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PAPER

Energy price and food price nexus in Europe: evidence from heterogeneous panel econometrics

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Abstract This study modelled increasing food prices across Europe to explore the long-term effect of energy prices along with the other demand and supply-side variables. The panel data of 27 European countries, from 1995 to 2019 are subjected to both first and second-generation panel econometrics to explore long-run coefficients. The panel cross-sectional dependence test's estimated result revealed cross-sectional dependency; whereas the findings of both panel IPS and CIPS unit root analysis revealed mixed order of integration. The food prices reveal trend stationary behaviour at the level, while agriculture value addition shows stationary behaviour at the level indicating stagnant or decreasing productivity growth.

The estimated result of pooled mean group (PMG) estimator has revealed that an increase in oil price, per capita GDP, foreign exchange reserve, and trade openness have a positive impact on food price in the long run; while an increase in agriculture value addition has a negative impact of higher intensity. The sensitivity analysis performed using panel fully modified ordinary least square and augmented mean group estimator have validated the establishment of long term relationships. This study urges selected European countries to enhance agricultural technology and diversify their energy supply by exploiting alternative green energy.

Keywords: Energy price, food prices, panel data, pooled mean group estimator, augmented mean group, FMOLS, Europe.

JEL Classification: C23, Q11.

1. Introduction

The global food price has increased phenomenally in recent years due to stagnation

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in agricultural productivity and the surge in food demand. This increase in food price is making Sustainable Development Goal 2 (eradicate hunger by 2030) relatively difficult to attain. Increasing food price is one of the major factors responsible for increasing malnourishment, for example stunted growth in children across the globe. Europe is witnessing a phenomenal increase in the price of basic food items, reducing the accessibility of food and aggravating food insecurities[1]. Controlling food price is a daunting task due to dependence on various external and domestic factors, i.e., oil prices, economic policies, and quantity of crops (Taghizadeh-Hesary et al. 2019). The surging food price severely affects the most vulnerable population of the low-income group.

Both supply and demand-side variables determine the price of basic food items. The continuous increase in population and per capita income is responsible for increasing demand for food items; whereas the supply of food is constrained by the reduction in the agricultural land and increasing input cost. Energy is a crucial factor input of agriculture sectors. It is used in the transportation of raw material, finished goods, and other factors of production. The recent volatility in global crude oil prices has the potential to influence global food prices. Consumers spend a greater proportion of their income on food items, and increasing food prices can severely affect global food affordability. The primary reason for the phenomenal increase in food price is the surging input prices or the cost of production. Increasing energy prices can severely affect global food prices, an essential input in agriculture value addition.

The review of empirical studies has not found any reliable study that has explored the nexus between oil price and food price in the context of European countries. This study fills this gap by establishing a robust long-term relationship between food price and crude oil prices along with other demand and supply-side variables on a sample of selected 27 European countries from 1995 to 2019. This objective is realised using recently advanced first and second-generation panel econometrics such as heterogeneous pooled mean group estimation (PMG), augmented mean group, and fully modified ordinary least square (FMOLS) estimation techniques. This study is organised as follows: Section 2 reviews the food security and agricultural productivity in Europe, which is followed by the review of selected literature in section 3. The methodological framework and data are discussed in section 4; whereas estimated results are analysed in section 5, and section 6 concludes the study and discusses some policy implications.

2. Food prices in Europe

Europe has adopted an ambitious 2030 Sustainable Development Agenda of developing more equitable and sustainable societies by attaining Sustainable Development Goals (SDGs) at their national level. The SDG-2 aims to eradicate hunger, improve nutrition, and promote sustainable agriculture by 2030. This objective depends on three essential

[1] see appendix A1 for the food prices in selected European countries

conditions: the production of food, price of food, and the affordability of domestic consumers. Although Europe has achieved tremendous success in the eradication of absolute hunger, yet some of the developing countries of Europe are still facing comparatively higher undernourishment, such as Moldova (8.5 % of the population), Georgia (7 % of the population), and Serbia (5.6 % of the population) (FAO 2019).

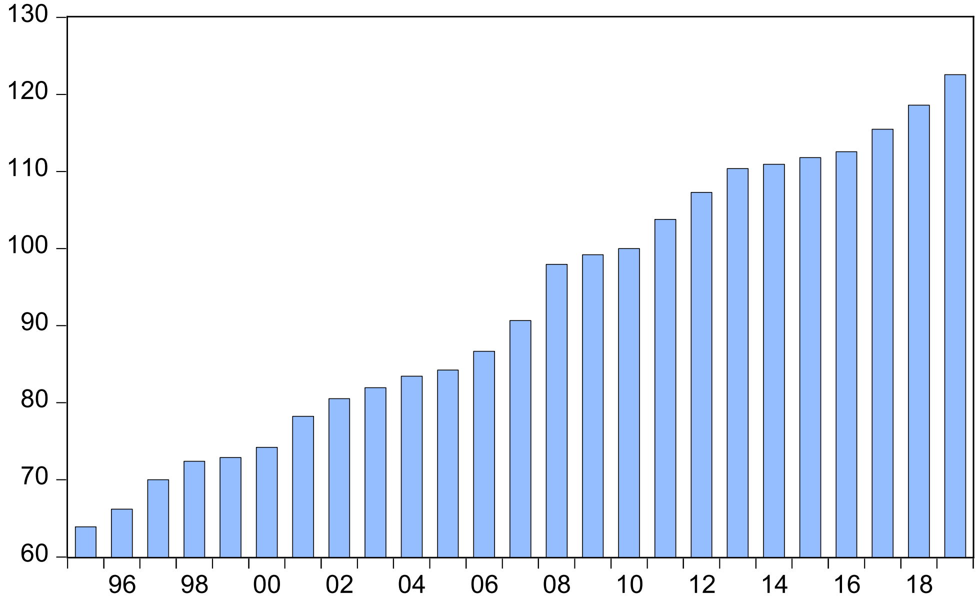

Figure 1. Mean food prices in Europe

Source: Authors' construction from data taken from International Monetary Fund.

Food security is a condition where all people have sufficient access to the basic dietary needs required for a healthy life. There are four major components of food security such as availability, accessibility, utilisation, and stability. Among these components, accessibility of food is the major component that is constraint by the stagnation in income level and exploding food prices.

The phenomenal increase in food prices reduces the accessibility of foods from lower-income level households. The aggregated food price in selected European countries is presented in Figure 1; whereas disaggregated food prices are reported in Appendix A1. Food prices of selected European countries have increased more than doubled during the sampled period. The average food price was 63 US$ in 1995 that has increased to 120 US$ in 2019. This increasing trend in food prices is observed in almost all sampled countries except Ireland and Switzerland, appendix A1.

This phenomenal increase in food prices is a matter of concern for both researchers and policymakers. Increasing food prices would distort food security and malnourishment as the lower-income population will not afford higher quality food items such as meat, dairy, and vegetables. Controlling the food price is the most challenging task for policymakers due to its dependence on various external and domestic factors. The current increase in food prices raises questions regarding the food management system's adequacy and the long-term sustainability of the production and distribution system.

2.1 Agriculture production

The food price is determined by the equilibrium interaction of aggregate supply and demand for food. The surge in demand for food in Europe is explained by increasing income and population levels, whereas aggregate supply is determined by the productivity of agriculture, farmland, and cost of production. Agriculture is the most important production sector as this sector's performance is vital to fulfilling the surging demand for food. The agriculture farms of European countries are of various sizes in terms of output and management structure. The majority of farms are small family-owned that have different soils, climates, and topographies.

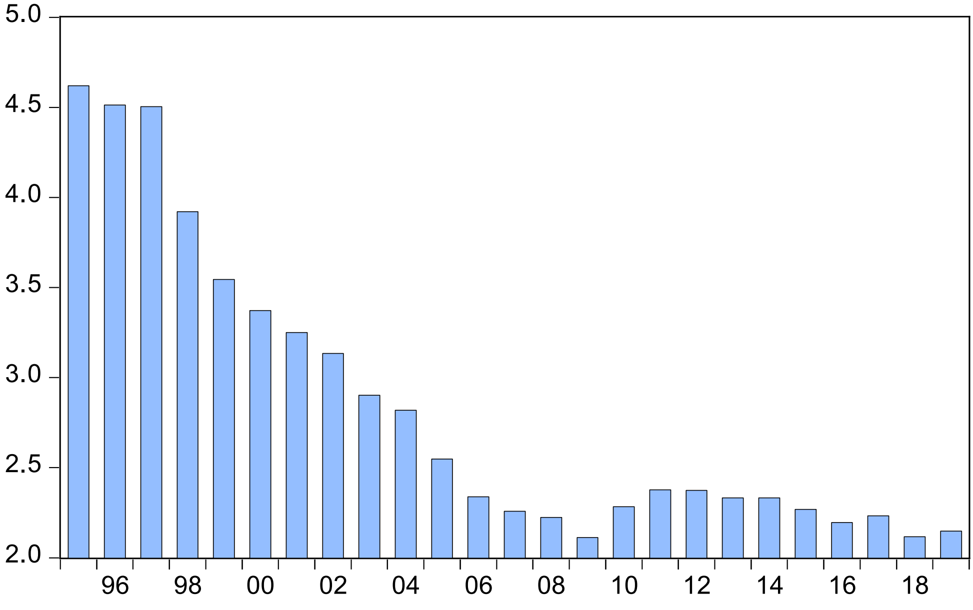

Figure 2. Mean of agriculture production as % of GDP in Europe

Source: Data collected from World Development Indicators published by the World Bank

Figure 2 reveals that the agricultural sector of selected European countries is facing a drastic reduction in its contribution from 4.7 per cent of GDP in 1995 to 2.2 per cent of GDP in 2019. This reduction in the European agriculture sector's productivity and increasing population and income level, is responsible for surging food prices. The agriculture sector of the European Union (EU) is operating under the common agricultural policy (CAP), which has been reformed many times over recent years.

In CAP reforms of 2018, the EU commission has put forwarded various proposals to enhance the role of farmers in emerging challenges to the environment along with the protection of food security and health quality.

According to the European Union (2018), there were 10.5 million agricultural land holdings in the EU in 2016, of which 96 percent are small family farms. According to FOA (2019), the agriculture sector of Europe has contributed only 1.2 % to the GDP in 2017 and created a value-addition of EUR 188.5 billion. The EU-28 countries are cultivating 173 hectares of agricultural land, approximately equal to 39 percent of their total land area. The agriculture sector of Europe employs 9.7 million people and a variety of crops along with mixed livestock.

3. Literature Review

This section discusses theoretical and empirical literature associated with food and energy prices.

3.1 Review of theoretical literature

The increase in food prices across the globe has been a great concern for policymakers over the past years. Despite the extensive research and development, the relationship between macroeconomic aggregates and food prices has remained a matter of concern. There are a plethora of theories that have explained this inflationary process. Milton Friedman considers food price inflation as a monetary phenomenon. Friedman (1936) urges that "*Inflation is always and everywhere a monetary phenomenon*". The famous quantitative theory of money associates increases in inflation with the increase in domestic money supply (Lim & Papi, 1997).

The popular demand-pull inflationary theories have urged that the general food prices can increase when aggregate demand for food exceeds the domestic supply of food. The cost-push inflation theories consider an increase in the cost of production as an essential determinant of increasing food prices. Energy is an crucial input in the production of the agriculture sector as it is required in all processes along the agricultural food chain: crop production, livestock, and fish production; post and pre-harvest operation, transportation, distribution, food processing, and storage. Being an essential input in agricultural production, increasing energy prices would induce the cost of production and price level. It implies that the increase in energy prices is one of the significant drivers of food price inflation.

3.2 Review of the empirical literature

The plethora of empirical literature on the nexus between energy and consumer prices across the globe has reported that the higher oil prices could distort economic growth in oil-importing countries along with the increasing price level. The rapid and substantial rise in global food prices has posed complex challenges for both developing and developed countries across the globe.

The major driver of food price, among others, is the fourfold increase in oil prices from October 1973 to February 1974. The other factors responsible for the hiking food prices, according to Eckstein and Heien (1978), are the monetary policies and rapid growth in per capita income in developing and advanced economies. The relationship between food prices and agricultural productivity, exchange rates, and oil prices in the USA is examined by Harri (2009) by employing Johansen and Juselius's cointegration analysis on overlapping periods. The findings have revealed the existence of cointegration and long-run estimates showed that the increasing commodity prices are associated with oil prices.

Ahsan et al. (2011) have investigated the determinants of food prices in Pakistan by incorporating both demand and supply-side factors and estimated. They have used Auto-Regressive Distributed Lag (ARDL) model from 1980 to 2008 to explore short-run and long-run impact. The estimated results show the significant positive impact of supply-side factors on food prices in the long run. Among demand-side variables, the domestic money supply has revealed a significant positive effect in both short and long run. Irz et al. (2013) have investigated the short-term and long-term determinants of food inflation in Finland from 1995 to 2010 using cointegration and vector error correction model (VECM). The estimated results have validated the statistically significant long-run equilibrium relationships between food prices and agricultural commodities, labour, and energy. The VECM model suggests that a relatively quick adjustment process dominates the dynamics of food price formation to the long-run equilibrium.

Ahmed and Singla (2014) have analysed the long-run determinants of surging food prices in India by employing Johansen's cointegration technique on monthly data from January 2006 to December 2013. The estimated results have revealed that in the long run, money supply, interest rate, exchange rate, crude oil, and rainfall, except world food prices, have a significant impact on increasing food prices. Lim and Sek (2015) have attempted to explore factors affecting food price inflation in two groups of countries, i.e., high inflation and low inflation group, from 1970 to 2011 by using the ARDL model. The findings revealed that the growth rate of GDP and imports of goods and services has a significant effect in low inflation countries in the long run, whereas money supply, national expenditure, and growth rate of GDP are major long-run determinants in the high inflation group.

In the short run, none of the variables have a significant effect. Alam and Alam (2016) have explored the short-run and long-run determinants of inflation in India by using the ARDL bounds testing approach to cointegration. The estimated results revealed that an increase in the money supply and depreciation of the exchange rate has emerged as major determinants in both the short run and the long run. Taghizadeh-Hesary et al. (2019) have investigated linkages between energy price and food prices in a sample of eight Asian countries over the period 2000–2016 by employing a panel-VAR model. The estimated results have shown that the increase in energy (oil) price has a significant positive effect on increasing food prices.

The above discussed and other empirical literature have revealed that the major determinants of increasing food prices are the phenomenal increase in global demand for food along with stagnation in agricultural technology. Oil being an imported input in the production process can contribute to rising food prices. This study does not find any reliable empirical study that has modelled nexus between oil price and food price in selected European countries.

4. Methodology

This section presents the model, estimation strategy, and data sources used to establish the relationship between energy price and food price inflation in selected European countries.

4.1 The model

The food price reflects the equilibrium between supply and demand forces. This study does not construct a fully structured model but took a guide from economic theory and literature for the selection of explanatory variables. Any model aiming to explain the behaviour of domestic prices should incorporate both demand and supply-side variables. The main demand-side variables considered are an increase in GDP growth rate and an increase in foreign exchange reserve; whereas supply-side variables are the agriculture value addition, oil prices, nominal exchange rate, and trade openness. The eclectic model used to realise research objectives is presented in Equation 1.

$$FPR_{it} = \beta_0 + \beta_1 OIL_{it} + \beta_2 YAGR_{it} + \beta_3 PCGDP_{it} + \beta_4 RES_{it} + \beta_5 TOPN_{it} + \mu_{it} \quad (1)$$

Where, FPR is the consumer prices index of food at constant 2010 US$; OIL is the oil prices; YAGR is agriculture value addition as a percentage of GDP, PCGDP is the per capita gross domestic product; RES is the total reserve including gold and precious metals as a percentage of GDP; TOPN is an index for the trade openness; μ_{it} is the white noise error term; β_0 is the constant; and β_1 to β_5 are the parameters of the modelled variables, respectively.

Oil is a major input in the production process, and the increase in oil prices will increase the domestic cost of production and food prices. The increase in agricultural productivity would increase the domestic supply of food, which would reduce food prices according to standard economic theory.

The coefficient of agriculture productivity is expected to be negatively associated with food prices. The increase in PCGDP would increase domestic demand for food, which would increase domestic prices according to the economic theory. The coefficient of PCGDP is expected to be positive. The increase in foreign exchange reserves implies an increase in domestic wealth, which would increase domestic demand for food and increase food prices. The coefficient of foreign exchange reserve is expected to be positive. The trade openness would either increase demand for domestic products and exert pressure on food prices or increase the inflow of cheaper international products and reduce food prices.

4.2 Estimation

This study aims to investigate the long-run impact of crude-oil prices along with other explanatory variables on increasing food prices in a panel of 27 heterogeneous European countries from 1995 to 2019. The panel data combine observations from heterogeneous cross-sections over the expanded period and thus provides relatively more information with a higher degree of freedom. The annual data for this study are taken from the World Development Indicators (WDI), the FAO (Food and Agriculture Organization) statistics, and the Energy Information Administration (EIA).

The data on food prices are converted to constant 2010 prices. The unavailability of data has restricted this study to selected European countries over the selected sample, presented in Appendix A2. The definition of selected variables and descriptive statistics are reported in Appendix A3.

4.2.1 Cross-sectional dependence

Panel data combines heterogeneous cross-sectional observations and there is a higher probability that the behaviour of variables would not be independent of cross-sectional dynamics. The traditional panel econometrics does not recognise this behaviour, leading to a biased inference. The recently advanced second generation of panel econometrics is based on the assumption of cross-sectional dependency. Therefore, this study employed the cross-sectional independence (CD) test of Pesaran (2004) to explore cross-sectional dependency. The null hypothesis of this test is that the cross-sectional behaviour of variables is independent, i.e., H_0: $\rho_{ij} = \rho_{ji} = (\varepsilon_{it}, \varepsilon_{jt}) = 0$ for $i \neq j$, while the alternative hypothesis is that the cross-sections are dependent, i.e. H_1: $\rho_{ij} = \rho_{ji}$ for some $i \neq j$. This test statistic is presented as follows:

$$CD = \sqrt{\frac{2T}{N(N-1)}}\left(\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\widehat{\rho_{ij}}\right) \sim N(0,1) \tag{2}$$

Where $\hat{\rho}_{ij}$ is the pair-wise Pearson's correlation coefficient that is obtained from the residual of ADF-type regression analysis

$$\hat{\rho}_{ij} = \hat{\rho}_{ji} = \frac{\sum_{t=1}^{T}\varepsilon_{ij}\varepsilon_{ji}}{\left(\sum_{t=1}^{T}\varepsilon_{ij}^{2}\right)^{\frac{1}{2}}\left(\sum_{t=1}^{T}\varepsilon_{ji}^{2}\right)^{\frac{1}{2}}} \tag{3}$$

4.2.2 Panel unit root test

Panel unit root and stationary tests have become extremely important and widely used in empirical research due to the existence of the non-stationary behaviour of economic variables. The contemporary literature on panel unit-root could be divided into two broad categories based on the treatment of cross-sectional dependency of variables, i.e., first and second generation. The literature on the first generation of panel unit root and stationary analysis assumes that the variables are cross-sectional independent, whereas second-generation considers the cross-sectional dependency.

The selected variables of this study are subject to both first-generation and second-generation panel unit root and stationary tests to explore the order of integration. There are many types of first-generation panel unit root and stationary tests based on the treatment of individual heterogeneities. The panel unit test suggested by Levin, Lin, and Chu (2002) explores the common root, whereas the unit root test proposed by Im, Pesaran, and Shin (2003), popularly known as the IPS test, considers individual roots for each cross-section. This study employed the IPS unit test from the first generation of panel unit root tests. The second generation of panel unit root and stationarity test introduced by Pesaran (2007) addresses the cross-sectional dependency. This second-generation panel unit root and stationarity tests are an augmented version of the test proposed by Im, Pesaran, and Shin (2003); therefore, it is named as CIPS test. The CIPS unit root test is a joint panel test that explores the null hypothesis that all panel units have unit root; whereas the alternative hypothesis is that at least some panel units are stationary.

4.2.3 Panel long-run estimates

Traditional panel regression models do not address the long-run and short-run impacts of explanatory variables. Whereas the autoregressive distributed lag model (ARDL) test of Pesaran et al. (2001) explores both short-run and long-run effects, but it does not address the short-run heterogeneities and convergences. Another issue with the ARDL approach is that the estimated parameters are very sensitive to the selection of cross-sections and periods.

Therefore, this study employed pooled mean group (PMG) estimator developed by Pesaran *et al.* (1999) has superior explanatory power over others. This method is becoming popular in heterogeneous panel data estimation. The optimum leg length is selected based on Schwarz Bayesian criteria. Following Pesaran *et al.* (1999), the estimated PMG model is presented in Equation 4:

$$\begin{aligned}\Delta FPR_{it} &= a_0 + \sum_{i=1}^{n}\beta_{1i}\Delta FPR_{it-j} + \sum_{i=0}^{n}\beta_{2i}\Delta OIL_{it-j} + \sum_{i=0}^{n}\beta_{3i}\Delta YAGR_{it-j} \\ &+ \sum_{i=0}^{n}\beta_{4i}\Delta PCGDP_{it-j} + \sum_{i=0}^{n}\beta_{5i}\Delta RES_{it-j} + \sum_{i=0}^{n}\beta_{6i}\Delta TOPN_{it-j} + \delta_1 FPR_{it-1} \\ &+ \delta_2 OIL_{it} + \delta_3 YAGR_{it} + \delta_4 PCGDP_{it} + \delta_5 RES_{it} + \delta_6 TOPN_{it} + \mu_{it}\end{aligned} \tag{4}$$

Where, *i* represents the number of groups (*i = 1, 2. . . , N*); and *t* reveals the number of periods *(t = 1, 2, . . . , 18)*. The increase in food prices in heterogeneous Europe and Central Asian countries may have varying tendencies to converge into equilibrium. The main disadvantage of the panel PMG estimator is that it does not address the cross-sectional dependency of selected panel variables and treat them with a linear trend. This problem is resolved by the AMG (augmented mean group) estimator of Eberhardt and Teal (2010), which addresses the cross-sectional dependency by introducing a common dynamic effect in the regression model. This study employs a panel augmented mean group model along with the fully modified ordinary least square estimator to explore the robustness of established relationships.

5. Estimated Results

This study explores the long-term effect of oil prices on food price inflation in selected European countries by constructing an eclectic model that incorporates both demand and supply-side variables. The panel data of selected variables are first tested to explore cross-sectional independence by employing the cross-sectional dependence (CD) test of Pesaran (2004). The result in Table 2 revealed that selected panel variables are cross-sectional dependent as a null hypothesis of cross-sectional independence is rejected at a higher level of significance. The findings of the CD test urge treatment for cross-sectional dependence by employing the second generation of panel econometrics. This study employs both first-generation and second-generation panel econometrics to establish relationships among variables of interest.

5.1 Unit root analysis

The estimated result of the panel first-generation unit root (IPS) test proposed by Im, Pesaran, and Shin (2003) and the second generation of unit and stationarity (CIPS) test proposed by Pesaran (2007) are reported in Table 1. The panel CIPS investigates the null hypothesis that all the units of panel cross-sections have a unit root. The distribution of the CIPS test is asymptotic, and Pesaran (2007) provided critical values for different combinations of N and T. The estimated results of the Pesaran CD test reveal the cross-sectional dependence of selected variables.

Table 1. Result of panel CD and unit root test

Variables	Pesaran CD test		IPS at level		IPS at first difference		CIPS Unit root
	CD test	**Prob.**	**C**	**C & T**	**C**	**C & T**	**Test stat.**
FPR	85.802	0.000	5.316	-1.438***	-11.699*	-9.485*	-2.939*
OIL	93.675	0.000	-0.351	3.234	-11.299*	-8.426*	-3.529*
YAGR	72.625	0.000	-8.473*	-1.804**	-13.148*	-14.514*	-4.189*
PCGDP	78.495	0,000	1.764	-2.057**	-11.606*	-6.136*	-1.578**
RES	85.802	0.000	-0.748	-0.034	-12.094*	-10.453*	-3.187*
TOPEN	71.981	0.000	-0.522	-4.852*	-14.250*	-11.230*	2.409**

*Source: Authors' estimation. Notes: *** and ** indicate the rejection of the null hypothesis at critical values of 10% and 5 % respectively*

The IPS and CIPS unit root test findings revealed a varying stationary level and order of integration. The IPS unit root test results show that the food prices are stationary at a level without trend and become stationary at a constant level and at a 10 % significance level. It implies that the food prices in selected European countries are witnessing a positive trend. This finding is validated by the individual behaviour of food prices reported in Appendix A1. The higher non-stationary behaviour at the level indicates high growth in food prices is a matter of concern for selected European countries. Among selected explanatory variables, oil prices and foreign exchange reserves are not stationary at a level and become stationary at first difference. At the same time, per capita GDP is not stationary at level with constant and becomes stationary at a level with constant and trend. The findings thus revealed a trend in increasing behavior of per capita, which can induce demand for food. The major reason for increasing food prices is stagnation in agricultural value addition, as presented by the unit root analysis as an agriculture value addition. YAGR is stationary with a constant at a 1 per cent significance level, which revealed distortion in agriculture value addition.

5.2 Results of PMG estimator

The selected panel variables with different stationary levels and order of integration are subjected to a pooled mean group (PMG) estimator that is proposed by Pesaran *et* *al*. (1999) to explore homogenous long-term and heterogeneous short-term estimates. It is a panel version of the autoregressive distributed lag (ARDL) model that explores the existence and nature of long-term relationship even if the variables are integrated at their level.

Table 2. Result of panel mean group estimators. Dependent variable: FPR

Variable	PMG model estimates		
	Coeff.	**t-Stat.**	**Prob.**
OIL	0.809	5.432	0.000
YAGR	-9.839	-9.57	0.000
PCGDP	0.26	14.676	0.000
RES	0.576	16.662	0.000
TOPN	0.282	22.35	0.000
Coint. Eq.	-0.175	-2.467	0.015
ΔOIL	-0.037	-0.918	0.361
ΔYAGR	2.277	1.087	0.28
ΔPCGDP	-0.063	-0.457	0.649
ΔRES	-0.676	-1.547	0.127
ΔTOPN	0.135	1.658	0.099
Constant.	14.658	2.648	0.01
Mean dependent var.		2.873	
S.E of regression		3.898	
Schwarz criteria		5.494	
Log Likelihood		-265.21	

Source: Authors' estimation.

The estimated result of PMG model estimates in Table 2 revealed that oil price has a significant positive effect on food prices in selected European countries in the long run, whereas an insignificant effect is observed in the short run. It implies that the increase in oil prices will increase food prices in the long run, along with the degradation of the environment by the emission of carbon and other greenhouse gases. This finding is consistent with the argument established by Taghizadeh-Hesary et al. (2019).

The results urge the selected European countries to diversify their energy sources by transforming agricultural technology into renewable energy. These countries have enough technology and capital resource needed for this transformation. The increase in agricultural value addition reveals the negative effect of higher intensity on food prices in the long run; whereas an insignificant effect is observed in the short run. An increase in agricultural production would reduce food prices by more than a proportional increase in agricultural output. It implies that besides energy prices, reduction in agricultural activities is responsible for higher food prices in selected European countries. The significant negative long-run impact is consistent with the findings of Ahsan et al. (2011), Ahmed and Singla (2014), Alper et al. (2016). This study urges selected European countries to enhance their research in agriculture to develop the technology of producing higher yield crops. Due to urbanisation and increasing population, the decreasing farmlands urge Europe to advance agricultural technology.

The estimated long-run estimates of the increase in per capita GDP and increase in foreign exchange reserve revealed a significant positive effect in the long run. The increase in per capita GDP and the foreign exchange reserve of European countries enhance their demand for food. The result of unit root analysis also revealed a non-stationary increase in per capita income and foreign exchange reserves that can increase food demand considerably. These long-run results are consistent with the theory of demand-pull inflation. Rising demand for food and stagnation in agricultural value addition have resulted in a phenomenal increase in food prices, as presented in Appendix A1. Trade openness is incorporated in the model to explore the effects of trade liberalisation on food prices in selected European countries. The findings revealed a significant positive effect of increased trade openness on food prices. Liberal trade policies of European countries have provided an opportunity for the domestic producer of food to sell their products to those countries with higher prices, which is responsible for the increasing price level on home countries.

5.3 Sensitivity analysis

The main disadvantage of the panel PMG estimator is that it does not address the cross-sectional dependency, which was resolved by Bond and Eberhardt (2009) and Eberhardt and Teal (2010) by introducing the augmented mean group (AMG) estimator that allows for cross-sectional dependency by introducing common dynamic effect in the regression model. This method addresses cross-sectional dependency and allows for heterogeneous slope coefficients. Established long-term relationships' sensitivity is explored using the AMG estimator and panel fully modified ordinary least square (FMOLS) estimator.

The result of sensitivity analysis is reported in Table 3. The estimated result of the AMG and FMOLS estimators revealed that an increase in oil prices, PCGDP, foreign exchange reserve, and trade liberalisation is increasing food prices. In contrast, an increase in agriculture value addition has a significant negative effect of high intensity. The estimated result of these estimators is consistent with the long-term estimates of the panel PMG estimator. The findings thus validate the robustness of established relationships.

Table 3. Result of sensitivity analysis. Dependent variable: FPR

Variable	Augmented Mean Group Estimator			FMOLS		
	Coeff.	**z-Stat.**	**Prob.**	**Coeff.**	**t-Stat.**	**Prob.**
OIL	0.567	5.50	0.000	0.210	7.164	0.000
YAGR	-5.428	-3.53	0.000	-7.029	-15.08	0.000
PCGDP	0.431	1.921	0.057	0.057	6.568	0.000
RES	0.109	0.66	0.053	0.073	5.364	0.000
TOPN	0.070	0.88	0.376	0.252	16.481	0.000

*Notes: ***, ** and * indicate the significance levels at the 1%, 5% and 10%, respectively.*

6. Conclusion

This study explores the long-term effect of energy price on food price in selected 27 European countries from 1995 to 2019 by constructing an eclectic model that includes crude oil price and the agriculture value addition, per capita GDP, foreign exchange reserve, and trade openness as explanatory variables. This study employs both first-generation and second-generation panel econometric analysis to realise its objectives. The estimated result of cross-sectional independence tests revealed dependency of cross-sectional observation that the enhanced importance of the second-generation of panel econometrics. The estimated result of both first and second generations of panel unit root test revealed varying orders of integration. The selected panel variables with varying stationary levels are subject to the PMG model. The findings of the PMG model revealed that an increase in oil price has a significant positive effect on food prices in the long run; whereas an insignificant effect is observed in the short run. The result of agricultural value addition showed a significant negative effect of higher intensity on food prices in the long run. It implies that a reduction in agriculture value addition is responsible for the increase in food prices. An increase in per capita income and foreign exchange reserve enhances purchasing power and demand, which results in the enhancement of food prices in the long run.

The study urges selected European countries to diversify their energy supplies by exploiting alternative green energy sources. In this regard, the production of green energy by using solar, wind, and water power and electrification of oil-based transportation, agriculture, and other manufacturing processes would be beneficial for environmental sustainability and food security. Moreover, attempts should be taken to, directly and indirectly, use renewable energy in agriculture and the manufacturing food chain. The use of alternative energy sources, i.e., fossil fuels and nuclear power, can improve food securities in European countries. The Europeans should ensure a long-term food supply by enhancing research in the agriculture sector to develop more environmentally friendly and resilient high-yield crops. The scope of the current study can be expanded in future studies by exploring the factor responsible for the considerable decline in agriculture value addition and figuring out alternative sources to provide higher yield agriculture output at a minimum environmental cost. Research on the exploration of the environmentally friendly and resilient variety of crops would be beneficial for ensuring food security and reducing environmental degradation.

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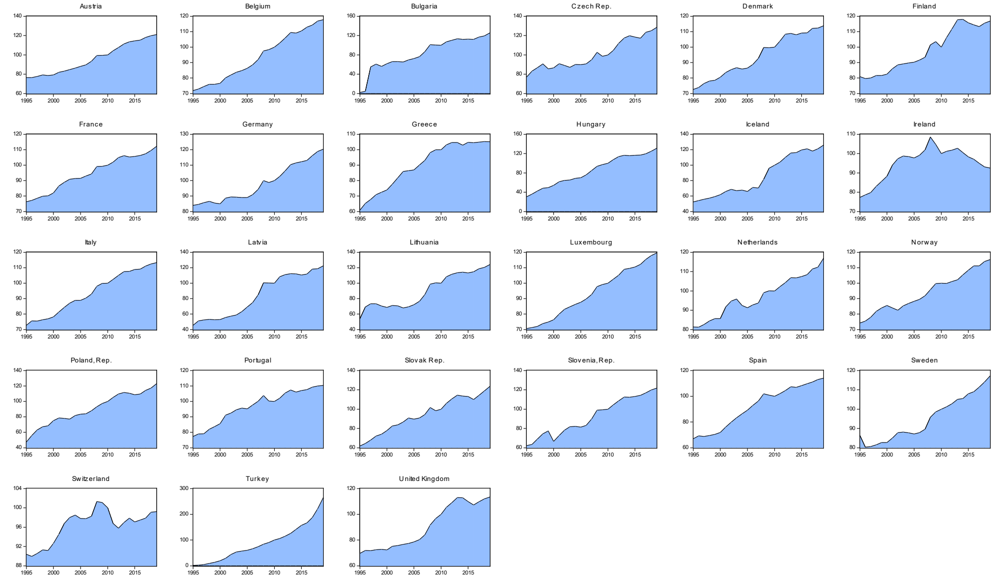
Appendix



A1. Food prices in selected European countries
Source: Authors construction

A2. List of sampled ECA countries

Countries	Cross ID	Countries	Cross ID
Austria	1	Lithuania	15
Belgium	2	Luxembourg	16
Bulgaria	3	Netherlands	17
Czech Republic	4	Norway	18
Denmark	5	Poland	19
Finland	6	Portugal	20
France	7	Slovak Republic	21
Germany	8	Slovenia	22
Greece	9	Spain	23
Hungry	10	Sweden	24
Iceland	11	Switzerland	25
Ireland	12	Turkey	26
Italy	13	United Kingdom	27
Latvia	14		

A3. Data definition and descriptive statistics

Variables	Descriptive Statistics	Mean	Max.	S.D	Data source
FPR	Food prices at base 2010 US$	92.634	264.41	22.328	IMF Stat. (2020)
OIL	Crude oil prices, US$	50.777	102.58	28.744	EIA (2020)
YAGR	Agriculture value addition, % of GDP	2.828	20.477	2.314	WDI (2020)
PCGDP	GDP per capita (100, current US$)	36542.56	111968	23582.9	WDI (2020)
RES	Total reserves includes gold, % of GDP	12.284	121.597	13.665	WDI (2020)
TOPEN	Total trade as percentage of GDP	102.018	408.363	56.476	WDI (2020)