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THE IMPACT OF MACROECONOMIC FACTORS ON FOOD PRICE INFLATION: THE CASE OF HUNGARY

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Recent episodes of high and volatile food inflation in developed and emerging economies have led policymakers around the world to confront the question of how effective monetary policy is in stabilising food price pressures. The small number of empirical studies has been limited to Central European countries, including Hungary. We analyze the role of macroeconomic factors on food inflation in Hungary from January 2007 to November 2022. The long-run relationship is confirmed among the variables using the ARDL bounds testing approach to cointegration.
Employing the Nonlinear Autoregressive Distributed Lag (NARDL) as estimation strategy, this study is probably the first attempt to examine the asymmetric relationship between food inflation and macroeconomic variables relevant to monetary policymaking. The results show that a change in consumer price index and USD exchange rate also induces changes in the food inflation in both directions in the long run. However we do not find signicant results for global food price index and monetary policy proxied monetary base. The symmetry test statistics suggest the existence of a symmetric relationship between food price inflation and macroeconomic variables in the long-run as well as in the short-run.

Keywords: food prices, inflation, monetary policy, nardl, long term

I. Introduction

Recent episodes of high and volatile food inflation in developed and emerging economies have led policymakers around the world to confront the question of how effective monetary policy is in stabilising food price pressures. Monetary restictions reduces output and income in response to food price shocks, but may not have a significant impact on food inflation because of the Engel law, while monetary policy has a larger impact on non-food prices and output. This raises a dilemma for policy makers regarding the role of monetary policy in the impact of food shocks.
Rising food inflation not only affects inflation but also creates uncertainty, leading to rising inflation expectations. This creates problems in forecasting aggregate inflation and achieving inflation targets. Producers face difficulties in making investment decisions due to rising inflation uncertainty. Furthermore, food prices negatively affect health and welfare activities by increasing infant and child mortality and malnutrition in developing countries (de Brauw, 2011; Kidane and Woldemichael, 2020).
The coronavirus epidemic and the Russian and Ukraine war have amplified these effects in Hungary. The inflation target of the Hungarian National Bank (MNB) is 3%, with a tolerance band of ±1 percentage point acceptable under the Hungarian inflation targeting system. Price growth reached 9.5% by April 2022, and prices have accelerated by over 20% since September 2022. Food price dynamics have diverged from inflation (see Figure 1).

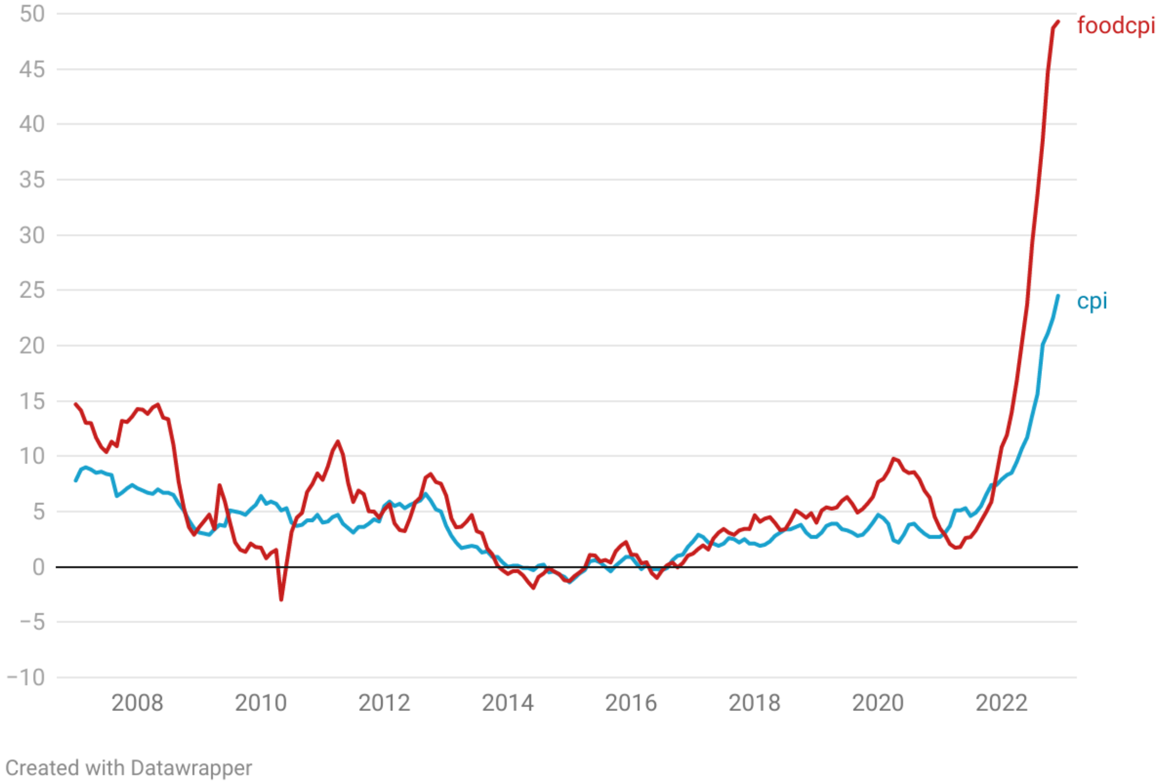

Figure 1: Food and overall inflation in Hungary

While some of the literature (Pourroy et al., 2016; Anand et al, 2015; Catao and Chang, 2015; Soto, 2003; and Aoki, 2001) provide a theoretical basis for optimal monetary policy to influence food inflation, empirical investigation of this relationship remains surprisingly limited (Bhattacharya and Jain, 2020). Recent studies focus mainly on Asian (Bhattacharya and Jain, 2020, Samal and Goyari 2022) and African countries (Iddrisu and Alagidede 2020, 2021), but there are few studies on European Union countries, and within them on Central European countries (except Bhattacharya and Jain, 2020).

The central question of our paper is: can monetary policy stabilise food price inflation? Our results provide empirical evidence on the effectiveness of monetary policy in combating domestic food price inflation. The paper contributes to the literature in several ways. Previous studies have mainly used VAR models to analyse the impact of monetary policy on food inflation. However, the related empirical literature has raised several criticisms of the use of VAR models (e.g. Iddrisu and Alagidede 2020, Samal and Goyari 2022). Food prices are among the most volatile, and therefore food prices can reach extreme values relatively quickly. The existence of extreme values in the distribution of food prices cannot be explained by an averaging approach, and hence not by the VAR model. In contrast, macroeconomic policy is based on asymmetric properties. Thus, the application of these techniques may give biased results. Following the recent empirical literature (Iddrisu and Alagidede 2020 and 2021, Samal and Goyari 2022), we use quantile regression to address this problem in order to understand the dynamics of different levels of price increases and to show the impact of monetary policy on different scenarios.

The limited number of empirical studies has been limited to Central European countries, including Hungary. Hungary is a good case study because it has a higher than average share of food in the consumer basket in the EU. Furthermore, as a small, open country exposed to world market processes, it is important to investigate the extent to which food prices in the world economy are reflected in domestic prices and the extent to which the central bank can effectively counteract this.

II. Review of related studies

Although there is a rich literature on the relationship between monetary policy and inflation, only a limited number of studies have analysed the impact of monetary policy on food inflation. One strand of the literature has focused on the United States, and in particular on the impact of monetary policy on product markets. Frankel (2008) examines the impact of monetary policy on real commodity prices in the United States over the period 1950-2005. The findings of the study show that increases in short-term real interest rates reduce aggregate commodity prices and, in 23 cases, agricultural commodity prices. Akram (2009) finds that a positive shock to real interest rates causes a decline in the real price of both oil and food. Scrimgeour (2015) finds a similar result, examining the response of commodity prices to changes in monetary policy in the United States. He estimates that a 1 per cent increase in the interest rate led to an immediate fall in commodity prices of 0.6 per cent. Hammoudeh, Nguyen, and Sousa (2015) conclude that tightening monetary policy has a lagged negative and significant effect on aggregate commodity prices. However, at the product level, tightening monetary policy significantly increases food inflation. Generalizing Dornbush's (1976) model in a new theoretical framework, Shaghaian and co-authors (2002) show that agricultural prices adjust more quickly to changes in the money supply than industrial prices, which affects relative prices in the short run, but strict long-run monetary neutrality does not hold. Alam and Gilbert (2017) find that monetary policy, global economic conditions, and the exchange rate of the US dollar play important roles in agricultural commodity price dynamics. These studies have two important features. First, they did not work directly with food inflation, but with aggregate agricultural prices, or more disaggregated product prices. On the other hand, VAR or VAR-based SVAR, FAVAR models were used in the empirical analysis.

Another group of studies deals with India. Anand, Ding and Tulin (2014) study the role of monetary policy on food price inflation in India using Bayesian techniques. The results of their study show that restrictive monetary policy reduces food inflation. Kumar and Dash (2020) conclude that monetary policy measures are more effective in reducing inflation in the manufacturing sector than in the agricultural sector. However, at the disaggregated level, tightening monetary policy significantly increases food inflation. Holtemoller and Mallick (2016) show that tightening monetary policy reduces food price inflation by raising interest rates in India. Using quantile regression analysis, Samal and Goyari (2022) find that monetary policy stabilises food inflation in all quantiles. They find that the transmission of monetary policy through exchange rate and asset price channels increases food inflation in all quantiles. In contrast, the bank credit and interest rate channels reduce it in the lower and middle quantile, i.e. at lower inflation rates.

Bhattacharya and Jain (2020) investigate the effectiveness of monetary policy in stabilizing food inflation in 16 advanced and emerging economies using quarterly data from 2006-16. The panel VAR results show that unexpected monetary tightening has a positive and significant impact on food inflation through the cost of production channel.

There are also few empirical studies available for African countries where food plays an important role in the consumption of the population. Iddrisu and Alagidede (2020) investigated the relationship between monetary policy and food prices for South Africa using quantile regression. Their results show that, in the case of rising food prices, restrictive monetary policy causes additional uncertainty in food prices. In a related study, Iddrisu and Alagidede (2021) found similar results for Ghana, where monetary policy tightening caused additional uncertainty in food prices.

For Central European countries, there are two related studies that examine the relationship between monetary policy and agricultural prices. Bakucs and co-authors (2012) examine the impact of monetary policy on agricultural prices using the theoretical model of Shaghaian and co-authors (2002). The results show that agricultural prices adjust more quickly to monetary shocks than industrial prices, which affects relative agricultural prices in the short run, but strict long-run monetary neutrality does not hold. In a related paper, Bakucs and Fertő (2014) find a similar result for Hungary, i.e. agricultural prices adjust faster to monetary shocks than industrial prices.

In short, the empirical literature confirms the impact of monetary policy on agricultural product markets and food inflation. The majority of the results find that monetary policy tightening is more likely to lead to increases in agricultural prices and food price inflation. Furthermore, they stress that in small, open economies, international processes fundamentally determine our economy, and in such an environment, the literature suggests that monetary policy is ineffective and even restrictive monetary policy can be harmful, as it introduces additional uncertainty into already highly volatile food price markets.

III. Monetary policy framework in Hungary

The main objective of the Hungarian National Bank (MNB) is to achieve and maintain price stability. To achieve this goal, the MNB has been using inflation targeting (IT) since June 2001. Effective IT requires a clear commitment by the central bank to maintain price stability as its primary objective. A key element is a clearly and quantifiably announced inflation target, which typically means low inflation of around 2-3%. Since March 2015, the MNB's inflation target has been 3% with a tolerance band of ±1 percentage point. The success of IT is significantly influenced by the transparency and accountability of the central bank.

From the mid-2000s, Hungary's economic prospects were favourable, but the global economic crisis that started in 2008 significantly reduced this, leading to a recession, high inflation and a significant increase in public debt. Inflation peaked in 2012 at 6.6%. The IMF provided the final bailout, which also involved restrictive financial policies. Food prices rose by more than 25% between 2007 and 2012, and the government responded by increasing subsidies to food producers, R&D spending and trying to reduce food imports. Despite this, food price increases have not slowed down, due to weather conditions and the ever increasing demand for food in emerging markets. In Hungary, food price increases are higher than the prevailing general inflation rate.

Responding to international trends, the Hungarian National Bank (MNB) reacted to the crisis by cutting interest rates and quantitative easing. However, inflationary pressures quickly forced the central bank to adopt a restrictive monetary policy in the early 2010s. In 2013, the MNB sought to counteract this effect by providing loans at very low interest rates to the SME sector. From 2014 onwards, a period of low interest rates was mediated, with inflation averaging around 2% until 2019, the base rate of the central bank below 2% until the end of 2021, and the central bank continued to take actions that stimulated the economy. The MNB has occasionally intervened in the foreign exchange market to manage exchange rate fluctuations and support the domestic economy.

The emergence of Covid-19 led to a sudden and severe economic decline, to which monetary policy responded by further easing, expanding its favourable SME lending programme and buying government bonds in the secondary market. In addition to monetary easing, the Hungarian government increased government spending. After more than a decade, the MNB raised interest rates significantly again and the central bank has communicated that it intends to maintain its restrictive monetary policy in the coming years, with the main aim of reducing inflation and strengthening financial stability.

IV. Data and Methodology

The analysis uses monthly data from January 2007 to December 2022. The source of the data used is the publicly available databases of the Magyar Nemzeti Bank (Central Bank of Hungary) and FRED. The following variables were included in the modelling:

- Food price inflation (foodcpi): prices of food and non-alcoholic beverages in the Hungarian consumer basket,
- Inflation (cpi): Hungarian inflation rate,
- Global food price index (gpfi): Food price inflation calculated from globally representative data,
- Dollar exchange rate (usd): USDHUF exchange rate,

- Money supply (M1, M2): Hungarian money supply data by M1 and M2.

For the USDHUF exchange rate, monthly averages were applied. In all cases, we used the logarithm of the variables on a natural basis.

In the analysis, an improved version of the ARDL model, the NARDL (Nonlinear Autoregressive Distributed Lag) model, was used to examine the impact of monetary policy. The models can be used when the model variables do not follow an I(2) process. For this reason as a first step in the analysis, the necessary unit root tests are performed (Elliott-Rothenberg-Stock, Phillips-Perron unit root tests). The use of the ARDL model is recommended to study long-term relationships when at least one cointegration vector exists. For cointegration studies, the test of Pesaran, Shin and Smith (2001) was used. The advantage of ARDL methods is that they provide reliable results even for small samples and are not sensitive to the order of integration of variables (Roy & Roy, 2022). With the NARDL model, asymmetric effects can be analysed, the model is similar to error correction models, and therefore repricing can be analysed.

In our study we used STATA version 17 for all tests and estimation procedures.

V. Results

In the presentation of results, the results of the unit root tests are presented first, followed by the cointegrations results and NARDL estimations. The results of the unit root tests are presented in Tables 1 and 2.

Table 1: Elliott-Rothenberg-Stock (AIC) unit root test

	intercept		intercept, trend	
	Level	First diff.	Level	First diff.
lngpfi	-1.144	-7.190***	-2.637**	-7.973***
lnfoodcpi	-0.911	-1.248	-0.926	-3.044**
lncpi	-0.351	-0.975	-0.223	-0.705
lnusd	-0.170	-9.600 ***	-3.621 ***	-10.020***
lnM1	2.821	-1.469	-1.140	-3.684***
lnM2	2.112	-0.718	-1.110	-2.878**

*** p<0.01; ** p<0.05; * p<0.1

The Elliott-Rothenberg-Stock unit root test is based on the Akaike information criterion lag. The results indicate that, ignoring trends, none of the variables can be considered stationary. With the first difference, global food inflation, dollar exchange rate are considered stationary at a confidence level of at least 95%. With the inclusion of the trend, two variables already "passed" the test without the first difference, with the first difference only the domestic inflation variable being considered non-stationary.

Table 2: Phillips-Perron unit root test

	intercept		intercept, trend	
	Level	First diff.	Level	First diff.
lngpfi	-2.217	-8.773***	-2.314	-8.749***
lnfoodcpi	1.794	-8.344***	1.999	-8.962***
lncpi	2.570	-8.560***	3.523	-9.365***
lnusd	-0.680	-10.677***	-3.775**	-10.666***
lnM1	2.415	-14.547***	0.342	-14.919***
lnM2	2.773	-15.076***	-0.085	-15.649***

*** p<0.01; ** p<0.05; * p<0.1

Based on the results of the Phillips-Perron unit root test, the dollar exchange rate can be considered stationary without a first difference when the trend is taken into account. Looking at the first differences, it can be seen that in all cases the variables are almost significant at 1% significance. Based on the two different unit root tests, the results are identical except for inflation, and the first difference of the variables should be used in further analyses. For inflation, a adjusted Dickey-Fuller test with and without trend was also performed. The result without trend for the first difference is (-8.626; p=0.000***), with trend included (-9.415; p=0.000***). Taking into account the results of the ADF test, the differentiated variable is included in the model building for inflation.
For the cointegration analyses, the optimal lag selection model was determined using the FPE, AIC, HQIC and SBIC criteria. The lags used were those proposed by the selection model in most cases. For M1 and M2, a lag of 2 was selected. Based on these, the results of the bounds tests of Pesaran, Shin and Smith (2001) are shown in Table 3. For the NARDL, there is a long-run relationship between Hungarian food prices and money.

Table 3: NARDL bounds testing approach

M1	M2
F = 3.864*	F = 4.012***
t = -3.309	t = -3.140

*** p<0.01; ** p<0.05; * p<0.1

The nonlinear ARDL model (Table 4) treats positive and negative long-run effects separately and allows for the measurement of asymmetries based on these effects (Table 6). The NARDL results suggest that international food prices and domestic inflation do not behave in the same way on the positive and negative sides. For decreasing international food prices, domestic food prices also decrease; increasing international food prices have no effect on domestic food price inflation. Increases in domestic inflation increase food prices, but this effect is not observed in the case of falling inflation, i.e. the fall in the general price level is not transmitted to food prices. As a small and open economy, foreign trade can have a significant impact on inflation, and in this study we have measured this effect through the exchange rate of the US dollar. A weakening HUF increases food prices, a strengthening HUF reduces prices. For the money stock, the sign of the coefficients is positive on both the negative and positive side, i.e. restrictive monetary policy (reducing the money supply) also increases food prices. However, these coefficients are not significant.

Table 4: NARDL model results (long term, M1)

	Long-run effect [+]			Long-run effect [-]		
	coef.	F-stat	p>F	coef.	F-stat	p>F
lngpfi	0.144	.6707	0.414	-0.461*	3.522	0.062
lncpi	1.913**	4.94	0.028	-1.522	1.889	0.171
lnusd	0.567**	4.15	0.043	-0.566**	5.336	0.022
lnM1	0.091	.1461	0.703	0.088	.04036	0.841

*** p<0.01; ** p<0.05; * p<0.1

The results for the short term are shown in Table 5. There are no significant differences compared to the long-run model (see Table 4). It is important to note that monetary policy cannot have a significant impact on food inflation in the short run either, i.e. monetary policy is ineffective in terms of M1 money supply.

Table 5: NARDL model results (short term, M1)

	coef.
lnfoodcpi t-1 (ECM)	-0.104***
d.lnfoodcpi t-1	0.212***
d.lnfoodcpi t-2	-0.027
d.lnfoodcpi t-3	0.134*
lngpfiPOS t-1	0.015
lngpfiNEG t-1	0.048**
lncpiPOS t-1	0.199*
lncpiNEG t-1	0.158
lnusdPOS t-1	0.059***
lnusdNEG t-1	0.059***
lnMPOS t-1	0.009
lnMNEG t-1	-0.009
d.lngpfiPOS	0.062
d.lngpfiPOS t-1	-0.060
d.lngpfiNEG	0.059
d.lngpfiNEG t-1	-0.031
d.lncpiPOS	0.501**
d.lncpiPOS t-1	-0.086
d.lncpiNEG	0.710**
d.lncpiNEG t-1	-0.318
d.lnusdPOS	0.010
d.lnusdPOS t-1	0.003
d.lnusdNEG	-0.066
d.lnusdNEG t-1	-0.019
d.lnMPOS	-0.011
d.lnMPOS t-1	-0.056
d.lnMNEG	0.116
d.lnMNEG t-1	0.169
constant	0.493***
N	187
R^2	0.543

*** p<0.01; ** p<0.05; * p<0.1

Based on the tests in Table 6, there is no difference between the magnitude of positive and negative effects. So, regardless of the direction of the shocks, the Hungarian food prices react in the same order of magnitude. Only in the short run is there a significant difference for the M1 variable, but for the short run outcome (Table 5) it can be seen that the M1 variable is not significant in either positive or negative direction.

Table 6: NARDL asymmetry tests (M1)

	Long-run		Short-run	
	F-stat	p>F	F-stat	p>F
lngpfi	0.896	0.345	0.049	0.825
lncpi	0.054	0.816	0.002	0.967
lnusd	0.000	0.995	0.799	0.373
lnM1	0.129	0.720	2.990	0.086*

*** p<0.01; ** p<0.05; * p<0.1

The Portmanteau test up to lag 40 (chi2) statistic is 80.22, p-value: 0.000, the Breusch/Pagan heteroskedasticity test statistic is 0.118, p-value: 0.731, the Ramsey RESET test F is 2.804, p-value: 0.042. Finally, the Jarque-Bera test on normality (chi2) is 117.9, p-value: 0.000. In all cases except the Breusch/Pagan heteroskedasticity test, the model does not perform well in the diagnostic tests.
To check the robustness of the results, nonlinear model estimates were also obtained for the one wider money supply (M2). The results are presented in Tables 7 and 8.

Table 7: NARDL model results (long term, M2)

	Long-run effect [+]			Long-run effect [-]		
	coef.	F-stat	p>F	coef.	F-stat	p>F
lngpfi	0.250	1.634	0.203	-0.429	2.594	0.109
lncpi	1.930**	4.195	0.042	-2.303*	2.908	0.090
lnusd	0.606**	4.065	0.045	-0.654**	5.634	0.019
lnM2	0.026	.01429	0.905	0.347	.3484	0.556

*** p<0.01; ** p<0.05; * p<0.1

The results are presented in the context of the differences for the M1 model. For international food prices (lngpfi), there is no significant effect on either the positive or negative side. These suggest that Hungarian food prices follow a different path than international food prices. In the model including M2, the general price level decrease already appears for food prices, reducing food prices as expected, but this effect is significant at 10%. The mechanism of action of the exchange rate is the same as in the M1 model. The variable representing monetary policy, which is the main subject of the analysis (lnM2), is not significant in either case, i.e. monetary policy continues to have no effect on food prices.
The model using the M2 money supply is not significantly different from the long-run model. It remains the case that monetary policy is ineffective in the short run.

Table 8: NARDL model results (short term, M2)

	coef
lnfoodcpi t-1 (ECM)	-0.092***
d.lnfoodcpi t-1	0.208***
lngpfiPOS t-1	0.023
lngpfiNEG t-1	0.040*
lncpiPOS t-1	0.178
lncpiNEG t-1	0.212**
lnusdPOS t-1	0.056***
lnusdNEG t-1	0.060***
lnMPOS t-1	0.002
lnMNEG t-1	-0.032
d.lngpfiPOS	0.072
d.lngpfiPOS t-1	-0.049
d.lngpfiNEG	0.043
d.lngpfiNEG t-1	-0.027
d.lncpiPOS	0.474**
d.lncpiPOS t-1	0.013
d.lncpiNEG	0.703**
d.lncpiNEG t-1	-0.308
d.lnusdPOS	-0.005

d.lnusdPOS t-1	0.004
d.lnusdNEG	-0.059
d.lnusdNEG t-1	-0.018
d.lnMPOS	0.000
d.lnMPOS t-1	0.008
d.lnMNEG	0.154
d.lnMNEG t-1	0.168
constant	0.437***
N	189
r2	0.532

*** p<0.01; ** p<0.05; * p<0.1

Table 9: NARDL asymmetry tests (M2)

	Long-run		Short-run	
	F-stat	p>F	F-stat	p>F
lngpfi	0.248	0.619	0.004	0.949
lncpi	0.036	0.851	0.024	0.878
lnusd	0.040	0.842	0.501	0.480
lnM2	0.348	0.556	2.139	0.146

*** p<0.01; ** p<0.05; * p<0.1

The asymmetry tests suggest that the effect size of each variable is the same on the positive and negative side, so that domestic food price inflation is neither more nor less affected by a shock.
The Portmanteau test up to lag 40 (chi2) stat. value is 85.1, p-value: 0.000, the Breusch/Pagan heteroskedasticity test stat. value is 0.102, p-value: 0.750, the Ramsey RESET test F value is 3.265, p-value: 0.023. Finally, the Jarque-Bera test on normality (chi2) stat. value is 124.6, p-value: 0.000. In all cases except the Breusch/Pagan heteroskedasticity test, the model does not perform well in the diagnostic tests.

VI. Conclusions

Food prices continue to play an important role in the overall inflation dynamics in many countries. This is particularly the case in countries where food has a larger share in the consumer basket. Surprisingly, the empirical evidence on the impact of monetary policy on food inflation is limited in the literature, especially for Central European countries. This paper partly fills this gap by examining Hungary. Currently, food inflation is one of the main challenges in Hungary. In our study, we have used NARDL model instead of the traditional VAR estimation prevalent in the literature to obtain a more detailed picture of food price dynamics and the effects of monetary policy for different levels of price increases. Due to the NARDL model, the shock effect in different directions can be measured, allowing the asymmetric effect to be investigated, while a classical VAR model assumes symmetric effects. Their results suggest that monetary policy has no effect on Hungarian food prices. In contrast, we find evidence that the general price level and the USDHUF exchange rate have an effect, with no clear evidence for international food prices. The symmetry test statistics suggest the existence of a symmetric relationship between food price inflation and macroeconomic variables in the long-run as well as in the short-run. However, inflation plays a significant role in driving food price increases. The results are robust to different specifications (M1 and M2). Our results are partially consistent with the international literature. While restrictive monetary policy can increase food price inflation in some countries (e.g., Battarcharya and Jain 2020; Iddrisu and Alagidede, 2020, 2021), this effect is not significant in Hungary. According to theories in the literature, food prices are determined by world price trends in the long run (e.g. Durevall et al., 2013), and monetary policy can only have an impact on domestic price increases. On this basis, monetary policy cannot effectively counter food price increases and cannot break an existing global market trend. They suggest that an excessively restrictive policy will slow economic growth while being ineffective on food price increases. The problem is exacerbated by the fact that families in the lower income brackets spend a higher proportion of their income on food than those in the more affluent brackets. Our results suggest that monetary policy is not effective in counteracting food prices, in such a situation fiscal policy should complement monetary policy, as suggested by Ginn and Pourroy (2019), in such a way that severe monetary policy tightening is not necessary Further research is needed to demonstrate and analyse these tools.

VII. Funding

Supported by the ÚNKP-22-4-II-MATE/3. New National Excellence Program of the Ministry for Culture and Innovation from the source of The National Research, Development and Innovation Fund.

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