EU Food price inflation amid global market turbulences during the COVID-19 pandemic and the Russia-Ukraine War

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Abstract

Since the Covid-19 pandemic and the Russia-Ukraine War, global food markets have been in turmoil. Agricultural input and energy prices doubled between 2020 and 2022, with immediate consequences on food accessibility. We examine the drivers of the EU food inflation patterns, and how trade integration shapes these dynamics. We find that food price inflation has been mainly driven by surges in agricultural production costs and, to a lesser extent, by global food price increases. Trade openness has not exacerbated the inflating dynamics during this period.

Keywords: Europe, food price inflation, Russia–Ukraine War, trade policy uncertainty, geopolitical risk

JEL codes: E31, Q11, Q18

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Introduction

Global food market turmoil has seen agricultural input and energy prices doubling between 2020 and 2022. The price increases drove up food prices with immediate consequences on access and availability of food (Santeramo and Dominguez, 2021; Kornher and von Braun; 2024). Global food market uncertainties caused by shortages in global grain and oilseed markets, as a direct result of the Russia–Ukraine War, and 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's (EU) agro-food system (Wieck et al., 2021) and led to unprecedented phenomena of food price inflation, 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 environmental and financial measures to boost agricultural production. In addition, the declaration reinforced the need for self-sufficiency in food, feed, and fertilizers (Matthews, 2023). While the EU has not machted the US Inflation Reduction Act, it has adopted a restrictive monetary policy, value-added tax cuts for energy and food products, and fiscal measures to counter the negative welfare impacts of inflation for consumers (Freier and Ricci, 2023). The EU agro-food system and the associated policy responses to the inflation crisis are under the direct influence of the EU Green Deal and the Farm-to-Fork Strategy, which are expected to increase food prices within the next couple of years (Badequano et al., 2022).

We study the dominant factors for increased EU food price inflation to comment on existing (and potential) anti-inflation policy responses, such as price measures and interventions to promote EU food production. The extant research has mostly focussed on variation in prices, margins, spatial and vertical arbitrage (Ferrucci et al. 2012; Santeramo, 2015; Rezitis et al., 2019), and on the effects of the trade regime (Fiankor and Santeramo, 2023; Santeramo and Lamonaca, 2022), with little attention devoted to the role of international and external drivers (Peersman, 2022). The rising importance of local and international trade networks has increased the complexity of trade relationships. For instance, the EU has signed 46 regional trade agreements (Jafari et al., 2022) and strengthened trade relationships with countries with which it sustained geopolitical tensions over the past decades. The Russia–Ukraine War and other geopolitical tensions cause geonomic fragmentation, which raises trade costs due to the need of the re-structuring of supply chains. The geopolitical risks are associated with market uncertainty, price volatility, trade route disruptions, tariff retaliation, and sanctions. In short, major geopolitical tensions and conflicts worsen the terms of international trade; specifically, if major trading countries are involved.

A few studies attempted to ascertain the extent to which prices are transmitted from international to markets in the EU (Irz, 2013; García-Germán et al. 2016, Bekkers et al. 2017; Peersmann, 2022). García-Germán et al. (2016) reported a long-run relationship between world agricultural commodities 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 the determinants of food prices in Finland over 1995-2010 employing a co-integration analysis and showed that the international prices of agricultural commodities and wages in the retail sector appeared as significant determinants of the dynamics in the food prices, while energy price inflation did not show a significant effect in this regard. Bekkers et al. (2017) tested the pass-through of international food prices onto domestic food prices by using first difference panel model. They found a significant deviation of the EU pass-through rates from the conditional average. On the contrary, Peersmann (2022) found that about 30% of Euro-area inflation volatility was explained by shifts in international food prices signifying the EU's deep integration in global food markets. However, these studies do not consider geopolitical tensions and how they may affect the transmission mechanism. For instance, the current food price spike could differ from earlier periods of international price spikes when EU food and input prices did not move along with international food prices (Figure A1).

Only a few studies concentrated on periods of extraordinary market behavior as came into play through the disruptive events of 2020-2022, i.e. Covid pandemic and the Russia–Ukraine War. Kirikkaleli and Darbaz (2022) argued that US policy uncertainty (including trade uncertainty), exchange rate, and energy prices are the key factors to be considered when explaining the variability of the food prices during this period. Martinez-Garcia et al. (2023) underlined the relevance of the embargo on Russian gas and oil for the price levels in the EU and showed that impacts varied across countries and sectors.

There is still limited evidence on the causes of the recent food price spikes; specifically how important global market turbulences were in explaining the price spike. Akter (2020), for the EU, and Dietrich et al. (2021), for low and middle income countries, showed that food price levels were positively related to the stringency of Covid containment policy and movement restrictions. Akter (2020) found the most significant surges in EU prices for perishable products. Algieri et al. (2024) found that both value chain disruptions and higher agricultural input prices as well as macroeconomic factors contributed to soaring food prices. For the US, Adjemian et al. (2023) attributed food price changes mostly to supply-side factors and money supply. Legrand (2023) showed that the uncertainty about the Ukrainian export supply drove commodity prices further up. These studies suggest that increasing geopolitical risk and geonomic fragmentation cause food price increases (Saadadou et al. 2022; Sun and Su, 2024). These studies do not provide evidence on the relative contribution of different drivers of EU food inflation and do not distinguish between international price levels and market risks due to the Covid pandemic and the Russia–Ukraine War , and the interactions of these effects with the level of integration in the global food trade system.

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 and 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 analyze European food inflation dynamics using a quarterly food sector and country panel from 2007-2022. As an identification strategy, we use variation across time, space, and sectors regarding the level of market 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 market risk and uncertainty factors with the country and sector-specific level of integration. 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.

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 index of a group of goods *k*, for instance cereals, p_k^D , is a 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 differentiated 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). [12] The transaction costs include standard trade costs from shipping tradeable goods from the exporting to the importing country as well as additional trade costs that increase in global market turbulences, such as costs from increasing market uncertainty, changing supply chain structures, and value chain disruptions. 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[3]:

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

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.

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[1] While the price of tradable goods is determined by trade arbitrage, the price of non-tradeable goods is determined by labor productivity, and thus, the price level is lower in countries with lower labor productivity (Maurer, 2023). For simplicity, we assume that the relative labor productivity remains constant in the short-run, and therefore, we do not need to consider this in our time series model.

[2] 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: $p_k^D = (1-\lambda_k)\, p_k^D + \lambda_k\, p_k^W$.

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

The consumer price index of goods in sector *k*, p_k^D , consists of the domestic component, the international component, and the transaction 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 (1) are 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 a 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 as 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*:

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

where the real food price of good *k* in country *i* and time *t*, rp_{kit}^D , is explained by the inverse supply function of the real price, $(c - Q_{kit})_r$, 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 and derive two hypotheses. While international food prices always influence domestic food prices, albeit to varying extents, global market turbulences, through the COVID-19 pandemic and the Russia–Ukraine war, increase transaction costs and subsequently domestic food prices. Hence, the first hypothesis to be tested is that global market turbulences have increased real food price inflation controlling for international food prices.

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

The second hypothesis considers the impact of transaction costs on food prices. 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. Therefore, the second hypothesis states that the larger the share of the traded goods in *k*, the more important international food price and transaction cost movements for real food price inflation. Conversely, the lower the share of the traded goods in *k*, 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.*

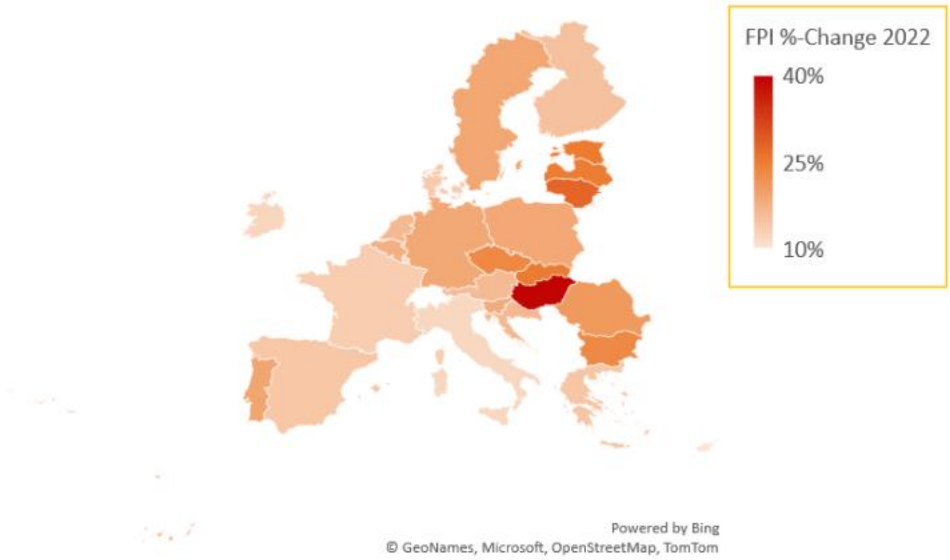
It has been argued that more integrated markets are more vulnerable to international food price shocks and show higher levels of international price transmission (Flachsbarth and Garrido, 2014; Kornher et al., 2017). This is because in more integrated markets a larger share of the market is determined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

H3: *The larger the trade openness, the larger the effects of the global price turbulences.*

Methods and data

We combine and use several data sets to describe the domestic, international, and transaction cost components that determine 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, vegetables, 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) estimators, 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:

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

Here, we construct the real food price in sector *k* and country *i*, rp_{kit}^{D} , 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) representing the inverse supply function from equations (1) and (2), $Openness_{kit}$ 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, τ_t representing the transaction cost related to global market turbulences, is parametrized by different variables; a time dummy for the Russia–Ukraine War period and indicators of geopolitical risk. None of these continuous variables captures the entire dimension of costs related to global market turbulences, but they capture different elements; namely market uncertainty and risks, tariffs, and trade costs. 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 on the general 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. 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* using extra-EU trade data from EUROSTAT (2023).[4] We control also for seasonality and vegetation index variables. The sector-specific international food price indices are taken from the World Bank Pinksheet and the FAO Food Price Index (FFPI); energy, oils, and cereals (World Bank, 2023), as well as, meat, dairy, and sugar (FAO, 2023a). For fruits and vegetables, we use the World Bank's index of other foods. The GPI is the global equivalent of a country's CPI and is obtained from the Federal Reserve Bank of St. Louis (IMF 2023). 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 (GIEWS) (FAO 2023b). We predominantly use the first season's data and replace it with the second season's only if the respective month is not available.[5]

[4] Overall trade openness is extracted from FAOSTAT (2023). We extrapolate the 2021 data to 2022.
[5] We include both the ASI value and the deviation (ASI deviation) from the long-term mean between 1984 and 2023 in the models.

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 GTA (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 Russia-Ukraine War, however, trade sanctions still undermine trading and increase the transaction 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 additional price surges in these markets (Algieri et al., 2024). However, generally the EU commodity 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. The definitions of the variables used in the analysis are shown in Table 1.

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 extra-EU trade openness for meat and oils, which is 10,000% (6,000%) respectively. The level of trade openness is 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, extra-EU 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 declined after 2009 by about 30% in 2015 but increased again in 2021 and 2022.

Table 1: Summary statistics

Variable	Definition	Mean	Std. Deviation	Within Std. Deviation
Food price index (FPI)	Quarterly food price index of each sector divided by the CPI	1.009	0.075	0.069
Input price index (IPI)	Quarterly production input price index divided by the CPI	1.022	0.091	0.089

Extra-EU trade openness (log)	Share of extra-EU trade over the gross value of production in each sector	3.988	2.181	0.880
International price	Quarterly average of World Bank and FAO sectoral price indices divided by the global production price index.	0.746	0.133	0.129
Geopolitical risk	EU country average geopolitical risks index (GPR) by Caldara and Iacoviello (2020).	94.546	22.639	22.622
# export restrictions	Number of export restrictions on the country in each sector	19.46	23.23	16.23
Sanction share	The share of exports in each sector that comes from sanctioned countries	0.021	0.015	0.013
GDP	Quarterly GDP	0.010	0.086	0086
International real energy price	World Bank energy price index divided by the global production price index	0.678	0.108	0.108
Real energy price	Quarterly energy price index divided by the CPI	1.028	0.121	0.129
Covid Stringency	Index measuring government restrictions on movements, travel, gathering, etc.	7.127	18.807	18.677
Agricultural Stress Index (ASI)	Percentage of the area under agricultural stress.	3.670	8.589	8.272
Agricultural Stress Index deviation	Deviation of ASI from long-term monthly average.	-3.103	8.337	8.070

All other variables are measured in index form and are 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 a few exemptions, such as Bulgaria, Cyprus, Czech Republic, Malta, and Slovakia. However, the relative growth rates have varied by year and were highest in 2022 with a 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)-(4): in columns (1)-(2), we show the main specifications without interaction, while in columns (3)-(4) we include interaction effects with the input price index. In column (2), we test specifically if a stronger intra-EU trade integration stabilizes food inflation. In all regressions, and the subsequent ones, we treat extra-EU 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 instruments in the system GMM estimation. The results in Table 2 and additional specifications, including more parsimonious models and a regression employing the difference GMM estimator 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.[6]

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 (2022) 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

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

coefficient of IPI is however always greater than the coefficient related to the international food price. The coefficient of the war dummy is significant and positive in all specifications suggesting that the food inflation was about 2%-points higher during the Russia–Ukraine War period. This confirms the first hypothesis. Extra-EU 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. We do not find a stabilizing effect of stronger intra-EU trade integration (column (2)). However, food inflation in countries and sectors with greater extra-EU trade openness appears to be less affected by the rise in input prices.

In columns (3)-(4) of Table 2, we show the coefficient estimates of the system GMM including the interaction term of IPI and extra-EU trade openness to examine if countries and sectors that are more integrated are more strongly determined by the international, vis-à-vis the domestic component. The negative coefficient of the interaction term confirms the second hypothesis. This is robust to a reduction of the sample to countries and sectors with high extra-EU trade openness only (column (4)). Instead, in all specifications increased trade openness is associated with a lower effect of the input prices on the FPI.

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

	(1)	(2)	(3)	(4)
	Full sample	Full sample	Full sample	High extra-EU trade openness >40%
L.Food price index	0.504***	0.515***	0.426***	0.573***
	(5.56)	(5.11)	(5.29)	(5.18)
L2. Food price index	-0.220***	-0.228***	-0.211***	-0.321***
	(-2.67)	(-2.97)	(-2.96)	(-4.24)
Input price index	0.033	0.070**	0.177***	0.220*
	(0.91)	(2.41)	(2.87)	(1.66)
Extra-EU trade openness (log)	0.005*		0.033**	0.053*
	(1.74)		(2.38)	(1.90)
Intra-EU trade share		-0.030		
		(-1.05)		
			-0.030**	-0.043*

Input price index × Extra-EU trade openness (log)			(-2.35)	(-1.83)
International price	0.025**	0.026**	0.030***	0.035***
	(2.38)	(2.53)	(3.12)	(2.63)
War dummy	0.020***	0.019***	0.052***	0.024***
	(3.87)	(3.81)	(5.15)	(3.81)
International price × War dummy				
Input price index × War dummy				
Vegetation variables	YES	YES	YES	YES
Additional controls	NO	NO	NO	NO
Year FE	YES	YES	YES	YES
Month FE	YES	YES	YES	YES
Number of instruments	84	84	115	116
Number of panel units	183	183	183	103
AR (2)	0.95	0.98	0.93	0.11
N	10634	10976	10634	5986

Note: t -statistics in parentheses* p<0.1, ** p<0.05, *** p<0.01 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.

In Table 3, we show the results using different indicators for international transaction costs related to the global market turbulences. We find that all coefficients of these indicators are positive and the coefficients for the war dummy and the number of export restrictions are statistically significantly different from zero. 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).[7] Therefore, it is reasonable to conclude that global market turbulence and risks associated with the Russia–Ukraine War contribute to increasing food price inflation in the EU. In Table 3, we also test the third hypothesis stating that countries and sectors with a higher integration in international food markets, indicated by a larger trade openness, were more strongly affected by international market turbulences. Interestingly, we do not find stronger impacts on countries and sectors that are more integrated into global food markets. In all cases, the interaction term with extra-EU trade openness is negative

[7] The respective coefficients are positive and significant in the specifications without the interaction term.

and significantly different from zero. 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 Russia-Ukraine war. Therefore, we find robust evidence that greater integration in the global food trade system did not exacerbate, possibly even limit, the inflation effects of global market turbulences. In other words, while increasing trade openness is generally associated with higher real food price inflation, the effect is not reinforced by recent global market turbulences. A plausible rationale is that a better integration in the global food system makes trade less vulnerable to increasing trade risks and costs from restructuring supply chains; for instance, greater trade integration is often associated with a more diversified trade network.

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

	(1)	(2)	(3)	(4)
L.Food price index	0.379***	0.508***	0.469***	0.555***
	(4.36)	(7.22)	(7.04)	(7.05)
L2.Food price index	-0.186**	-0.252***	-0.228***	-0.284***
	(-2.22)	(-4.25)	(-4.09)	(-4.88)
Input price index	0.051	0.098***	0.096***	0.070**
	(1.44)	(4.08)	(3.36)	(2.25)
Extra-EU trade openness (log)	0.004*	0.005**	0.006**	0.007**
	(1.91)	(2.35)	(2.20)	(2.44)
International price	0.026**	0.039***	0.036***	0.040***
	(2.49)	(4.14)	(3.85)	(3.86)
War dummy	0.101***			
	(3.84)			
War dummy × Extra-EU trade openness (log)	-0.013**			
	0.101***			
Geopolitical risk		0.023		
		(0.60)		
Geopolitical risk × Extra-EU trade openness (log)		-0.018**		
		(-2.16)		
Sanction share			0.365	
			(1.32)	
Sanction share × Extra-EU trade openness (log)			-0.137**	
			(-2.30)	
#export restrictions				0.001**
				(2.12)

#export restrictions × Trade openness (log)				-0.000* (-1.74)
Vegetation variables	YES	YES	YES	YES
Additional controls	NO	NO	NO	NO
Year FE	YES	YES	YES	YES
Month FE	YES	YES	YES	YES
Number of instruments	89	145	145	145
Number of panel units	183	183	183	176
AR (2)	0.64	0.56	0.84	0.34
N	10634	10634	10634	10270

Note: t -statistics in parentheses* p<0.1, ** p<0.05, *** p<0.01. 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

In the sector-specific analysis, we consider sectors with different degrees 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 countries 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 fixed effect regressions are presented in detail in Table A3.[8] 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

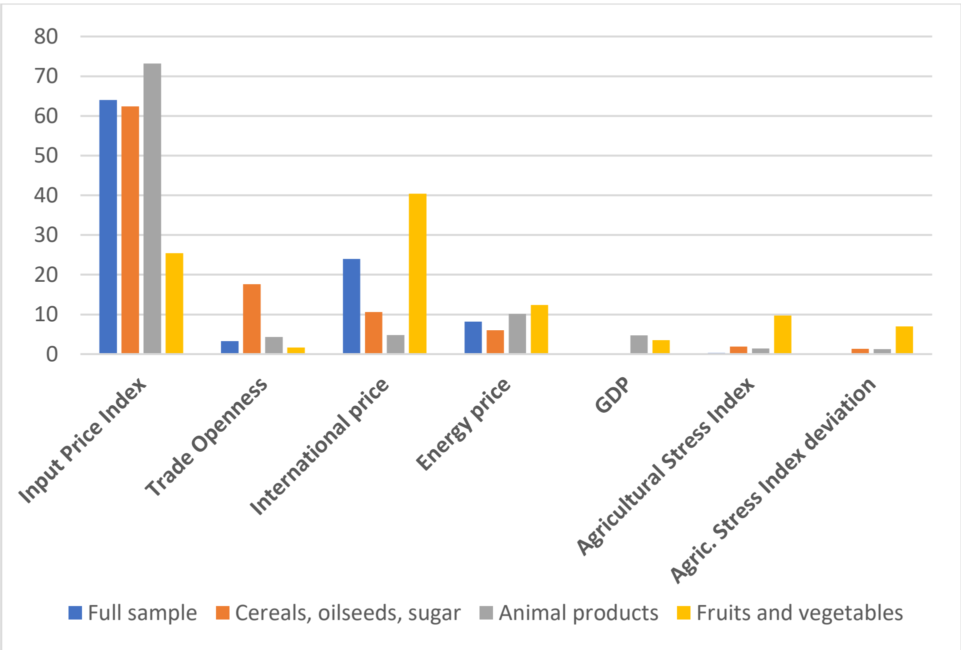
[8] We prefer the fixed effect regression due to the high number of time-invariant interaction terms included in the specifications.

and animal products, but much lower for fruits and vegetables. This is because fruit and vegetable production is more labor intensive and storable commodities and meat does require the bulk of inputs (e.g. fertilizer) (EU Commission, 2019), which has become expensive in recent years. In fact, the coefficient estimates of IPI and the interaction of IPI with fruits and vegetables almost cancel each other out. Coherently, we find that trade openness and 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 to a lesser extent, possibly owed to the fact that the EU is more self-sufficient in these commodities.

In line with our earlier findings, the transaction cost variables are positive and significant (with the exemption of GPR). However, the coefficients of the war dummy and the sanction share 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. Another possible explanation is that geopolitical risks restrict labor movement to and within the EU which leads to labor shortages in the labor-intensive fruits and vegetable sector. In addition to that, the EU's fruit and vegetable trade partners are different from its grain and oilseed trade partners. Fruits and vegetable 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.

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 also consider the period 2000-2022 separately. We show the results for the whole sample and for the three categories of food sectors in Figures 2&3. The input price index is the most important variable in explaining real food price inflation in the EU within the 2007-2022. 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.

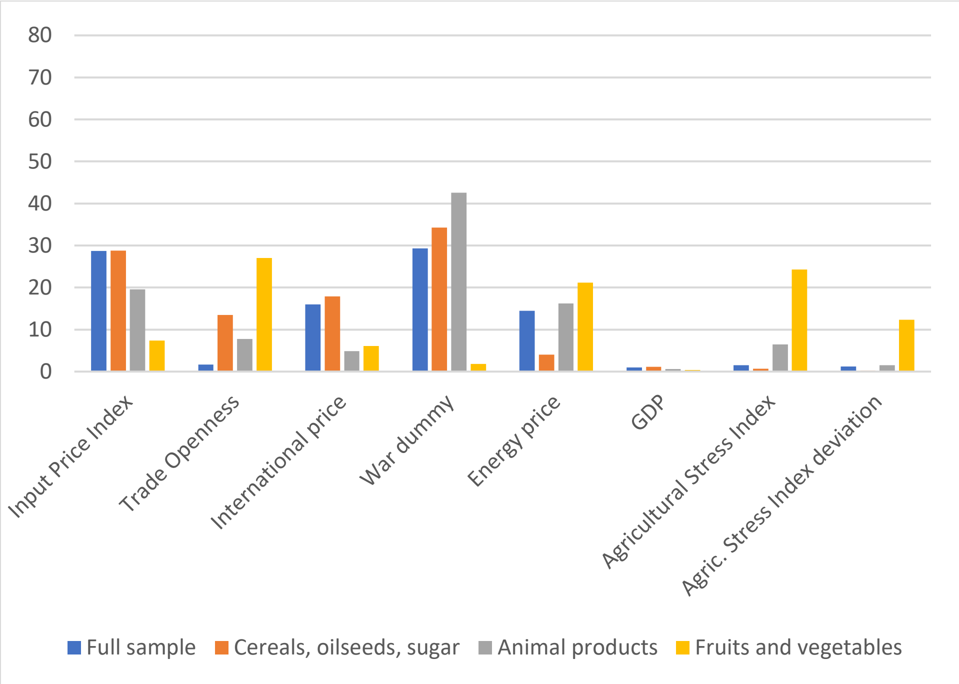
Figure 2: Relative importance of independent variables (net effect) in the variation of the dependent variable from Shapley Decomposition for the period 2007-2022



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

For the period between 2020 and 2022, the war dummy explains most variation for all sectors except fruits and vegetables. Among the remaining drivers, the input prices, the international price, and the energy price are important drivers, while the relative contribution varies across sectors. For cereals and oilseeds, the input price index dominates followed by the international prices. For animal products, variation in input prices and energy prices were almost equally important. Last, for fruits and vegetable products, input prices were less important but variations in trade openness and energy prices contributed most to inflation dynamics.

Figure 3: Relative importance of independent variables (net effect) in the variation of the dependent variable from Shapley Decomposition for the period 2020-2022



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 had little influence on agricultural price dynamics, which confirms findings by Martinez-Garcia et al. (2023) suggesting that energy price increase were more relevant for transport and industry than for agriculture. Secondly, global input and commodity market risks result in EU real food price variability, and therefore, endanger EU food security. Lastly, whilst short-term global market risks, including the Russia–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 the external drivers of post-2020 food inflation patterns in Europe, and the effects of the global market turbulences due to the Covid pandemic and the Russia-Ukraine war on real food price inflation in the EU. The Covid pandemic has affected the agri-food supply chains boosting input and output prices, as well as through changes in the regulatory regimes, as a result of the increasing number of measures adopted to face the crisis (Fatouh et al., 2021). We also investigate the role of international trade in the transmission of global shocks to EU food markets.

Generally, supporting the existing literature, we find that food price inflation was fueled by global market turbulences, namely geopolitical risks and conflict is associated with higher transaction costs of trading. In addition to that, real food price inflation has been driven mainly by rises in input prices, but marked differences are observed across sectors. For fruits and vegetables, the international price has had stronger effects on EU food price inflation. The energy price inflation has also contributed to the inflationary process, but possibly to a lesser extent than in other sectors. Trade openness has been an important driver of price changes for cereals, oilseeds, and sugar.

These 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 among the few investigations on the effects of the Russia-Ukraine war on EU food prices. Different from related studies by Adjemian et al. (2023) and Algieri et al. (2024), we control 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. The supply-side effects are confirmed: the increase in agricultural production costs has been the main driver of food price inflation.

Trade openness, i.e., a larger integration into global food markets, is found to be not associated with larger real food price inflation among the EU countries. Instead, trade integration absorbs parts of the global market shocks on EU food prices. This seemingly counterintuitive result can be explained by the structure of international food trade. Higher trade integration does not necessarily create additional vulnerability to global market shocks insofar as it is generally associated with lower transaction costs of trade. In addition, international trade creates efficiencies in production by creating a comparative advantage for countries with lower production costs. Countries and sectors that are more integrated were able to source imports from countries that experienced lower agricultural input price inflation, limiting the inflationary process.

These findings provide insights for the policy debate. First, reducing global market risks and uncertainties may reduce EU food price inflation pressure. 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 may 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 availability. Third, EU countries should diversify trade relations to reduce the vulnerability to global market shocks and to exploit the efficiency gains from trade. Last, EU policies that aim at increasing EU food production may be helpful if they reduce international market risks, but our results indicate that less market integration will not isolate the EU agro-food sector from the effects of global market turbulences.

The study is admittedly limited, among other issues, by the lack of a comprehensive analysis of the EU trade regime, which is far beyond the scope of this paper. The extant regulatory regime and its effects on trade would have added complexity to the analysis. We traded-off the complexity with the necessity to provide timely results, 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. https://doi.org/10.1002/aepp.13378

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. https://doi.org/10.1002/aepp.13286

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. https://doi.org/10.1007/s12571-020-01082-3

Algieri, B., Kornher, L. and von Braun, J. (2024). "The changing drivers of food inflation – macroeconomics, inflation, and war." ZEF Discussion Papers on Development Policy No. 339, Center for Development Research (ZEF). http://dx.doi.org/10.2139/ssrn.4748639

Baquedano, F**.**, Jelliffe, J., Beckman, J., Ivanic, M., Zereyesus, Y., and Johnson, M. **(**2022**)**. " Food security implications for low- and middle-income countries under agricultural input reduction: The case of the European Union's farm to fork and biodiversity strategies." *Applied Economic Perspectives and Policy* 44(4): 1942–1954. https://doi.org/10.1002/aepp.13236

Bekkers, E., Brockmeier, M., Francois, J., and Yang, F. (2017). "Local food prices and international price transmission" *World Development*, 96, 216-230. https://doi.org/10.1016/j.worlddev.2017.03.008

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. https://doi.org/10.1016/j.eneco.2019.104523

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. https://doi.org/10.1038/s43016-023-00729-6

Caldara, Dario and Matteo Iacoviello (2022), "Measuring Geopolitical Risk," American Economic Review, 112(4), 1194-1225. *https://doi.org/10.1257/aer.20191823*

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. https://doi.org/10.1016/j.foodpol.2023.102405

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. https://doi.org/10.1111/ajae.12278

EU Commission (2019). "Fertilisers in the EU". *EU Agricultural Markets Briefs*, 15, European Comission, Brussels.

EUROSTAT (2023). Statistical Office of the European Commission, Luxemburg, URL https://ec.europa.eu/eurostat/web/main/data/database

Fackler, P. L. and Goodwin, B. K. (2001). "Spatial price analysis.", ch. 17, 971-1024 in Gardner, B. L. and Rausser, G. C. eds., Handbook of Agricultural Economics, vol. 1, Part 2, Elsevier.

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. https://doi.org/10.1016/j.econlet.2021.110138

FAO (2023a). Food and Agriculture Organization (FAO) Food Price Index (FFPI, URL https://www.fao.org/worldfoodsituation/foodpricesindex/en/

FAO (2023b). Food and Agriculture Organization (FAO) - Agricultural Stress Index System (ASIS), URL http://www.fao.org/giews/earthobservation/

FAOSTAT (2023). Food and Agriculture Organization (FAO) Statistical Database. Rome, URL https://www.fao.org/faostat/en/#data

Felbermayr, G., Kirilakha, A., Syropoulos, C. Yalcin, E. and Yotov, Y.V. (2020). “The Global Sanctions Data Base.” *European Economic Review*, 129. 103561. https://doi.org/10.1016/j.euroecorev.2020.103561

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. and Santeramo, F. G. (2023). “Revisiting the impact of per-unit duties on agricultural export prices.” *Applied Economic Perspectives and Policy* 45(3): 1472–1492. https://doi.org/10.1002/aepp.13368

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. https://doi.org/10.5424/sjar/2014124-6292

Freier, M. and Ricci, M. (2023), “How fiscal policy offset the negative welfare effect of euro area inflation”, *VoxEU*, 25th October 2023. https://cepr.org/voxeu/columns/how-fiscal-policy-offset-negative-welfare-effect-euro-area-inflation

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. https://doi.org/10.1111/agec.12209

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

GTA (2023). “Global Trade Alert”, https://www.globaltradealert.org/

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. https://doi.org/10.1038/s41562-021-01079-8

IMF (2023). 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. https://doi.org/10.1007/s10888-006-9036-6

Jafari, Y., Engemann, H., and Zimmermann, A. (2023). "Food trade and regional trade agreements – A network perspective," *Food Policy,* 119(C). https://doi.org/10.1016/j.foodpol.2023.102516

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. https://doi.org/10.1007/s12076-022-00319-3

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, LEI Wageningen UR..

Kornher, L., and von Braun, J. (2024). “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.

Legrand, N. (2023). "War in Ukraine: The rational “wait-and-see” mode of global food markets." *Applied Economic Perspectives and Policy* 45(2), 626-644. https://doi.org/10.1002/aepp.13335

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. https://doi.org/10.1111/agec.12393

Martínez-García, M. Á., Ramos-Carvajal, C., and Cámara, Á. (2023). "Consequences of the energy measures derived from the war in Ukraine on the level of prices of EU countries," *Resources Policy*, 86(B), 104114.

Matthews, A. (2023). “Food price situation in Europe.” *Studies in Agricultural Economics* 125, 60-68. https://doi.org/10.7896/j.2563

Maurer, R. (2023). “The Divergence of Price Levels in the European Union.” *Intereconomics Review of European Economic Policy* 58 (6), 342-346. https://doi.org/10.2478/ie-2023-0069

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. https://doi.org/10.1162/rest_a_00939

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. https://doi.org/10.1016/j.econmod.2018.08.004

Roodman, D. (2009). "How to do xtabond2: An introduction to difference and system GMM in Stata." *The Stata Journal*, 9(1), 86-136. https://doi.org/10.1177/1536867X0900900106

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. https://doi.org/10.1002/aepp.13351

Saâdaoui, F., Ben Jabeur, B., S., and Goodell, J.W. (2022). "Causality of geopolitical risk on food prices: Considering the Russo–Ukrainian conflict," *Finance Research Letters*, Elsevier, vol. 49(C). https://doi.org/10.1016/j.frl.2022.103103

Santeramo, F. G. (2015). "Price transmission in the European tomatoes and cauliflowers sectors." *Agribusiness*, 31(3), 399-413. https://doi.org/10.1002/agr.21421

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. https://doi.org/10.1002/aepp.13276

Sun, T.-T. and Su, C.W. (2024). "How is geopolitical risk associated with food prices?", International Journal of Emerging Markets, forthcoming, https://doi.org/10.1108/IJOEM-01-2023-0004

Syropoulos, C., Felbermayr, G., Kirilakha, A., Yalcin, E., & Yotov, Y. V. (2024). "The global sanctions data base–Release 3: COVID-19, Russia, and multilateral sanctions." *Review of International Economics*, 32(1), 12–48. https://doi.org/10.1111/roie.12691

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).

World Bank (2023). "World Bank Commodities Price Data (The Pink Sheet)", URL https://www.worldbank.org/en/research/commodity-markets

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)	(5)	(6)
L.Food price index	0.440***	0.569***	0.584***	0.624***	0.353***	0.470***
	(5.72)	(6.40)	(5.87)	(7.04)	(4.38)	(5.84)
L2. Food price index	-0.160*	-0.259***	-0.253***	-0.280***	-0.290***	-0.225***
	(-1.87)	(-3.64)	(-3.28)	(-4.59)	(-4.21)	(-3.47)
Input price index	0.103***	0.054*	0.088***	0.030	0.512***	0.392***
	(5.24)	(1.89)	(2.87)	(1.08)	(3.41)	(3.31)
Extra-EU trade openness (log)	0.019*	0.006	0.011	0.004	0.045	0.059***
	(1.68)	(0.69)	(1.28)	(0.50)	(1.41)	(2.76)
Input price index × Extra-EU trade openness (log)					-0.062***	-0.052***
					(-2.65)	(-2.80)
International price	0.045***	0.026***	0.014	0.031***	0.031***	0.027***
	(4.59)	(2.61)	(1.14)	(3.12)	(3.69)	(2.77)
War dummy	0.010*	0.019***	0.023***	0.023***	0.012**	0.019***
	(1.95)	(3.91)	(3.03)	(5.08)	(2.37)	(3.91)
System/Diff gmm	System	System	System	System	Diff	System
Vegetation variables	NO	NO	YES	YES	YES	YES
Additional controls	NO	NO	NO	YES	NO	NO
Year FE	NO	YES	YES	YES	YES	YES
Month FE	NO	YES	YES	YES	YES	YES
Time trend	YES	NO	NO	NO	NO	NO
Number of instruments	83	84	86	118	111	116
Number of panel units	183	183	177	183	183	183
AR (2)	0.54	0.68	0.56	0.43	0.26	0.89
N	10634	10634	10262	10634	10451	10634

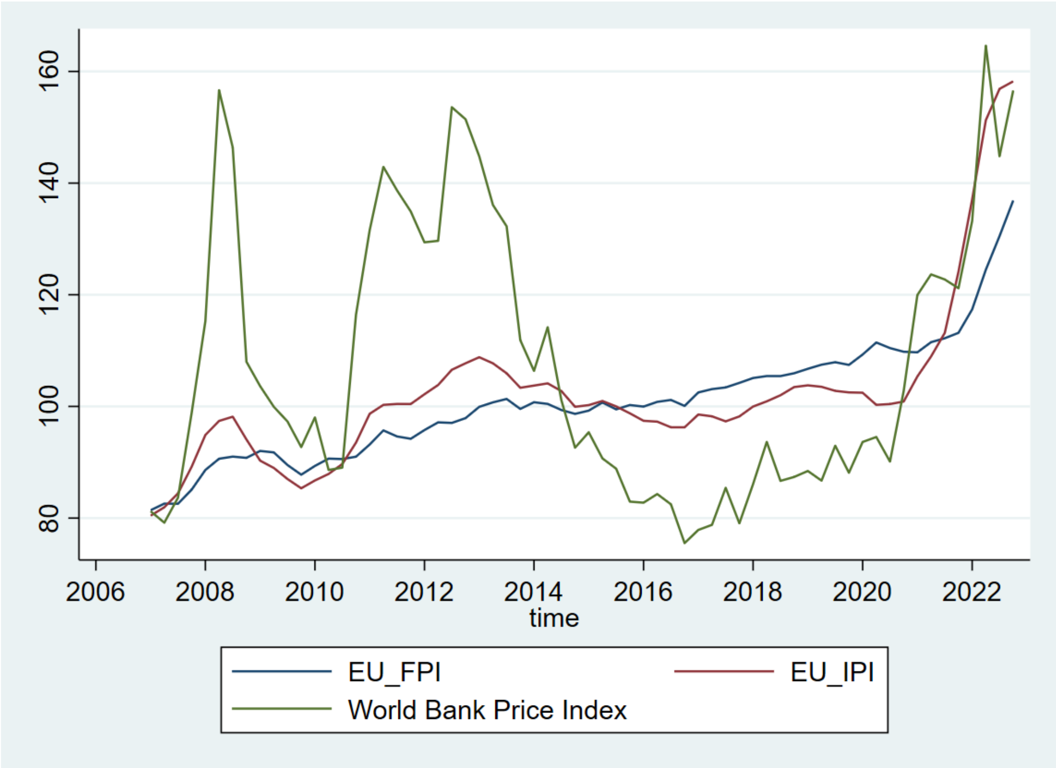
Note: t -statistics in parentheses* p<0.1, ** p<0.05, *** p<0.01. We treat the lagged dependent variable as predetermined. Input price index, Trade openness, and its interaction are considered endogenous.

Table A3: Drivers of real food price inflation: sectoral heterogeneity using the FE estimator

	(1)	(2)	(3)	(4)	(5)	(6)
L.Food price index	0.705***	0.704***	0.705***	0.702***	0.705***	0.706***
	(72.23)	(72.22)	(72.21)	(72.05)	(72.23)	(72.30)
L2. Food price index	0.050***	0.046***	0.049***	0.054***	0.049***	0.049***
	(5.06)	(4.69)	(4.98)	(5.43)	(4.97)	(4.91)
Input price index	0.0501***	0.0353***	0.0358***	0.0268**	0.0780***	0.0873***
	(4.50)	(3.73)	(3.78)	(2.80)	(12.49)	(15.41)
Input price index × animal products	-0.004 (-0.34)					
Input price index × F&V	-0.046*** (-3.73)					
Extra-EU trade openness (log)	0.000 (0.77)	-0.000 (-0.14)	0.000 (0.92)	0.000 (0.69)	0.000 (0.82)	0.000 (0.78)
Extra-EU trade openness (log) × animal products		-0.000 (-0.03)				
Trade openness (log) × F&V		0.014*** (5.24)				
International price	0.044***	0.044***	0.039***	0.045***	0.046***	0.049***
	(9.01)	(9.19)	(6.25)	(9.36)	(9.63)	(9.95)
International price × animal products			-0.005 (-0.53)			
International price × F&V			0.032*** (3.63)			
War dummy				0.031***		
				(6.41)		
War dummy × animal products				-0.005 (-0.53)		
War dummy × F&V				-0.025***		
				(-5.06)		
GPR					-0.005	
					(-0.81)	
GPR × animal products					-0.015* (-1.71)	
GPR × F&V					-0.010	
					(-1.15)	
Sanction share						0.129**
						(2.47)
Sanction share × animal products						-0.029 (-0.30)
Sanction share × F&V						-0.111
						(-1.11)
Vegetation variables	YES	YES	YES	YES	YES	YES
Additional controls	NO	NO	NO	NO	NO	NO
Year FE	YES	YES	YES	YES	YES	YES
Month FE	YES	YES	YES	YES	YES	YES
N	10634	10634	10262	10634	10634	10634

Note: t -statistics in parentheses* p<0.1, ** p<0.05, *** p<0.01. 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 World Bank (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. World Bank Price Index is the World Bank's price index for cereals.