WORKING PAPER

ANALYSIS OF THE DEGREE AND DYNAMICS OF INPUT PRICE PASS-THROUGH TO OUTPUT PRICES ALONG THE INDUSTRIAL-FOOD PRODUCT CHAIN IN SERBIA

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Analysis of the degree and dynamics of input price pass-through to output prices along the industrial-food product chain in Serbia

Andrea Jović, Stojan Janković and Lazar Radivojević

Abstract: The research examines price transmission within the industrial-food chain in Serbia, investigating the relationships between exchange prices of primary agricultural commodities, producer prices, and consumer food prices, with a focus on the dynamics and asymmetry in this pass-through. Applying the NARDL model to monthly data, an assessment was made of the short-term and long-term effects of positive and negative price shocks, with appropriate control variables included in the models to capture specific influences from the international environment. The obtained results indicate the existence of a statistically significant and economically relevant asymmetric price pass-through along the entire chain, with the intensity of asymmetry differing between individual stages. In the processing stage, a 1% increase in the exchange prices of primary agricultural commodities leads to a 0.62% increase in producer prices, while a 1% decrease in exchange prices results in a 0.51% reduction in the prices of primary agricultural commodities, indicating incomplete transmission with moderate asymmetry. Stronger asymmetry and a more powerful pass-through effect were estimated in the retail stage, where a 1% increase in producer prices raises consumer prices by 1.12%, while a decrease in producer prices leads to a 0.71% reduction in consumer prices. The findings suggest that price shocks intensify as we approach the final consumer, and that increases in input costs have a stronger and more complete impact on raising retail prices than on their reduction, which can be associated with the phenomenon of downward nominal price rigidity. The findings in the paper have significant implications for understanding price dynamics in the food sector and for formulating economic policy measures aimed at mitigating and controlling inflationary pressures.

Key words: Asymmetry, industrial-food chain, producer prices, consumer prices, NARDL.
[JEL Code]: E31, Q11, C32

Non-Technical Summary

Theoretical and empirical literature concur on the assessment that cost-push pressures are transmitted throughout the entire production chain – from processing to retail – but that the pass-through is neither complete nor symmetrical. While the supply-side approach emphasizes that increases in input prices stimulate rises in output prices, the demand-side approach indicates that increased consumer demand can also lead to higher prices in production. Numerous studies confirm that producer prices often precede consumer prices, but there are also findings of bidirectional influences, depending on market characteristics and the observed period. Particular attention in the literature is devoted to asymmetric price pass-through, i.e. the phenomenon whereby increases in input costs are transmitted to final prices more quickly and strongly than their decreases. This phenomenon is explained by specific market structure, differing bargaining power of participants in the production chain, concluded long-term contracts, and downward nominal price rigidity, and has been empirically demonstrated precisely in the food sector, where the retail segment plays a decisive role in forming final prices for consumers.

Empirical analysis shows that price shocks along the industrial-food chain in Serbia are transmitted asymmetrically and with varying dynamics – more strongly when input costs rise than when they fall, and to a greater extent in the retail stage. In the processing stage, an increase in the prices of primary agricultural products (wheat, corn, soybean) on the domestic market leads to a rise in producer food prices of approximately 0.62%, while a decrease in these same costs leads to a price reduction of 0.51%, which is statistically significantly lower than in the case of an increase. In the retail stage, the asymmetry is even more pronounced, as the increase in producer prices on average passes through more than proportionally to consumer prices (1.11%), while the effect of their decrease is significantly weaker (0.71%). In addition to movements on the domestic market, global factors also play a significant role in the formation of food prices. Movements in global energy prices and the exchange rate of the dinar against the euro and the dollar affect the dynamics of producer and consumer food prices, while world prices of certain raw materials (such as cocoa and coffee) are relevant for specific production segments. The obtained results confirm the existence of a stable long-term relationship between the observed variables, but also relatively slow adjustment following price shocks, given that approximately 5–7% of deviations from equilibrium are corrected each month, meaning that the effects of shocks extend over a period longer than one year.

Overall, the findings suggest that cost transmission in the food sector is asymmetrical in both stages of the industrial-food chain, with it being complete and more pronounced in the retail stage. This has significant implications for understanding food and overall inflation dynamics, as it indicates that global and domestic cost-push pressures can have a more lasting and stronger effect on consumer prices.

Contents

1 Introduction

Price dynamics in the food sector significantly determines overall inflation, given that food has a relatively high share in the household consumption basket, particularly in emerging and developing economies such as Serbia. After reaching record highs during 2021 and 2022, cost-push pressures in the food market were gradually eased from the beginning of 2023 to mid-2025. Nevertheless, they remained elevated compared to pre-crisis levels, primarily due to adverse weather conditions affecting below-average agricultural seasons, as well as rising energy prices and high real wage growth, which influenced higher labour costs. In addition to the aforementioned factors, the persistent increase in food prices at the retail level on the domestic market was also influenced by the continuous increase in trade margins of leading retail trade chains in recent years.

Understanding the mechanism of price pass-through from agricultural producers through processors to retailers is an important issue for both economic theory and the economic policy making. A number of authors agree in their assessment that the pass-through is often neither complete nor symmetrical, but rather depends on a range of structural and institutional factors, such as the degree of market concentration and competition, the level of participants' bargaining power, the regulatory framework, characteristics of consumer demand and consumer habits, and others. Therefore, this paper examines the phenomenon of asymmetric price pass-through in the processing and retail stages of the industrial-food chain in the case of Serbia, under the assumption that increases in input prices are transmitted to output prices more strongly and quickly than their decreases. In the literature, this psychological-economic phenomenon is most often associated with *downward nominal price rigidity*, which implies that prices adjust downwards more slowly and to a lesser extent than upwards. This is particularly pronounced in the retail stage, where relatively high market concentration and unequal bargaining power between market participants lead to prices rarely being reduced even under conditions when procurement costs are decreasing. Such margin dynamics directly affect the movement of consumer food prices, as well as the perception of inflation by corporates and households, which creates an additional challenge for economic policymakers. The paper applies the Nonlinear Autoregressive Distributed Lag (NARDL) model, which enables the separation of positive and negative changes in input prices and the estimation of their short-term and long-term effects on output prices. The application of the NARDL model allows for a more precise insight into differences in the degree of pass-through and price dynamics, which cannot be captured by linear models. The obtained results can serve to interpret the dynamics of food and overall inflation in Serbia, as well as for creating measures aimed at preserving the living standard and purchasing power of the population, such as the current Decree.

The paper is structured as follows. The second chapter provides an overview of the relevant theoretical and empirical literature on price pass-through along the industrial-food product chain. The third chapter presents movements in the index of exchange prices of agricultural commodities, as well as producer and consumer food prices on the domestic market. The fourth chapter shows the data and the methodological framework used for the research, while the fifth chapter interprets the results of the empirical analysis. Also in the fifth chapter, the effects to date of the adopted Serbian Government's Decree are considered, while

the final chapter summarises the main theoretical-empirical findings and their practical value for economic policymakers.

2 Theoretical framework and an overview of empirical literature

The concept of inflation in economic literature is most often defined as the rise in the general price level of goods and services, which is why it represents one of the key macroeconomic determinants and indicators of the real sector. Inflation is of exceptional importance for economic policymakers, primarily when it comes to monetary policy, bearing in mind that in the inflation targeting regime applied by Serbia, the central bank's primary goal is maintaining price stability. Also, the level and dynamics of prices are of essential importance for the economy, as they affect profitability through the relationship between input and output prices, as well as for households, since they directly determine real purchasing power and the living standard.

In practice, inflation is most often measured by changes in the consumer price index, which represents the prices from the basket of goods and services purchased by households. From the perspective of the economy, movements in the producer price index are also important, as it represents the prices at which producers sell their products to other participants in the production chain. When analysing the relationship between these two indices, the producer price index is usually used as a leading indicator for the consumer price index, i.e. **it is expected that increases in producer prices will pass through to increases in consumer prices**. However, the relationship between these two indices is more complex and does not necessarily imply a one-way link, because their mutual interaction is also possible, and in certain circumstances changes in consumer prices can, through feedback, affect producer prices. In this regard, Asik (2024) cites two leading approaches in interpreting inflationary pressures and their transmission: (1) the supply-side approach and (2) the demand-side approach.

Within the supply-side approach, inflation is viewed as a consequence of rising cost-push pressures (cost-push inflation), which are passed through via producer prices to consumer prices. In other words, an increase in input costs encourages producers to pass this increase partially or completely onto final product prices (Tiwari, 2012). This transmission mechanism occurs through multiple stages of the production process, as primary raw materials are first incorporated into intermediate goods, which then serve as inputs in the production of final goods intended for consumption. In contrast, **within the demand-side approach, an increase in consumer prices arising from increased demand can also be reflected in producer prices**. Consumer preferences for certain products indirectly result in greater demand for raw materials and intermediate goods involved in their production chain, leading to price increases for those products (Caporale et. al, 2002).

Numerous authors have analysed the pass-through between producer and consumer prices. In one of the first studies on this topic, a one-way relationship from producer to consumer prices was confirmed in the USA (Silver & Dudley, 1980). Similar results were obtained by Caporale et al. (2002) using the example of G7 member countries, analysing price movements in developed economies during the period Q1 1976 – Q4 1999. More recent papers have shown

that the relationship between producer and consumer prices may be conditioned by special components such as food and energy prices, whereby if these components are excluded, the observed relationships weaken significantly (Belton & Nair-Reichert, 2007). Similar research has also been conducted in developing countries, where a one-way relationship between producer and consumer prices has been confirmed in various macroeconomic environments. The impact of producer on consumer prices was demonstrated by Ghazali et al. (2008) using the example of Malaysia for the period January 1986 – April 2007, with confirmed cointegration. The same results were obtained in the case of Mexico, where it was emphasized that the inclusion of producer prices in models could significantly improve inflation projections (Sidaoui et al., 2009). As for countries in the region, Katsouli et al. (2002) using the example of Greece, with the help of an error correction model (ECM), confirmed cointegration between the two indices, whereby changes in producer prices cause changes in consumer prices. Similarly, Su et al. (2016) using the example of Slovakia confirmed a one-way relationship, with the authors emphasizing that in certain periods there is a two-way relationship between these two indices. An analysis of ten Central and Eastern European countries determined that producer prices, in the Granger sense, cause consumer prices in most observed countries in the panel (Latvia, Lithuania, Romania, Slovakia and Slovenia), with the exception of Hungary, where reverse causality was confirmed, i.e. the influence of consumer on producer prices (Khan et al., 2018).

In addition to the approach that emphasizes the role of cost-push pressures, empirical research also employs the demand-side approach, which proceeds from the assumption that movements in consumer prices determine producer prices. The first authors to question the conventional supply-side approach were Colclough and Lange (1982), who, using the example of the USA for the period January 1945 – December 1979, established that consumer prices cause producer prices. A similar analysis showed that in the period before the outbreak of the global financial crisis (January 2001 – August 2008), inflation in China was mainly driven by demand-side factors, given that changes in consumer prices caused changes in producer prices, with a lag of one to three months (Fan et al., 2009). Such research has also been conducted for Australia and Pakistan, where a relationship from consumer prices to producer prices was also observed (Tiwari, 2012; Shahbaz et al., 2012). Although most studies indicate a one-way relationship between producer and consumer prices, some research demonstrates the existence of a bidirectional causal relationship between these two indices in certain macroeconomic environments (Jones, 1986; Shahbaz et al., 2009; Kwon & Koo, 2009; Ozpolat, 2020). Such findings indicate that in certain periods, consumer prices can influence producer prices and vice versa, highlighting the complexity of the transmission mechanism of inflationary pressures throughout the entire value chain – from production, through processing and distribution, to retail. Although there is no consensus in the economic literature regarding the direction of causality between producer and consumer prices, as it primarily depends on the specific circumstances of the observed countries and periods, the cost-push supply-side approach is nevertheless more frequently represented.

Bearing in mind that price formation takes place throughout the entire production chain – from the stage of raw material procurement, through their processing, to wholesale and retail trade – **changes in input prices represent a key transmission channel through which cost-push pressures are passed on to final product prices**. In this regard, the literature includes

research dealing with the degree of input pass-through to product sales prices, whereby this transmission is not necessarily symmetrical. Meyer & Cramon-Taubadel (2004) showed that increases in input costs often lead more quickly and completely to rises in output prices than cost reductions affect their decrease. This psychological-economic phenomenon is explained in the literature by the concept of **downward nominal price rigidity, which indicates the tendency of prices to adjust faster upwards than downwards** (Rotemberg, 1982). The asymmetric price pass-through results from multiple factors, including market concentration and the degree of competition, unequal bargaining power of participants in the chain, as well as the existence of fixed costs, long-term contracts, and various pricing strategies and policies. Particularly in the final retail stage of the production chain, participants with greater bargaining power relatively quickly incorporate increases in input costs into sales prices, while cost reductions in their operations are transmitted more slowly and incompletely to final consumers. Considering these theoretical mechanisms, the empirical analysis of the degree of price pass-through requires the application of a methodological approach that enables distinguishing the effects of positive and negative cost changes, as well as identifying long-term and short-term effects in price pass-through along the entire chain.

One of the more comprehensive studies dealing with this topic concerns the analysis of asymmetry in the pass-through of crude oil prices to retail petrol prices in the USA, whereby it was empirically determined that petrol prices adjust more quickly and intensely to increases in crude oil prices than to their decreases (Borenstein et al., 1997). **Analyses of asymmetric price pass-through are particularly prevalent in food market research, given the complexity of vertically integrated production chains, as well as the key role of the retail segment in forming final prices**. Examining the dynamics of wholesale and retail prices in the US butter market, Chavas and Mehta (2004) confirmed strong short-term and long-term asymmetry in price pass-through, with imperfect competition in retail being the determining factor. Similarly, asymmetric transmission in the vertical value chain in the USA was also observed for pork prices during the period 1987–1998 (Goodwin & Harper, 2000). Using the example of Greece, Reziti (2005) examined price pass-through for potatoes, tomatoes, oranges and milk across the production, wholesale and retail stages. Empirical results showed that there is strong asymmetry between producer and consumer prices for all observed products, while transmission from producer to wholesale prices is symmetrical, indicating the key role of retail in generating price asymmetries in the vertical chain. Using the examples of Indonesia, South Africa and Turkey, it was shown that there is short-term asymmetry in pass-through between producer and consumer prices, while in Brazil and India symmetrical price adjustment dynamics were determined (Mert, 2023).

3 Price dynamics in Serbia's food product market

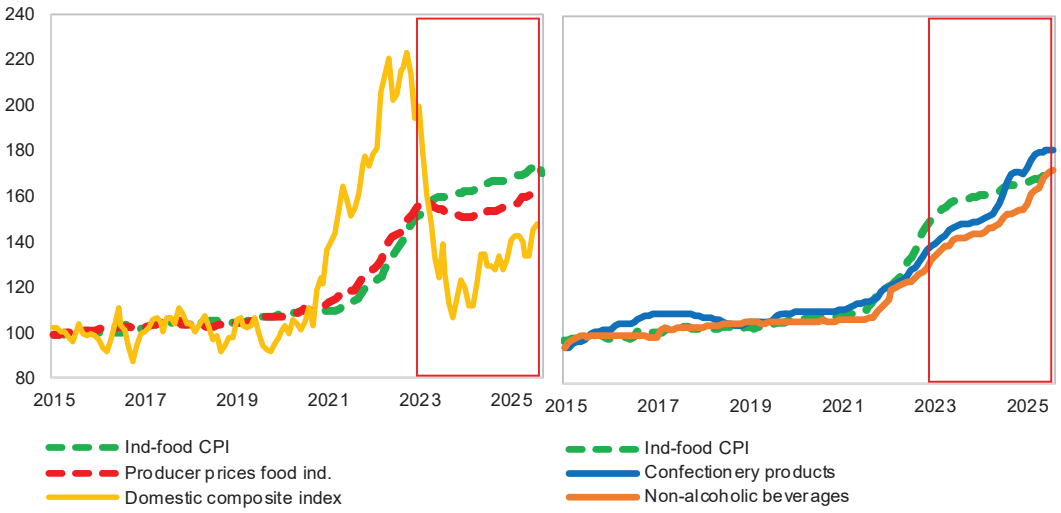
Prices in the domestic industrial-food product chain moved relatively steadily during the period from 2015 to 2020, due to low cost-push pressures in the domestic and international markets. Following the recovery from the pandemic, there was an increase in demand, which, under conditions of disruptions in global supply chains, had an inflationary effect on world prices of primary commodities. The strong rise in world food and energy prices since end-

2021 was transmitted to the domestic market, whereby the stimulus for price increases on the domestic market also came from poorer agricultural seasons at home in two consecutive years (real decline in agricultural production of 2.4% in 2021 and 7.4% in 2022).

In the period from January 2023 to August 2025, cost-push pressures eased compared to the record levels of 2021 and 2022, but remained present (Chart 1), as evidenced by the domestic composite exchange index, which is at a level one-third higher compared to the pre-crisis period of 2015–2020. Food prices, both in production and consumption, still remain above the levels recorded before the pandemic due to the effect of various structural factors, making it difficult to expect their return to pre-pandemic levels. On the supply side, persistent price increases are driven by factors such as climatic conditions, geopolitical tensions, logistical disruptions and labour costs, while on the demand side, the cumulative growth of real wages of approximately 18% in the observed period, which meant greater disposable income for the population.

In the period from January 2023 to August 2025, consumer prices of industrial-food products cumulatively increased by 15.7%, with the price growth in the category of non-alcoholic beverages and confectionery products, which were influenced by higher global prices of coffee and cocoa, being almost twice as fast and amounting to approximately 30%.

Chart 1 **Dynamics of prices in the domestic chain of industrial-food products**
(in index points, 2015 = 100)



Sources: SORS, Novi Sad Commodity Exchange and author's calculation.

4 Research data and methodology

For the purposes of this research, monthly data were used for the period January 2013 – August 2025, up to and including the month preceding the entry into force of the Decree on Special Conditions for Trade in Certain Types of Goods (hereinafter: Decree), which, for a period of six months starting from September 2025, limited trade margins for an initial 23 product categories to a maximum rate of 20%. As dependent variables in the empirical analysis, consumer prices of industrial-food products (*cpi_preh*) were used, as well as

producer prices in the food industry (*ppi_preh*), which data are published by the Statistical Office of the Republic of Serbia. In addition, the analysis used the composite index of primary agricultural commodities (*domaci_kmp*), consisting of the prices of wheat, corn and soybean from the Novi Sad Product Exchange, as well as world cocoa prices (*kakao*), expressed in US dollars per tonne, taken from the FRED database. To capture the impact of international factors on price transmission, the World Bank world energy price index (*eng*), composed primarily of crude oil prices, followed by natural gas and coal prices, was used, as well as the nominal effective exchange rate of the dinar (*neer*), observed in relation to a currency basket (euro and dollar), whereby an increase in the index indicates a strengthening of the dinar. All variables were initially transformed into logarithmic form to reduce heteroscedasticity and enable the interpretation of the estimated parameters as elasticity coefficients.

The following section shows that all observed series are integrated of order *I*(0) or *I*(1), which is why we consider the Autoregressive Distributed Lag (ARDL) model, developed by Pesaran et al. (2001), to be an adequate econometric model for estimating the causal relationships among the observed variables. The original ARDL model was subsequently extended by Shin et al. (2014) with a nonlinear variant (NARDL), through which, in our empirical analysis, we examined the effects of cumulative positive and negative shocks in the independent variables on the dependent variable in the long run, as well as the (a)symmetry of these effects on the dependent variable in terms of the degree and intensity of their transmission. The general form of the model is as follows:

$$y_t = \sum_{j=1}^{p} \phi y_{\tau-1} \sum_{j=0}^{g} \left(\theta_j^+ x_{\tau-j}^+ + \theta_j^- x_{\tau-j}^-\right) + \varepsilon_\tau \quad (1)$$

where:

- y_t – the dependent variable,
- $x_{\tau-j}^+$ – decomposed positive changes of the independent variable,
- $x_{\tau-j}^-$ – decomposed negative changes of the independent variable,
- ε_τ – the stochastic error.

Cumulative positive and negative changes of the independent variable are defined as follows:

$$x_\tau^+ = \sum_{j=0}^{t} \Delta x_j^+ = \sum_{j=0}^{t} max(\Delta x_j, o);\ x_\tau^- = \sum_{j=0}^{t} \Delta x_j^- = \sum_{j=0}^{t} min(\Delta x_j, o) \quad (2)$$

The advantage of this approach is reflected in a more adequate capture of short-run and long-run interactions between variables, whereby the inclusion of their estimated values mitigates the problem of serial correlation of residuals. Additionally, the NARDL model enables simultaneous testing of cointegration in the presence of asymmetry, i.e. examining the long-run equilibrium relationship between variables without the need for all series to be integrated of the same order. In this regard, within the empirical analysis, we conducted the Bounds Test, as well as the Wald test for long-run and short-run asymmetry.

5 Results of the empirical analysis

In the following section, unit root tests – ADF and KPSS – were conducted, and their results are presented in Table 1. For the time series *cpi_preh*, *ppi_preh, domaci_kmp* and *kakao,* the tests agree in indicating that they do not contain a unit root, whereas for the time series *eng* and *neer*, the findings are mixed. Specifically, the ADF test suggests that the aforementioned series contain one unit root, which is eliminated by applying the first difference, while the KPSS test indicates the absence of a unit root, i.e. that the series are stationary in levels. Such findings justify the use of the NARDL model.

Table 1 **Results of unit root tests on the series of observed variables**

Variable	Variable level	ADF (k) test	Unit root	KPSS test	Unit root	Determ. comp.	Order of integration
cpi_preh	cpi_preh_t	–1.48 (3)	yes	0.33	yes	*const.+ trend*	***I*(1)**
	Δcpi_preh_t	**–3.62 (15)**	**no**	**0.09**	**no**		
eng	eng_t	–2.53 (1)	yes	**0.22**	**no**	*const.*	***I*(1) / *I*(0)**
	Δeng_t	**–8.44 (0)**	**no**	-	-		
neer	$neer_t$	–2.15 (12)	yes	**0.21**	**no**	*const.*	***I*(1) / *I*(0)**
	$\Delta neer_t$	**–8.01 (0)**	**no**	-	-		
ppi_preh	ppi_ind_t	–2.27 (6)	yes	0.31	yes	*const.+ trend*	***I*(1)**
	Δppi_ind_t	**–4.66 (1)**	**no**	**0.11**	**no**		
kakao	$kakao_t$	–0.53 (1)	yes	0.55	yes	*const.*	***I*(1)**
	$\Delta kakao_t$	**–9.52 (0)**	**no**	**0.25**	**no**		
domaci_kmp	$domaci\_kmp_t$	–1.74 (1)	yes	0.72	yes	*const.*	***I*(1)**
	$\Delta domaci\_kmp_t$	**–9.67 (0)**	**no**	**0.15**	**no**		

Source: Author's calculation and overview using the statistical package EViews.
Note: A logarithmic transformation was applied to the series. Deterministic components were chosen by applying the Stock-Watson procedure, and critical values at the 5% significance level amount to: –2.88 (for τ_μ) and –3.44 (for τ_t) in ADF test, and 0.46 (for τ_μ) and 0.15 (for τ_t) in KPSS test. Designation *k* in the ADF test relates to the number of correction terms that need to be added in order to eliminate autocorrelation up to a specified lag.

The results of the Granger causality tests, presented in Table 2, show that price movements in the industrial–food chain are primarily driven by changes in input prices in production and sales. Unidirectional causality was established from world energy prices to consumer prices of industrial–food products, as well as from the composite index of agricultural product prices on the domestic commodity exchange to producer prices. Moreover, a bidirectional causality was identified between consumer and producer prices of industrial-food products, **with the influence of producer prices on consumer prices being statistically significant at all conventional significance levels (1%, 5%, and 10%) and stronger than in the opposite direction**. This finding indicates a strong price linkage between the processing and retail stages within the industrial-food chain, where price movements in one segment of the chain precede and influence movements in the other, further justifying the analysis of the price transmission mechanism.

Table 2 **Results of Granger causality tests on the series of observed variables**

Null hypothesis	Probability	Findings
ppi_preh does not cause *cpi_preh* *cpi_preh* does not cause *ppi_preh*	0.0000 0.0153	Bidirectional causality between consumer and producer prices of industrial-food products
eng does not cause *cpi_preh* *cpi_preh* does not cause *eng*	0.0275 0.9625	Unidirectional causality from world energy prices to consumer prices of industrial-food products
neer does not cause *cpi_preh* *cpi_preh* does not cause *neer*	0.3640 0.3985	No causality was established between the variables

Null hypothesis	Probability	Findings
kakao does not cause *ppi_preh* *ppi_preh* does not cause *kakao*	0.0053 0.0086	Bidirectional causality between world cocoa prices and the producer price index of industrial-food products
domaci_kmp does not cause *ppi_preh* *ppi_preh* does not cause *domaci_kmp*	0.0000 0.7959	Unidirectional causality from the composite index of wheat, corn, and soybean prices on the Serbian market to the producer price index of industrial-food products

Source: Author's calculation using the EViews statistical package.

Based on the observed relationships, we consider it justified to model consumer prices of industrial-food products as a function of food producer prices, world energy prices, and the nominal exchange rate, and to model producer prices as a function of world cocoa prices and the domestic composite index of primary agricultural commodity prices. The optimal number of lags was determined based on an auxiliary VAR model, with most information criteria agreeing that including two lags in the model is sufficient. Based on the conducted tests, the appropriate NARDL models were specified. The established Granger causality indicates short-term interaction between prices in the industrial-food chain but does not imply the existence of a long-term relationship, which was further examined using the F-bounds test. The focus on the long-term impact is emphasized because the transmission of price shocks along the industrial–food chain typically occurs gradually. According to Kozłowska & Awantang (2023), food product markets often cannot fully adjust to shocks in input prices in the short term, because the pass-through of world prices to domestic prices is conditioned by the level of infrastructure development, the exchange rate regime and trade policy, the adequacy of commodity reserves, and other factors.

Building on the presented theoretical framework and comparable empirical literature, we examined the extent and dynamics of input price pass-through to output prices along the industrial-food chain in Serbia. In this regard, the null and alternative hypotheses were formulated (Table 3) to test whether the effects of increases and decreases in commodity exchange prices on producer prices (at the processing stage) and of producer prices on consumer food prices (at the retail stage) are of equal magnitude, with the rejection of the null hypothesis at any stage implying the presence of asymmetry in the transmission of price shocks.

Table 3 **Research hypotheses**

Industrial-food chain	Null hypothesis	Alternative hypothesis
Processing stage	$\beta^{+}_{domaci\_kmp^{+}} = \beta^{-}_{domaci\_kmp^{-}}$	$\beta^{+}_{domaci\_kmp^{+}} \neq \beta^{-}_{domaci\_kmp^{-}}$
Retail stage	$\beta^{+}_{ppi\_preh^{+}} = \beta^{-}_{ppi\_preh^{-}}$	$\beta^{+}_{ppi\_preh^{+}} \neq \beta^{-}_{ppi\_preh^{-}}$

Source: Author's overview using the EViews statistical package.

5.1 Analysis of the extent and dynamics of input price pass-through to output prices in the processing stage of the industrial-food chain

In the ***processing stage***, we examined the impact of the composite index of wheat, corn, and soybean prices, derived from data from the Commodity Exchange in Novi Sad, on producer prices in the food industry in the long run. The composite index was used as an indicator of cost-push pressures in the production of the majority of food categories on the domestic market, while the world cocoa price index was additionally included in the analysis to capture its effect on confectionery prices, which have recorded prolonged high growth on the domestic market. In this context, we estimated the following NARDL specification:

$$\Delta lnppi\_preh_{\tau} = \beta_0 + \sum_{j=1}^{p-1} \lambda_j \Delta lnppi\_preh_{t-i} + \sum_{i=0}^{q} \delta_i^{+} \Delta \ln domaci\_kmp\_pos_{t-i} + \sum_{i=0}^{q} \delta_i^{-} \Delta \ln domaci\_kmp\_neg_{t-i} + \sum_{i=0}^{q} \gamma_i \Delta \ln kakao_{\tau-i} + \rho lnppi\_preh_{\tau-1} + \Phi^{+} \ln domaci\_kmp\_pos_{t-1} + \Phi^{-} \ln domaci\_kmp\_neg_{t-1} + \theta_1 \ln kakao_{\tau-1} + \varepsilon_t \quad (3)$$

Where:

- β_0 – the constant in the model,
- λ_j – short-term coefficient of the model's autoregressive component,
- δ_i^{+} and δ_i^{-} – short-term coefficients for the partial sums of positive and negative changes in the composite index of primary agricultural product prices, respectively,
- γ_i – short-term coefficient for world cocoa prices,
- ρ – long-term coefficient of the model's autoregressive component,
- Φ^{+} and Φ^{-} – coefficients for the long-term effects of positive and negative cumulative shocks in the composite index of primary agricultural commodity prices, respectively,
- θ_1 – long-term coefficient for world cocoa prices.

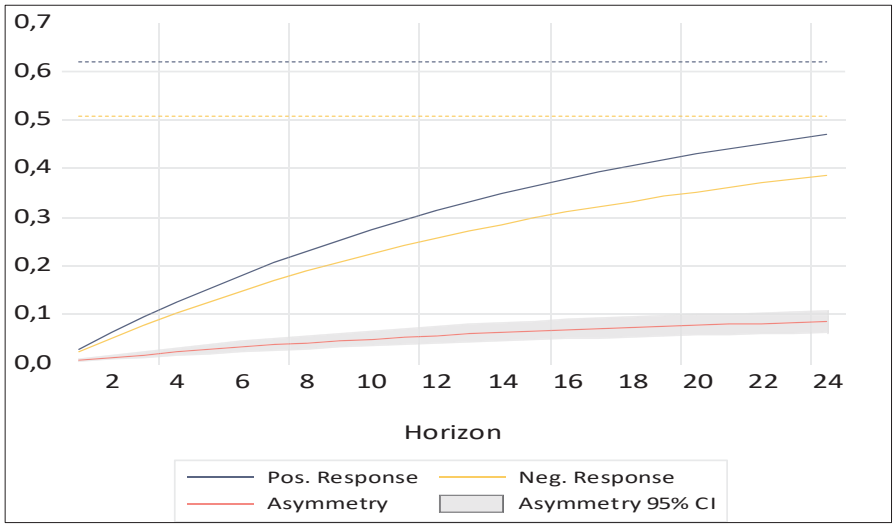
Table 4 **Long-term effects of input price changes on output prices in the processing stage**

Variables	Results of the estimated equation
Dependent variable: *ppi_preh$_t$*	
***domaci_kmp$_t$* (cumulative positive effects)**	**0.6202** ***
***domaci_kmp$_t$* (cumulative negative effects)**	**0.5082** ***
kakao$_t$	**0.0677** * **
c	4.3664 ***
F-Bounds test statistics	15.7893 ***
Adjustment speed coefficient *ECT$_{t-1}$*	–0.0474 ***
Analysis period	January 2013 – August 2025
*** Statistically significant at the 1% significance level ** Statistically significant at the 5% significance level * Statistically significant at the 10% significance level	

Source: Author's calculation using the EViews statistical package.
Notes: All analysed variables were previously logarithmically transformed. The estimated coefficients were obtained from the cointegration equation.

The results of the estimated NARDL model, presented in Table 4, indicate the existence of a statistically significant long-term relationship between, on the one hand, domestic prices of primary agricultural commodities and world cocoa prices, and on the other, producer prices in Serbia's food industry. The cumulative coefficient for positive changes in the composite index of domestic commodity exchange prices is statistically significant at all significance levels and is larger than the corresponding coefficient for negative changes, confirming a stronger pass-through of input price increases in the food processing stage compared to their decreases. Specifically, **a 1% increase in the exchange prices of wheat, corn, and soybean is associated with an approximately 0.62% rise in producer prices, while the effect of their decrease is slightly weaker, amounting to 0.51%**.

Chart 2 **Asymmetry of the cumulative effect of shocks in exchange prices on food producer prices in Serbia**



Source: Author's calculation using the EViews.

The same conclusion is supported by the Wald test result, which rejects the null hypothesis of equality of long-term coefficients and confirms the presence of long-term asymmetry in the pass-through of exchange prices to food producer prices in the processing stage. The curve of asymmetry between positive and negative price shocks is positive and increasing (Graph 2), and the 95% confidence interval does not include the abscissa over a 24-month horizon, indicating that the observed long-term asymmetry is statistically significant. Given that the estimated parameters for the domestic composite index are less than one, the transmission of price changes is incomplete, meaning that a portion of these changes, both positive and negative, is absorbed in producers' profits. World cocoa prices also show a statistically significant positive effect on producer prices of 0.07%. The intensity of this effect is considerably weaker, which is expected given the narrower production use of cocoa compared to staple cereals.

The statistics F-bounds test value (15.79) significantly exceeds the upper critical value at all significance levels, confirming the existence of a stable long-term equilibrium relationship among the observed variables. At the same time, the estimated adjustment speed coefficient ECT_{t-1} has a negative sign, which means that the system returns to long-term equilibrium after a short-term deviation caused by a shock (Sendhil et al., 2013, Olipra, 2020). The obtained value of –0.05 indicates that approximately 5% of the deviation of the dependent variable from the long-term equilibrium is corrected each month. This means that after a price shock in one month, the effects of that shock spill over into the processing phase for almost the next two years. This is influenced by the existing rigidities in the setting and adjustment of prices by retailers, long-term contractual relationships within the production chain, frequent price shocks that prevent a faster return to long-term equilibrium, as well as the specific characteristics of the domestic food market. The estimated model is stable and correctly specified, as it satisfies the basic statistical assumptions of no autocorrelation, homoscedasticity, and normally distributed residuals (Table 5). Overall, the **results suggest that producer prices in the food industry are strongly influenced in the long run by movements in the prices of primary agricultural products, with this price transmission**

being incomplete and asymmetric, and more pronounced in the case of cost increases than in the case of their decline.

Table 5 **Results of conducted statistical tests**

Assumptions	Test	p-value
Normality	Jarque-Bera	0.0145
Autocorrelation	Breusch-Godfrey	0.1523
Heteroscedasticity	Glejser	0.1950
Model specification	Ramsey RESET	well specified
Model stability	CUSUM	stable

Source: Author's calculation using the EViews.

5.2 Analysis of the degree and dynamics of input price pass-through to output prices in the retail phase of the industrial-food chain

In the retail phase of the industrial-food chain, we examined the impact of producer prices on consumer prices of industrial-food products in the long run. As an indicator of cost-push pressures from the global market, the World Bank's index of world energy prices was used. Since most world prices of primary commodities are expressed in dollars, the model also includes the nominal effective exchange rate of the dinar against a currency basket consisting of the euro and the dollar. In this context, we estimated the following NARDL specification:

$$\Delta lncpi\_preh_{\tau} = \beta_0 + \sum_{j=1}^{p-1} \lambda_j \Delta lncpi\_preh_{t-i} + \sum_{i=0}^{q} \delta_i^{+} \Delta \ln ppi\_preh\_pos_{t-i} + \sum_{i=0}^{q} \delta_i^{-} \Delta \ln ppi\_preh\_neg_{t-i} + \sum_{i=0}^{q} \gamma_i^{1} \Delta \ln eng_{\tau-i} + \sum_{i=0}^{q} \gamma_i^{2} \Delta \ln neer_{\tau-i} + \rho lnppi\_preh_{\tau-1} + \Phi^{+} \ln ppi\_preh\_pos_{t-1} + \Phi^{-} \ln ppi\_preh\_neg_{t-1} + \theta_1 \ln eng_{\tau-1} + \theta_2 \ln neer_{\tau-1} + \varepsilon_t \quad (4)$$

Where:

- β_0 – the constant in the model,
- λ_j – short-term coefficient with the model's autoregressive component,
- δ_i^{+} and δ_i^{-} – short-term coefficients for the partial sums of positive and negative changes in the producer price index of industrial food products, respectively,
- γ_i^1 – short-term coefficient for world energy prices,
- γ_i^2 – short-term coefficient for the nominal effective exchange rate,
- ρ – coefficient of the model's autoregressive component in the long run,
- Φ^{+} and Φ^{-} – coefficients of the long-term effects of positive and negative cumulative shocks in producer prices of industrial food products, respectively,
- θ_1 – coefficient for world energy prices in the long run, and
- θ_2 – coefficient for the nominal effective exchange rate in the long run.

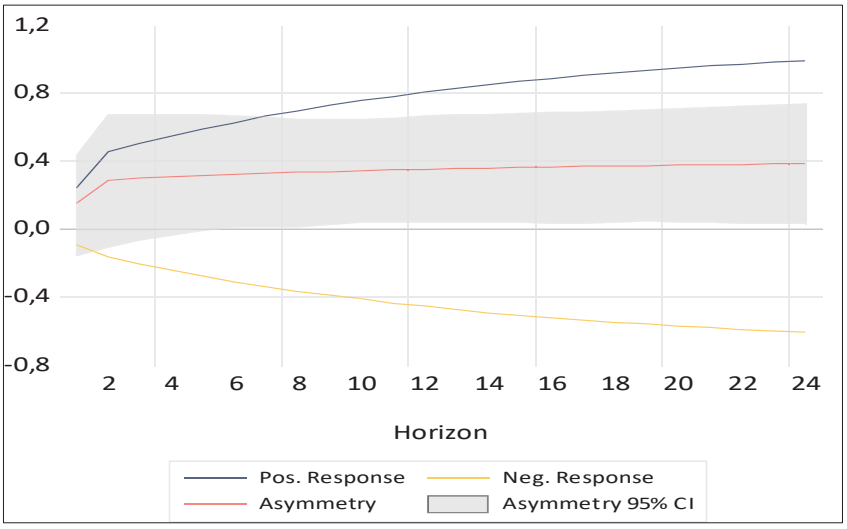
Table 6 **Effects of changes in input prices on output prices in the retail phase in the long run**

Variables	Results of the estimated equation
Dependant variable: *cpi_preh*$_t$	
***ppi_preh*$_t$ (cumulative positive effects)**	**1.1163** ***
***ppi_preh*$_t$ (cumulative negative effects)**	**0.7081** * **
***eng*$_t$**	**0.0877** ***
***neer*$_t$**	**–0.6212** ***
c	7.0387 ***
F-Bounds test statistics	13.2844 ***
Adjustment speed coefficient ECT$_{t-1}$	–0.0732 ***
Analysis period	January 2013 – August 2025
*** Statistically significant at the 1% significance level ** Statistically significant at the 5% significance level * Statistically significant at the 10% significance level	

Source: Author's calculation using the EViews statistical package.
Note: All the analysed variables were previously log-transformed. The estimated coefficients were obtained from the cointegration equation.

Even in this phase of the industrial-food chain, a positive and statistically significant long-term relationship between producer and consumer prices was established, with the parameters presented in Table 6. Specifically, the cumulative effect of positive changes in producer prices (1.11%) is noticeably larger than the cumulative effect of negative price changes (0.71%), with the Wald test confirming the presence of pronounced asymmetry in the pass-through of input prices to output prices. The asymmetry curve in price transmission is statistically significant in the long run, with the transmission of positive cost shocks being considerably stronger and faster compared to negative shocks (Chart 3).

Chart 3 **Asymmetry of the cumulative effects of shocks in producer prices on food consumer prices in Serbia**



Source: Author's calculation using the EViews.

Thus, **the increase in producer prices of industrial-food products has a greater impact on the rise of retail prices than their decline has on price reductions.** Moreover, **the degree of pass-through of food producer prices to consumer prices is complete in the case of higher producer prices, and incomplete in the case of their decline**. These findings are consistent with economic theory and are most often interpreted in the literature as the economic-psychological phenomenon of downward nominal price rigidity. The impact of the nominal effective exchange rate on food consumer prices is also statistically significant and of

the expected sign, in the sense that a depreciation of the domestic currency against the currency basket leads to an increase in consumer prices of industrial food products, while an appreciation has the opposite effect. Given the relative stability of the dinar against the euro over the past eight years, it can be concluded that its movements are largely determined by the dynamics of the euro–dollar exchange rate. Moreover, higher energy prices in the previous month are reflected in the increase of retail prices in the current month, mainly through higher transportation and logistics costs.

The statistics F-bounds test value (13.28) significantly exceeds the upper critical value at all significance levels, confirming the existence of a stable long-term equilibrium relationship among the observed variables. Negative and statistically significant adjustment speed coefficient ECT_{t-1} of –0.07 suggests that around 7% of the deviation of the dependent variable from the long-term equilibrium is corrected each month. These estimates suggest that the effects of price shocks are transmitted slowly through the retail phase as well, over a horizon of approximately 14 months. In practice, the effects of price shocks are gradually transmitted from the production to the retail segment as well, due to constraints in short-term price adjustments, contractual relationships with suppliers, consumer market habits, retail business models, and so on. **Overall, the increase in food producer prices strongly affects food inflation in Serbia, while a decrease in production prices leads to only a partial reduction in consumer food prices**, which can be linked to market concentration in retail, that is, to the degree of market competition and the bargaining power of participants in the production chain. The results of the conducted tests show that the residuals are normally distributed, not autocorrelated, and that their variances are homoscedastic (Table 7).

Table 7 **Results of conducted statistical tests**

Assumptions	Test	p-value
Normality	Jarque-Bera	0.8279
Autocorrelation	Breusch-Godfrey	0.0855
Heteroscedasticity	Glejser	0.4208
Model specification	Ramsey RESET	well specified
Model stability	CUSUM and CUSUM Sq.	stable

Source: Author's calculation using the EViews.

5.3 Comparison of the degree and dynamics of input price pass-through to output prices in the processing and retail phases of the industrial-food chain

The empirical analysis showed that there is asymmetry in price transmission both in the processing phase and in the final phase of the food supply chain, i.e. the effect of rising input costs on output prices is more pronounced than the effect of their decline (Chart 4). In the case of the domestic market, it is observed that price transmission asymmetry is more pronounced in the retail phase than in the processing phase, and that transmission is not complete in the processing phase. In other words, as we move closer to the final consumer, increases in input costs are increasingly and more fully reflected in higher final food prices, while their decline is reflected much more slowly and to a lesser extent in food price reductions. This phenomenon is often referred to in the economic literature as the "rockets and feathers effect," meaning that price increases are often compared to the speed of a rocket, while price decreases move at the speed of a feather (Tappata, 2009). Asymmetric price adjustment is often explained by the existence of information asymmetry, that is, the

incomplete awareness of consumers about relevant market prices and production costs, which allows companies at all stages of the production chain to transmit increases in input costs more quickly and fully than their reductions. According to Peltzman (2000), this market distortion is present in both concentrated and atomized markets, which means that the level of competition is not a decisive factor for price asymmetry. In terms of overall inflation dynamics, negative price shocks, such as a sharp decline in world prices of primary commodities and producer prices, are not reflected to the same extent in the reduction of consumer prices, which contributes to the persistence of inflationary pressures, even when the effects of exogenous shocks fade.

As previously shown, the degree of input price pass-through to output prices differs between the processing and retail phases (Chart 4). Specifically, **in the processing phase, an increase in exchange prices of primary agricultural commodities is not fully passed through to higher producer prices of industrial food products (0.6%), whereas in the final phase of the food supply chain, the increase in producer prices, which represent input costs for retailers, is fully passed through to higher consumer prices (1.1%)**. Moreover, a coefficient of elasticity above one indicates not only full but also amplified transmission, which may be a consequence of the way trade margins are formed, as these have significantly increased in recent years alongside rising inflationary pressures. This finding confirms that in the industrial-food chain there is limited price flexibility and an unequal market position between food producers and retailers. Overall, along the value chain, the intensity of transmission increases as we approach the final consumer: while the processing sector acts as a "buffer" for a part of the price shocks, the retail segment incorporates them to a greater extent and more quickly into final prices.

6 Conclusion

Our research focused on analysing price pass-through in the industrial-food chain in Serbia, with a particular emphasis on asymmetry in this process. The importance of the analysis stems from the fact that the prices of industrial-food products we purchase daily have a significant share in the overall inflation structure, as well as a direct impact on household living standards. In this paper, using the NARDL model, we examined the effects of changes in the composite index of primary agricultural commodity prices on producer prices in the food industry, and subsequently the impact of producer prices on consumer prices of industrial-food products, with an emphasis on long-term effects. The main objective was to assess the strength of the channels and the dynamics of price shock transmission, as well as to estimate the degree of asymmetry in different phases of the chain.

The research confirmed the existence of a two-way relationship between producer and consumer prices in Serbia's food sector, with the impact of producer prices on consumer prices being complete and of greater intensity. This finding is consistent with the theoretical supply-side approach to inflation and the concept of cost-push inflation, according to which an increase in input prices generates pressure for higher output prices. The results obtained indicate the existence of asymmetric transmission of exchange prices of primary agricultural commodities to producer prices in the food industry, whereby increases in these prices lead to

a stronger rise in producer prices than equivalent decreases lead to a reduction in producer prices. The asymmetry is even more pronounced in the retail phase, where transmission occurs from producer to consumer prices: increases in producer prices are more strongly reflected in the rise of consumer prices of industrial-food products than their decreases are in lowering consumer prices. From this, it can be concluded that retailers possess greater market and bargaining power compared to other participants in the industrial-food supply chain. Additionally, it is observed that increases in world energy prices, as well as depreciation of the domestic currency, have a statistically significant impact on the rise of consumer prices of food products in Serbia. At the level of the entire industrial food chain, a stable long-term equilibrium relationship between the observed variables was confirmed, which means that price shocks, although of different intensities, are gradually integrated into the long-term dynamics of food prices in production and consumption. Future research could focus on a disaggregated analysis by product groups or individual products.

Based on the findings of the conducted empirical analysis, it is possible to propose specific measures for economic policymakers, aimed at improving the living standards of the population and creating a more competitive business environment in the food sector. In this regard, it is necessary to strengthen the institutional and regulatory framework to prevent excessive market power of individual participants, especially in the retail segment, which would help mitigate the observed price asymmetries and provide more effective consumer protection. Moreover, systematic and continuous monitoring of the price formation process, together with closer cooperation between policymakers and relevant market participants, would enable more accurate tracking of inflationary pressures, timely responses to market disruptions, and stabilisation of consumers' inflation expectations. Furthermore, additional promotion of competition in the food sector and the entry of new market participants could lead to a self-regulating limitation of profits, increased efficiency, and greater symmetry in price transmission along the entire production chain.

Overall, the results of this research contribute to a better understanding of the price pass-through mechanism in Serbia's food sector and, as such, provide a useful basis for designing economic policy measures that would help stabilise food prices and overall inflation, as well as preserve the living standards of the population.

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