTENCE IN UKRAINE: A FRACTIONAL INTEGRATION MODEL

This study analyzes food inflation persistence in Ukraine before and during the Russian-Ukrainian war using univariate fractional integration techniques. The findings indicate a consistent low food inflation rate with long-term memory properties across all scenarios. This suggests that shocks will fade in the short term, so there is no strong impact of the Russian-Ukrainian war on the food inflation rate persistence in Ukraine. This explains that the Ukrainian government's monetary policy strongly absorbs the impacts of the Russian-Ukrainian war.

***Keywords**: Food inflation rate persistence; Russian-Ukrainian war; fractional integration; ARFIMA model; Ukraine.*

Inflation rate persistence is a closely related economic phenomenon that has been the subject of extensive research in the field of macroeconomics. Inflation is often exposed to numerous macroeconomic shocks that pull it away from its mean, which is generally identified by the central bank's inflation target. Shocks can be

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persistent or could have persistent effects on inflation because of, for example, nominal rigidities, leading to persistent deviations of inflation from its target. Knowing the persistence of these shocks and inflation deviations from target plays an essential role for the central bank whose primary aim is to achieve price stability. The adjustment of inflation towards its long-run level after a shock can be characterized by the speed with which it converges back to its mean. The greater this speed, the less complicated the central bank's task of maintaining price stability. Inflation persistence is a measure of this convergence speed, based on different kinds of properties of the impulse response function within the model built to describe inflation (Darvas, Varga, 2014). In contrast, the lower the stability, the greater the "policy space", which is defined as the ability of monetary policy to absorb temporary price shocks (Roache, 2014).

Studying inflation rate persistence is crucial because it influences the design of monetary policy and the ability of authorities to simultaneously stabilize production and inflation, affecting the overall effectiveness of these policies (Antonakakis et al., 2016).

N. Batini et al. (2001) in their work distinguish three different types of persistence: a) "positive serial correlation in inflation", b) "lags between systematic monetary policy actions and their (peak) effect on inflation", c) "lagged responses of inflation to non-systematic policy actions (i.e. policy shocks)"; In addition J. Fuhrer & G. Moore (1995) mentioned another type of persistence, which is the reaction of inflation to its own shocks.

Maintaining economic stability manifests through comprehending the behavior of inflation persistence and the implementation of appropriate monetary policies by the monetary authorities (Bernanke et al., 1997).

Specific food inflation rates can fluctuate frequently due to various factors, including economic conditions, global market trends, domestic agricultural output, and security conditions such as war. The Russian-Ukrainian war, which escalated significantly following Russia's full-scale invasion of Ukraine in February 2022, has had profound impacts on various aspects of Ukraine's economy, with food inflation being a particularly critical issue.

The Russian-Ukrainian war has significantly impacted food inflation in Ukraine due to disruptions in agriculture, supply chain issues, and rising global food prices. This inflation has undermined the economic stability and food security of many Ukrainians and reverberated throughout the global food market. As the conflict persists, ongoing assessments are necessary to gauge its long-term implications for food security in Ukraine and beyond.

Inflation persistence has been studied through various models, ranging from simple auto-regressions to complex dynamic general equilibrium frameworks. Research on univariate autoregressive time-series models often indicates high persistence, with some studies unable to reject the unit root hypothesis over a 50-year period since World War II in both the United States and the euro area. Recent studies suggest that inflation series have several structural breaks, largely due to historical events like the 1970s oil crises. Analyzing autoregressive models for sub-periods defined by these break points reveals significantly lower persistence, particularly in recent years. Therefore, inflation persistence seems to be evolving over time.

An increase in the persistence of food inflation in Ukraine due to the Russian-Ukrainian war suggests a weakness in monetary policy effectiveness, necessitating a review of the policy. Conversely, if the inflation rate continues to decline or remains stable, it indicates that the current monetary policy is effective and no review is needed. Monetary policy that reacts to price shocks in a more accommodating fashion is likely to result in more enduring inflation rates over time. This tendency suggests that when monetary authorities choose to accommodate inflationary pressures, they may inadvertently contribute to the persistence of inflation in the economy. Consequently, the notion that failing to respond to inflation shocks is often viewed as a necessary condition for achieving lower levels of inflation persistence gains traction. The relationship between monetary policy responses and inflation behavior highlights the significant impact that such decisions can have on long-term inflation dynamics (Alogoskoufis, Smith, 1991).

This paper aims to measure food inflation persistence in Ukraine for the first time, providing insights into inflation characteristics. The literature identifies two main approaches to measuring inflation persistence: the univariate approach, which uses a simple time-series representation of inflation, and the multivariate approach, which employs structural econometric models to explain inflation behavior through additional variables. In the univariate approach, inflation is assumed to follow an autoregressive process, with shocks represented by white noise components. This study also aimed to create a time series model for the food inflation rate in Ukraine, more specifically an ARFIMA model based on food inflation rate data in Ukraine. The auto-regressive integrated moving average model ARFIMA is used because the food inflation rate in Ukraine is time-series data with long-term memory. The results of this study are expected to serve as an input to develop a time series model for the food inflation rate in Ukraine, especially the ARFIMA model. The targeted findings and outcomes of this study are time series models, particularly the best ARFIMA time series model for food inflation rates in Ukraine. We will use the Autoregressive Integrated Moving Average model by allowing for fractional integration. This means that the differencing parameter, which is usually an integer in ARIMA models, can take on non-integer values in ARFIMA models. This feature allows ARFIMA models to capture long memory processes in time series data, where correlations between observations decay more slowly than would be expected in processes modeled by standard ARIMA models.

The organization of this study after this introductory section is as follows: Section 2 reviews the existing literature, evaluates its findings, and highlights the added value of our study; Section 3 presents the data and its temporal evolution; Section 4 outlines the methodological framework of the study; Section 5 presents the results and discussion; and finally, Section 6 concludes the paper.

THEORETICAL BACKGROUND

Inflation dynamics have garnered significant attention from researchers and policymakers, with the pursuit of price stability being recognized as a crucial factor in mitigating inflation persistenc (Beechey, Österholm, 2018).

B. Bilici & S. Çekin (2020) define persistence as the speed of reversion to equilibrium following a shock. Numerous studies have focused on inflation persistence. The first part of the research addressed inflation persistence by examining the intrinsic characteristics of the inflation rate. Predominant findings across these studies, despite employing diverse techniques such as tests for stationarity, fractional integration, time-varying parameter estimation, and fractional cointegration, exhibited a remarkable degree of symmetric. For instance, consider the study by A. Canepa (2024), which employed a model AR(1)-APARCH-ML-in-mean-level. It employs an AR(1)-APARCH(1,1)-in-mean-level model with breaks to capture the time-varying behavior of inflation and its volatility, and revealed that inflation persistence increases with heightened levels of inflation uncertainty. In contrast, the study by B. Bilici & S. Çekin (2020) utilized a Time-Varying Parameter (TVP) estimation model, demonstrating that inflation persistence in Turkey exhibits an upward trend and heightened volatility during periods of high inflation. Similarly, Z. Darvas & B. Varga (2014) investigated inflation persistence in Central European countries employing Time-Varying Coefficient Auto-regression, uncovering an increase in persistence during periods of escalating inflation, In the context of Asia-Pacific countries, S. Gerlach & P. Tillmann (2012) examined inflation persistence under inflation targeting regimes implemented by central banks. The findings revealed variations in the speed of convergence across different countries, with a less pronounced decline in persistence observed within inflation-targeting economies. The study by B. Meller & D. Nautz (2012) provides new evidence on inflation persistence before and after the European Monetary Union (EMU). Results obtained from panel estimation indicate that the degree of long run inflation persistence has converged. In line with theoretical predictions, they find that the persistence of inflation has significantly decreased in the Euro area, probably as a result of the more effective monetary policy of the ECB. The study by A. Vaona & G. Ascari (2012) discusses the issue of regional inflation persistence in Italy, where economic gaps within Eurozone countries emerge as a significant political matter. The study focuses on Italy with a detailed geographical level (NUTS-3) and shows that economically lagging regions experience greater inflation persistence, which is also linked to a lower level of competitiveness in the retail sector. Finally, the results indicate that national inflation persistence does not suffer from geographical bias, but rather equals the average inflation persistence of regional data. The study by V. Kota & S. Lazaretou (2011) aims to estimate inflation persistence in Albania from 1993 to 2008. Using a univariate approach with both constant and time-varying means for headline and core inflation, the authors also examine potential structural changes in persistence. The findings indicate that headline inflation persistence was higher during inflationary periods but began to decline after 1997, coinciding with stabilized inflationary expectations, suggesting that monetary policy was effective in reducing inflation. In contrast, core inflation showed no structural break in persistence, remaining relatively higher than that of headline inflation.

The second part of literature highlights how expectations influence inflation persistence based on the differences between the general inflation target and the central bank's specific target. Study by B. Granville & N. Zeng (2019) explore the relationship between inflation persistence and monetary policy, revealing that persistence varies according to expectations formed from past inflation trends. Additionally, Y. Hirose et al. (2023) show that the Federal Reserve's transition from a passive to an active inflation stance and a decline in firms' price expectations affect inflation persistence, while A. Orphanides & J. Williams (2005) argue that active central banks seeking to stabilize output may hinder the learning process about inflation, increasing its persistence. Hence, a political system's commitment to price stability can help reduce inflation's persistence. Furthermore, a recent analysis by L. Brandao-Marques et al. (2024) highlights the implications of central banks misjudging inflation persistence in European countries post-COVID-19, stressing the vital role of expectations. The study found significant discrepancies in financial experts' perspectives on inflation persistence, indicating substantial uncertainty about future inflation trends, which can lead to poor monetary policy decisions. If central banks underestimate inflation persistence and ignore uncertainty, it may result in prolonged inflation above targets, complicating their objectives.

The third part of the literature examined how structural economic factors — such as human capital, progressive taxation, exchange rate regimes, and oil price fluctuations — affect inflation persistence. Findings varied significantly. for example The study R. Benkhelouf & A. Sahed (2023) dealt with the effect of oil price shocks on the inflation rate persistence in Algeria, and the study R. Benkhelouf & A. Sahed (2024) dealt with the effect of gold price shocks on the inflation rate persistence in Algeria using the FCVAR model. The results of the study of these two important factors (gold price and oil price) show that inflation rate persistence in Algeria continues for a longer period due to the oil price shock or the gold price shock before it eventually fades away. Study by T. Oloko et al. (2021b) used a VAR model with fractional cointegration to assess the effects of oil price shocks on inflation persistence in ten oil-exporting and oil-importing countries, accounting for oil price asymmetries. They found that oil price shocks did not significantly increase inflation persistence in either group, indicating that monetary policy effectively mitigates these shocks regardless of the exchange rate regime. In another study T. Oloko et al. (2021a) analyzed how gold price shocks influenced inflation persistence across countries with different income levels and monetary policies. They discovered that in developing countries, the effects of gold price shocks on inflation persistence were long-lasting, while in developed nations, they were brief. P. Dua & D. Goel (2021) conducted research in India to measure inflation persistence using the Wholesale Price Index (WPI) and the Consumer Price Index for Industrial Workers (CPI-IW). Using a Time-Varying Parameter Vector Autoregression (VAR-TVP) model, they found that high output shocks decreased inflation persistence and that supply shocks, particularly from fuel and food prices, significantly impacted it, highlighting the need for monetary policies to consider supply-side factors. Additionally, G. Geronikolaou et al. (2020) explored how progressive taxation and human capital affect inflation persistence, revealing that the distribution of human capital across sectors increases inflation persistence, which is further intensified by rising progressive taxes. J.-W. Wu & J.-L. Wu (2018) studied the effect of exchange rate systems on inflation persistence in industrialized countries, finding ambiguous results. Similarly, G. Canarella & S. Miller (2016) investigated the relationship between inflation targeting and inflation persistence, reporting mixed outcomes based on the level of economic development.

Our study falls within the first part from the literature addressed inflation persistence by examining the intrinsic characteristics of the inflation rate. Our primary contribution lies in Focusing on another country, which is Ukraine, which was not been addressed in previous studies. We aim to fill a research gap by studying and measuring the food inflation rate persistence in Ukraine using a fractional integration model (ARFIMA). We also expand the analysis by examining the impact of the Russian-Ukrainian war on the persistence of food inflation in Ukraine.

DATA AND PRELIMINARY ANALYSES

In this study, we use monthly data on the food inflation rate in Ukraine expressed as a percentage, from May 2015 to January 2024. This dataset includes 105 observations, covering periods of high and low food inflation rate in Ukraine Before the Russian-Ukrainian war (from May 2015 to February 2022), and during the war (from March 2022 to January 2024). Food inflation was reported by the State Statistics Service of Ukraine, published by the website Statista [1]. The pre-war is defined as the period before March, 2022, while the dur-war includes the war period. Since the effect of the war seems to impact on macroeconomic fundamentals in Ukraine. As shown in Table 1, all the food inflation rates recorded higher mean and standard deviation values during the beginning of the war. In other words, food inflation rates were higher and more volatile during the beginning of the war (after March 2022). Also, the series seems to exhibit more asymmetry during the period of pre-war than the dur-war, as shown in Fig. 1.

Ukraine's economic development is anticipated to persist. In December, the IMF predicted 3.2 percent growth in Ukraine's GDP. In January 2024, the research firm Consensus Economics revealed that its compilation of expert forecasts for 2024 projects a 4.3 percent increase in Ukraine's GDP this year and a 5.4 percent raise the following year. Although forecasts are inherently uncertain due to changes in the conflict's trajectory, the positive trends from last year allow for cautious optimism. The economy could recover swiftly should hostilities cease.

[1] *Statista*. URL: https://www.statista.com/ (accessed on: 20.07.2024).

FRACTIONAL INTEGRATION AS MEASURE OF PERSISTENCE

Recent evidence in the literature suggest that stationary economic series may not necessarily take integer values but any real number that can be given in a fractional form (Gil-Alana, Carcel-Villanova, 2018). Furthermore, fractional integration implies that economic series may be fractionally integrated, meaning that the impact of policy shocks may not be permanent but rather only disappear over extremely long horizons, as opposed to assuming that economic series are $I(1)$, which may imply that the impact of policy shocks will be permanent. In the literature, this method has also been used to investigate inflation persistence for various nations (Canarella, Miller, 2017a, 2016, 2017b). Thus, we use fractional integration to test for the persistence of food inflation for Ukraine.

Long Memory Model Estimation. The GPH (Geweke-Porter-Hudak) test and the Local Whittle estimator are both methods used in the analysis of time series data, particularly in the context of long memory processes.

GPH Test. The GPH test is a statistical test used to detect the presence of long memory in time series data. It is named after the authors, G. Geweke and H.D. Porter-Hudak, who proposed the method. It is applied according to the following steps:

• Periodogram: Compute the periodogram of the time series, which is an estimate of the spectral density;

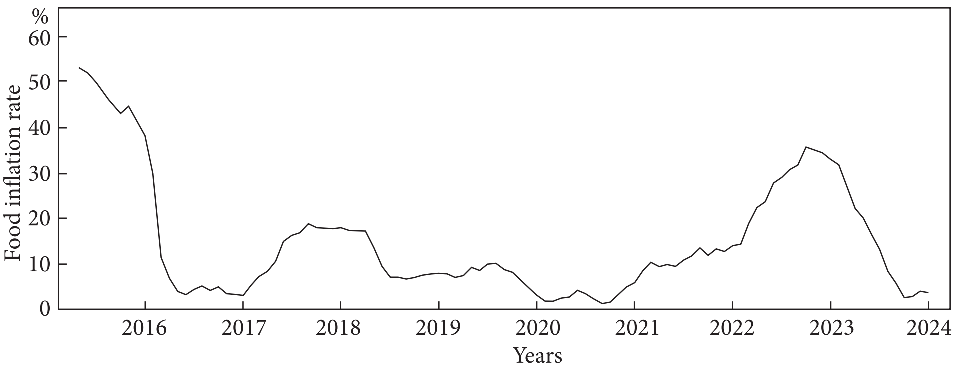

Fig 1. Trends in Food inflation rate in Ukraine before the Russian-Ukrainian war
Source: computed by the authors.

Table 1. **Descriptive Statistics**

Inflation rate	Mean	Median	Standard deviation	Skewness	Kurtosis	Obs
Full	14.77	9.90	12.94	1.34	3.93	105
Pre-war	13.10	8.65	12.85	1.89	5.63	82
Dur-war	20.87	22.40	11.57	–0.38	1.73	23

Source: computed by the authors.

• Logarithmic Transformation: Perform a logarithmic transformation using the periodogram. The idea is to utilize the fact that, for a long memory process, the log-periodogram exhibits linearity in certain ranges of frequencies;

• Regression: Fitting a linear regression model to this transformed periodogram data;

• Hypothesis Testing:

Null Hypothesis (H_0): The time series does not exhibit long memory ($d = 0$, where d is the memory parameter);

Alternative Hypothesis (H_1): The time series does exhibit long memory ($d > 0$);

• Critical Value: Calculate the test statistic, often involving the slope of the regression line, and compare it against critical values to determine whether to reject the null hypothesis.

Local Whittle Estimator. The Local Whittle estimator is a non-parametric technique used to estimate the memory parameter (d) in long memory processes. It is particularly useful because it allows for more flexibility and can provide consistent estimates even for non-stationary processes. It is applied according to the following steps:

• Whittle Estimator: The basic idea is to use the Whittle likelihood, which is based on the log-periodogram, to estimate (d);

• Local Fitting: Instead of fitting the entire data set, it focuses on a "local" set of frequencies that are relevant for estimation. This helps alleviate issues that might arise from non-stationarity or other characteristics of the data;

• Tuning Parameter: The choice of the bandwidth (tuning parameter) is crucial. It controls how much of the data is used in the estimation and impacts the consistency and efficiency of the estimator;

• Asymptotic Properties: The Local Whittle estimator has desirable asymptotic properties and converges in distribution to a Gaussian variable.

ARFIMA (p, d, q) model. To study the statistical properties of time series, we follow a mathematical notation where a time series x_t, $t = 1, 2, ...$ follows an integrated of order d process (and denoted as $x_t \approx I(d)$).

The fractionally integrated process y_t is defined as

$$(1-L)^d x_t = u_t, \; t = 0, \; \pm 1, \; ..., \tag{1}$$

where d can be any real value, L is the lag-operator ($Lx_t = x_t - 1$) and u_t is $I(0)$, defined as a covariance stationary process with a spectral density function that is positive and finite at the zero frequency. Displaying potentially a type of time dependence in a weak form. So, if u_t is ARMA (p, q), x_t is then said to be ARFIMA (p, d, q).

The polynomial $(1 - L)^d$ in (1) can be expressed through its binomial expansion for all real d.

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

and thus

$$(1-L)^d x_t = x_t - dx_{t-1} + \frac{d(d-1)}{2} x_{t-2} - ... \tag{3}$$

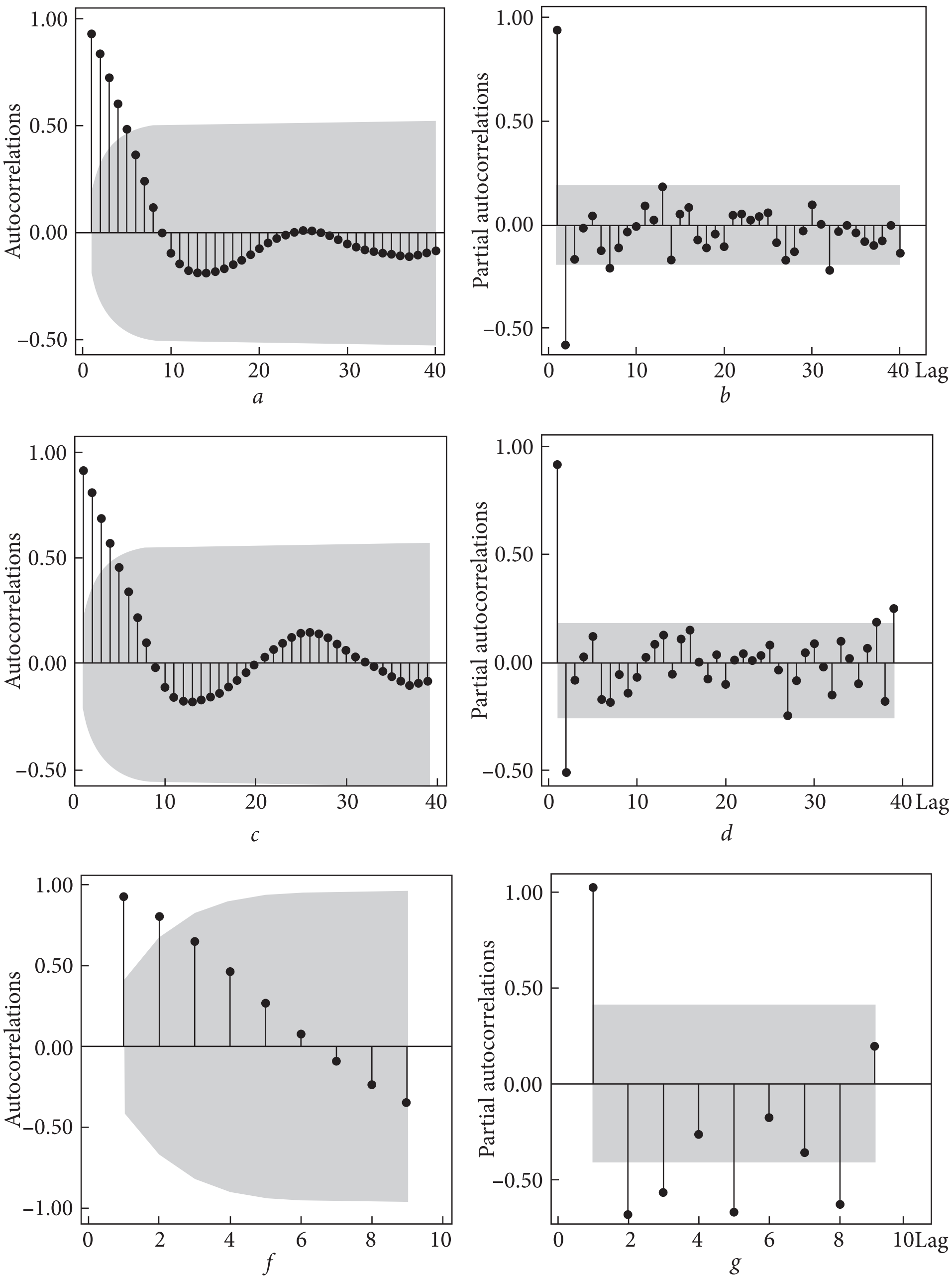

Fig 2. Autocorrelation Function ACF and Partial Autocorrelation Function PACF
Source: computed by the authors.
Notes: *a* — Autocorrelation function of the food inflation rate (Bartlett's formula for MA(q) 95% confidence bands); *b* — Partial Autocorrelation function of the food inflation rate (95% Confidence bands [se = 1/sqrt(n)]); *c* — Autocorrelation function of the food inflation rate (pre-war) (Bartlett's formula for MA(q) 95% confidence bands); *d* — Partial Autocorrelation function of the food inflation rate (pre-war) (95% Confidence bands [se = 1/sqrt(n)]); *f* — Autocorrelation function of the food inflation rate (dur-war) (Bartlett's formula for MA(q) 95% confidence bands); *g* — Partial Autocorrelation function of the food inflation rate (dur-war) (95% Confidence bands [se = 1/sqrt(n)])

Table 2. **Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) test results**

Phillips-Perron test (PP)	At Level	Full	Pre-war	Dur-war
With Constant	*t*-Statistic Prob	−2,9669 0,0414 **	0.3357 0.0207 **	−0.2933 0.9112 No
With Constant & Trend	*t*-Statistic Prob	−2,8224 0,1928 No	−2.4829 0.3357 No	−2.3707 0.3829 No
Without Constant & Trend	*t*-Statistic Prob	−2,7391 0,0065 ***	−3.0491 0.0027 ***	−0.7679 0.3720 No
Augmented Dickey-Fuller test (ADF)	At Level	Full	Pre-war	Dur-war
With Constant	*t*-Statistic Prob	−3,4794 0,0105 **	−3.4926 0.0106 **	−3.3258 0.0289 **
With Constant & Trend	*t*-Statistic Prob	−3,4229 0,0540 *	−3.0163 0.1344 No	−2.1146 0.5088 No
Without Constant & Trend	*t*-Statistic Prob	−2,7208 0,0069 ***	−2.9765 0.0034 ***	−1.1907 0.2060 No

Notes: ***, **, * — Significant at the 1, 5% and 10%, respectively; No — Not Significant.
Source: computed by the authors.

Implying that Eq. (1) can be expressed as

$$x_t = dx_{t-1} - \frac{d(d-1)}{2} x_{t-2} + \ldots + u_t. \quad (4)$$

The result of the parameter d allows us to conclude that if $d < 0$, x_t is anti-persistent, and this occurs when the series changes sign more frequently than occurs in a random process and when it has zero spectral density at the origin (see Dittmann, Granger, 2002).

Given the parameterization in (1) we can distinguish different cases depending on the value of d. If $d = 0$, $x_t = u_t$, x_t is said to be "short memory" or $I(0)$; if $d > 0$, x_t is said to be "long memory", because of the strong association between observations which are far in time. Here, if d belongs to the interval (0, 0.5) then x_t is still covariance stationary, while $d \geq 0.5$ implies non-stationarity. Finally, if $d < 1$, the series is mean reverting, meaning that the effect of shocks will eventually disappear in the long run, contrary to what happens if $d \geq 1$, with shocks persisting forever (Gil-Alana, Carcel-Villanova, 2018).

In order to choose the most appropriate ARFIMA model for the analysis, the Akaike information criterion (AIC, 1973) and the Bayesian Information Criterion (BIC, 1979) have been employed.

THE RESULTS

Stationarity of Data. Table 2 displays the results of classical unit root tests, specifically the ADF (Augmented Dickey-Fuller) and PP (Phillip Peron) tests, applied to the food inflation rate series (full, before and during the Russian-Ukrainian war). The tests were conducted under three regression scenarios: i) without intercept and trend, ii) with intercept only, and iii) with both intercept and trend. By conducting Augmented Dickey-Fuller (ADF) and Philips-Perron (PP) tests. With the exception of the case of the series during the war, we do not reject the hypothesis that there is a unit root in each of the time series of the food inflation rate for full times and pre-war, since the "*t*" statistics have greater than critical values at all levels of conventional significance. The probabilities also show that the unit-root hypothesis is not rejected. Additionally, since unit root tests (ADF and PP) are not sensitive to fractional unit roots, a more robust unit root test is necessary to accurately determine the unit root order of the time series, which is crucial for modeling, forecasting, and policymaking (Box et al., 2008).

RESULTS OF LONG MEMORY TESTS

Identification of Long Memory Pattern. To determine whether the data has a long-memory pattern, it can be done by looking at the ACF plot and calculating the Hurst statistics value. The ACF plot can be seen in Fig. 2 (using software Minitab 14). It is observable that there was a long memory because the ACF plot decreased slowly and hyperbolically. And this requires us to apply the long memory model to carry out the modeling and forecasting process.

Fractional integrated model estimation. Table 3 and Table 4 present the results of the fractional unit root (i.e. fractional integration) on the time series, using both Local Whittle Estimator and log-periodogram (GPH) approaches. The results are computed for three periodogram points $m = j^{0.6}$, $m = j^{0.7}$ and $m = j^{0.8}$. Fractional integration estimates, ds are computed fairly around 1 in all cases across the three periodogram points for the full series case and two case series (pre-war and dur-war), respectively.

The results are computed for three period-gram points $m = j^{0.6}$, $m = j^{0.7}$ and $m = j^{0.8}$. Fractional integration estimates, dues are computed confined either less than 1 or greater than it in all cases across the three period-gram points for the time series (food inflation rate).

So the fact that the integration factor for the food inflation rate in Ukraine differ from zero and from the one, which indicates that the food inflation rate in Ukraine are fractional integrated in the all cases (full, pre-war, and dur-war).

ARFIMA MODEL ESTIMATION

Fractional methods and ARFIMA (*p, d, q*) models are utilized due to the low power of unit root tests in long-term memory contexts (Diebold, Rudebusch, 1991; Hassler, Wolters, 1994; Lee, Schmidt, 1996). The Akaike Information Criterion (AIC, 1973) and the Bayesian Information Criterion (BIC, 1979) are applied to

Table 3. **Local Whittle estimator and GPH test using Full Sample**

Period / test	m	Local Whittle estimator			GPH test		
		D	std errors	z-test	d	std errors	t-test
Full	$T^{0.6}$	0.863692	0.125	6.90953	0.818227	0.192506	4.2504
	$T^{0.7}$	1.07416	0.0980581	10.9543	0.964337	0.122523	7.8707
	$T^{0.8}$	1.01787	0.0780869	13.0351	0.968885	0.0797115	12.1549
	p-value	0.0000 ***			0.0000 ***		

Notes: total sample T is 105 and the three period-gram points, $T^{0.6}$, $T^{0.7}$ and $T^{0.8}$ are 16, 26 and 41, respectively, asterisks *** indicate 1% level of significance; d — estimated degree of integration.
Source: computed by the authors.

Table 4. **Local Whittle estimator and GPH test using Pre-war and Dur-war**

Period / test	m	Local Whittle estimator			GPH test		
		D	std errors	z-test	d	std errors	t-test
Pre-war	T 0.6	0.9764521.1092	0.133631	7.30709	0.970873	0.192516	5.04307
	T 0.7	1.07583	0.1066	10.4053	1.10602	0.132407	8.35318
	T 0.8		0.0857493	12.5463	1.11722	0.0935142	11.9471
	p-value	0.0000 ***			0.0000 ***		
Period / test	m	Local Whittle estimator			GPH test		
		D	std errors	z-test	d	std errors	t-test
Dur-war	T 0.6	1.4496711.344	0.188982	7.67091	1.58856	0.285338	5.56731
	T 0.7	1.28505	0.166667	8.06401	1.46052	0.222242	6.57176
	T 0.8		0.150756	8.52403	1.50073	0.233826	6.41814
	p-value	0.0000 ***			0.0000 ***		

Notes: Pre-war T is 82 and the three period-gram points, $T^{0.6}$, $T^{0.7}$ and $T^{0.8}$ are 14, 22 and 34, respectively; dur-war T is 23 and the three period-gram points, $T^{0.6,}$ $T^{0.7}$ and $T^{0.8}$ are 7, 9 and 11, respectively; asterisks *** indicate 1% level of significance; d — estimated degree of integration.
Source: computed by the authors.

Table 5. **Results of ARFIMA (*p, d, q*) models**

Data analyzed	Model selected	d	Standard deviation	z-value	$Pr > \|z\|$	d
Full	ARFIMA (3, d, 0)	0.4996	0.000003464	14 4220	***	$I(d < 1)$
Pre-war	ARFIMA (2, d, 0)	0.4963	0.000002710	18 3165	***	$I(d < 1)$
Dur-war	ARFIMA (2, d, 1)	0.4852	0.0000007785	62 3278	***	$I(d < 1)$

Notes: The table reports the long memory test results. In bold we have selected the ARFIMA (p, d, q) model following the criteria (greater value) of AIC and BIC; asterisks *** indicate 1% level of significance.
Source: computed by the authors.

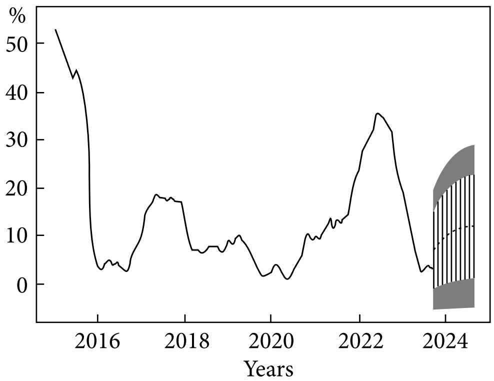

Fig 3. ARFIMA forecast for next 12 months
Source: constructed by the authors.

select the optimal AR and MA orders. Table 5 displays the AR and MA terms, along with the fractional parameter *d*, derived from Sowell's (1992) maximum likelihood estimator across various ARFIMA specifications for all combinations of $p, q \leq 2$.

Table 5 presents the estimation results of the memory parameter for the food inflation rate series. First of all, the estimation results show that memory parameters for all cases (full, pre-war, and dur-war) are within the stationary range ($0 < d < 0.5$). Nevertheless, the estimates of *d* suggest that the inflation series exhibits a long memory because of the strong association between observations, which are far in time, meaning that the effect of shocks will eventually disappear in the short run in all cases (full, pre-war, and dur-war). Secondly, the equal value of the persisted (*d*) in a case before heat and during war explains that there is no strong impact of the Russian-Ukrainian war on the food inflation rate persistence in Ukraine. This explains why the Ukrainian government's monetary policy strongly absorbs the shocks and effectively mitigates the impacts of the Russian-Ukrainian war.

Forecasting food inflation rates in Ukraine for the next 12 months based on the model ARFIMA (3, 0.4996, 0). Fig. 3 shows the historical data (solid line), the forecast (dashed line), and the confidence intervals for the forecast (shaded areas).

Expectations seem to indicate a rise in the food inflation rate in the current period. This is considered an important indicator of food inflation in Ukraine. The country's economic and social problems are indicated by the inflation rate's persistent rise, and political and economic circumstances may have an effect on food prices and availability.

THE DISCUSSION

Food inflation rates surged and became volatile after the Russian-Ukrainian war began in March 2022, revealing economic instability. Before the war, food inflation was uneven. Our analysis shows that Ukraine's food inflation rates are fractionally integrated, with integration factors ranging from zero to one throughout all periods (full, pre-war, and post-war). This indicates long-term memory properties, where past shocks have a lasting but diminishing effect. The memory parameters for food inflation rates remain within the stationary range ($0 < d < 0.5$) for all periods, suggesting that while the series exhibits long memory, the short-term impact of shocks will fade. The persistence of the memory parameter (*d*) before and during the war is unchanged, indicating that the conflict hasn't significantly altered food inflation persistence. This reflects the effectiveness of the Ukrainian government's monetary policies in absorbing shocks and mitigating inflation impacts during the war. The study forecasts higher food inflation rates, highlighting ongoing economic and social challenges in Ukraine. Political and economic factors continue to affect food prices and availability. These findings demonstrate the resilience of Ukraine's economy and the effectiveness of its monetary policies in managing inflation amid conflict. The long-term memory characteristics suggest that although shocks have lasting impacts, they eventually dissipate, allowing for potential economic recovery.

CONCLUSION

The preliminary analysis of food inflation rate data in Ukraine indicates the inflation rate in Ukraine is higher and more volatile. As it rose in the first year with the intensification of the Russian-Ukrainian war and then decreased after that. It has been confirmed that Ukraine is characterized by high inflation rates, especially during periods of war.

The results of the fractional integration test applied to food inflation rate data in Ukraine showed that it is a fractional integration in the all cases (full, pre-war, and dur-war).

The study's main findings indicate that the estimated memory parameter for the food inflation rate series — across all cases (full, pre-war, and post-war) — falls within the stationary range ($0 < d < 0.5$). However, the estimates suggest that the food inflation series displays long memory due to a strong correlation between distant observations, implying that the effects of shocks dissipate in the short run in all scenarios. The equal value of the persisted (d) in a case before heat and during war shows that there is no strong impact of the Russian-Ukrainian war on the food inflation rate persistence in Ukraine. This underscores the effectiveness of the Ukrainian government's monetary policy in absorbing shocks and mitigating the war's effects.

Expectations indicate an increase in the rate of food inflation during the future period, and this is considered an important indicator of food price inflation in Ukraine. The country's economic and social problems are evident in the continuing rise in the inflation rate, and political and economic conditions may have an impact on food prices and availability.

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ВПЛИВ РОСІЙСЬКО-УКРАЇНСЬКОЇ ВІЙНИ НА СТІЙКІСТЬ РІВНЯ ПРОДОВОЛЬЧОЇ ІНФЛЯЦІЇ В УКРАЇНІ: МОДЕЛЬ ДРОБОВОГО ІНТЕГРУВАННЯ

Це дослідження має на меті перевірити стійкість продовольчої інфляції в Україні за допомогою методів одновимірного дробового інтегрування. Тест Гевеке — Портер-Гудак (GPH) і локальна оцінка Віттла є методами, які використовують в аналізі даних часових рядів, особливо в контексті процесів з довгою пам'яттю. На додаток до вимірювання стійкості рівня продовольчої інфляції за допомогою моделі ARFIMA емпіричні результати також свідчать про стійкість низького рівня продовольчої інфляції в Україні, хоча й з тією самою тенденцією, до й під час російсько-української війни. Крім того, рівень продовольчої інфляції має властивості довгої пам'яті, незалежно від використаної вибірки. Результати показують, що параметри пам'яті для всіх випадків (загальний, довоєнний і під час війни) перебувають у стаціонарному діапазоні ($0 < d < 0{,}5$) і є майже однаковими. Однак оцінки d свідчать про те, що ряди рівнів продовольчої інфляції демонструють довгу пам'ять, а ефект шоків зрештою зникне в короткостроковій перспективі в усіх випадках (загальний, довоєнний і під час війни). Отже, сильного впливу російсько-української війни на стійкість рівня продовольчої інфляції в Україні немає. Це вказує на те, що монетарна політика українського уряду забезпечує успішне поглинання шоків та ефективно пом'якшує наслідки російсько-української війни. Можливість додатково використовувати дробове інтегрування в одновимірному варіанті при моделюванні продовольчої інфляції є головним внеском цього дослідження, й ігнорування цієї можливості може призвести до неправильних висновків.

Ключові слова: *стійкість рівня продовольчої інфляції; російсько-українська війна; дробове інтегрування; модель ARFIMA; Україна.*

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