EU Food price inflation amid global market turbulences

Kornher, L., Balezentis, T., Santeramo, F.G.

University of Bonn, Germany

Lithuanian Centre for Social Sciences, Lithuania

University of Foggia and European University Institute

Abstract:

Global food markets are in turmoil with agricultural input and energy prices doubling between 2020 and 2022, and driving food price inflation with immediate consequences on food accessibility. We examine the causes of the recent EU food inflation patterns, focusing on domestic vis-à-vis international components, and on the role of transaction costs. Using cross country and cross sectoral panel regressions, we show that the EU food price inflation has been mainly driven by changes in the costs of agricultural production and, to a lesser extent, by global food price dynamics. Furthermore, trade openness has not excarbated the inflating dynamics.

Keywords: Europe, food price dynamic, international food crisis, trade policy uncertainty

JEL codes: E31, Q11, Q18

Introduction

Global food markets are currently in turmoil with agricultural input and energy prices doubling between 2020 and 2022. These price increases drove up the food prices already before the Ukraine-war with immediate consequences on access and availability of food (Santeramo and Dominguez, 2021; Kornher and von Braun; 2023). Global food market uncertainties caused by shortages in global grain and oilseed markets, as a direct result of the Ukraine-war, international trade restrictions during the post-Covid period (Ahn and Steinbach, 2022; Brander et al., 2023; Consoli et al. 2023), and the sanctions imposed on Russia and Belarus in several sectors have amplified global food system disruptions (Glauber and Laborde, 2022).

The market disruptions have unfolded the vulnerability of the European Union (EU) agro-food system (Wieck et al., 2021) and led to unprecedented phenomena of food price inflation in Europe and in the rest of the world, with wide economic implications (Rose et al. 2023) and increasing food insecurity risks (Menyhert, 2022; Rabbi et al. 2023). Following the Versailles Declaration by EU leaders in March 2022, the European Commission adopted short-term measures to encourage increased agricultural production by relaxing the ecological conditions and financially supporting farmers. In addition to that, the declaration called for a reinforced strategty to establish autonomy in food, feed, and fertilizers (Matthews, 2023).

This study seeks to understand the dominant factors for increased food price inflation in the EU to comment on the suitability of the existing policy responses and to make appropriate proposal for limiting EU food price inflation. The extant research on EU food price dynamics has mostly focussed on variation in margins and prices due to vertical integration and spatial within EU integration(Ferrucci et al. 2012; Santeramo, 2015; Rezitis et al., 2019), with little attention devoted to the role that the international and external drivers have played on the dynamics of food inflation in the EU (Peersman, 2022). The raising importance of local and international trade networks has increased the complexity of trade relationships. Several studies attempted to ascertain the extent to which prices are transmitted from international to domestic markets and which role is played by country-specific and ‘international’ determinants, as well as by trade flows (Stephens et al., 2012; Badequano and Liefert, 2014; García-Germán et al. 2014, Bekkers et al. 2017; Kornher et al., 2017).

García-Germán et al. (2014) reported a long-run relationship between world agricultural commodity and food prices in the EU for the majority of member states, which was lower in eurozone member states. Irz et al. (2013) looked into determinants of food prices in Finland over 1995-2010. The co-integration analysis, including the seasonal components, showed that the prices of agricultural commodities and labor force in the retail sector appeared as significant determinants of the dynamics in the food prices. Energy price inflation did not show a significant effect in this regard. Bekkers et al. (2017) tested the pass-through of the international food prices onto the domestic food prices by using first difference panel model. The authors argue that applying the vector error correction model was not necessary, due to the lack of cointegration evidence for most of the countries worldwide (their study covered 147 countries and years 2000-2012). The study did not find a significant deviation of the EU pass-through rates from the conditional average. On the contrary, Peersmann (2022) found that about 30% euro-area inflation volatility was explained by shifts in international food prices signifying the EU’s deep integration in global food markets. Indeed, the current food price spike may also differ from earlier periods of international price spikes when EU food and input prices did not move along international food prices (Figure A1).

Only a few studies concentrated on periods of extraordinary market behavior as came into play through the disruptive events 2020-2022, i.e. Covid pandemic and Ukraine war. Headey and Fan

(2008) describe the order of events and multiple factors during the 2008 food crisis. Durevall et al. (2013) examined food inflation patterns in Ethiopia during the 2008-2011 period and showed that both agricultural factors, such as seasonality and supply shocks, and macroeconomic factors explained short-and long-run price dynamics in Ethiopia. Kirikkaleli and Darbaz (2022) discussed the factors of the food prices and empirically addressed the case of the US. They argued that policy uncertainty (including trade uncertainty), exchange rate, and energy prices are the key factors to be considered when explaining variability of the food prices. Up today, there is still limited evidence on the causes the recent food price spikes. Akter (2020) for the EU and Dietrich et al. (2021) for low and middle income countries showed that food price levels were positive related with the stringency of Covid containment policy and movement restrictions. Akter (2020) finds the most significant surges in EU prices for perishable products like meat, fish & seafood, and vegetables. Algeri et al. (2023) decomposed the different factors that drove recent international price movements and found that both value chain disruptions and higher agricultural input prices as well as macroeconomic factors, such as expansive fiscal and monetary policy during the world-wide Covid recovery period and exchange depreciations against the US dollar, contributed the soaring food prices. For the US, Adjemian et al. (2023) also attributed food price changes mostly to supply-side factors and money supply. However, these studies do not explicitly analyze changes and patterns of food price dynamics due to the global market turbulences from Covid and the Ukraine war.

Understanding the drivers of recent European food price inflation and identifying policy options for stabilizing food prices is essential to improve food security and well-being. Not all countries in food sectors are equally suffering from food price inflation, and in fact distinct variation of this phenomenon can be observed across European countries. For instance, a country’s sector-specific trade status may determine the interconnectedness of domestic and international food price dynamics. Moreover, agricultural input costs and energy prices have different relevance across agri-food sectors. Examining these differences is relevant to suggest potential policy responses.

We analyse European food inflation dynamics using a quarterly food sector and country panel from 2007-2022. As identification strategy, we use variation across time, space, and sectors regarding the level of markets interconnectedness as well as the country-level policy stimuli responses. We use a dynamic panel estimator and the Arellano-Bond estimator for short panels, with GMM-type instrumentation, to account for dynamics, and endogeneity bias. We operationalize our identification strategy by interacting the variables representing the external risk and uncertainty factors with the country and sector specific level of integration. Besides providing insights on the role of the geopolitical and trade uncertainties on food inflation dynamics, our contribution is at least threefold: first, this research stands out as one of the first studies examining post-2020 food inflation patterns in Europe, with a focus on the effects of risk and uncertainties related to international trade on food price patterns; second, we quantify the contribution of international and external drivers of the current food price spike; third, we link the findings to specific EU policies that could limit food price inflation.

Next section presents the analytical framework and draws hypotheses guiding this work. Section three and four introduce the data, describe the econometric approach and present the results. The last section is devoted to a discussion of the findings and to policy reflections.

Conceptual framework

We use a simple price model to illustrate the relevance of the domestic and international components in explaining EU food price inflation. The (domestic) price aggregate indices of a group of goods k, for instance cereals, p_k^D , is function of the price of non-traded goods, p_k^D , and traded goods, p_k^w , proxying the free-on-board (FOB) price at the export destination.

Following the Law of One Price (LOP), which postulates that prices of tradeable goods in spatially separated markets are divided by the trade costs to move the good from the cheaper to the expensive market, we replace the price for imported (traded) goods, with the international price, p_k^W , (equal to the export price) plus the transaction costs, τ_k (Fackler and Goodwin, 2011; Lence et al., 2018).[1] In reality, no country is an importing (exporting) country for all traded consumer goods in the group of goods k and all their inputs, i.e. even if a country is an exporting country for all cereals it may import seeds, fertilizer, or pesticides. This leads to the following equation[2]:

$$(1) \qquad p_k^D = (1-\lambda_k)D^{-1}(Q_k) + \lambda_k p^W{}_k + \lambda_k \tau_k$$

where λ_k is the share of the international component: the share of traded goods in all goods of group *k*, i.e. the value of trade over the total gross output of group *k*; p_k^W is the international price for goods *k* in *t* with τ_k being the transaction cost of trading.

The consumer price index of *k*, p_k^D , consists of the domestic component, the international component, and the trade cost component, whereas the respective relevance of these components depends upon the trade share of goods in k. We postulate that all components in equation (3) are

---

[1] This leads to $p_k^D = (1-\lambda_k)p_k^D + \lambda_k(p_k^W + \tau_k)$ for an importing country. For exporting countries, the international component is only represented by the international price p_k^W , which leads to: $p_k^D = (1-\lambda_k)p_k^D + \lambda_k p_k^W$.

[2] We replace the price for non-tradeables, p_k^D , by the inverse demand function $D^{-1}(Q_k)$ for non-traded goods in group *k*.

time-invariant, including the share of the international component; henceforth trade openness. Trade openness exhibits both time-invariant and time-variant features. On the one hand, the preferences for domestic vis-à-vis international products (i.e. the Armington elasticities) tend to be time-invariant. On the other hand, trade openness varies with the relative domestic price (vis-à-vis international price) and decreases (increases) if the relative domestic price goes up (declines); also as result of substitution towards the cheaper good.

Moreover, for each specific sector *k* (say cereals or vegetables), the price is likely influenced by the overall consumer price index of country *i*. To isolate the sector-specific effects, we divide (1) by the overall price index. This transformation allows us to ignore exchange rate fluctuations (in that the exchange rates appear in the nominator and the denominator, and therefore cancel out) and other macroeconomic factors such monetary policy issues, which are less relevant in the EU with the majority of countries using the same currency. Furthermore, it removes the time trend and thus reduces the risk of spurious regression.

The final econometric model describes the price index of goods *k* in country *i* at time *t*:

$$(2)\quad \begin{aligned} rp_{kit}^{D} &= \alpha + \beta_1 (c - dQ_{kit})_r + \beta_2 (c - dQ_{kit})_r \times \lambda_{kit} + \beta_3 \lambda_{kit} + \beta_4 rp^{W}{}_{kt} + \beta_5 \tau_{kit} \\ &\quad + \beta_6 rp^{W}{}_{kt} \times \lambda_{kit} + \beta_7 \tau_{kit} \times \lambda_{kit} + \varepsilon_{kit} \end{aligned}$$

where the real food price of good *k* in country *i* and time *t*, rp_{kit}^{D}, is explained by the inverse demand function of the real price, $(c - dQ_{kit})_r$, the real international price of *k* international price index, $rp^{W}{}_{kt}$, trade openness of county *i* in *k*, λ_{kit}, international transaction costs, and the interaction of all these variables with trade openness.

With respect to our stated research objectives, we focus on two main variables in equation (2): (1) transaction costs and (2) trade openness. While international food prices always influence domestic food prices, albeit at varying extent, global market turbulences, through the Covid-19 pandemic and the Ukraine-war, increase transaction costs and subsequently domestic food prices. Hence, the first hypothesis to be tested is if variables associated with global market turbulences have increased real food price inflation controlling for international food prices.

H1: *Real food price inflation increase with international market risks and uncertainties.*

Equation (2) shows the relevance and dominant role trade openness in explaining real food price dynamics. Intuitively, the model describes that the relevance of the international and transaction cost (domestic) component, increases (decreases) in trade openness. In other words, the larger the share of the traded goods in k is, the more important are international food price and transaction cost movements for real food price inflation. Conversely, the lower the share of the traded goods in k is, the more important are domestic factors for real food price inflation.

H2: *The importance of the international/domestic components [in explaining food price inflation] depends on the trade openness of a country and sector*.

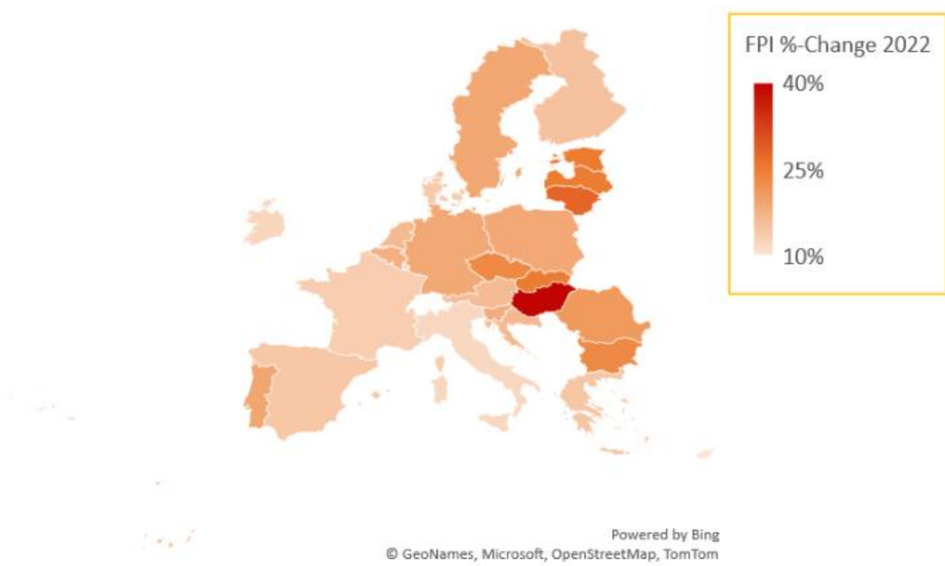
It has been argued that more integrated markets are more vulnerable to international food price shocks and show higher levels of international price transmission (Flachsbarth and Garrido 2014; Kornher et al., 2017). This is because in more integrated markets a larger share of the market is determined by non-internal factors. However, this has been hardly empirically tested, and therefore, we are also interested to understand if trade openness of EU countries has exacerbated the effect of global market turbulences on real food price inflation.

H3: *The larger trade openness, the larger will be the effect of the global market turbulences price shock.*

Methods and data

We combine and use several data sets to describe the domestic, international, and trade cost component that determines real food price inflation in the EU. The dataset includes all 27 EU countries, (with varying duration related to data availability and the duration of the countries' membership) and seven individual food sectors – namely, cereals and bread, fruits, vegetable, sugar, dairy, meat, oils, and fats. We consider the period 2007-2022 using quarterly data: the panel dataset consists of 189 groups (N) and 63 time periods (T). Figure 1 shows the annual nominal food price inflation in 2023, highlighting marked differences across Member States.

Figure 1: %-change in FPI across EU countries (Jan 2022-Jan 2023)



Source: Own illustration based on Eurostat (2023).

Econometric approach

Since commodity prices tend to be characterized by a high degree of autocorrelation, we include lags of the dependent variable in the model. The inclusion of a lagged dependent variable, however, creates a potential endogeneity because the lagged dependent variable may induce correlation among the regressors and the error term (i.e. the independent variables can become predetermined, correlated with the lagged error term, or strictly endogenous). System and difference generalized methods of moments (GMM) estimator, such as the Arellano Bond estimator, can resolve the potential endogeneity issues by instrumenting endogenous variables by their lagged values, their first difference or orthogonal deviations and all strictly exogenous regressors. The Arellano-Bond system GMM estimator is more efficient, as compared to other GMM estimators, in that all periods are utilized and more instruments are available (Rodman, 2009). Including the lagged dependent variable, the estimated quarterly (t) model becomes as follows:

$$\begin{aligned} rfpi_{kit} &= \alpha + \delta rfpi_{kit-1} + \beta_1 rIPI_{it} + \beta_2 rIPI_{it} \times Openness_{kit} + \beta_3 GDP_{it} + \beta_4 Openness_{ijt} \\ &+ \beta_5 rpW_{kt} + \beta_6 \tau_t + \beta_7 rpW_{kt} \times Openness_{ijt} + \beta_8 \tau_t \times Openness_{ijt} + \gamma X' + \mu_{ij} + \varepsilon_{ijt} \end{aligned} \quad (3)$$

Here, we construct the real food price in sector *k* and country i, rp^D_{kit} , as as the food price index divided by the overall consumer price index (CPI), $rIPI_{it}$ is the real agricultural input price index (IPI) in country *i* (IPI devided by CPI) , $Openness_{kit}$ is the share of total trade in sector *k* and country *i* over the gross value added of production of country *i* in the corresponding year, GDP_{it} is the quarterly GDP of country *i*, and rpW_{kt} is the sector-specific real international price index constructed from sector-specific international price indices divided by the global price index of all commodities (GPI). Last but not least, $\gamma X'$ stands for the further control variables, such as the real energy price index of country *i*, the real international energy price index, and the average stringency of Covid-19 policies, with the latter being zero before 2020. In addition, we include the agricultural stress index (ASI) and the deviation of the ASI from its long-term country- and month-specific average. Finally, μ_{ij} and ε_{ijt} are, respectively, the fixed effects and the i.i.d. error term.

Data sources and variable construction

First of all, we use quarterly food price index data from Eurostat for all foods, bread and cereals, meat and products, fish and products, dairy products, vegetables, fruits, and oils and fat, as well as an on the general consumer price index (CPI) and the energy component. The IPI captures "the index of purchase prices of the means of agricultural production" in each country and is provided by Eurostat. This covers costs for fertilizers, pesticides, feed, seed, energy and lubricants, maintenance, and repairs. The IPI covers sector-level food production effects, while the GDP, also from Eurostat, covers country-level macroeconomic demand shifts. Trade openness is extracted from the FAOSTAT of the Food and Agriculture Organization (FAO).[3] To control for the possibility that trade openness primarily reflects within EU trade, we also construct the extra-EU trade openness as the share of total extra-EU trade in sector k and country i. We control also for seasonality and vegetation index variables. The sector-specific international food price indices are taken from the World Bank Pinksheet, energy, oils, and cereals, as well as the FAO, meat, dairy, and sugar. For fruits and vegetables, we use the World Bank's index of other foods. The GPI is the equivalent of a country's CPI and is obtained from the Federal Reserve Bank of St. Louis (IMF 2023b). The monthly ASI represents the area of cropland affected by severe drought. We use the country-level aggregation generated by FAO's Global Information and Early Warning System

[3] We interpolate the 2021 data to also include 2022.

(GIEWS) (FAO 2023). We predominantly use the first season's data and replace it with the second season's only if the respective month is not available.[4]

The main variables of interest are those capturing the distortions, market risks, and transaction costs due to the Ukraine war. We use three variables for this. Firstly, a simple dummy variable for the war period starting in Q2 of 2022. Secondly, the geopolitical risks index (GPR) by Caldara and Iacoviello (2020) constructs the global and country-level geopolitical risk based on a tally of newspaper articles. Specifically, the GPR is calculated as the share of articles in 10 US newspapers related to adverse geopolitical events in combination with the respective country or its main cities. We compute the EU's geopolitical risks as the unweighted average of the country-level risks of Denmark, Finland, Hungary, Poland, Sweden, Belgium, France, Germany, Italy, The Netherlands, Portugal, and Spain. Thirdly, we construct the country and sector specific number of export trade restrictions imposed by trading partners on each EU country using the data by the Global Trade Alert (2023). Lastly, we construct a variable that captures the share of sector-specific exports from countries under multi-lateral sanctions using trade share from FAOSTAT and the global sanctions database provided by Kirilakha et al. (2021), Felbermayr et al. (2020), and Syropoulos et al. (2022). We concentrate on trade and financial sanctions. We are aware that food products are often exempted from sanctions, like the sanction on Russia after the Ukraine war, however, trade sanctions still undermine trading and increase the transactions cost of trading with the sanctioned country (Glauber and Laborde 2022). We control for Covid-19 policy responses using the Oxford Stringency Index (Hale et al. 2021). Financial speculation in grain and oilseed futures markets has increased during the post-Covid period in both the US and the EU, which could have also triggered

[4] We include both the ASI value and the deviation (ASI deviation) from the long-term mean between 1984 and 2023 in the models.

additional price surges in these markets (Algeri et al. 2023). However, generally the EU exchanges were less prone to speculative activities than the US exchanges in the past. Therefore, and, because financial speculation is irrelevant for perishable products, we do not consider this in our empirical specification.

Descritive statistics

Before turning to the results of the econometric model, we present the descriptive statistics of all variables used in the analysis (Table 1). Because we mainly rely on models driven by within variability, we report the within standard deviation. All main variables are measured as real price indices, and thus, the coefficients are easily comparable in the regression output. In this case, a change by 1, aka 100% percentage points change, leads to an equivalent change by x-percentage points of the dependent variable.

Generally, trade openness among the EU countries across all sectors is very high being averagely greater than 100% for all sectors. The lowest trade openness among the EU countries is observed for dairy products with only 150% overall trade openness and 42% extra-EU trade openness. We find the largest trade openness for meat and oils, which is 20,000% (16,000%) respectively. The level of trade openness may be generally overestimated as we use the gross value of production as the denominator, while the nominator, exports and imports, is measured at the point of sales including all value addition along the value chain. Similarly, trade openness varies across EU member states being highest in the Netherlands, Malta, and Belgium and lowest in Croatia, France, and Italy. The average trade openness across sectors and countries was relatively stable since 2007, but has significantly increased since 2016.

Table 1: Summary statistics

Variable	Mean	Std. Deviation	Within Std. Deviation
Food price index	1.009	0.075	0.069
Input price index	1.022	0.091	0.089
Trade openness (log)	5.726	1.532	0.292
International price	0.746	0.133	0.129
Geopolitical risk	94.546	22.639	22.622
Sanction share	0.021	0.015	0.013
GDP	0.010	0.086	0086
International real energy price	0.678	0.108	0.108
Real energy price	1.028	0.121	0.129
Covid Stringency	7.127	18.807	18.677
Agricultural Stress Index	3.670	8.589	8.272
Agricultural Stress Index deviation	-3.103	8.337	8.070

All other variables are measured in index form and difficult to interpret. The average nominal food price inflation growth rate since 2007 was 3% p.a. and the average nominal agricultural input price inflation was 4% p.a.. Indeed, nominal agricultural input price inflation was larger than nominal food price inflation in all but few exemptions, such as Bulgaria, Cyprus, Czech Republic, Malta, and Slovakia. However, the relative growth rates vary by year and were highest in 2022 with 12% increase in nominal food price inflation and 29% in nominal agricultural input price inflation. All the indicators for transaction costs during the recent period of global market turbulences show an increasing trend during the period 2020-2022, however, there are some distinct trajectories during the entire observation period.

Results

Full sample estimates

In Table 2, we present the results of the dynamic panel regression employing the Arellano Bond system GMM estimator. We use two lags of the dependent variable to avoid problems of autocorrelation, and present different specifications in columns (1)-(6): in columns (1)-(2), we add different control variables, while in columns (3)-(6) we include the variables representing international turbulences and risk. In all regressions, and the subsequent ones, we treat trade openness, IPI, and the energy price, as well as all related interaction terms as strictly endogenous variables, which implies that we use only deeper lags as instruments. In all tables, we report the number of instruments and the AR (2) *p-value* indicating – when it does not suggest a rejection – that lags are valid instrument in the system GMM estimation. The results in columns (1)-(2) of Table 1 and additional specifications, including a regression employing the difference GMM estimator, are presented in Table A1 in the appendix suggest that our model specification is stable and independent from the set of control variables included. We, therefore, opt for the parsimonious specification, as shown in column (1), as our base model. The reason is that our additional controls may be correlated with the main variables of interest.[5]

Generally, the model estimates suggest that both internal and external factors have contributed to real food price inflation dynamics among EU countries since 2007, which is in line with Peersman (2023) for the Euro area and Adjemian et al (2023) for the US. This is indicated by the significant and positive coefficients of both IPI, the input producer price, and the international price. The coefficient of IPI is however always greater than the coefficient related to the international food

[5] The pairwise correlation is reported in Table A1 in the appendix.

price. Trade openness appears insignificant without the interaction with the IPI included and becomes positive and significantly associated with the real food price when the interaction term is included. However, the price in countries and sectors with greater trade openness appears to be less affected by the rise in input prices. We find a strong correlation between recent food inflation patterns with economic sanctions and geopolitical risk, a relationship that previously was mainly observed for energy and asset price dynamics (Bouoiyour et al. 2019). The coefficient of sanction share, the global export share of all sanctioned countries, is positive and significantly different from zero at the 90 percent level of significance. Therefore, it is reasonable to conclude that global market turbulence and risks associated with the Ukraine-war contribute to increasing food price inflation in the EU.

In Table 3, we show the coefficient estimates of the system GMM including a variety of interaction terms to examine if countries and sector that are more integrated into international food markets, indicated by a larger trade openness, were affected by shocks in international markets. Interestingly, we do not find stronger impacts on countries and sectors that are more integrated into global food markets. A plausible rationale is that, while increasing trade openness is generally associated with higher real food price inflation, the effect is not reinforced by recent global market turbulences. Instead, in all specification increased trade openness is associated with a lower effect of the input prices on the FPI. The latter is in line with the predictions from the conceptual framework presented above. Overall, holding the direct effect of trade openness on food price inflation constant, countries and sectors with higher trade openness were less exposed to price increases during the period of the Ukraine war. The results are robust to different proxies for trade openness (incl only considering extra-EU trade openness) as shown in Table A2 in the appendix.

Table 2: Drivers of real food price inflation using the Arellano Bond estimator

	(1)	(2)	(3)	(4)	(5)	(6)
L.Food price index	0.478***	0.521***	0.446***	0.893***	0.856***	0.756***
	(6.08)	(6.71)	(5.73)	(10.81)	(10.96)	(10.49)
L2. Food price index	-0.254***	-0.275***	-0.238***	-0.407***	-0.379***	-0.352***
	(-3.92)	(-3.97)	(-3.70)	(-4.52)	(-4.51)	(-4.50)
Input price index	0.389***	0.305***	0.350***	0.304***	0.337***	0.344***
	(4.67)	(4.29)	(4.15)	(5.08)	(5.49)	(5.17)
Trade openness (log)	0.045**	0.036**	0.045***	0.037***	0.038***	0.037***
	(3.37)	(3.06)	(3.31)	(3.53)	(3.57)	(3.24)
Input price index × Trade openness (log)	-0.045**	-0.036**	-0.045***	-0.034***	-0.036***	-0.037***
	(-3.46)	(-3.15)	(-3.38)	(-3.61)	(-3.69)	(-3.69)
International price	0.036***	0.036***	0.034***	0.038***	0.044***	0.044***
	(3.99)	(4.05)	(3.66)	(6.33)	(5.79)	(5.81)
War dummy			0.025***			
			(6.32)			
Geopolitical risk				0.030**		
				(2.72)		
Sanction share					0.122	
					(1.77)	
#export restrictions						0.00028***
						(3.04)
Agricultural Stress	YES	YES	YES	YES	YES	YES
Additional controls	NO	YES	NO	NO	NO	NO
Year FE	YES	YES	YES	NO	NO	NO
Month FE	YES	YES	YES	YES	YES	YES
Number of instruments	213	279	214	199	199	199
AR (2)	0.52	0.41	0.72	0.16	0.20	0.20
N	10634	10262	10634	10634	10634	10270

Note: t -statistics in parentheses* p<0.05, ** p<0.01, *** p<0.001. All regressions are two-step system GMM and treat the lagged dependent variable as predetermined. Two-step robust standard errors, incorporating theWindmeijer correction, are in parentheses. Input price index, Trade openness, and its interaction are considered endogenous.

Table 3: Drivers of real food price inflation with interaction effects using the Arellano Bond estimator

	(1)	(2)	(3)	(4)	(5)
L.Food price index	0.806***	0.438***	0.403***	0.795***	0.702***
	(10.37)	(5.63)	(5.60)	(13.47)	(11.13)
L2.Food price index	-0.380***	-0.242***	-0.176**	-0.316***	-0.306***
	(-4.70)	(-3.74)	(-2.91)	(-4.79)	(-4.68)
Input price index	0.303***	0.231***	0.368***	0.359***	0.311***
	(4.32)	(3.68)	(5.22)	(6.01)	(5.35)
Trade openness (log)	0.035**	0.027**	0.043***	0.042***	0.038***
	(2.76)	(2.95)	(4.00)	(4.05)	(3.39)
Input price index × Trade openness (log)	-0.035***	-0.026**	-0.041***	-0.038***	-0.033***
	(-3.31)	(-2.90)	(-3.61)	(-4.11)	(-3.50)
International price	0.038	0.034***	0.040***	0.049***	0.043***
	(1.41)	(3.68)	(4.49)	(6.54)	(5.35)
International price × Trade openness (log)	-0.001				
	(-0.13)				
War dummy		0.093**			
		(2.93)			
War dummy × Trade openness (log)		-0.011*			
		(-2.06)			
Geopolitical risk			0.006		
			(0.09)		
Geopolitical risk × Trade openness (log)			-0.010		
			(-0.92)		
Sanction share				0.305	
				(0.79)	
Sanction share × Trade openness (log)				-0.034	
				(-0.52)	
#export restrictions					0.0008***
					(2.15)
#export restrictions × Trade openness (log)					-0.000
					(-1.08)
Vegetation variables	NO	YES	YES	YES	YES
Additional controls	NO	NO	YES	NO	NO
Year FE	YES	YES	YES	YES	YES
Month FE	YES	YES	YES	YES	YES
Number of instruments	344	222	339	329	308
AR (2)	0.17	0.81	0.79	0.52	0.33
N	10634	10634	10262	10634	10270

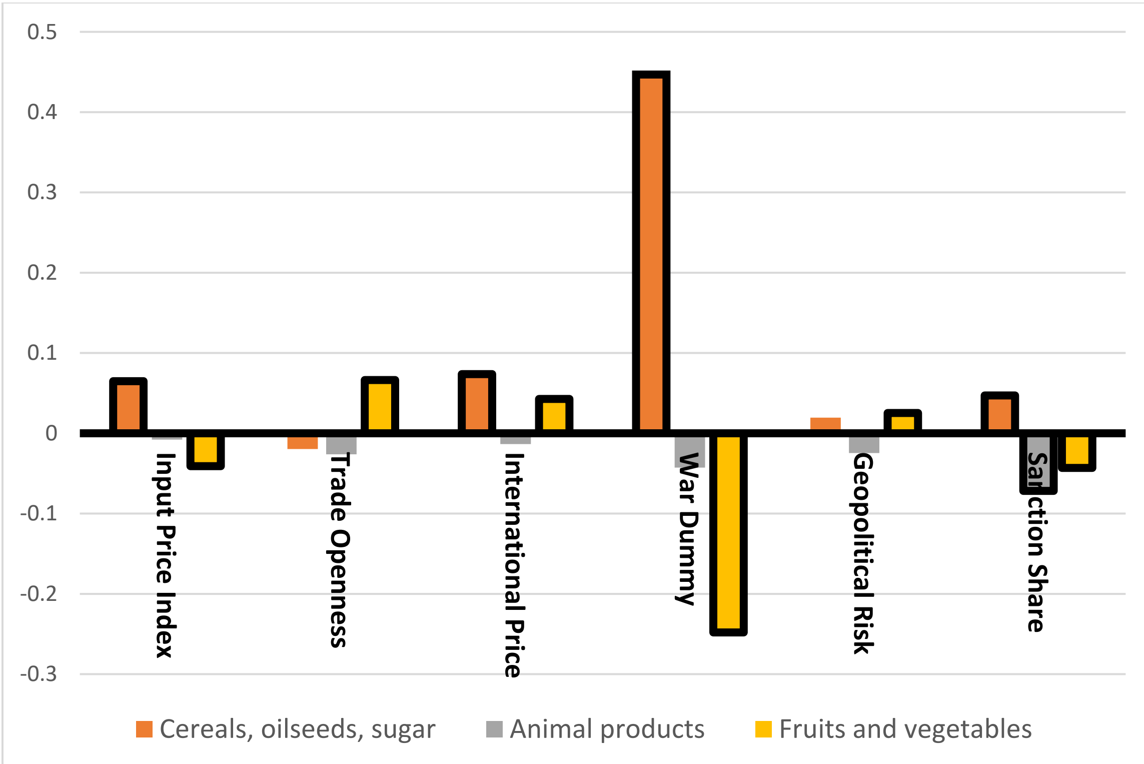
Note: t -statistics in parentheses* p<0.05, ** p<0.01, *** p<0.001. All regressions are two-step system GMM and treat the lagged dependent variable as predetermined. Two-step robust standard errors, incorporating theWindmeijer correction, are in parentheses. Input price index, Trade openness, and its interaction are considered endogenous.

Sector-specific results

We consider sectors with different degree of storability. Cereals and oilseeds are easily storable. Meat, dairy products, fruits, and vegetables are perishable. Moreover, the importance of Ukraine and Russia in international markets varies across these sectors. Both are important cereal and oilseed exporters. On the other hand, they do not engage much in international fruit and vegetable trade or the trading of animal products. Lastly, the import dependency of the European countries across these sectors also varies. The EU is a net exporter of cereals, a net importer of oilseeds, a net exporter of vegetables, and a net exporter of dairy and meat. Therefore, we provide a nuanced analysis taking account of the product and market differences of these sectors. We classify the sectors into three categories: (1) cereals, oilseeds, and sugar, (2) dairy and meat, and (3) fruits and vegetables. We interact these categories with all important independent variables.

The results of the system GMM regression are summarized in Figure 2 and presented in detail in Table A4. The base category is always cereals, oilseeds, and sugar; the storable commodities. First, we find that the effect of the input price on EU real food price inflation is significant and positive for storable commodities and animal products, but much lower for fruits and vegetables. This is because F&V production is more labor intensive and storable cmmodities and meat do require the bulk of inputs (e.g. fertilizer) (EU Comission, 2019), which became expensive in recent years. In fact, the coefficient estimates of IPI and the interaction of IPI with fruits and vegetables almost cancel each outer out. Coherently, we find that trade openness and the international price are more strongly associated with real food price inflation for vegetables and fruits than for storable commodities and animal products. This hints at a strong international integration of EU fruits and vegetable markets. EU markets of storable commodities as well as dairy and meat are also internationally integrated, but at a lesser extent, possibly owed to the fact that the EU is more selfsufficient in these commodities. In line with our earlier findings, greater integration is associated with the reduced effect of the sanctions on real food price inflation. In fact, the coefficients of the sanction variables are positive and significant only for storable commodities, such as cereals, oilseeds, and sugar, and significantly lower for animal products and fruits and vegetables. This can be explained by the large importance of Ukraine and Russia for these markets. On the other hand, the geopolitical risk is also positively associated with real food price inflation for fruits and vegetables. A possible explanation is that geopolitical risks restricts labor movement to and within the EU which leads to labor shortages in the labor intensive F&V sector. In addition to that, the EU's F&V trade partners are different from its grain and oilseed trade partners. F&V trade partners are mostly African, in particular northern African, countries, with greater political instability. This could indicate that international market risks usually affect fruits and vegetable prices as or even stronger than they affect other sectors, but that the current food crisis is different.

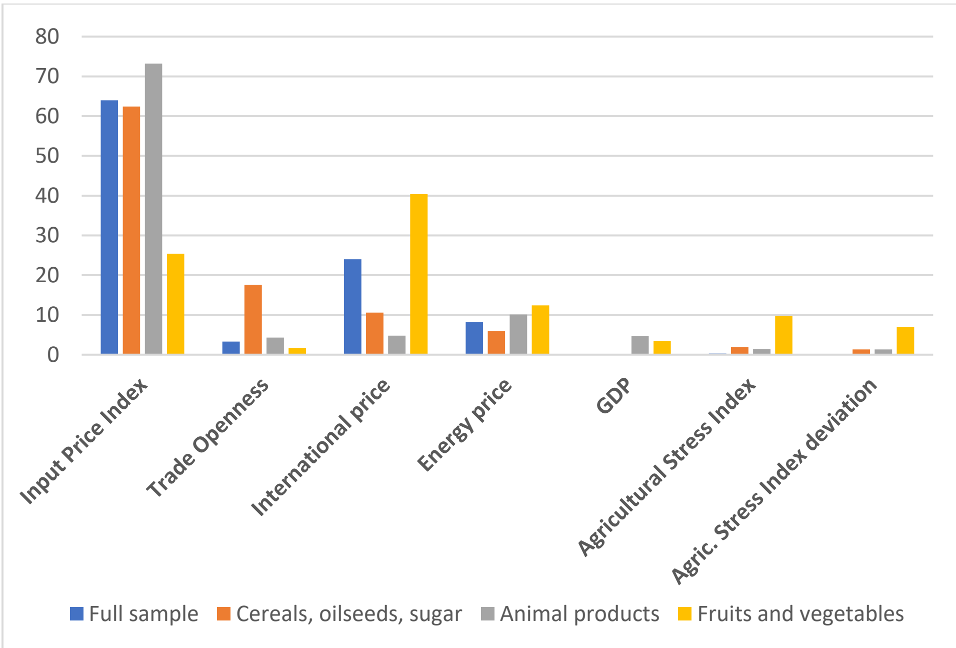
Figure 2: Standardized coefficients of Arellano Bond estimation with sectoral interaction terms



Note: Coeffients are taken from Table A.4 and standardization was made using sector-specific within variation of dependent and independ variables. Statistically significant coefficients are marked by bold borders.

Last, in this section, we conduct a standard Shapley decomposition (Israeli, 2007) to understand the importance of the different independent variables on overall real food price inflation during the period 2007-2022. We show the results for the whole sample and for the three categories of food sectors in Figure 3. The input price index is the most important variable in explaining real food price inflation in the EU. This is, however, not the case for real food price inflation of fruits and vegetable products. For fruits and vegetable products, the international price has the largest contribution. Energy price inflation is equally important for all sectors and more important overall than changes in the GDP. Trade openness is found to be most important for cereals, oilseeds, and sugar but much less for the other sectors. Last, weather abnormalities, i.e., vegetation variations, explain little changes in real food price inflation in the EU, however, they play some role for fruits and vegetable products.

Figure 3: Relative importance of independent variables (net effect) in variation of dependent variable from Shapley Decomposition



Note: The net effect refers to a simple OLS regression without FE and time dummies.

This has several important implications. Firstly, agricultural market factors dominate in explaining EU real food price inflation, while energy prices (only indirectly through input prices) and macroeconomic aspects have little influence on agricultural price dynamics. Secondly, global input and commodity market risks results in EU real food price variability, and therefore, endanger EU food security. Lastly, whilst short-term global market risks, including the Ukraine-war, drive EU real food price inflation, the costs of production remain the dominant factor for EU food price formation.

Discussion and conclusions

We investigate the dynamics and external drivers of post-2020 food inflation patterns in Europe. In particular we investigate the effects of risk and uncertainties related to global market turbulences due to the Covid pandemic and the Ukraine war on real food price inflation in the EU by quantifying the contribution of different components. Covid pandemic not only affected the agri-food supply chains with a direct effect on the input and output prices, but also indirectly effect through changes in the macroeconomic environment as a result of the increasing number of measures adopted to face the crisis (Fatouh et al., 2021). We investigated the role of international trade vis-à-vis the transmission of global shocks to EU food markets.

Food price inflation has been mainly driven by changes in the input price index, but marked differences are observed across sectors. More precisely, for fruits and vegetable products, the international price has driven the most the food price inflation. Another important driver has been the energy price inflation, which had a stronger effect on non-food inflation, and a net negative impact on real food price inflation in the EU. Lastly, we found that trade openness has been an important driver of price changes for cereals, oilseeds, and sugar, whereas the agricultural stress index explains only little the changes in real food price inflation in the EU.

Our empirical findings are in line with existing studies that reported increased food inflation during the post-Covid period (e.g. Akter, 2020). However, our study is (to the best of our knowledge) among the few investigations of the effects of the Ukraine war on EU food prices, and the role of the conflict on market risks and uncertainties. Different from related studies by Adjemian et al. (2023) and Algeri et al. (2023), we chose an empirical specification that controls for economy-wide macroeconomic effects, such as monetary policy and exchange rate fluctuations, to concentrate on the impact of global market turbulences on different food sectors. Despite the different approaches, the supply-side effects are confirmed: the increase in agricultural production costs has been the main driver of food price inflation.

Our empirical results suggest that trade openness, i.e., a larger integration into global food markets, was not associated with larger real food price inflation among the EU countries. Instead, trade integration seems to absorb parts of the global market shocks on EU food prices. While this may seem counterintuitive, it can be explained by the structure of international food trade. For instance, higher trade integration does not necessarily create additional vulnerability to global market shocks because higher trade integration is also associated with lower transaction costs of trade, due to economies of scale and the importance of a diversified supply network. In addition to that, international trade creates efficiencies in production by creating a comparative advantage for countries with lower production costs. In consequence of the strong increase in EU agricultural input prices adversely impacted on real food price inflation in EU countries and sectors with lower trade integration much stronger. Instead, countries and sectors that are more integrated were able to source imports from countries that experienced lower agricultural input price inflation.

These findings have implications for EU policy makers. First, reducing global market risks and uncertainties will reduce EU food price inflation pressure significantly. This could be achieved by keeping food markets open − avoiding export restrictions, e.g., India’s wheat export ban −, minimizing the transaction costs of economic sanctions, and by enabling both Russia and Ukraine to supply to global food markets. Second, measures to reduce agricultural input price inflation are a leverage to reduce the pressure on EU food price inflation. Input subsidies and transfer programs would only help in the very short-run and increasing EU fertilizer demand will impair global fertilizer fertilizer availability; particularly for low income countries. Instead, improvements in the allocative efficiency of agricultural inputs, particurly nitrogen fertilization, are required also to meet sustainability standards set by the EU Green Deal. Third, EU countries should take account of the necessity to diversify trade relations to reduce the vulnerability to global market shocks and to fully exploit the efficiency gains from trade. This could be supported by reforming the trade regime in favor of like-minded and strategie trading parteners..

The study is admittedly limited by the lack of a comprehensive analysis of the EU trade regime. Taking into account the large set of trade agreements, pricing and non-pricing mechanisms, and their heterogeous effects on trade (e.g. Fiankor and Santeramo, 2023; Santeramo and Lamonaca, 2022) would have added complexity to the analysis. We traded-off the complexity with the necessity to provide timely results, so as to understand the effects of global shifts in the geopolitical situation.

References

Adjemian, M. K., Arita, S., Meyer, S. and Salin, D. (2023). Factors Affecting Recent Food Price Inflation in the United States. Applied Economic Perspectives and Policy 1–29.

Ahn, S. and Steinbach, S. (2023). The impact of COVID-19 trade measures on agricultural and food trade. Applied Economic Perspectitve Policy, 45, 911-927.

Akter, S. (2020). The impact of COVID-19 related ‘stay-at-home’ restrictions on food prices in Europe: findings from a preliminary analysis. Food Security. 12, 719–725.

Algeri, B., Kornher, L. and von Braun, J. (2023). Food price inflation, its causes and speculation risks. Rural 21, 57, 10-12.

Baquedano, F. G. and Liefert, W. (2014). Market integration and price transmission in consumer markets of developing countries, Food Policy, 44, issue C, 103-114.

Bekkers, E., Brockmeier, M., Francois, J., and Yang, F. (2017). Local food prices and international price transmission. World Development, 96, 216-230.

Bouoiyour, J., Selmi, R., Hammoudeh, S., and Wohar, M.E. (2019). What are the categories of geopolitical risks that could drive oil prices higher? Acts or threats? Energy Economics, 84, 104523.

Brander, M., Bernauer, T. and Huss, M. (2023). Trade policy announcements can increase price volatility in global food commodity markets. Nature Food 4, 331–340

Consoli S, Egas Yerovi J.J., Machiorlatti M., and Morales Opazo, C. (2023). Real-time monitoring of food price policy interventions during the first two years of COVID-19. Food Policy 102405.

Dietrich, S., Giuffrida, V., Martorano, B. and Schmerzeck, G. (2022). COVID-19 policy responses, mobility, and food prices. American Journal of Agricultural Economics 104(2), 569–588.

Durevall, D., Loening, J. L, and Birru, Y.A. (2013). Inflation dynamics and food prices in Ethiopia. Journal of Development Economics, 104, 89-106.

EU Commission (2019). Fertilisers in the EU. EU Agricultural Markets Briefs, 15. June 2019.

EUROSTAT (2023).

Fackler, P. L. and Goodwin, B. K. (2001). Spatial price analysis. Handbook of agricultural economics, 1, 971-1024.

Fatouh, M., Giansante, S., & Ongena, S. (2021). Economic support during the COVID crisis. Quantitative easing and lending support schemes in the UK. *Economics letters*, *209*, 110138.

FAO (2023). FAO - Agricultural Stress Index System (ASIS), http://www.fao.org/giews/earthobservation/, [16th June 2023]

FAOSTAT (2023).

Felbermayr, G., Kirilakha, A., Syropoulos, C. Yalcin, E. and Yotov, Y.V. (2020). The Global Sanctions Data Base. European Economic Review, 129. 103561.

Ferrucci, G., Jiménez-Rodríguez, R. and Onorantea, L. (2012). Food Price Pass-Through in the Euro Area: Non-Linearities and the Role of the Common Agricultural Policy. International Journal of Central Banking, 8(1), 179-218.

Fiankor, D. D., & Santeramo, F. G. (2023). Revisiting the impact of per-unit duties on agricultural export prices. Applied Economic Perspectives and Policy.

Flachsbarth, I. and Garrdio, A. (2014). The effect of agricultural trade openness on food price transmission in Latin American countries. Spanish Journal of Agricultural Research, 12(4), 927-940.

García-Germán, S., Bardají, I. and Garrido, A. (2016), Evaluating price transmission between global agricultural markets and consumer food price indices in the European Union. Agricultural Economics, 47, 59-70.

Glauber, J. and Laborde, D. (2022). How sanctions on Russia and Belarus are impacting exports of agricultural products and fertilizer? IFPRI Blog. November 9, 2022, Available at:

https://www.ifpri.org/blog/how-sanctions-russia-and-belarus-are-impacting-exports-agricultural-products-and-fertilizer

Hale, T., Angrist, N., Goldszmidt, R. et al. (2021). A global panel database of pandemic policies (Oxford COVID-19Government Response Tracker). Nat Hum Behav 5, 529–538.

Headey, D. and Fan, S. (2008). Anatomy of a crisis: the causes and consequences of surging food prices. Agricultural Economics, 39, 375-391.

Iacoviello, M., & Caldara, D. (2020). Geopolitical risk (GPR) index.

IMF (2023a). Pink Sheets.

IMF (2023b). Global Price Index of All Commodities [PALLFNFINDEXQ], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/PALLFNFINDEXQ, July 21, 2023.

Israeli, O. (2007). A Shapley-based decomposition of the R-square of a linear regression. The Journal of Economic Inequality, 5, 199-212.

Kirikkaleli, D., and Darbaz, I. (2022). New insights into an old issue: modelling the US food prices. Letters in Spatial and Resource Sciences, 15(3), 675-689.

Kirilakha, A., Felbermayr, G., Syropoulos, C, Yalcin, E. and Yotov, Y.V. (2021). The Global Sanctions Data Base: An Update that Includes the Years of the Trump Presidency, in The Research Handbook on Economic Sanctions. Edited by Peter A.G. van Bergeijk.

Kornher, L., Kalkuhl, M. and Mujahid, I. (2017) Food price volatility in developing countries the role of trade policies and storage. FOODSECURE Working Paper 57.

Kornher, L., and von Braun, J. (2023). Global food crisis and implications for actions in the context of war and pandemic shocks. In Food and Humanitarian Crises: Science and Policies for Prevention and Mitigation, Proceedings of the workshop. Editor J. von Braun, Scripta Varia 147 | Vatican City, forthcoming.

Lence, S. H., Moschini, G., and Santeramo, F. G. (2018). Threshold cointegration and spatial price transmission when expectations matter. Agricultural Economics, 49(1), 25-39.

Matthews, A. (2023). Food price situation in Europe. Studies in Agricultural Economics 125, 60-68.

Menyhert, B. (2022). The effect of rising energy and consumer prices on household finances, poverty and social exclusion in the EU, EUR 31257 EN, Publications Office of the European Union, Luxembourg.

Peersman, G. (2022). International food commodity prices and missing (dis)inflation in the Euro area. The Review of Economics and Statistics 104(1), 85-100.

Rabbi, M.F., Ben Hassen, T., El Bilali, H., Raheem, D. and Raposo, A. (2023). Food Security Challenges in Europe in the Context of the Prolonged Russian–Ukrainian Conflict. Sustainability, 15, 4745. https://doi.org/10.3390/su15064745

Rezitis, A. N. and Tsionas, M. (2019). Modeling asymmetric price transmission in the European food market. Economic Modelling, 76(C), 216-230.

Roodman, D. (2009). How to do xtabond2: An introduction to difference and system GMM in Stata, Stata Journal, StataCorp LP, vol. 9(1), 86-136.

Rose, A., Chen, Z., and W., Dan (2023). The Economic Impacts of Russia–Ukraine War Export Disruptions of Grain Commodities. Applied Economic Perspectives and Policy 45(2), 645– 665.

Santeramo, F. G. (2015). Price transmission in the European tomatoes and cauliflowers sectors. Agribusiness, 31(3), 399-413.

Santeramo, F. G., and Dominguez, I. P. (2021). On the effects of the COVID epidemic on global and local food access and availability of strategic sectors: Role of trade and implications for policymakers (No. 938-2021-378).

Santeramo, F. G., & Lamonaca, E. (2022). Standards and regulatory cooperation in regional trade agreements: What the effects on trade?. Applied Economic Perspectives and Policy, 44(4), 1682-1701.

Stephens, E. C., Mabaya, E., Cramon-Taubadel, S. V., & Barrett, C. B. (2012). Spatial price adjustment with and without trade. Oxford Bulletin of Economics and Statistics, 74(3), 453-469.

Syropoulos, C., Felbermayr, G. Kirilakha, A, Yalcin, E. and Yotov, Y.V. (2022). The Global Sanctions Data Base - Release 3: COVID-19, Russia, and Multilateral Sanctions," School of Economics Working Paper Series 2022-11, LeBow College of Business, Drexel University, https://ideas.repec.org/p/ris/drxlwp/2022_011.html

Wieck, C., Dries, L., Martinez-Gomez, V., Kareem, O. I., Rudloff, B., Santeramo, F. G., Sliwinska, M., and Sliwinski, R. (2021). European and Member State Policy Responses and Economic Impacts on AgriFood Markets due to the COVID-19 Pandemic (No. 938-2021-1067).

Appendix

Table A1: Pairwise correlation

Variables	IPI	#export restrictions	Sanction share	International price	GPR
GDP	0.024*	0.002	0.009	-0.086*	0.004
International real energy price	0.302*	-0.267*	-0.212*	-0.427*	-0.146*
Real energy price	0.580*	0.105*	0.092*	-0.274*	0.370*
Covid Stringency	0.069*	0.216*	0.151*	0.035*	0.118*

Note: * $p<0.05$.

Table A2: Drivers of real food price inflation using the Arellano Bond estimator: robustness analysis with different specifications and estimators

	(1)	(2)	(3)	(4)
L.fpi	0.368***	0.666***	0.415***	0.725***
	(5.90)	(7.57)	(5.65)	(9.91)
L2.fpi	-0.182**	-0.365***	-0.286***	-0.129*
	(-2.61)	(-4.46)	(-4.55)	(-2.36)
IPI	0.133***	0.085***	0.446***	0.270***
	(6.03)	(3.87)	(4.61)	(5.17)
Trade openness (log)	0.001	0.002	0.051	0.025**
	(0.16)	(0.24)	(1.66)	(2.92)
IPI × Trade openness (log)			-0.049***	-0.026**
			(-3.41)	(-3.28)
International price	0.042***	0.033***	0.033***	0.030***
	(4.32)	(3.75)	(4.15)	(4.62)
System/Diff gmm	System	System	Diff	System
Vegetation variables	NO	NO	YES	YES
Additional controls	NO	NO	NO	NO
Year FE	YES	YES	YES	YES
Month FE	NO	YES	YES	YES
Number of instruments	148	148	208	210
AR (2)	0.66	0.13	0.26	0.11
N	10634	10634	10451	10634

Note: t -statistics in parentheses* $p<0.05$, ** $p<0.01$, *** $p<0.001$. We treat the lagged dependent variable as predetermined. Input price index, Trade openness, and its interaction are considered endogenous.

Table A3: Drivers of real food price inflation with interaction effects using the Arellano Bond estimator: using extra-EU trade openness instead of total trade openness

	(1)	(2)	(3)	(4)	(5)
L.fpi	0.764***	0.460***	0.458***	0.759***	0.679***
	(10.35)	(6.12)	(5.89)	(12.88)	(11.29)
L2.fpi	-0.349***	-0.261***	-0.229***	-0.280***	-0.277***
	(-4.61)	(-4.01)	(-3.54)	(-4.37)	(-4.61)
PPI	0.218***	0.183***	0.203***	0.240***	0.211***
	(5.06)	(4.00)	(4.54)	(7.27)	(6.42)
Trade openness (log)	0.034**	0.034***	0.028***	0.029***	0.027***
	(2.80)	(3.69)	(3.51)	(3.74)	(3.41)
PPI × Trade openness (log)	-0.030**	-0.030***	-0.025**	-0.026***	-0.023***
	(-3.28)	(-3.54)	(-3.11)	(-3.91)	(-3.47)
International price	0.056**	0.040***	0.043***	0.050***	0.043***
	(2.80)	(4.30)	(4.85)	(6.60)	(5.12)
International price × Trade openness (log)	-0.004				
	(-1.05)				
War dummy		0.051**			
		(2.76)			
War dummy × Trade openness (log)		-0.005			
		(-1.29)			
GPR			-0.000		
			(-0.01)		
GPR × Trade openness (log)			-0.012		
			(-1.21)		
Sanction share				0.001	
				(0.01)	
Sanction share × Trade openness (log)				0.005	
				(0.09)	
#export restrictions					0.001**
					(2.64)
#export restrictions × Trade openness (log)					-0.000
					(-1.31)
Vegetation variables	YES	YES	YES	YES	YES
Additional controls	NO	NO	NO	NO	NO
Year FE	YES	YES	YES	YES	YES
Month FE	YES	YES	YES	YES	YES
Number of instruments	465	217	335	450	434
AR (2)	0.23	0.49	0.81	0.62	0.51
N	10138	10138	10138	10138	10138

Note: t -statistics in parentheses* $p<0.05$, ** $p<0.01$, *** $p<0.001$. All regressions are two-step system GMM and treat the lagged dependent variable as predetermined. Two-step robust standard errors, incorporating theWindmeijer correction, are in parentheses. Input price index, Trade openness, and its interaction are considered endogenous.

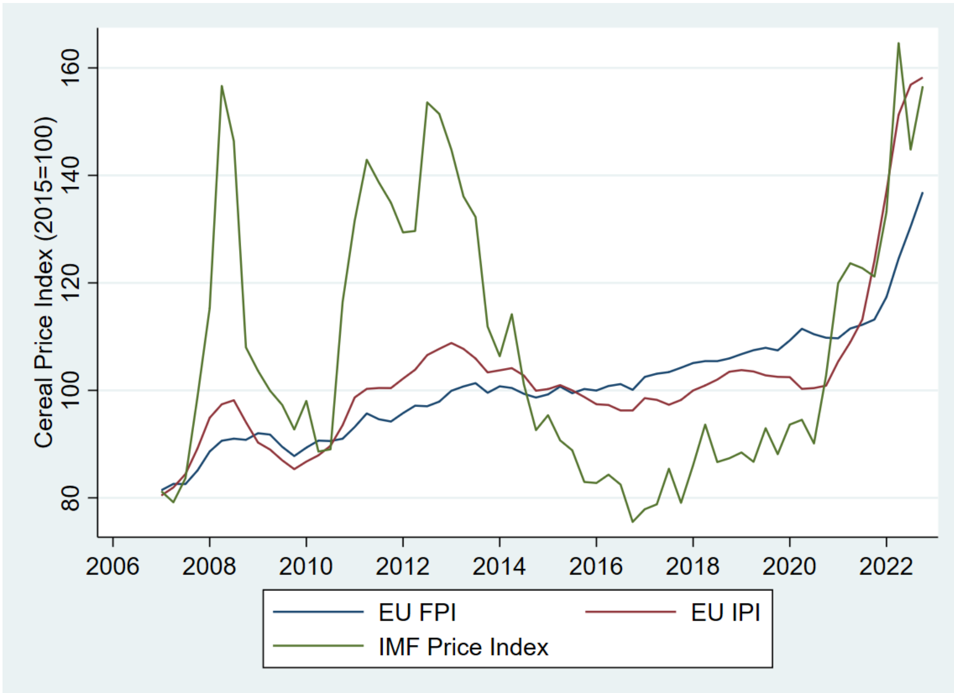
Table A4: Drivers of real food price inflation: sectoral heterogeneity using the FE estimator

	(1)	(2)	(3)	(4)	(5)	(6)
L.fpi	0.693***	0.694***	0.697***	0.695***	0.697***	0.697***
	(65.66)	(68.17)	(68.34)	(68.26)	(68.27)	(67.56)
L2.fpi	0.051***	0.047***	0.052***	0.054***	0.051***	0.045***
	(4.73)	(4.61)	(5.01)	(5.29)	(4.98)	(4.35)
IPI	0.0501***	0.0353***	0.0358***	0.0268**	0.0780***	0.0873***
	(4.50)	(3.73)	(3.78)	(2.80)	(12.49)	(15.41)
IPI × animal products	-0.00428					
	(-0.35)					
IPI × F&V	-0.0456***					
	(-3.73)					
Trade openness (log)	0.00172	-0.00363	0.00193	0.00175	0.00551***	0.00442**
	(0.99)	(-1.73)	(1.11)	(1.01)	(3.42)	(2.70)
Trade openness (log) × animal products		-0.00590				
		(-1.21)				
Trade openness (log) × F&V		0.0234***				
		(6.21)				
International price	0.0435***	0.0427***	0.0393***	0.0447***	0.0393***	0.0430***
	(9.01)	(8.93)	(6.26)	(9.37)	(9.81)	(10.91)
International price × animal products			-0.00518			
			(-0.56)			
International price × F&V			0.0314***			
			(3.61)			
War dummy				0.0307***		
				(6.42)		
War dummy × animal products				-0.00206		
				(-0.42)		
War dummy × F&V				-0.0246***		
				(-5.06)		
GPR					0.0000483	
					(1.52)	
GPR × animal products					-0.0000426	
					(-0.91)	
GPR × F&V					0.0000902	
					(1.93)	
Sanction share						0.186***
						(4.44)
Sanction share × animal products						-0.313***
						(-3.61)
Sanction share × F&V						-0.406***
						(-4.55)
Vegetation variables	YES	YES	YES	YES	YES	YES
Additional controls	NO	NO	YES	NO	NO	NO
Year FE	YES	YES	YES	YES	NO	NO
Month FE	YES	YES	YES	YES	YES	YES

N	10634	10634	10262	10634	10634	10634

Note: t -statistics in parentheses* p<0.05, ** p<0.01, *** p<0.001. All regressions are two-step system GMM and treat the lagged dependent variable as predetermined. Two-step robust standard errors, incorporating theWindmeijer correction, are in parentheses. Input price index, Trade openness, and its interaction are considered endogenous.

Figure A1: Cereal price dynamics between 2007-2023 (2015=100)



Source: Own illustration based on Eurostat (2023) and IMF (2023).

Note: EU price indices are unweighted averages across all member states. FPI is the nominal food price index, IPI is the nominal input price index. IMF Price Index is IMF's index for cereals.