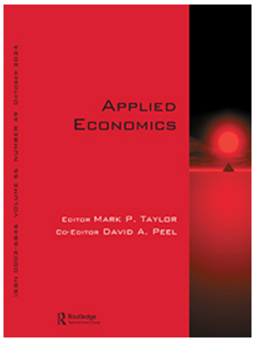
Geopolitical risks, institutional environment, and food price inflation



Routledge
Taylor & Francis Group

Applied Economics

ISSN: (Print) (Online) Journal homepage: www.tandfonline.com/journals/raec20

Geopolitical risks, institutional environment, and food price inflation

Chenggang Li, Wanyue Zhang, Xing Huang & John F. Zhang

To cite this article: Chenggang Li, Wanyue Zhang, Xing Huang & John F. Zhang (11 Aug 2024): Geopolitical risks, institutional environment, and food price inflation, Applied Economics, DOI: 10.1080/00036846.2024.2386853

To link to this article: https://doi.org/10.1080/00036846.2024.2386853

Published online: 11 Aug 2024.

APPLIED ECONOMICS
https://doi.org/10.1080/00036846.2024.2386853

Geopolitical risks, institutional environment, and food price inflation

Chenggang Li[a,b], Wanyue Zhang[a], Xing Huang[c] and John F. Zhang[d]

[a]School of Big Data Application and Economics, Guizhou University of Finance and Economics, Guiyang, Guizhou, China; [b]Guizhou Key Laboratory of Big Data Statistical Analysis, Guizhou University of Finance and Economics, Guiyang, Guizhou, China; [c]Henley Business School, University of Reading, Henley-on-Thames, UK; [d]School of Business, Macau University of Science and Technology, Taipa, Macao, China

ABSTRACT
This study investigates the relationship between heightened geopolitical risks and food price inflation using a panel data model that includes 33 countries from 2001 to 2020. Key findings show that geopolitical risks significantly raise the level of food price inflation, with a more pronounced effect observed in developing countries, and a reduced effect in countries characterized by high levels of individualism and masculinity. Furthermore, the effect of geopolitical risks on food inflation is moderated during economic booms and amid climate change concerns. In addition, we find that countries with strong connections to major food producers experience less impact from geopolitical risks. The study concludes that geopolitical risks are a crucial factor in food price inflation, particularly for vulnerable countries, suggesting that they should incorporate geopolitical considerations into their economic policies and strengthen ties with major food producers to mitigate this risk.

KEYWORDS
Geopolitical risk; food price inflation; national culture; fixed-effects regression

JEL CLASSIFICATION
F51; Q18; E31; Z10

I. Introduction

In the complex interplay of global economics, food price inflation emerges as a critical macroeconomic indicator, directly impacting individual well-being and national economic stability. The maintenance of stable food prices is crucial, as it not only safeguards the interests of farmers and consumers, but also promotes agricultural investment and socio-political stability, and encourages economy-wide investment (Dawe and Timmer 2012). For example, Negi (2022) illustrates the direct effects of increased rice and wheat prices on Indian households, showing a rise in labour hours among adult males and a significant decline in household welfare.

Previous studies on food price inflation mainly focus on microeconomic aspects, treating food products as typical market commodities influenced by supply and demand dynamics. For example, evidence shows that energy prices such as oil and ethanol have a significant impact on food price and volatility, underscoring the energy-food price nexus (e.g. Lee, Olasehinde-Williams, and Akadiri 2021a; Lee, Olasehinde-Williams, and Özkan 2023; Serra and Gil 2013; Taghizadeh-Hesary, Rasoulinezhad, and Yoshino 2019). Complementing these perspectives, other studies examine determinants such as food production, infrastructure, climate change, and imports that directly shape food price inflation, integrating seasonal, environmental, and demand-related variations into the broader context of food market fluctuations (Gedik and Günel 2021; Ismaya and Anugrah 2018).

Furthermore, Gilbert (2010) points out that food price inflation is not solely influenced by market-related factors but also by macroeconomic- and political-related factors, in particular geopolitical risks.[1] Caldara et al. (2022) define geopolitical risk as the threat, realization, and escalation risk arising from adverse events

CONTACT Xing Huang xing.huang@henley.ac.uk Henley Business School, University of Reading, Henley-on-Thames RG6 6UD, UK

[1]Studies have found that a country's monetary policy plays a crucial role in the stability of its food prices. Both expansionary and restrictive monetary policies can profoundly influence food price inflation, with restrictive policies particularly contributing to increased food price levels across both developed and developing countries (Iddrisu and Alagidede 2020). In the context of price inflationary pressure in the food sector, monetary tightening may destabilize food prices as well as the overall level of inflation in the region's economy (Bhattacharya and Jain 2020). Macroeconomic volatility can also contribute to food price instability (Serra and Gil 2013). The higher the level of economic integration, the less volatile food prices are in that country, and this correlation is statistically significant in middle- and high-income countries (Gozgor 2019).

related to war, terrorism, and interstate tensions affecting the peace process in international relations.[2] The backdrop of increasing geopolitical risks, such as trade disputes, international conflicts, and sanctions, further complicates the food pricing landscape, exacerbating volatility in food markets. These geopolitical factors can disrupt supply chains, resulting in food shortages and fluctuations in prices (Lee, Olasehinde-Williams, and Akadiri 2021a). Such volatility in food prices impacts not only affordability and access but also has broader economic implications, including the potential for inflationary pressures and social unrest. Specifically, geopolitical risks primarily impact prices of farm commodities and energy which are regarded as major influencing factors on food prices (Baek and Koo 2010).

Against the backdrop of the current global landscape and financial globalization, the significant repercussions for international food markets have been widely recognized around the world. This context creates a pressing need to examine the specific impacts of geopolitical risks on food price inflation – a topic that remains understudied in the existing literature. To date, however, only a few studies have shed light on the impact of geopolitical risks on food prices, primarily focused on specific aspects such as the impact of geopolitical risks on medium-term agricultural spot markets, commodity prices such as oil, minerals and natural resources (Jana and Ghosh 2023; Saâdaoui, Jabeur, and Goodell 2022; Tiwari et al. 2021). Moreover, they highlight that geopolitical risks are exogenous and fall beyond the reach of food producers' preventive measures, and are therefore unlikely to be hedged or mitigated (Tiwari et al. 2021). Despite their contributions, the broader implications of geopolitical risks on food price inflation remain relatively understudied. Therefore, it is crucial to investigate the effects of geopolitical risks on food price inflation to gain insights that promote stable and sustainable economic growth worldwide.

In this paper, we examine the impact of geopolitical risks on the level of food price inflation using a sample of 33 countries over the period 2001–2020. We use the measure of geopolitical risks constructed by Caldara and Iacoviello (2022) and utilize data obtained from the World Bank's Prospects Group to proxy other variables.[3] Our study applies a fixed-effects regression model to analyse unbalanced panel data at both monthly and yearly frequencies. The results show that geopolitical risks are significantly and positively correlated with food price inflation levels. The main finding holds across various robustness tests.

We further explore the impact of geopolitical risks on food price inflation by analysing the mediating role of different institutional environments. Institutional environments shape the stability of international relationships by influencing uncertainties and costs, which in turn impact trade and foreign investments (Balcilar, Tokar, and Godwin 2020; Martínez-Zarzoso and Márquez-Ramos 2019). For example, Engemann, Jafari, and Heckelei (2023) show that the stability of agri-food exports from sub-Saharan African to the EU improves with enhanced institutional quality in the exporting countries and when institutional frameworks align between trading partners. This aspect of stability also influences food prices, which are critical for economic welfare across borders but may be disrupted by geopolitical tensions intensified by institutional conditions.

In this study, we consider five dimensions of institutional environments: national culture, market development, business cycle, climate change, and intercountry relations. Specifically, we find that geopolitical risks have a more pronounced impact on food price inflation in developing markets, while the effect is moderated in developed markets. Moreover, using Hofstede, Hofstede, and Minkov (2010) cultural dimensions, we find consistent evidence, both in monthly and annual data, that the positive relationship between geopolitical risks and food price inflation can be mitigated by two cultural traits: individualism and masculinity.

[2]Although there have been no wars since the 21st century at a scale comparable to World War I and II, there have been incidents such as terrorist threats, violent conflicts, and non-violent tensions. In the 2015 Global Risks Report, the World Economic Forum in Davos views geopolitical risk as a global risk that is systemic, geographically and sectorally diverse, covering violent interstate conflicts, civil strife in key countries, large-scale terrorist attacks, the proliferation of weapons of destruction, and the failure of global governance.

[3]These data can be collected from the World Bank's 'A Global Database of Inflation'. A detailed data description is provided by Ha, Kose, and Ohnsorge (2021).

In contrast, the positive effect is intensified by stronger cultural tendencies towards uncertainty avoidance. We additionally considered the effects of the business cycle and climate change. The results show that geopolitical risks have a reduced impact on food price inflation during economic booms and amid climate change concerns. Finally, we find that strong relations between target countries and major food-producing countries significantly mitigate the impact of geopolitical risk on food price inflation. Moreover, in the long run, we observe a substitution effect between geopolitical risk and international country relations, both of which positively affect food price inflation.

The contributions of this paper are as follows. First, this paper contributes to the literature on determinants of food price inflation. Existing studies highlight that food price inflation is influenced by a range of factors, including demographic considerations include the population size of a country or region, financial metrics such as exchange rate and GDP per capita, as well as agricultural factors like the scale of food production and import levels (Dorward 2013; Samal, Ummalla, and Goyari 2022; Wong and Shamsudin 2017). In addition, macroeconomic factors play an important role, specifically monetary policies (Bhattacharya and Jain 2020) and economic interconnectedness among countries or regions (Gozgor 2019). Our paper extends the literature by adding empirical evidence that, even after controlling for the above variables, geopolitical risk remains a significant factor influencing changes in food price inflation. Our findings establish a positive and significant correlation between geopolitical risk and fluctuations in food price levels, shedding light on an understudied area in previous research. This study not only broadens the range of recognized determinants of food price inflation but also highlights the unique impact of geopolitical dynamics.

Further, this paper provides unique insight into the interconnectivity of geopolitics, food prices, and inflation in the global economy. This insight is especially important in the face of escalating geopolitical tension in many regions. It expands literature on the consequences of geopolitical risk with a particular focus on food price inflation. Given the high level of economic and financial globalization, geopolitical tensions may disrupt international trade and negatively affect commodity trade (Singh and Roca 2022). Previous studies have documented that a higher level of geopolitical risks can lead to price-level changes for various commodities. For instance, El-Gamal and Jaffe (2018) find that military conflicts have a significant impact on oil supplies and prices by disrupting production facilities or transportation networks, while Singh and Roca (2022) suggest that geopolitical risks can also disrupt world trade and financial markets. However, empirical evidence regarding the impact on the global food market remains relatively limited. Contributing to this strand of literature, we show that increased food price inflation is a significant result of geopolitical risk, highlighting its impact on societal welfare and economic growth. These findings highlight the importance for policymakers and stakeholders to factor in geopolitical dynamics in strategies for food price stability and economic resilience.

Third, we extend the literature by utilizing comprehensive panel data across various national cultures and provide a more extensive examination. While a few recent studies have attempted to study the relation between geopolitical risks and food prices (Jana and Ghosh 2023; Saâdaoui, Jabeur, and Goodell 2022; Tiwari et al. 2021), they mainly rely on time-series data from single countries. Our approach leverages the benefits of panel data in exploring the relationship between geopolitical risks and food price inflation. Specifically, it addresses endogeneity issues caused by unobservable individual heterogeneity such as unobserved variables, or the possible reverse causation of food price inflation on geopolitical risks. In addition, the broader sample size in this study allows for more insights into the dynamic interplay of variables, such as culture, business cycles, and climate change, thus enhancing the validity of our conclusions.

The structure of this paper is as follows. Section II details the research design of this paper, mainly including the introduction of the sample and variables. Section III is the empirical analysis for baseline results. Section IV is the robustness test of the research results. Section V provides further analysis and discussion on this basis. Section VI concludes the paper with an outlook.

II. Data and methodology

Data and variables

We measure geopolitical risks using the index developed by Caldara and Iacoviello (2022), which aggregates the frequency of mentions of each country across 10 newspapers as an indicator of the level of geopolitical risk in a country (region). The benchmark *Geopolitical Risk Index* (*GPR*) has been compiled since 1985, based on these newspaper sources. Alternatively, Caldara and Iacoviello (2022) have also constructed the *Geopolitical Risk Historical Index* (*GPRH*) which employs the same methodology as *GPR* but is derived from three newspapers, with data starting from 1900.[4] To ensure the robustness of our results, we use both *GPR* and *GPRH* in the empirical analyses.

Figure 1 illustrates annual geopolitical risks across countries over the sample period, especially highlighting five major geopolitical conflicts. The data shows that the levels of the geopolitical risk are higher during these major geopolitical conflicts, with the peak observed during the Iraq war. Figure 1 emphasizes the importance of accounting for temporal variations, which has led us to include a time-fixed effect in our analysis.

The data on food price inflation and each control variable are obtained from the World Bank's Prospects Group, which has compiled a global database covering 196 countries starting in 1970.[5] These data are accessible through the World Bank's 'A Global Database of Inflation'. A detailed data description of the data is provided by Ha, Kose, and Ohnsorge (2021). Based on this data, we construct our explanatory variable, the rate of food price inflation (*FPI*).

After the data matching process, our final sample consists of 33 countries[6] that have relatively complete data from January 2001 to February 2020. Data from other countries was excluded due to inconsistencies or incompleteness, thereby ensuring analytical accuracy and generalizability of our findings.[7]

Figure 2 reports geopolitical risks and food price inflation by country using monthly data; Panel

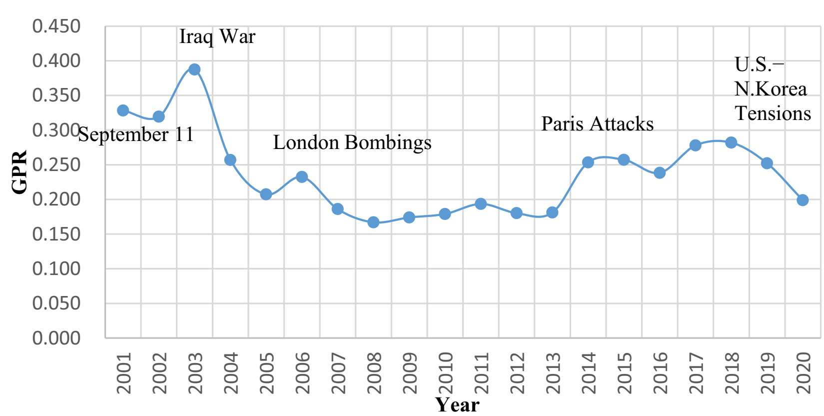


Figure 1. Overall geopolitical risk changes. This figure shows the change in overall geopolitical risk of all sample countries over time. The major events related to geopolitical risks are also indicated in the graph. The data are based on annual values by averaging the monthly data. The sample period covers from January 2001 to February 2022.

[4]The dataset covers 43 countries and is well accepted in the literature such as Saâdaoui, Jabeur, and Goodell (2022) and Tiwari et al. (2021). See a detailed data description at https://www.matteoiacoviello.com/gpr.htm. and https://www.policyuncertainty.com/gpr.html.

[5]The data can be downloaded from https://www.worldbank.org/en/research/brief/inflation-database (A Global Database of Inflation).

[6]These countries include: ARG, BEL, BRA, CAN, CHE, CHL, DEU, DNK, ESP, FIN, FRA, GBR, HKG, HUN, IDN, IND, ISR, ITA, JPN, MEX, MYS, NLD, NOR, PHL, POL, PRT, RUS, SAU, SWE, THA, TUR, U.S.A., ZAF.

[7]We argue that these countries represent a wide range of economic systems, covering from developed economies such as the US, Japan and Germany, to emerging economies such as Brazil, India, and Indonesia. The geographical spread in major continents and regions, including North America, South America, Europe, Asia, Africa, and Oceania, adds to the representativeness in global geopolitical and economic conditions in our investigation. In addition, these countries contribute a significant portion of the world's GDP, covering some of the largest economies such as the US, Japan, China, and Germany. Their economic activities significantly influence global trade patterns, investment flows, and financial markets. Lastly, these countries are heavily involved in the world's supply chain and trade networks, allowing for reliable insights into the dynamics of food price inflation influenced by geopolitical risks.

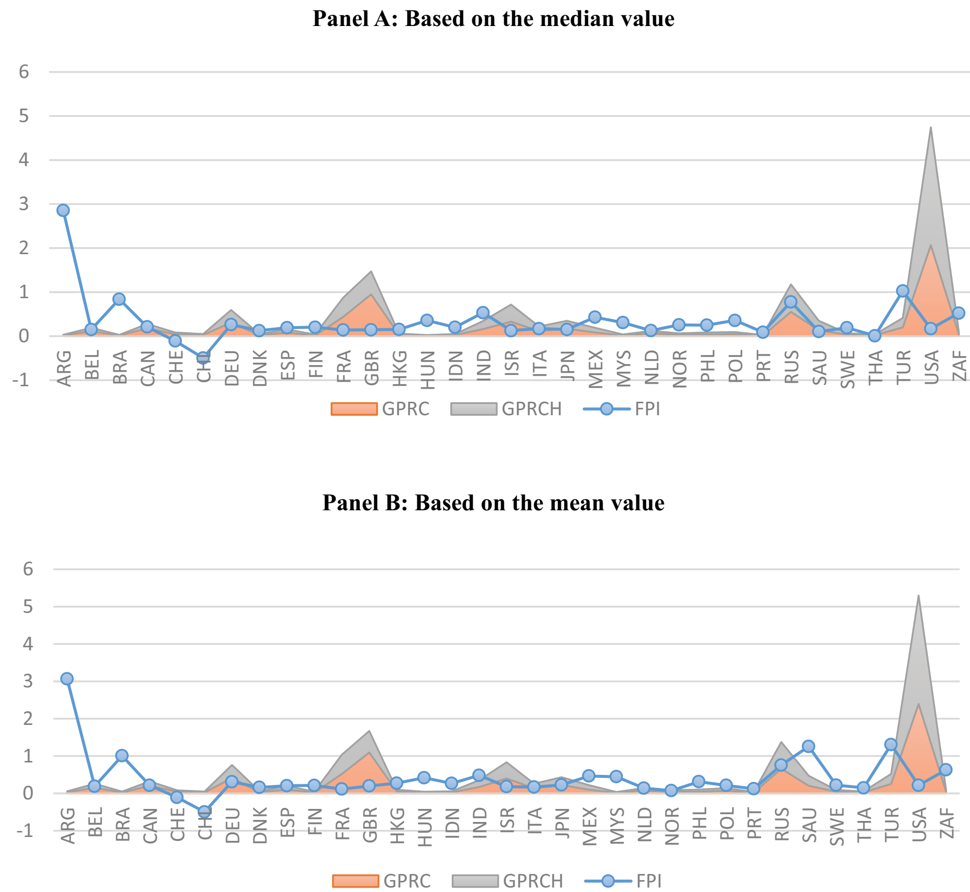


Figure 2. Geopolitical risk and food price inflation by country. This figure shows country-level geopolitical risk and food price inflation. *GPCR* represents geopolitical risks measured according to the tones of 10 papers. *GPRCH* represents geopolitical risks measured historically according to the tones of three papers. *FPI* represents food price inflation. The data are based on monthly values over the period from January 2001 to February 2022.

A and Panel B use the medians and means, respectively. Both panels generally indicate that countries with lower geopolitical risks experience reduced food price inflation, although there are notable exceptions. The most evident example is the U.S. where despite relatively high geopolitical risks, food price inflation remains low. Furthermore, despite its lower geopolitical risk, Argentina experiences higher food price inflation. This highlights the importance of a comprehensive analysis of food price inflation that extends beyond geopolitical risks.

Empirical model

To test the relationship between geopolitical risk and food price inflation, we construct the following empirical model:

$$FPI_{i,t} = \beta_0 + \beta_1 GPR_{i,t} + \beta_2 Controls_{i,t} + FE + \varepsilon_{i,t} \tag{1}$$

where $FPI_{i,t}$ is the food price inflation rate of a country i at the end of period t; GPR denotes the geopolitical risk index for a country i at the end of period t; $Controls$ represent control variables including the energy price index (EPI); the natural logarithm of real GDPs, using 2017 international currency as the base year (GDP); the natural logarithm of total populations (POP); net food imports, calculated as total food imports minus exports and scaled by GDP of the country (FIMP); cereal yield, measured in kilograms per hectare (YIELD); permanent cropland, measured in the percentage of land area (LAND); the industry structure, quantified by the share of agriculture industry in total GDP (SHR01); and the annual effective official exchange rate (EX).

Due to missing data across various countries and years, excluding these observations would reduced our sample size and diminish the statistical robustness of our regression analysis. To mitigate this issue, this study utilizes a fixed-effects regression model applied to unbalanced panel data, which allows for a better utilization of the available data while controlling for unobserved heterogeneity. Specifically, this approach includes time-fixed effects and utilizes double cluster standard errors on time and country.[8] Although monthly data offer higher frequency, most macroeconomic data are available annually. We therefore conduct both monthly and annual analyses to capture a comprehensive understanding of the relationship.

In the analysis using monthly data, control variables include the energy price index (*EPI*), real exchange rate (*EX*), net export calculated as total export minus import scaled by GDP (*NX*), and currency importance, measured by percentage and ranking of a specific currency. Data used to construct these variables are obtained from the World Bank, with complementary data from the China Stock Market and Accounting Research (CSMAR) database. A drawback of monthly data is that most economic indicators are not reported monthly, potentially leading to omitted variable issues. We therefore conduct another analysis using annual data.

In our annual data analysis, we first employ the means and medians of monthly *GPR* and *GPRH* each year to estimate the annual values. Then we obtain annual food price inflation and energy price inflation data provided by Ha, Kose, and Ohnsorge (2021). Control variables include the natural logarithm of real GDP (*GDP*); the natural logarithm of total populations (*POP*); net food imports (*FIMP*); cereal yield (*Yield*)[9]; permanent cropland (*LAND*)[10]; the industry structure (*SHR01*); and the annual effective official exchange rate (*EX*). Table 1 presents summary statistics of those variables. The Appendix provides detailed variable descriptions.

III. Baseline results

Unit root test

Before proceeding with the empirical analysis, we conduct a unit root test on the unbalanced panel data to ensure that the variables do not exhibit any non-stationary behavior, which could potentially affect our results.[11] We utilize the Fisher-type unit root test, which is suitable for datasets with uneven sample sizes across panels. As reported in Table 2, we are able to reject the null hypothesis at the 1% significance level for all variables, confirming their stationarity. This finding validates the inclusion of these variables in our regression model, as it ensures that our analysis will not be compromised by spurious correlations resulting from data non-stationarity.

Monthly data analysis

The regression results using monthly data are shown in Table 3. Columns (1) to (3) use *GPR* to measure geopolitical risks, while columns (4) to (6) use *GPRH*. The coefficients on both *GPR* and *GPRCH* are consistently positive at the 1% level of significance. These results suggest that geopolitical risks are significantly and positively related to the food price inflation of a country.

The results for control variables are also noteworthy. In columns (1) and (4), the coefficients on *EPI* are significantly and positively associated with *FPI*, indicating that higher energy prices in a country correspond to higher food prices. However, when we control for currency status in columns (2), (3), (5), and (6), the significant effect of *EPI* disappears. Instead, the influence of the currency becomes significant. For example, in columns (2) and (5), *Currency (percentage)* is significantly and negatively related to *FPI*, indicating that countries with a larger share of

[8]In this case, it is not feasible to control for country-level fixed effect because our key independent variable, geopolitical risk, does not significantly change year by year. A time demeaning on the country-level variables would make the value of geopolitical risk very minimal.

[9]According to the World Bank, the measure of cereal yield is defined as 'kilograms per hectare of harvested land, includes wheat, rice, maize, barley, oats, rye, millet, sorghum, buckwheat, and mixed grains'. Production data on cereals relate to crops harvested for dry grain only. Cereal crops harvested for hay or harvested green for food, feed, or silage and those used for grazing are excluded. The FAO allocates production data to the calendar year in which the bulk of the harvest took place. Most of a crop harvested near the end of a year will be used in the following year'. See a detailed description at https://databank.worldbank.org/metadataglossary/world-development-indicators/series/AG.YLD.CREL.KG.

[10]The World Bank defines permanent cropland as 'the land cultivated with crops that occupy the land for long periods and need not be replanted after each harvest, such as cocoa, coffee, and rubber. This category includes land under flowering shrubs, fruit trees, nut trees, and vines, but excludes land under trees grown for wood or timber'. See a detailed description at https://databank.worldbank.org/metadataglossary/africa-development-indicators/series/AG.LND.CROP.ZS.

[11]We thank an anonymous referee for suggesting this section.

Table 1. Summary statistics.

Variable	Obs.	Mean	Std Dev	P10	Median	P90
FPI	14,872	0.66	4.30	−0.67	0.26	1.68
GPRC	14,939	0.23	0.50	0.01	0.07	0.56
GPRCH	14,939	0.23	0.53	0.01	0.07	0.51
GPR (mean)	1,457	0.21	0.41	0.02	0.07	0.48
GPR (median)	1,457	0.18	0.37	0.02	0.06	0.42
GPRH (mean)	2,035	0.22	0.47	0.02	0.07	0.48
GPRH (median)	2,035	0.19	0.44	0.02	0.06	0.43
EPI	13,543	0.75	10.86	−1.26	0.23	2.51
NX	7,942	1.50	9.02	−1.48	0.16	1.40
EX	11,363	101.43	77.33	79.60	98.80	114.50
Currency (%)	2,565	14.42	16.44	0.35	1.84	37.46
Currency (#)	2,565	7.86	6.37	2.00	6.00	18.00
EPU	1,432	135.91	91.62	61.45	109.13	241.93
FIMP	5,638	−13.28	25.01	−53.99	−4.47	11.24
GDP	4,682	24.95	2.18	22.06	24.78	27.80
GDP per capita	4,700	8.98	1.23	7.29	9.06	10.56
POP	7,228	15.65	1.97	12.74	15.83	18.01
SHR01	7,231	15.13	13.83	1.77	10.75	35.35
YIELD	6,721	7.66	0.77	6.72	7.68	8.61
LAND	6,737	12.95	3.08	7.94	13.61	16.19
FERT	6,331	189.05	617.28	4.20	83.33	351.14

This table provides descriptive statistics of variables used in the empirical analysis. *FPI* is the food price inflation rate, *GPRC* denotes the monthly geopolitical risk index; *GPRCH* denotes the monthly geopolitical risk index measured by historical approach; *GPR* denotes the annual geopolitical risk index; *GPRH* denotes the annual geopolitical risk index measured by historical approach. Mean and Median indicate if the *GPR* and *GPRH* are computed using mean or median monthly data. *EPI* is energy price index, *NX* is the natural logarithm of net export calculated as total export minus import, *EX* is real or effective exchange rate, Currency (%) and Currency (#) evaluate the importance of a currency as measured by percentage and ranking of a certain currency used in the transactions, *FIMP is* the net food import calculated as total food import minus export and the value is then scaled by GDP of the country, *GDP* is the natural logarithm of real GDP with 2017 international currency as the constant, *GDP per capita* is natural logarithm of real GDP per capita with 2017 international currency as the constant, *POP* is the natural logarithm of total population, *YIELD* is cereal yield as measured by kilogram per hectare, *LAND* is permanent cropland as the percentage of land area, *SHR01* is the industry structure as measured by the share of agriculture industry as the component of total GDP, and *FERT* is fertilizer consumption as measured by kilograms per hectare of arable land. 'Obs'. stands for the number of observations. 'Mean' column reports the average value. 'Std Dev' stands for standard deviation. 'P10' column reports the 10th percentile value. 'Median' column reports the median value. 'P90' columns report the 90th percentile value.

Table 2. Unit root test.

Variable	Inverse chi-squared	p-value
FPI	1997.891	0.000
GPRC	1915.157	0.000
GPRCH	1834.030	0.000
GPR (mean)	408.160	0.000
GPR (median)	346.918	0.000
GPRH (mean)	491.118	0.000
GPRH (median)	437.951	0.000
EPI	2175.590	0.000
NX	218.053	0.000
EX	1046.605	0.000
Currency (%)	199.456	0.000
Currency (#)	244.641	0.000
EPU	77.739	0.000
FIMP	1017.437	0.000
GDP	773.235	0.000
GDP per capita	515.036	0.000
POP	668.663	0.000
SHR01	977.370	0.000
YIELD	1077.842	0.000
LAND	1083.549	0.000
FERT	1046.146	0.000

global transactions in their currency experience lower food price inflation. Similarly, significant and positive coefficients on *Currency (rank)* in columns (3) and (6) support this conclusion, suggesting that countries with stronger currencies may mitigate the impact of energy prices on food prices. Therefore, although energy prices are positively correlated with food prices, the strength of a country's currency may counteract this effect.

In addition, the results also show that *NX* is positively related to *FPI* and *EX* is negatively related to *FPI*, with all coefficients significant at the 1% level. This suggests that countries with a trade imbalance, where imports exceed exports, as well as countries with higher exchange rates, generally experience lower food price inflation. This could explain why the U.S., despite experiencing higher geopolitical risks, has lower food price inflation compared to Argentina, as shown in Figure 1.

Overall, after controlling for other determinants of the food price, the results in this section provide evidence that an increase in geopolitical risk is associated with a rise in food price inflation in a country during the observed period.

Table 3. Regression results on the effect of geopolitical risks on food price inflation – monthly data analysis.

	Dependent variable: FPI					
	(1)	(2)	(3)	(4)	(5)	(6)
GPRC	0.089***	0.138***	0.162***			
	(6.22)	(5.24)	(6.08)			
GPRCH				0.077***	0.128***	0.137***
				(6.55)	(5.82)	(6.30)
EPI	0.043***	−0.005	−0.006	0.043***	−0.005	−0.006
	(3.98)	(−0.46)	(−0.60)	−3.99	(−0.45)	(−0.58)
NX	0.005***	0.005***	0.005***	0.005***	0.005***	0.005***
	(5.10)	(4.36)	(4.17)	(5.05)	(4.35)	(4.15)
EX	−0.020***	−0.013***	−0.010***	−0.019***	−0.013***	−0.010***
	(−13.24)	(−5.95)	(−4.90)	(−13.22)	(−5.99)	(−4.90)
Currency (%)		−0.003***			−0.003***	
		(−3.08)			(−3.30)	
Currency (#)			0.019***			0.018***
			(6.69)			(6.58)
Constant	2.848***	1.999***	1.539***	2.829***	1.995***	1.541***
	(12.05)	(7.34)	(5.89)	(12.00)	(7.39)	(5.91)
Fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.131	0.101	0.118	0.13	0.102	0.118
F-statistic	4.04	3.46	3.71	4.04	3.49	3.72
Number of observations	7,585	2,501	2,501	7,585	2,501	2,501

This table shows the regression results of food price inflation on geopolitical risks with monthly data. *FPI* is the food price inflation rate, *GPRC* denotes the monthly geopolitical risk index, *GPRCH* denotes the monthly geopolitical risk index measured by historical approach, *EPI* is energy price index, *NX* is the natural logarithm of net export calculated as total export minus import, *EX* is real exchange rate, Currency (%) and Currency (#) evaluate the importance of a currency as measured by percentage and ranking of a certain currency used in the transactions. The t-statistics are reported in parentheses. *, ** and *** indicate that the variables are significant at 10%, 5% and 1% significance levels, respectively.

Annual data analysis

To obtain more robust empirical findings, we include additional country-level control variables that may affect food price inflation. For example, McCalla (2009) reports that macroeconomic variables drive the agricultural boom, which can in turn affect food prices. Since macroeconomic variables are mostly published on an annual basis, this section utilizes annual data to enrich our analyses.

In Section 3.2, we outlined the variables employed in our analysis of annual data. As for geopolitical risks, we aggregate the monthly (and daily) data from Ha, Kose, and Ohnsorge (2021) into annual data. To ensure the unbiasedness of the results, we conduct the data transformation in two ways: by calculating the monthly median and mean of *GPRC* and *GPRCH*, respectively. This approach yields four annual measures of geopolitical risks for each country in a given year, labelled as *GPR* for the annual mean and median values derived from *GPRC*, and *GPRH* for those from *GPRCH*. Although it is not feasible to control for country-fixed effects, we incorporate year-fixed effects in all regression models and apply double clustering of standard errors by country and year to enhance the robustness of our findings.

In Table 4, we report the results of analyses using annual data. Columns (1) and (2) use *GPR* to capture geopolitical risks, showing that the coefficients of *GPR* are positive at the 5% level. Columns (3) and (4) use *GPRH* to capture geopolitical risks, showing that the coefficients of *GPRH* are positive and significant at the 10% level or stronger. These results are consistent with those obtained from monthly data analyses, confirming that geopolitical risks are significantly and positively related to food price inflation of a country.

In both annual and monthly data analyses, EPI is positively associated with food price inflation and EX is negatively associated, indicating that food price inflation is higher in countries with higher energy prices and lower exchange rates. Contrary to the monthly data results, international trade, as measured by net food imports, does not significantly impact food price inflation after controlling for domestic economic structure and agricultural production activities. Moreover, *GDP*, *YIELD*, and *LAND* are negatively related to *FPI*, indicating that a country with higher GDP, cereal yield, and cropland tend to experience lower food price inflation. In contrast, *SHR01* and *POP* are positively related to *FPI*, suggesting that countries with a greater proportion of primary industries and larger populations

Table 4. Regression results on the effect of geopolitical risks on food price inflation – annual data analysis.

Dependent variable	FPI			
Column	(1) Mean	(2) Median	(3) Mean	(4) Median
GPR	2.060**	2.035**		
	(2.57)	(2.20)		
GPRH			1.692**	1.591*
			(2.09)	(1.88)
EPI	0.141***	0.141***	0.142***	0.142***
	(2.90)	(2.90)	(2.90)	(2.91)
FIMP	0.052	0.053	0.053	0.054
	(1.08)	(1.09)	(1.09)	(1.11)
EX	−0.138***	−0.137***	−0.136***	−0.135***
	(−4.22)	(−4.19)	(−4.19)	(−4.17)
GDP	−1.995***	−1.959***	−1.955***	−1.919***
	(−2.96)	(−2.90)	(−2.85)	(−2.79)
SHR01	0.412**	0.412**	0.402**	0.404**
	(2.32)	(2.32)	(2.27)	(2.28)
POP	2.113***	2.102***	2.131***	2.119***
	(3.32)	(3.30)	(3.33)	(3.30)
YIELD	−1.067**	−1.071**	−1.023**	−1.024**
	(−2.11)	(−2.12)	(−2.05)	(−2.05)
LAND	−0.317***	−0.318***	−0.319***	−0.320***
	(−5.61)	(−5.63)	(−5.60)	(−5.62)
Constant	46.354***	45.631***	44.476***	43.734***
	(4.63)	(4.49)	(4.37)	(4.25)
Fixed effects	Yes	Yes	Yes	Yes
Adjusted R^2	0.405	0.404	0.404	0.403
F-statistic	9.44	9.40	9.43	9.40
Number of observations	908	908	908	908

This table shows the regression results of food price inflation on geopolitical risks with annual data. *FPI* is the food price inflation rate, *GPR* denotes the annual geopolitical risk index, *GPRH* denotes the annual geopolitical risk index measured by historical approach. Mean and Median indicate if the *GPR* and *GPRH* are computed using mean or median monthly data. *EPI* is energy price index. Other control variables include the natural logarithm of real GDP with 2017 international currency as the constant (*GDP*), the natural logarithm of total population (*POP*), the net food import calculated as total food import minus export and the value is then scaled by GDP of the country (*FIMP*), cereal yield as measured by kilogram per hectare (*YIELD*), permanent cropland as the percentage of land area (*LAND*), the industry structure as measured by the share of agriculture industry as the component of total GDP (*SHR01*), and the annual effective official exchange rate (*EX*). The t-statistics are reported in parentheses. *, ** and *** indicate that the variables are significant at 10%, 5% and 1% significance levels, respectively.

face higher food price inflation. In addition, it is noteworthy that the adjusted R^2 in the regression results of annual data analyses exceed 40%, which represents a better fit compared to those of monthly data analyses. This suggests that the variables included in the annual data analysis have greater explanatory power.

In sum, the main finding that geopolitical risk positively affects food price inflation is robustly supported. In the current global financial landscape, economies are deeply interconnected and vulnerable to the escalating geopolitical risks that have the potential to disrupt international commodity trade, leading to price changes (Singh and Roca 2022). For example, geopolitical risks could lead to a reduction in oil supplies due to interrupted production or transportation networks, subsequently affecting oil prices (El-Gamal and Jaffe 2018). In a similar vein, geopolitical risks may also disrupt supply chains in the global food industry, resulting in food shortages and price inflations (Lee, Olasehinde-Williams, and Akadiri 2021a). Indeed, previous studies show that geopolitical risks may affect food prices via the transmission from farm commodities and energy price volatility (Baek and Koo 2010). Our findings extend and endorse this strand of literature by providing empirical evidence regarding the impact on the global food market, which still remains scarce. We also contribute to the existing literature on the determinants of food price inflation (e.g. Dorward 2013; Samal, Ummalla, and Goyari 2022; Wong and Shamsudin 2017) by shedding light on geopolitical risks.

IV. Robustness tests

Alternative variables

To ensure the robustness of the above regression results, we conduct robustness tests with alternative measures. In our main analyses, we use the measure developed by Caldara and Iacoviello (2022) to capture the historical geopolitical risk of a particular country or region. As an alternative, following the aruguments of Yilanci and Kilci (2021) and supported by evidence of a positive correlation between geopolitical risk and economic policy uncertainty (EPU) (Shen and Hong 2023), we consider regional instability as potentially reflected through economic policy uncertainty. Previous research has similarly examined both geopolitical risk and economic policy uncertainty in various market contexts, including carbon trading, emerging stock markets, and renewable energy (Feng et al. 2024; Das 2019; Zhao et al. 2023). These studies have revealed a significant negative relationship between economic policy uncertainty and macroeconomic fundamentals (Baker, Bloom, and Davis 2016). By utilizing both indices, we ensure methodological consistency and robustness in our analysis (Baker, Bloom, and Davis 2016; Caldara and Iacoviello 2022). Moreover, while the EPU Index primarily focuses on domestic economic policy uncertainty and the GPR Index on international geopolitical risks, there is a natural overlap between the uncertainties they measure. This allows us to capture a comprehensive spectrum of uncertainties affecting food price inflation, considering the interconnectedness between economic policies and geopolitical events.

We therefore construct the monthly and annual measures of *EPU* using a similar approach as we did for *GPR*. The data for *EPU* is provided by Baker, Bloom, and Davis (2016).[12] We then replace *GPR* measures with *EPU* measures to estimate Equation (2). The results are reported in Panel A of Table 5.

In Panel A, columns (1) to (3) of Table 5 present the results with monthly data and columns (4) and (5) present the results with annual data. The evidence shows that the coefficients on *EPU* are positive and significant in regressions with monthly data analyses. This confirms that economic policy uncertainty is also associated with food price inflation. However, the coefficients on *EPU* are insignificant in regressions with annual data analyses. These results indicate that while both of the regional instability measures are positively correlated with food price inflation, the effect of economic policy uncertainty appears to be predominantly short-term, in contrast to the effects of geopolitical risks.

Panel B of Table 5 include alternative control variables. We include net exports (NX) in our annual analysis, as reported in column (1) of Panel B. Employing other alternative measures of international trade yielded similar results,[13] suggesting food price inflation is predominantly driven by domestic factors. In addition, replacements of GDP with GDP per capita and cereal yield with fertilizer consumption (*FERT*)[14] consistently resulted in negative and significant coefficients. Finally, we account for the importance of currency in our annual data analyses.[15] The results are consistent with those obtained from monthly analyses, suggesting that a strong currency contributes to reducing food prices. In all these regressions, geopolitical risk remains positively related to food price inflation at the 10% significance level or better,[16] verifying our baseline result.

Endogenous problems

To address potential endogeneity issues, we use two period-lagged geopolitical risks as instrumental variables and estimate two-stage least squares (2SLS) regressions. The selection of the instruments is based on the first stage regression where geopolitical risk is the dependent variable,

[12]The data can be downloaded through https://www.policyuncertainty.com/index.html.

[13]Specifically, we use current account balance (the sum of net exports of goods and services, net primary income, and net secondary income), merchandise trade as a share of GDP (the sum of merchandise exports and imports divided by the value of GDP), and agricultural raw materials imports versus exports (% of merchandise exports). The results remain insignificant.

[14]Fertilizer consumption is defined by the World Bank to 'measure the quantity of plant nutrients used per unit of arable land'. Fertilizer products cover nitrogenous, potash, and phosphate fertilizers (including ground rock phosphate). Traditional nutrients – animal and plant manures – are not included. For the purpose of data dissemination, FAO has adopted the concept of a calendar year (January to December). Some countries compile fertilizer data on a calendar year basis, while others are on a split-year basis. Arable land includes land defined by the FAO as land under temporary crops (double-cropped areas are counted once), temporary meadows for mowing or for pasture, land under market or kitchen gardens, and land temporarily fallow. Land abandoned as a result of shifting cultivation is excluded'. See a detailed description at https://databank.worldbank.org/metadataglossary/all/series?search=Fertilizer%20consumption%20(kilograms%20per%20he.

[15]One issue with this analysis is that we cannot obtain the exact annual data because the Bank for International Settlements provides data after some time intervals. For example, the most recent data are available for 2010, 2013, 2016, 2019, and 2022. For a more detailed explanation, please refer to https://www.bis.org/statistics/rpfx22_fx.pdf.

[16]Here we measure *GPR* using month means. Using monthly medians generates similar results.

Table 5. Results with alternative measures.

	Dependent variable: FPI				
	(1)	(2)	(3)	(4)	(5)
Panel A: Alternative key independent variable of interest					
EPU (Monthly)	0.001***				
	(3.15)				
EPU (Monthly)		0.001**			
		(2.27)			
EPU (Monthly)			0.001***		
			(3.06)		
EPU (Mean)				0.005	
				(1.47)	
EPU (Median)					0.004
					(1.25)
Constant	1.703***	0.417	−0.217	72.437***	72.130***
	(5.39)	(0.98)	(−0.53)	(5.12)	(5.12)
EPI	Yes	Yes	Yes	Yes	Yes
NX	Yes	Yes	Yes	Yes	Yes
EX	Yes	Yes	Yes	Yes	Yes
Currency (%)	No	Yes	No	No	No
Currency (#)	No	No	Yes	No	No
Home feature	Yes	Yes	Yes	Yes	Yes
Fixed effects	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.106	0.133	0.212	0.437	0.436
F-statistic	2.28	4.57	5.37	6.79	6.82
Observations	915	319	319	5,292	5,292
Panel B: Alternative control variables					
GPR	2.331***	2.559***	2.239**	2.111**	1.773*
	(2.65)	(2.76)	(2.56)	(2.35)	(1.72)
NX	0.080				
	(1.55)				
GDP per capita		−4.559***			
		(−5.03)			
FERT			−1.138***		
			(−3.64)		
Currency (%)				−5.312**	
				(−2.09)	
Currency (#)					0.026
					(1.06)
Constant	51.269***	79.494***	47.085***	48.720***	50.106***
	(4.32)	(5.57)	(4.30)	(3.24)	(3.13)
Other controls	Yes	Yes	Yes	Yes	Yes
Fixed effects	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.384	0.501	0.394	0.475	0.473
F-statistic	8.94	9.57	8.73	14.29	14.26
Observations	905	926	903	801	801

This table shows the regression results of food price inflation on geopolitical risks with alternative variables. *EPU* is economic policy uncertainty, *NX* is net export, *GDP per capita* is natural logarithm of real GDP per capita with 2017 international currency as the constant, *FERT* is fertilizer consumption as measured by kilograms per hectare of arable land, and Currency (%) and Currency (#) evaluate the importance of a currency as measured by percentage and ranking of a certain currency used in the transactions. The t-statistics are reported in parentheses. *, ** and *** indicate that the variables are significant at 10%, 5% and 1% significance levels, respectively.

as reported in columns (1) and (3) of Table 6. We first carry out endogeneity tests using Wooldridge's (1995) robust score test and a robust regression-based test, considering our 2SLS estimations used the robust variance-covariance matrices (VCEs). The results from both tests were not statistically significant, meaning that endogeneity does not compromise our analyses. Furthermore, apart from the lagged geopolitical risks, all control variables in the first stage does not significantly influence geopolitical risks, which reduces the concern for reverse causality. Second, we test for over-identification by performing Wooldridge's (1995) robust score test and obtain insignificant results. This means that our structural model is specified appropriately. Finally, we show that the first stage robust F-statistics are 1573.15 for monthly data analyses and 312.83 for annual data analysis with at least a 1% significance level. Both values are greater than the critical value of 10 suggested by Stock, Wright, and Yogo (2002) and better than the 5% level of significance suggested by Hall, Rudebusch, and Wilcox (1996). All of the results suggest that our instruments are valid.

Table 6. Instrumental variable regression results.

	Panel A: Monthly analysis		Panel B: Annual analysis	
	First-stage (1)	Second-stage (2)	First-stage (3)	Second-stage (4)
Geopolitical risk		0.146***		2.018**
		(5.34)		(2.41)
Lagged Geopolitical risk	0.6600***		0.7463***	
	(11.76)		(10.78)	
Lagged 2 Geopolitical risk	0.3061***		0.1774**	
	(5.55)		(2.46)	
EPI	0.0006	−0.005	0.0006	0.237**
	(0.31)	(−0.47)	(1.16)	(2.08)
NX	−0.0002	0.005***	0.0001	0.075
	(−0.87)	(4.49)	(0.16)	(1.37)
EX	0.0005	−0.013***	0.0004	−0.108***
	(1.19)	(−6.09)	(0.98)	(−3.52)
Currency (%)	0.0003	−0.003***	0.0733	−5.238**
	(1.61)	(−3.19)	(0.76)	(−2.08)
FIMP			0.0001	0.021
			(0.18)	(0.48)
GDP			0.0044	−2.308***
			(0.33)	(−3.02)
SHR01			−0.0012	0.151
			(0.40)	(1.23)
POP			0.0066	2.598***
			(0.56)	(3.63)
YIELD			0.0004	−1.562**
			(0.04)	(−2.44)
LAND			−0.0004	−0.181***
			(0.39)	(−3.32)
Constant	0.0809	1.706***	−0.3309	45.694***
	(1.25)	(6.41)	(1.52)	(3.32)
Endogeneity test				
Robust score c^2	0.4921		0.0882	
	[0.78]		[0.77]	
Robust regression F-statistic	0.4684		0.0831	
	[0.49]		[0.77]	
Over-identification test				
Score c^2	0.0102		0.3005	
	[0.92]		[0.58]	
Weak-instrument-test				
Robust F- statistic	1573.1500		312.8300	
	[0.00]		[0.00]	
Fixed effects	Yes	Yes	Yes	Yes
Adjusted R^2	0.900	0.101	0.142	0.475
F-statistics/Wald c^2	46.11	413.24	70.96	613.59
Observations	2,501	2,501	801	801

This table shows the 2SLS regression results of food price inflation on geopolitical risks. The dependent variable is geopolitical risks as measured by *GPRC* in column (1) and *GPR* in column (3), respectively. The dependent variable in the 2nd stage is *FPI*, the food price inflation rate. All variables are defined in Appendix. The t-statistics are reported in parentheses and p-values are reported in bracket. *, ** and *** indicate that the variables are significant at 10%, 5% and 1% significance levels, respectively.

The second stage of results is shown in columns (2) and (4) of Table 6, where column (2) belongs to Panel A and uses monthly data analysis and column (4) belongs to Panel B and uses annual data analysis. The coefficient on geopolitical risk is positively related to *FPI* at the 5% significance level in column (2) and at the 1% significance level in column (4). These results suggest that geopolitical risks significantly contribute to food price inflation even after accounting for past information and addressing the endogeneity. Coefficients on control variables are also consistent with the baseline.

Alternative techniques

This section uses alternative econometric techniques to verify the robustness of the main results derived from ordinary least squares (OLS) estimations. One potential issue with OLS regression is heteroskedasticity within the error term, which may lead to biased results. To address this concern, we employ weighted least square (WLS) regressions, wherein each squared residual is weighted and less weight is given to observations with higher error variance. The results with WLS regressions are reported in column (1) of Table 7. Strictly

Table 7. Alternative techniques.

	Dependent variable: FPI				
Technique	WLS (1)	GLS (2)	RE (3)	FE (4)	QLS (5)
Panel A: Monthly data analysis					
GPRC	0.109***	0.138***	0.139**	0.046	0.047***
	(4.66)	(4.24)	(2.08)	(0.57)	(2.75)
Constant	1.380***	1.999***	1.979***	1.870***	1.392***
	(8.90)	(9.13)	(3.60)	(3.68)	(3.56)
EPI	Yes	Yes	Yes	Yes	Yes
NX	Yes	Yes	Yes	Yes	Yes
EX	Yes	Yes	Yes	Yes	Yes
Currency (%)	Yes	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.029				
Log likelihood		−2774.719			
Within R^2			0.123	0.126	
Between R^2			0.427	0.013	
Overall R^2			0.142	0.088	
Pseudo R^2					0.096
F/c^2/Sum dev.	15.88	415.23	368.56	2.99	607.474
Observations	2,501	2,501	2,501	2,501	2,501
Panel B: Annual data analysis					
GPR	1.557**	2.014***	2.143**	3.225**	0.674**
	(2.14)	(3.07)	(2.29)	(2.08)	(2.15)
Constant	32.929***	42.296***	44.389***	48.044	22.042***
	(3.50)	(4.54)	(2.77)	(0.44)	(4.08)
EPI	Yes	Yes	Yes	Yes	Yes
FIMP	Yes	Yes	Yes	Yes	Yes
EX	Yes	Yes	Yes	Yes	Yes
GDP	Yes	Yes	Yes	Yes	Yes
SHR01	Yes	Yes	Yes	Yes	Yes
POP	Yes	Yes	Yes	Yes	Yes
YIELD	Yes	Yes	Yes	Yes	Yes
LAND	Yes	Yes	Yes	Yes	Yes
Currency (%)	Yes	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.469				
Log likelihood		−2342.596			
Within R^2			0.407	0.425	
Between R^2			0.832	0.408	
Overall R^2			0.530	0.276	
Pseudo R^2					0.326
F/c^2/Sum dev.	71.82	910.24	739.11	13.96	916.91
Observations	804	804	804	804	804

This table shows the regression results of food price inflation on geopolitical risks using alternative econometric techniques. *FPI* is the food price inflation rate, *GPRC* is the monthly geopolitical risk index, *GPR* is the annual geopolitical risk index. All control variables are defined in Appendix. F represents F-statistics for WLS, c^2 represents Wald c^2 for GLS, RE, and FE, Sum dev. Represent minimum sum of deviations for QLS. The t-statistics are reported in parentheses. *, ** and *** indicate that the variables are significant at 10%, 5% and 1% significance levels, respectively.

speaking, WLS is one special form of generalized least squares (GLS) estimator. In a panel data structure like ours, it may contain not only cross-sectional correlation and heteroskedasticity across panels but also time series autocorrelation within panels. We therefore also apply panel-data GLS estimation and report results in column (2) of Table 7. Then we use two standardized panel data models: Random-effects (RE) and fixed-effects (FE) models. The main issue that the two models tend to deal with is if the unobserved time-invariant component is correlated with the regressors. If it does, then estimates from the fixed-effects model are consistent; if it does not, then estimates from the fixed-effects model are inefficient relative to estimates from the random-effects model. Columns (3) and (4) of Table 7 report the regression results with RE and FE models, respectively. Finally, we use quartile least squares (QLS), a median regression that estimates the median of the dependent variable, conditional on the values of the independent variable. The results with QLS are reported in column (5) of Table 7.

The results overall confirm the positive relationship between geopolitical risks and food price inflation, except for the FE estimation on monthly data. As previously mentioned, *GPRC* exhibits minimal monthly fluctuations, leading to a marginal value after time-demeaned adjustments. In sum, the tests in this subsection show that the use of alternative techniques does not alter our main finding.

V. Further analysis

In this section, we further consider more fundamental country-level factors to examine their potential mediating effects on the positive relationship between geopolitical risks and food price inflation. Specifically, we explore underlying mechanisms across different institutional environments, including national culture, business cycle, market development level, climate change, and intercountry relations.

Cultural effects

National culture fundamentally shapes a country's societal and economic dynamics. For instance, Widdig (2001) studies Weimar Germany and identifies a relationship between the value of money and personal perceptions of social interaction. Furthermore, national culture affects how members in a society deal with social-level uncertainty. For example, Schneider and De Meyer (1991) find that Latin Europeans tend to view the deregulation of the U.S. banking industry as a crisis or threat, whereas other cultures may consider it as an opportunity. Similarly, the impact of geopolitical risks on food price inflation may also be moderated by national cultural factors.

To measure national culture, we use six cultural dimensions collated by Hofstede, Hofstede, and Minkov (2010): Power distance index (*PDI*), individualism index (*IDV*), masculinity index (*MAS*), uncertainty avoidance index (*UAI*), long-term orientation index (*LTO*), and indulgence index (*IVR*).[17] This paper adopts models (2) to test whether cultural factors affect the strength of the effect of geopolitical risk on food price inflation:

$$FPI_{i,t} = \beta_0 + \beta_1 GPR_{i,t} + \gamma_1 (PDI_i/IDV_i/MAS_i/UAI_i/LTO_i/IVR_i) + \delta_1 (PDI_i/IDV_i/MAS_i/UAI_i/LTO_i/IVR_i) \times GPR_{i,t} + \beta_2 Controls_{i,t} + FE + \varepsilon_{i,t} \quad (2)$$

By adding interactions between geopolitical risks and each of these cultural dimensions, the analyses of the cultural effect test are reported in Table 8. Panel A reports monthly data analysis, showing that all cultural dimensions have significant effects. Among them, *PDI*, *UAI*, and *LTO* have positive effects whereas *IDV*, *MAS*, and *IVR* have negative effects. Panel B reports annual data analysis, showing that only negative effects associated with *IDV* and *MAS* remain. These results suggest that individualism culture and masculinity culture have moderating effects on the positive relationship between geopolitical risk and food price inflation, particularly in the short term.

Business cycle

When a country is in a boom stage of its business cycle, characterized by increasing productivity and accelerated economy growth, there is a positive economic output. Accordingly, various sectors, including agricultural production, can be stabilized, which in turn has an impact on food price inflation. The classification is based on the GDP growth rate, where the growth rate is in the vicinity of 2% is the boom period

In this paper, in accordance with previous studies such as Jones, Taylor, and Uhlig (2016), a boom period is defined as a GDP growth rate in the range of 2%-3%. A dummy variable (Business cycle) is introduced, where the business cycle in the

[17]Hofstede proposed six basic problems that societies need to solve and collated them by countries for estimation, and all these cultural dimensions are mostly expressed by a scale from 0 to 100, and these indices do not change over time. Power distance (*PDI) is the* degree of acceptance of the imbalance in the distribution of power in a society or organization; societies with a high degree of acceptance are hierarchical and have a large power distance. Individualism (*IDV*) This cultural dimension focuses on the degree to which people treat the relationship between the collective and the individual, i.e. whether they tend to exist and act as individuals or as part of a group. The cultural dimension of masculinity (*MAS*) refers to the extent to which people emphasize self-confidence, competition, and materialism (career success orientation) or interpersonal relationships and the interests of others (quality of life orientation). Uncertainty avoidance (*UAI*) refers to the degree of tolerance for uncertainty in things, with people in low uncertainty avoidance cultures being risk-takers and confident about the future, while the opposite is true for people in high uncertainty avoidance cultures. The long-term orientation (*LTO*) cultural dimension refers to whether people look to the present or to the future. *Indulgence (IVR)* represents the degree of freedom in the culture of the country or region, the lower the degree of *indulgence*, the higher the responsibility of the members of the society.

Table 8. Further analysis of cultural factors.

	Dependent variable: FPI					
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Month data analysis						
GPRC	−0.097	0.909***	1.096***	−0.058	0.000	0.691***
	(−1.01)	(4.09)	(4.51)	(−0.60)	(−0.00)	(3.90)
PDI	0.003***					
	(3.24)					
PDI × GPRC	0.005**					
	(2.27)					
IDV		−0.003***				
		(−3.88)				
IDV × GPRC		−0.009***				
		(−3.51)				
MAS			0.001			
			(1.57)			
MAS × GPRC			−0.016***			
			(−4.15)			
UAI				0.002**		
				(2.27)		
UAI × GPRC				0.004**		
				(2.13)		
LTO					−0.002**	
					(−2.27)	
LTO×GPRC					0.004**	
					(2.14)	
IVR						0.001
						(0.79)
IVR×GPRC						−0.009***
						(−3.30)
Constant + Controls +FE	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.112	0.115	0.108	0.108	0.102	0.105
F-statistic	3.67	3.59	3.57	3.49	3.47	3.52
Observations	2,501	2,501	2,501	2,501	2,501	2,501
Panel B: Annual data analysis						
GPRC	0.870	7.426***	11.52***	0.0222	1.893	6.214*
	(0.57)	(3.32)	(4.36)	(0.02)	(1.29)	(2.54)
PDI	0.0403**					
	(2.58)					
PDI × GPRC	0.0238					
	(0.74)					
IDV		−0.0147				
		(−1.38)				
IDV × GPRC		−0.0660*				
		(−2.56)				
MAS			0.0214*			
			(2.14)			
MAS × GPRC			−0.172***			
			(−3.91)			
UAI				0.0141		
				(1.52)		
UAI × GPRC				0.0345		
				(1.38)		
LTO					0.0489***	
					(4.03)	
LTO×GPRC					0.0161	
					(0.55)	
IVR						−0.00815
						(−0.69)
IVR×GPRC						−0.0663
						(−1.82)
Constant + Controls +FE	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.460	0.459	0.460	0.456	0.437	0.423
F-statistic	68.32***	68.08***	68.32***	67.31***	65.78***	60.73***
Observations	834	834	834	834	882	856

This table reports the results of an analysis that further considers the impact of cultural factors at the county level. PDI is power distance, IDV is individualism, MAS is masculinity, UAI is uncertainty avoidance, LTO is long-term orientation and IVR is indulgence, all these measures are Hofstede, Hofstede, and Minkov (2010) culture dimensions. All regressions include control variables. The t-statistics are reported in parentheses. *, ** and *** indicate that the variables are significant at 10%, 5% and 1% significance levels, respectively.

boom period is assigned a value of 1, and 0 otherwise. The results of the grouped regressions are shown in Table 9, columns (1) and (2), where A is analysed using monthly data and B is analysed using annual data. Column (1) presents the regression results for the non-boom period, while column (2) includes the regression results for the boom period. The results show that the regression coefficients for the boom period in column (1) (2) of Panel A are not significant, while the regression coefficients for the non-boom period are significantly positive. Similarly, the regression coefficients for the boom period in column (1) (2) of Panel B are not significant, while the regression coefficients for the non-boom period are significantly larger than the original regression coefficients. This suggests that geopolitical risk has a greater impact on food price inflation when a country is in a non-boom business cycle and that the long-run impact of the business cycle is more pronounced than the short-run impact.

Market development level

Market development involves multiple factors, such as market system soundness, effective demand-supply mechanisms, and typically lower inflation rates. Given these complexities, it is worthwhile to investigate whether the positive effect of geopolitical risks on food price inflation can be mitigated by the development level of a country. Specifically, we group the full sample

Table 9. Other further analysis.

	Dependent variable: FPI				
	(1)	(2)	(3)	(4)	(5)
Panel A: Month data analysis					
GPRC	0.190***	0.041	0.276***	0.295	0.355***
	(4.11)	(1.27)	(3.90)	(1.09)	(4.28)
Developed			−0.283***		
			(−11.12)		
Developed × GPRC			−0.164*		
			(−2.23)		
TGGE				0.051***	
				(4.55)	
TGGE×GPRC				−0.019	
				(−1.09)	
IPTD					−0.123***
					(−6.56)
GPRC×IPTD					−0.076**
					(−2.61)
Constant+Controls +FE	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.027	0.155	0.062	0.005	0.013
F-statistic	88.76***	2.893*	125.3***	38.97***	46.82***
Observations	3683	1356	7585	5821	5821
Panel B: Annual data analysis					
GPR	3.403**	0.151	5.055**	19.829**	2.474
	(3.22)	(0.17)	(1.652)	(6.407)	(1.759)
Developed			−3.190***		
			(0.668)		
Developed × GPRC			−2.729		
			(1.673)		
TGGE				0.794	
				(0.543)	
TGGE×GPR				−1.256**	
				(0.447)	
IPTD					0.672*
					(0.302)
GPR×IPTD					−0.240
					(0.652)
Constant+Controls +FE	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.371	0.529	0.382	0.360	0.361
F-statistic	45.92***	15.84***	54.655***	50.158***	43.216***
Observations	741	167	908	908	776

This table shows further analysis based on business cycles, market development level, climate change, and interstate relations. Develop is a dummy variable that equals to 1 is a market is the developed market and otherwise 0. TGGE denotes total greenhouse gas emissions. IPTD denotes the political preference distance between the target country and the main food-producing countries. The t-statistics are reported in parentheses. *, ** and *** indicate that the variables are significant at 10%, 5% and 1% significance levels, respectively.

into developed and developing markets based on the classification by four institutions: FTSE Group, MSCI, Standard and Poor's, and STOXX. A market is regarded as a developed market only if it meets the criteria of all four institutions.[18] Then we introduce a dummy variable $Developed_{i,t}$ that equals one for developed markets and otherwise zero. This paper takes model (3) to test whether the level of market development affects the strength of the role of geopolitical risk on food price inflation:

$$FPI_{i,t} = \beta_0 + \beta_1 GPR_{i,t} + \gamma_2 Developed_{i,t} + \delta_2 Developed_{i,t} \times GPR_{i,t} + \beta_2 Controls_{i,t} + FE + \varepsilon_{i,t} \tag{3}$$

We further include an interaction term between the dummy variables and geopolitical risks. The analyses are reported in column (3) of Table 9, where Panel A reports the results using monthly data and Panel B with annual data. The results show that the coefficient on the interaction term is significantly negative in column (3) of Panel A, suggesting that the level of market development indeed mitigates the effect of geopolitical risk on food price inflation in the short run. While still negative, the coefficient on the interaction term turns insignificant in column (3) of Panel B, suggesting that the level of market development does not alter the effect of geopolitical risk on food price inflation in the long run.

Climate change

Climate change exhibits an adverse impact on the agricultural sector worldwide (Hellin et al. 2020), leading to a reduction in crop yields, and consequently, higher food prices (Sam, Abidoye, and Mashaba 2021). This paper argues that changes in the climate will have a moderating effect on the relationship between geopolitical risk and food price inflation. Greenhouse gases such as carbon dioxide, methane, and nitrous oxide are considered to be the main cause of global climate change (Moiceanu and Dinca 2021). To study the impact of climate change, we choose Total Greenhouse Gas Emission (TGGE) as a measure of climate change in our baseline regression and examine the interaction between climate change and geopolitical risk. Model (4) is employed to test whether climate change affects the relationship between geopolitical risk and food price inflation:

$$FPI_{i,t} = \beta_0 + \beta_1 GPR_{i,t} + \gamma_3 TGGE_{i,t} + \delta_3 TGGE_{i,t} \times GPR_{i,t} + \beta_2 Controls_{i,t} + FE + \varepsilon_{i,t} \tag{4}$$

The regression results are shown in column (3) of Table 9. The coefficient of the interaction term in Panel A is not significant, indicating that in the short run its climate change does not have an impact on the relationship between geopolitical risk and food price inflation. In Panel B, the coefficient of the interaction term is significantly negative, indicating that in the long run, total GHG emissions have a significant negative effect on the positive relationship between geopolitical risk and food price inflation. This indicates that as climate change worsens, the impact of geopolitical risk on food price inflation weakens.

Intercountry relations

The economic viability of the agri-food industry in any country significantly depends on robust international relations (Afesorgbor and Beaulieu 2021), which directly influence food prices in the countries involved. In this paper, we refer to Bailey, Strezhnev, and Voeten (2017), which utilized Ideal Point (IP) estimation to measure a country's geopolitical position. The absolute difference in IP values between countries was termed as the International Political Tendency Distance (IPTD), a measure of the international political tendency distance between a target country and major food-producing countries, as shown in Equation (5).

$$IPTD = \left| Ideal\ Point_{max,t} - Ideal\ Point_{i,t} \right| \tag{5}$$

where Ideal $Point_{max,t}$ is the ideal point for the country with the largest food production in year t, and is the ideal point for target country i in year t.

We then adopts model (6) to test whether intercountry relations affect the strength of the effect of geopolitical risk on food price inflation:

[18]After the screening, the list of developed markets are AUS, AUT, BEL, CAN, DNK, FIN, FRA, DEU, HKG, IRL, ISR, ITA, JPN, LUX, NLD, NZL, NOR, PRT, SGP, ESP, SWE, CHE, GBR, U.S.A.

$$FPI_{i,t} = \beta_0 + \beta_1 GPR_{i,t} + \gamma_4 IPTD_{i,t} + \delta_4 TGGE_{i,t} \times GPR_{i,t} + \beta_2 Controls_{i,t} + FE + \varepsilon_{i,t} \quad (6)$$

The regression results after adding the interaction term between geopolitical risk and interstate relations are shown in column (5) of Table 9. In Panel A, the coefficients of the interaction terms are all significantly negative, while in Panel B the coefficients of the interaction terms are not significant, suggesting that in the short run, inter-country relations have a moderating effect on the relationship between geopolitical risk and food price inflation. In the long run, however, country relations do not play a moderating role.

VI. Conclusions

In this study, we contend that geopolitical risks, such as terrorism and conflicts, play a significant role in driving the inflationary effects associated with food price inflation. Specifically, by utilizing a time-fixed effect model and data from 33 countries from 2001 to 2020 in both monthly and yearly frequencies, this paper empirically studies the transmission of geopolitical risks into food price inflation. Our main finding suggests a positive relationship between geopolitical risks and food price inflation. We verify the robustness of our main finding in additional tests and argue that it is applicable to the global geopolitical landscape. Particularly, it highlights the importance for governments to continuously monitor geopolitical events and implement targeted measures afterwards to ensure the stability of food prices.

We then explore underlying mechanisms across different institutional environments, including national culture, business cycle, market development level, climate change, and intercountry relations. Further tests show that: the positive relationship is more pronounced in developing countries than in developed ones; cultural traits of individualism and masculinity can mitigate the positive effect of geopolitical risk; the impact of geopolitical risks on food price inflation is greater when the business cycle is in a non-boom period; in the long run, an increase in total greenhouse gas emissions will dampen the impact of geopolitical risk on food price inflation; the positive correlation between geopolitical risk and food price inflation is weakened by the relationship between countries and major food producers. These findings suggest that, first, governments may consider prioritizing economic development and stability as a strategic approach to build resilience against external shocks and, therefore, to mitigate the effects of geopolitical risks on food price inflation. Second, governments are advised to customize their strategies for managing geopolitical risks to align with the unique cultural attributes of their countries. Moreover, government efforts in maintaining strong relationships with major food producers could serve as an additional strategy to mitigate the adverse effects of geopolitical risks on food prices.

This study acknowledges several potential limitations. First, while the representativeness of our sample has been previously justified, it is important to acknowledge that its generalizability may still be constrained. Future research could consider expanding the dataset to enhance the robustness and generalizability of the findings. Second, due to scope limitations, this study does not investigate the potential long-term impact of geopolitical risks on food price inflation. Future research could incorporate lagged variables and extend this analysis to fully assess these effects. Lastly, the control variables in this study may not be comprehensive. Future studies may explore additional factors that can mitigate the effect of geopolitical risks on food price inflation and include more county-level variables in their analyses.

Acknowledgements

The authors appreciate comments and suggestions from Kirsten Jenkins, Junyan Li, and Lefan Li, and participants at the 2nd conference on FinTech, Innovation and Development. The authors also thank Yikang Wang for his research assistant work.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

Guangdong Province Philosophy and Social Sciences Planning Project [No.: GD21CYJ31]; 2020 University Level Scientific Research Fund Project of Guizhou University of Finance and Economics [No.: 2020XZD01].

References

Afesorgbor, S. K., and E. Beaulieu. 2021. "Role of International Politics on Agri-Food Trade: Evidence from US–Canada Bilateral Relations." *Canadian Journal of Agricultural Economics/Revue Canadienne D'agroeconomie* 69 (1): 27–35. https://doi.org/10.1111/cjag.12267.

Baek, J., and W. W. Koo. 2010. "Analyzing Factors Affecting US Food Price Inflation." *Canadian Journal of Agricultural Economics/Revue Canadienne D'agroeconomie* 58 (3): 303–320. https://doi.org/10.1111/j.1744-7976.2010.01186.x.

Bailey, M. A., A. Strezhnev, and E. Voeten. 2017. "Estimating Dynamic State Preferences from United Nations Voting Data." *The Journal of Conflict Resolution* 61 (2): 430–456. https://doi.org/10.1177/0022002715595700.

Baker, S. R., N. Bloom, and S. J. Davis. 2016. "Measuring Economic Policy Uncertainty." *Quarterly Journal of Economics* 131 (4): 1593–1636. https://doi.org/10.1093/qje/qjw024.

Balcilar, M., B. Tokar, and O.-W. Godwin. 2020. "Examining the Interactive Growth Effect of Development Aid and Institutional Quality in Sub-Saharan Africa." *Journal of Development Effectiveness* 12 (4): 361–376. https://doi.org/10.1080/19439342.2020.1796759.

Bhattacharya, R., and R. Jain. 2020. "Can Monetary Policy Stabilise Food Inflation? Evidence from Advanced and Emerging Economies." *Economic Modelling* 89:122–141. https://doi.org/10.1016/j.econmod.2019.10.005.

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

Das, D., M. Kannadhasan, and M. Bhattacharyya. 2019. "Do the Emerging Stock Markets React to International Economic Policy Uncertainty, Geopolitical Risk and Financial Stress Alike?" *The North American Journal of Economics & Finance* 48:1–19. https://doi.org/10.1016/j.najef.2019.01.008.

Dawe, D., and C. P. Timmer. 2012. "Why Stable Food Prices are a Good Thing: Lessons from Stabilizing Rice Prices in Asia." *Global Food Security* 1 (2): 127–133. https://doi.org/10.1016/j.gfs.2012.09.001.

Dorward, A. 2013. "Agricultural Labour Productivity, Food Prices and Sustainable Development Impacts and Indicators." *Food Policy* 39:40–50. https://doi.org/10.1016/j.foodpol.2012.12.003.

El-Gamal, M. A., and A. M. Jaffe. 2018. "The Coupled Cycles of Geopolitics and Oil Prices." *Economics of Energy & Environmental Policy* 7 (2): 1–14. https://doi.org/10.5547/2160-5890.7.2.melg.

Engemann, H., Y. Jafari, and T. Heckelei. 2023. "Institutional Quality and the Duration of Agri-Food Trade Flows." *Journal of Agricultural Economics* 74 (1): 135–154. https://doi.org/10.1111/1477-9552.12491.

Feng, Y.-S., M.-J. Ling, and J. Gao. 2024. "Interplay Multifractal Dynamics Among Carbon Trading Market, Geopolitical Risk and Economic Policy Uncertainty." *Fluctuation and Noise Letters* 2450029. https://doi.org/10.1142/S0219477524500299.

Gedik, M. A., and T. Günel. 2021. "RETRACTED ARTICLE: The Impact of Climate Change on Edible Food Production: A Panel Data Analysis." *Acta Agriculturae Scandinavica, Section B Soil & Plant Science* 71 (5): 318–323. https://doi.org/10.1080/09064710.2021.1897155.

Gilbert, C. L. 2010. "How to Understand High Food Prices." *Journal of Agricultural Economics* 61 (2): 398–425. https://doi.org/10.1111/j.1477-9552.2010.00248.x.

Gozgor, G. 2019. "Effects of the Agricultural Commodity and the Food Price Volatility on Economic Integration: An Empirical Assessment." *Empirical Economics* 56 (1): 173–202. https://doi.org/10.1007/s00181-017-1359-6.

Ha, J., M. A. Kose, and F. Ohnsorge. 2021. "One-Stop Source: A Global Database of Inflation." *Policy Research Working Paper, 9737*. Washington DC: World Bank. https://doi.org/10.2139/ssrn.3881526.

Hall, A. R., G. D. Rudebusch, and D. W. Wilcox. 1996. "Judging Instrument Relevance in Instrumental Variables Estimation." *International Economic Review* 37 (2): 283–298. https://doi.org/10.2307/2527324.

Hellin, J., J. Balié, E. Fisher, A. Kohli, M. Connor, S. Yadav, V. Kumar, et al. 2020. "Trans-Disciplinary Responses to Climate Change: Lessons from Rice-Based Systems in Asia." *Climate* 8 (2): 35. https://doi.org/10.3390/cli8020035.

Hofstede, G. H., G. J. Hofstede, and M. Minkov. 2010. "Cultures and Organizations, Software of the Mind. Intercultural Cooperation and Its Importance for Survival." *Southern Medical Journal* 13 (3): S219–S222. https://doi.org/10.1016/S1076-6332(98)80110-4.

Iddrisu, A.-A., and I. P. Alagidede. 2020. "Monetary Policy and Food Inflation in South Africa: A Quantile Regression Analysis." *Food Policy* 91:101816. https://doi.org/10.1016/j.foodpol.2019.101816.

Ismaya, B. I., and D. F. Anugrah. 2018. "Determinant of Food Inflation: The Case of Indonesia." *Bulletin of Monetary Economics & Banking* 21 (1): 1–14. https://doi.org/10.21098/bemp.v21i1.926.

Jana, R. K., and I. Ghosh. 2023. "Time-Varying Relationship Between Geopolitical Uncertainty and Agricultural Investment." *Finance Research Letters* 52:103521. https://doi.org/10.1016/j.frl.2022.103521.

Jones, C. I. J. B. Taylor & H. Uhlig, edited by. 2016. *Chapter 1—The Facts of Economic Growth*, 3–69. Vol. 2. Elsevier. https://doi.org/10.1016/bs.hesmac.2016.03.002.

Lee, C.-C., G. Olasehinde-Williams, and S. S. Akadiri. 2021a. "Are Geopolitical Threats Powerful Enough to Predict Global Oil Price Volatility?" *Environmental Science and Pollution Research* 28 (22): 28720–28731. https://doi.org/10.1007/s11356-021-12653-y.

Lee, C.-C., G. Olasehinde-Williams, and O. Özkan. 2023. "Geopolitical Oil Price Uncertainty Transmission into Core Inflation: Evidence from Two of the Biggest Global Players." *Energy Economics* 126:106983. https://doi.org/10.1016/j.eneco.2023.106983.

Martínez-Zarzoso, I., and L. Márquez-Ramos. 2019. “Exports and Governance: Is the Middle East and North Africa Region Different?” *World Economy* 42 (1): 143–174. https://doi.org/10.1111/twec.12633.

McCalla, A. F. 2009. “World Food Prices: Causes and Consequences.” *Canadian Journal of Agricultural Economics* 57 (1): 23–34. https://doi.org/10.1111/j.1744-7976.2008.01136.x.

Moiceanu, G., and M. N. Dinca. 2021. “Climate Change-Greenhouse Gas Emissions Analysis and Forecast in Romania.” *Sustainability* 13 (21): 12186. https://doi.org/10.3390/su132112186.

Negi, D. S. 2022. “Global Food Price Surge, In-Kind Transfers and Household Welfare: Evidence from India.” *World Development* 158:106009. https://doi.org/10.1016/j.worlddev.2022.106009.

Saâdaoui, F., S. B. Jabeur, and J. W. Goodell. 2022. “Causality of Geopolitical Risk on Food Prices: Considering the Russo–Ukrainian Conflict.” *Finance Research Letters* 49:103103. https://doi.org/10.1016/j.frl.2022.103103.

Sam, A. G., B. O. Abidoye, and S. Mashaba. 2021. “Climate Change and Household Welfare in Sub-Saharan Africa: Empirical Evidence from Swaziland.” *Food Security* 13 (2): 439–455. https://doi.org/10.1007/s12571-020-01113-z.

Samal, A., M. Ummalla, and P. Goyari. 2022. “The Impact of Macroeconomic Factors on Food Price Inflation: An Evidence from India.” *Future Business Journal* 8 (1): 1–14. https://doi.org/10.1186/s43093-022-00127-7.

Schneider, S. C., and A. De Meyer. 1991. “Interpreting and Responding to Strategic Issues: The Impact of National Culture.” *Strategic Management Journal* 12 (4): 307–320. https://doi.org/10.1002/smj.4250120406.

Serra, T., and J. M. Gil. 2013. “Price Volatility in Food Markets: Can Stock Building Mitigate Price Fluctuations?” *European Review of Agricultural Economics* 40 (3): 507–528. https://doi.org/10.1093/erae/jbs041.

Shen, L., and Y. Hong. 2023. “Can Geopolitical Risks Excite Germany Economic Policy Uncertainty: Rethinking in the Context of the Russia-Ukraine Conflict.” *Finance Research Letters* 51:103420. https://doi.org/10.1016/j.frl.2022.103420.

Singh, V., and E. D. Roca. 2022. “China’s Geopolitical Risk and International Financial Markets: Evidence from Canada.” *Applied Economics* 54 (34): 3953–3971. https://doi.org/10.1080/00036846.2021.2019185.

Stock, J. H., J. H. Wright, and M. Yogo. 2002. “A Survey of Weak Instruments and Weak Identification in Generalized Method of Moments.” *Journal of Business & Economic Statistics* 20 (4): 518–529. https://doi.org/10.1198/073500102288618658.

Taghizadeh-Hesary, F., E. Rasoulinezhad, and N. Yoshino. 2019. “Energy and Food Security: Linkages Through Price Volatility.” *Energy Policy* 128:796–806. https://doi.org/10.1016/j.enpol.2018.12.043.

Tiwari, A. K., M. K. Boachie, M. T. Suleman, and R. Gupta. 2021. “Structure Dependence Between Oil and Agricultural Commodities Returns: The Role of Geopolitical Risks.” *Energy* 219:119584. https://doi.org/10.1016/j.energy.2020.119584.

Wong, K., and M. N. Shamsudin. 2017. “Impact of Crude Oil Price, Exchange Rates and Real GDP on Malaysia’s Food Price Fluctuations: Symmetric or Asymmetric?” *International Journal of Economics & Management* 11 (1): 259–275.

Wooldridge, J. M. 1995. “Score Diagnostics for Linear Models Estimated by Two Stage Least Squares.” In *Advances in Econometrics and Quantitative Economics: Essays in Honor of Professor C*, edited by R. Rao, G. S. Maddala, P. C. B. Phillips, and T. N. Srinivasan, 66–87. Oxford: Blackwell.

Yilanci, V., and E. N. Kilci. 2021. “The Role of Economic Policy Uncertainty and Geopolitical Risk in Predicting Prices of Precious Metals: Evidence from a Time-Varying Bootstrap Causality Test.” *Resources Policy* 72:102039. https://doi.org/10.1016/j.resourpol.2021.102039.

Zhao, X., K. Si Mohammed, Y. Wang, P. Stępień, and G. Mentel. 2023. “Effect of Geopolitical Risk and Economic Uncertainty Indices on Renewable Energy.” *Geoscience Frontiers* 101655. https://doi.org/10.1016/j.gsf.2023.101655.

Appendix: Variable description

Variable	Description	Data source
FPI	The food price inflation rate	Ha, Kose, and Ohnsorge (2021)/ World Bank
GPRC	The monthly geopolitical risk index	Caldara and Iacoviello (2022)
GPRCH	The monthly geopolitical risk index measured by historical approach	Caldara and Iacoviello (2022)
GPR (mean)	The annual geopolitical risk index computed using mean monthly data	Caldara and Iacoviello (2022)
GPR (median)	The annual geopolitical risk index computed using median monthly data	Caldara and Iacoviello (2022)
GPRH (mean)	The annual geopolitical risk index measured by historical approach	Caldara and Iacoviello (2022)
GPRH (median)	The annual geopolitical risk index measured by historical approach	Caldara and Iacoviello (2022)
EPI	The energy price index	Ha, Kose, and Ohnsorge (2021)/ World Bank
NX	The natural logarithm of net export calculated as total export minus import, scaled by GDP	World Bank
EX	The real or effective exchange rate	World Bank
Currency (%)	The percentage of a certain currency used in the transactions	World Bank
Currency (#)	The ranking of a certain currency used in the transactions	World Bank
EPU	The economic policy uncertainty index	Baker, Bloom, and Davis (2016)
FIMP	The net food import calculated as total food import minus export and the value is then scaled by GDP of the country	World Bank
GDP	The natural logarithm of real GDP with 2017 international currency as the constant	World Bank
GDP per capita	The natural logarithm of real GDP per capita with 2017 international currency as the constant	World Bank
POP	The natural logarithm of total population	World Bank
SHR01	The industry structure as measured by the share of agriculture industry as the component of total GDP	World Bank
YIELD	Cereal yield as measured by kilogram per hectare	World Bank
LAND	Permanent cropland as the percentage of land area	World Bank
FERT	Fertilizer consumption as measured by kilograms per hectare of arable land	World Bank