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Article

Impact of Logistic Performance on Food Security: Revisiting the Trade Openness-Food Security Nexus

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Abstract

This study investigates the impact of logistics performance on food security using the trade openness-food security nexus. Specifically, this study uses panel data from 160 countries for 2007, 2010, 2012, 2014, 2016, and 2018. The reason for selecting these periods was the data availability of the logistic performance index (LPI) offered by the World Bank. Using the generalized method of moments, we found that trade openness and LPI have negative and positive effects on food security in the short and long term, respectively. Additionally, while LPI does not significantly affect food security in high-income countries, it has negative and positive effects on the food security of low-income countries in the short- and long-term, respectively. Our results highlight the need to create a backup policy for the short-term negative effect of trade openness and LPI on food security. Additionally, this study determines that low-income countries might consider the development of logistics to enjoy the effect of trade openness among low, middle, and high countries.

Keywords

Food security, Logistics performance index, Trade openness

Introduction

According to the International Food Policy Research Institute, food security is defined by the United Nations Committee on World Food Security: "All people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their food preferences and dietary needs for an active and healthy life." Thus, the food security problem is significant for people's health. However, despite progress in agriculture and economic growth

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worldwide, the food insecurity problem has not been resolved across many countries (Dithmer & Abdulai, 2017). Moreover, it is well known that food insecurity problems exist even in advanced capitalist countries (Long et al., 2020).

Trade policies have been emphasized to solve the food security problem since the World Food Summit of 1996 (Dithmer & Abdulai, 2017). There are several possible reasons for the important role of trade policies in food security. First, trade creates a flow of food from food-abundant to food-scarce areas. In other words, trade links food production in food-abundant countries and food consumption in food-scarce nations globally (Runge et al., 2003). Second, trade buffers food price volatility by managing excess food demand and supply in the domestic market (Dithmer & Abdulai, 2017). Third, trade provides domestic consumers with diverse food choices (Dithmer & Abdulai, 2017). In turn, free trade policies are expected to solve food security problems.

However, free trade policies may lead to food insecurity, especially in developing countries. Developing countries might expand their agricultural exports if they aim for long-term economic growth. It is because exports are expected to contribute to economic growth based on the export-leg growth hypothesis (ELG). As Dawson (2005) highlights, exports can contribute to economic growth by the effects of foreign exchange multipliers and capital formation. Since developing countries have a comparative advantage in the agricultural sector, free trade policy tools might increase agricultural exports rather than imports. In other words, free trade policies can expand or reduce food insecurity in developing countries.

Some empirical studies, such as Dithmer and Abdulai (2017) and Fusco et al. (2020), have recently examined the relationship between trade openness and food security problems. Dithmer and Abdulai (2017) explored the impact of trade openness on food security in 151 countries during1980–2007. Using the generalized method of moments (GMM), they found that trade openness positively affects dietary consumption. In other words, their results support the positive role of trade openness or trade openness policies on food security. Fusco et al. (2020) examined the impact of trade openness on food security in European countries and showed that trade openness positively affects food security. In other words, their results also support the trade openness-food security framework.

However, these previous studies have ignored two possible problems. First, previous studies did not consider an important factor that might significantly affect food security. In other words, previous empirical studies of the impact of trade openness on food security have the omitted variable problem. The estimated results will be biased if there is an omitted variable problem (Wilms et al., 2021). The omitted variable in the trade openness-food security nexus may be the distribution or transportation of the food environment. Even though food volume is sufficient for national food security, food security problems arise if there is a food distribution or transportation problem. This is well demonstrated in the framework of Orjuela-Castro and Adarme-Jaimes (2018) (see. Figure 1). Orjuela-Castro and Adarme-Jaimes (2018) show that the food security problem is associated with logistics operations that reflect a food distribution ability or level. Therefore, logistics operations can affect the efficiency of food distribution, which may be related to food access and security. In addition, logistics operations can be related to food loss linked to food security. In other words, logistics operations reflecting food distribution may significantly affect food security.

The second possible problem of previous empirical studies on trade openness and food security is that they did not divide the long- and short-run effects. Dividing the short- and long-run effects might be important, especially in developing countries. Developing countries are expected to export their agricultural products with trade openness trends for their development. In other words, the effect of trade openness on solving food security problems is vague in the short-run and clear in the long-run. In the short-run, if trade openness expands the agricultural exports

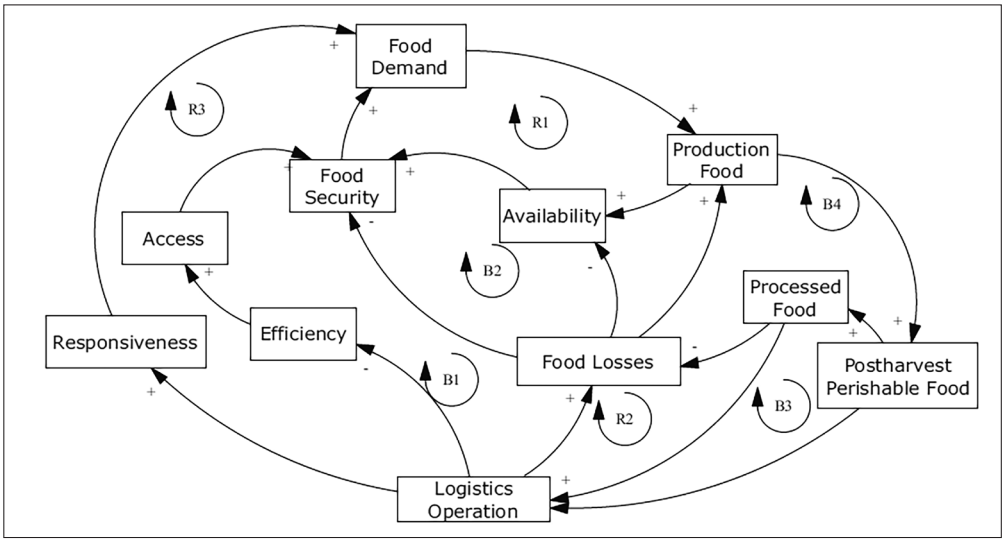

Figure 1. Framework of Orjuela-Castro and Adarme-Jaimes (2018)
Source: Orjuela-Castro & Adarme-Jaimes (2018, p. 260).

of developing countries compared to agricultural imports, then the free trade policy cannot solve food security problems in developing countries. However, trade openness expands agricultural imports rather than exports. Therefore, the food security problem can be solved using a free-trade policy. In this sense, the short-run effect of trade openness on food security problems is vague. However, trade openness is expected to solve the food security problems of developing countries based on the export-led growth hypothesis. Therefore, developing countries promote economic growth and reduce food security problems using the free trade policy. As this economic growth process requires a long period, trade openness has a long-run positive effect on solving food security problems, especially in developing countries.

This study investigates the impact of trade openness and logistics operations on food security based on the trade openness-food security nexus. We utilize the GMM method to address the potential endogeneity and unobserved heterogeneity of the explanatory variables (Dithmer & Abdulai, 2017). This study uses the Logistics Performance Index (LPI) offered by the World Bank to measure logistics operations. As the LPI covers only 2007, 2010, 2012, 2014, 2016, and 2018, we use the data from those years. Furthermore, we divide our sample into low-, middle-and high-income countries. We expect that the effect of LPI on food security will be higher in high-income countries than in low-income countries. This is because high-income countries' social overhead capital (SOC) is expected to be lower than low-income countries due to the relatively low capital in developing countries. In addition, the trade openness effect may be higher in low-income countries than in high-income countries. This is because food security problems are more severe in developing countries than in developed countries.

Our analysis contributes to the literature in three ways. First, this study addresses a possible omitted variable problem in previous studies on the trade openness-food security nexus. Specifically, we consider the variable of the logistic performance index for the trade openness-food security nexus. Second, this study investigates the impact of trade openness and logistics index on food security by dividing countries based on income levels. Previous studies have not

compared these effects on food security in developing and developed countries, even though these effects are expected to differ between developing and developed countries. Third, we attempted to estimate the effect of trade openness and the logistics index on food security in the short and long run. Considering the export-led growth hypothesis, the impact of trade openness on food security in developing countries may differ according to the development stage of the country. However, based on the in-depth literature review, previous studies have not covered this topic.

Previous Studies for Trade Openness and Food Security

There are several ways to improve food security by increasing trade openness. The first is the food supply increase effect of trade openness. According to the neoclassical approach, trade and productivity levels are increased by reducing trade barriers (Dowrick & Golley, 2004). Additionally, trade theory suggests that an increase in trade enhances productivity (Grossman & Helpman, 1991; Krugman, 1981). Many empirical studies have found that trade openness contributes to increased productivity. For example, Wong (2009) focused on manufacturing industries in Ecuador and found a positive effect of trade openness on export-oriented industries' productivity after adopting trade reforms. Abizadeh and Pandey (2009) presented results that support the positive effect of trade openness on the total factor productivity. Specifically, they found that trade openness positively affects the overall productivity growth in 20 OECD countries. Kacou et al. (2022) used the panel vector autoregressive model for 61 developing countries to determine the relationship between trade openness and labor productivity. Their results showed a positive relationship between trade openness and labor productivity, with only countries with a higher level of trade openness.

The second path is to stabilize food prices through trade openness. According to Romer's hypothesis, trade openness and inflation are inversely related (Romer, 1993). Based on Romer's hypothesis, inflation reflects the price level of goods; trade openness contributes to lowering the price of goods. Several empirical studies have tested Romer's hypothesis and found mixed results. Gruben and McLeod (2004) found a negative relationship between trade openness and inflation. Munir and Kiani (2011) investigated the relationship between trade openness and inflation using Pakistan's time-series data during 1976–2010. Their results do not support Romer's hypothesis in the case of Pakistan because of the positive long-run effect of trade openness on inflation. Ada et al. (2014) tested Romer's hypothesis using Nigerian data and the vector error correction model (VECM). Their estimated cointegration vector showed that trade openness and inflation have a negative long-run relationship. Chhabra and Alam (2020) found the opposite result to Romer's hypothesis using the case of India.

The third path is enhanced food choice set from trade openness. Melitz (2003) developed an intra-industry trade model rather than an inter-industry trade model. This is because trade has increased among countries with the same product type. In other words, intra-industry trade indicates that specialization of the same type of products occurs with an increase in trade. Trade openness is closely related to quality and trade issues. In this context, Murphy and Shleifer (1997) explained trade between economically similar countries. Specifically, they set up a theoretical trade model focused on international income similarity. Dithmer and Abdulai (2017) highlighted that increasing trade openness might enhance a variety of foods.

The food security problem might be improved by increasing food supply, price, and variety. Recently, Dithmer and Abdulai (2017) and Fusco et al. (2020) examined the possible linkage between trade openness and food security. Dithmer and Abdulai (2017) and Fusco et al. (2020) used data from 151 countries and EU countries, respectively. These two studies found a positive

effect of trade openness on food security.

However, we focus on developing countries' food security problems rather than developed ones. The trade openness effect on food security might not be positive, especially in the short rather than the long run. If developing countries set up development policies based on the export-led growth hypothesis, trade openness may cause food insecurity in the short run. This is because the effect of trade openness on the increase in agricultural exports can dominate the increase in agricultural imports in developing countries in the short run. However, the export income effect is expected to solve food security problems in developing countries in the long run. In other words, the effect of trade openness on the food security of developing countries might differ in the short and long run.

In addition, previous studies on trade openness and food security have identified potential problems. The basic assumption of these studies is that food supply, variety, and price level are insufficient in terms of food security. However, this assumption might ignore that even though food supply, variety, and price level are good enough, people might not improve their food security problems because of other factors that might affect food security. For example, one important factor for food security is the distribution or transportation environment. In other words, previous studies on trade openness and food security might have problems with omitted variables.

Research Methods

We utilize a dynamic panel regression to establish the dynamic empirical effect of trade openness and LPI on food security for a cross-section of countries. To estimate the dynamic effects in panel data, we set the current food security levels as a function of previous and current explanatory variables. Through the lagged food security variable, we can control for long-term relations of all variables and find the effect of omitted variables highly correlated with the food security variable. Our specification model is as follows:

$$\mathrm{FS}_{\mathrm{i,t}} = \alpha + \beta FS_{i,t-1} + \gamma LPI_{i,t} + \delta X_{i,t} + \theta_i + \mu_t + \epsilon_{i,t} \quad (1)$$

Where the subscripts i and t represent country and period, respectively. *FS* is food security measured by dietary energy consumption in kilocalories per day. This variable (FS) has been widely used in previous studies, such as by Dithmer and Abdulai (2007), Fusco et al. (2020), and Smith and Haddad (2000), as a proxy variable for food security. *LPI* represents a logistics performance index for the performance of trade logistics operations. X is a set of control variables that significantly impact food security, such as trade openness, natural disasters, GDP growth, arable land, population, and inflation. These variables are explained in detail below: θ_i and μ_t are the country and time fixed effects, respectively, and $\epsilon_{i,t}$ is the error term.

Equation (1) may generate an endogeneity bias in which a lagged dependent variable is correlated with an error term, or other error terms are affected. There are possible sources of endogeneity, unobserved heterogeneity, simultaneity, and dynamic endogeneity (Ullah et al., 2018; Wintoki et al., 2012). This endogeneity bias can result in inconsistent estimates, leading to incorrect theoretical interpretation and inference. Thus, OLS estimation generates an inconsistent estimate, even in the fixed or random-effects model, because the lagged dependent variable is correlated with the error term (Dithmer & Abdulai, 2017).

The GMM model for dynamic panel data was used to obtain consistent estimates in the presence of some sources of endogeneity. Traditionally, the GMM model removes endogeneity through a statistical process in which a variable's past value is subtracted from its present value

(Ullah et al., 2018). Using the previous value of the variables as instruments uncorrelated with error terms, we first differentiate Equation (1) as follows:

$$\mathrm{FS}_{\mathrm{i,t}} - \mathrm{FS}_{\mathrm{i,t-1}} = \beta(FS_{i,t-1} - FS_{i,t-2}) + \gamma(LPI_{i,t} - LPI_{i,t-1}) + \delta(X_{i,t} - X_{i,t-1}) + (\mu_t - \mu_{t-1}) + (\epsilon_{i,t} - \epsilon_{i,t-1}) \quad (2)$$

The transformation in which a previous value is subtracted from its present value $(FS_{i,t-1} - FS_{i,t-2})$ is an instrument that deals with endogeneity bias. These structures allow the explanatory variables to be uncorrelated with the future of the error term values (DeJong & Ripoll, 2006).

Several methods can be applied to transform instrumental variables for dynamic panel data. First is the difference GMM method, which can derive results with a less consistent estimate if the series are persistent (Bun & Windmeijer, 2010). Second, the first-difference approach, called one-step GMM, was used to enhance the efficiency of the results. However, this approach loses too many observations by subtracting past values from the current value (Roodman, 2009). The second method is the second-order approach, the two-step GMM. Two-step GMM can prevent potential data loss in one-step GMM. Our study shows the estimated results using the three approaches for comparison.

We performed specification tests to validate the instruments and autocorrelation in terms of error. The Sargan test was used to test the hypothesis: the validity of the instruments. To check for autocorrelation in error terms, we check the autocorrelation tests (AR(1) and AR(2)) of the serial correlation properties of $(\epsilon_{i,t} - \epsilon_{i,t-1})$.

Data

This study collected all available data from 160 countries with LPI indices for 2007, 2010, 2012, 2014, 2016, and 2018. With aggregated LPI, we also selected the six indicators of LPI: customs (*lpic*), infrastructure (*lpiinfra*), international shipments (*lpiship*), quality, and competence (*lpiqual*), tracking and tracing (*lpitrack*), and timeliness(*lpitime*). These LPI indicators were obtained from the World Bank. The LPI values range from 1 to 5, with 5 indicating high logistic performance and 1 representing low logistic performance. Table 1 summarizes the LPI statistics. There are 907 LPI observations, and the minimum and maximum values are 1.21 and 4.23, respectively. These values imply that some countries have very low logistic performance, whereas others have high performance. Specific LPI indicators also showed similar values to the aggregated LPI. As the survey for the LPI indicator is not performed on yearly sequences, we collect data periods for other variables based on the LPI indicator series.

We collected explanatory variables representing significant country characteristics for food security (*fs*). The World Bank collects GDP growth (*gdpgrowth*) data to capture each country's economic level. A natural disaster (*disas*) could affect food security; therefore, we collected data on disasters from the International Disaster Database's EM-DAT. An essential factor for food security is population (*popgrowth*) since population can be considered a proxy variable for food demand. Our study contains the share of the rural population (*ruralpop*) and the total population growth rate from the World Bank. In addition, arable land (*land*) data that reflect food supply were gathered from the World Bank. This study hypothesizes that the development stage of each country may have an impact on food security, as the development stage is expected to be correlated with the level of LPI. We categorize the three income groups based on gross national

Table 1. Summary statistics

Variable	Definition	Obs	Mean	SD	Min	Max
lpi	Logistic performance index	907	2.87	0.59	1.21	4.23
lpic	Custom of logistics	907	2.67	0.61	1.11	4.21
lpiinfra	Infrastructure of logistics	907	2.72	0.70	1.10	4.44
lpiship	International shipment of logistics	907	2.84	0.54	1.22	4.24
lpiqual	Service quality of logistics	907	2.81	0.62	1.25	4.32
lpitrack	Tracking and tracing of logistics	907	2.88	0.65	1.00	4.38
lpitime	Timeline of logistics	906	3.28	0.60	1.38	4.80
tradeopen	Trade openness index	887	88.82	57.60	1.30	430.57
disas	1 if disaster was in place, 0 otherwise	626	3.34	4.19	1.00	33.00
fs	Dietary energy consumption in kilocalories per day	911	2855.78	471.69	1432.00	3876.00
gdpgrowth	GDP growth	931	4.14	5.38	-24.00	123.14
land	Arable land	946	0.23	0.25	0.00	1.85
ruralpop	Rural population	944	40.60	22.58	0.00	90.14
popgrowth	Population growth	944	1.49	1.58	-4.53	17.51

Table 2. Correlation analysis

	Food security	LPI	Trade openness	gdp growth	land	disaster	rural population	population growth
Food security	1	0.684	0.2	-0.326	0.181	0.027	-0.654	-0.553
LPI		1	0.206	-0.239	0.004	0.192	-0.607	-0.404
Trade openness			1	0.024	-0.079	-0.248	-0.19	-0.256
gdp growth				1	-0.028	0.142	0.336	0.297
land					1	-0.066	-0.064	-0.085
disaster						1	0.034	-0.083
rural population							1	0.396
population growth								1

income. Specifically, we divided countries into 53 in the high-income group, 41 in the middle-income group, and 66 in the low-income group.

Table 2 summarizes the results of the correlation matrices. This correlation matrix was used to check for collinearity among the independent variables. The results confirmed no collinearity in our model because the absolute correlation values are less than 0.7. In addition, we found that the food security variable was highly correlated with all the input variables.

Empirical Results

The Effect of LPI on Food Security

Table 3 presents the results of the primary model using the total sample with our specifications. Column 1 presents the baseline model, which is a two-step System-GMM. The lagged dependent variable is significant, and its magnitude is greater than one. This means that food security changes quickly over time and relies on the previous levels. The LPI and trade openness variables are significant, with magnitudes less than one and negative. Negative coefficients for these variables imply that an increase in LPI or trade openness reduces food security in the short term. The impact of the change in LPI is more significant than the change in trade openness. Sun and Zhang (2021) showed that the impact of trade openness on food security is U-shaped; the impact in the short term is negative, but it turns positive in the long term. Our results were consistent with those of Sun and Zhang (2021).

Our results show that improvements in LPI improve food security in the long term. Our model is a logarithmic regression using log data as the dependent variable. Hence, the long-term effect of a one-unit change in LPI and trade openness are 3.07 (1.02/(1-(-0.07)) and 0.66 (1.02/(1-(-0.02)), respectively. The results imply that the long-term effect on LPI is relatively large in terms of the effect on trade openness, and the long-term response in the absolute value is greater than the short-term response is -0.07 for LPI and -0.02 for trade openness. These positive values indicate that changes in LPI and trade openness positively impact food security long-

Table 3. The effect of LPI on food security

	Sys-GMM	All lags included	One-step SYS-GMM
FS(-1)	1.02*** (0.008)	1.06*** (0.010)	1.08*** (0.020)
LPI	-0.07*** (0.020)	-0.17*** (0.040)	-0.25*** (0.060)
Trade openness	-0.02** (0.006)	-0.03** (0.010)	-0.04*** (0.010)
GDP growth	0.001 (0.001)	0.001 (0.001)	0.001 (0.001)
Arable land	0.001 (0.002)	0.002 (0.004)	0.001 (0.004)
Disaster	0.001 (0.001)	0.0001 (0.001)	0.0006 (0.001)
Rural population	-0.01** (0.001)	-0.03*** (0.010)	-0.05*** (0.010)
Population growth	-0.001 (0.001)	-0.003 (0.003)	-0.006 (0.004)
Obs.	756	756	756
Number of country	126	126	126
Sargan test	23.15**	8.87	12.83
AR(1)	-0.05**	-0.66**	-1.34**
AR(2)	-1.36	-0.76	-0.19

Notes: *, **, and *** indicate significance at the 1%, 5%, and 10% levels, respectively. The parentheses represent standard errors.

term. Dithmer and Abdulai (2017) measured the long-term effect as we applied and showed that the long-term impact of trade openness on food security is approximately 2.27, which is smaller than our result. Fig. 1 shows that a change in the LPI leads to a reduction in food security due to changes in efficiency and an increase in food loss in the short term. However, improving LPI increases food security in the long run.

Other factors also affect food security; rural populations negatively impact food security. Economic growth positively affects food security, implying the importance of economic development in increasing food security. Dithmer and Abdulai (2017) argued that some developing countries' economic growth does not improve food security. As our dataset includes all countries, we need to separate them into income level groups to test whether the impact of trade openness and LPI on food security differs according to countries' income levels.

Instruments for the system GMM are valid, and the autocorrelation of the first-order in error terms is presented in the data. The Sargan test shows that we cannot reject the hypothesis that the instruments are valid at the 5% significance level. The AR(1) autocorrelation tests imply that our models have autocorrelations in error terms. AR(2) was not present in the data. These specification tests confirm that the GMM estimator is allowed in our model.

We compare the additional model specifications. Column 2 shows the results from the GMM estimation, including all lags in the instruments, and Column 3 shows the results of the one-step GMM estimation. The main results are consistent with those of the system GMM estimation. LPI negatively affects food security in the short term but positively affects food security in the long term. The magnitude of the LPI effect on food security is larger than that of the trade openness effect on food security in the alternative GMM estimation. However, in the long term, both LPI and trade openness positively affect food security, and the effect size of LPI is larger than that of trade openness.

The Effect of Specific LPI on Food Security

The LPI comprises six components: customs, infrastructure, international shipments, service quality, tracking, and timeliness. As each LPI component can be correlated, estimating the effect of LPI, including all components on food security, can lead to multicollinearity. Hence, we estimated each component to avoid multicollinearity (Martí et al., 2014). Table 4 presents the effects of the six LPI components on food security. We used the two-step system GMM to compare the magnitude of the impacts.

Table 4 shows that except for the LPI custom, the LPI components negatively impact food security in the short term. The effects of all six LPI components on food security are consistent with the results of the overall LPI, reflecting all six components. However, we find that the effect of each LPI component on food security has a different magnitude with a negative sign. For example, an improvement in the logistics timeline decreases food security in the short term, but the magnitude is the smallest among the six LPI components. The impact of service quality and tracking and tracing logistics on food security are relatively large for short-term infrastructure and international logistics shipments. These results imply that LPI improvement's effect on trade might be concentrated on exports rather than imports. Martí et al. (2014) mentioned that improving the LPI components can increase trade flow growth in the short term. However, if the effect of LPI on exports is larger than that on imports, then the improvement in LPI might deteriorate food security in the short term.

In the long term, improving LPI components increases food security. Lagged food security has a more significant coefficient: if each LPI component has a negative coefficient and less than one, the long-term elasticity is positive. International shipments of logistics have the largest impact on

Table 4. The effect of specific LPI on food security

	Sys-GMM						
FS(-1)	1.02*** (0.008)	1.004*** (0.001)	1.01*** (0.001)	1.008*** (0.005)	1.014*** (0.008)	1.016*** (0.006)	1.015*** (0.005)
LPI	-0.07*** (0.020)						
LPI_custom		-0.015*** (0.010)					
LPI_Infrastructure			-0.036*** (0.010)				
LPI_shipment				-0.035*** (0.010)			
LPI_quality					-0.044*** (0.010)		
LPI_track						-0.045*** (0.010)	
LPI_time							-0.052*** (0.010)
Trade openness	-0.02** (0.006)	-0.005 (0.007)	-0.01* (0.006)	-0.006 (0.006)	-0.01* (0.006)	-0.01** (0.006)	-0.01** (0.005)
GDP growth	0.001 (0.001)	0.001** (0.001)	0.001** (0.0008)	0.001** (0.0007)	0.001** (0.0008)	0.001** (0.0007)	0.001** (0.0007)
Arable land	0.001 (0.002)	-0.0006 (0.001	0.0003 (0.001)	-0.0007 (0.001)	-0.0001 (0.001)	-0.0001 (0.003)	-0.0004 (0.001)
Disaster	0.001 (0.001)	(0.001) 0.0004	-0.001 (0.0005)	0.001 (0.0003)	0.001 (0.0004)	-0.0001 (0.0004)	0.0001 (0.0004)
Rural population	-0.01** (0.001)	(0.001) (0.004)	-0.005 (0.004)	-0.003 (0.003)	-0.005 (0.005)	-0.006 (0.004)	-0.004 (0.003)
Population growth	-0.001 (0.001)	0.0001 (0.002)	0.0001 (0.002)	0.0002 (0.002)	0.0002 (0.002)	-0.0002 (0.002)	0.0005 (0.002)
Obs.	756	756	756	756	756	756	756
Number of country	126	126	126	126	126	126	126
Sargan test	23.15**	29.08***	27.92***	27.24***	28.10***	23.41**	23.94**
AR(1)	-0.05**	-0.31**	-0.43**	-0.28**	-0.36**	0.01**	0.12**
AR(2)	-1.36	-1.59	-1.59	-1.72	-1.51	-1.81	-1.29

Notes: *, **, and *** indicate significance at the 1%, 5%, and 10% levels, respectively. The parentheses represent standard errors.

food security in the long term. These results imply that the facilitating role of logistics in trade is the most important factor among all logistics aspects in improving food security. The next largest impact on food security is the timeline of logistics, which has the largest impact in the short term. Other components can also lead to increased food security. These results imply that even though improvements in the LPI components can reduce food security in the short term, they can positively impact food security in a U-shaped manner in the long term.

Table 5. The effect of LPI on food security in each income group

		High-income group		Middle-income group		Low-income group	
		(1)	(2)	(1)	(2)	(1)	(2)
	FS(-1)	1.01*** (0.01)	0.75 (0.93)	1.01*** (0.01)	1.03*** (0.01)	1.004*** (0.01)	1.07*** (0.04)
Short-term effect	*LPI*	-0.04 (0.03)	0.03 (0.20)	-0.03 (0.03)	-0.07** (0.03)	-0.06** (0.02)	-0.24** (0.10)
Long-term effect	*LPI*	4.00	0.12	3.00	2.33	15.00	3.43

Notes: *, **, and *** indicate significance at the 1%, 5%, and 10% levels, respectively. The parentheses represent standard errors.

The Effect of LPI on Food Security in Each Income Group

The effect of LPI on food security differs according to economic size and the degree of economic development. Therefore, we divide the income group into high-, middle-, and low-income groups based on gross national income per capita in 2020 at nominal values. Table 5 shows the results from (1) the two-step system GMM and (2) the GMM, including all lags in the instruments to replace the instrument with the principal factors used in (1). To compare the effects of LPI among the three groups on food security, lagged food security and LPI are presented.

The improvement in LPI in the high-income group does not affect food security in the short and long term. One possible explanation is that high-income countries do not have severe food security problems because most countries are expected to have enough income to handle food security problems. In addition, their logistics system level is high enough to distribute food across countries. However, the LPI in the middle-income group is statistically significant at the 5% level, which means improved LPI increases food security. Moreover, the low-income group shows that LPI statistically changes food security in the GMM estimations. Specifically, LPI negatively affects food security in the short term in the middle- and low-income groups, as shown in Table 5. Moreover, the magnitude of the effect in the low-income group is relatively large compared to that in the middle-income group. This implies that the low-income group, which does not have a good logistic system, is sensitive to LPI on food security.

The long-term effect of LPI on food security was positive in both groups. The magnitude of the effect of LPI in the low-income group is relatively larger than in the middle-income group. The results imply that if middle- and low-income groups improve the LPI system, they can increase food security. Middle- and low-income groups have not yet developed an LPI system, implying that a change in LPI significantly affects food security. Middle- and low-income countries might have relatively more severe food security problems than high-income countries. This means that the improvement in LPI can contribute to solving the problem of food security in the long term, even though LPI negatively affects food security in the short term.

Conclusion and Policy Implication

This study investigates the impact of the logistics performance index (LPI) and trade openness on food security in the short- and long-term using two types of GMM methods. Specifically, we utilize the nexus of trade openness-food security to estimate the impact of the logistics performance index on food security. We simultaneously analyzed the long-and short-term effects of trade

openness and logistics performance on food security. Moreover, we tried to estimate the impact of the LPI in detail according to the income levels of countries by dividing it into low, middle, and high income. Low-income groups may use agricultural exports to develop their economies based on an export-led growth strategy. In other words, it is expected that LPI improvements in low-income countries might increase exports of their agricultural products more than imports in the short term for their development. However, the LPI of improved low-income countries might contribute to solving the food security problem as their income levels have grown.

Our results show that trade openness and LPI negatively affect food security in the short term. However, the effects of these factors on food security are positive in the long run. These results also supported, even though we divide LPI into six components and analyze the impact of trade openness and six specific LPI components on short and long-term food security. While the effects of LPI on food security do not appear in the high-income group of countries, the long-term positive effect of LPI on food security is highest in the low-income group of countries. However, the negative short-term effect of LPI on food security is also highest in the low-income group among the three types of income groups.

Based on our results, this study has several policy implications. First, trade openness policies for solving food security problems are effective tools; policymakers should establish a backup plan. While trade openness policies improve food security in the long term, they deteriorate these problems in the short term. In turn, policymakers should consider plans to alleviate the adverse effects of trade openness on food security in the short term. Second, policymakers in low-income countries should consider developing logistics to benefit from trade openness. Since LPI has a negative role in alleviating food security problems, the governments of low-income countries also adopt backup policies to handle the adverse effects of LPI. Finally, high-income countries should develop policies, except for trade openness, since trade openness and LPI do not significantly affect food security problems in high-income countries. High-income countries already have sufficient food volume in domestic markets; thus, policymakers need to develop policies to distribute food to improve food security.

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References

Abizadeh, S., & Pandey, M. (2009). Trade openness, structural change and total factor productivity. *International Economic Journal*, *23*(4), 545–559.

Ada, O. E., Oyeronke, A., Odunayo, A. J., Okoruwa, V. O., & Obi-Egbedi, O. (2014). Trade openness and inflation in Nigerian economy: A Vector Error Correction Model (VECM) approach. *Research Journal of Finance and Accounting*, *5*(21), 74–85.

Bun, M. J., & Windmeijer, F. (2010). The weak instrument problem of the system GMM estimator in dynamic panel data models. *The Econometrics Journal, 13*(1), 95–126.

Chhabra, M., & Alam, Q. (2020). An empirical study of trade openness and inflation in India. *Decision*, *47*(1), 79–90.

Dawson, P. J. (2005). Agricultural exports and economic growth in less developed countries. *Agricultural Economics*, *33*(2), 145–152.

DeJong, D. N., & Ripoll, M. (2006). Tariffs and growth: An empirical exploration of contingent relationships. *The Review of Economics and Statistics, 88*(4), 625–640.

Dithmer, J., & Abdulai, A. (2017). Does trade openness contribute to food security? A dynamic panel analysis. *Food Policy*, *69*, 218–230.

Dowrick, S., & Golley, J. (2004). Trade openness and growth: Who benefits? *Oxford Review of Economic Policy*, *20*(1), 38–56.

Fusco, G., Coluccia, B., & De Leo, F. (2020). Effect of trade openness on food security in the EU: A dynamic panel analysis. *International Journal of Environmental Research and Public Health*, *17*(12), 4311.

Grossman, G. M., & Helpman, E. (1991). *Innovation and growth in the global economy*. The MIT Press.

Gruben, W. C., & McLeod, D. (2004). The openness-inflation puzzle revisited. *Applied Economics Letters*, *11*(8), 465–468.

Kacou, K. Y. T., Kassouri, Y., Evrard, T. H., & Altuntaş, M. (2022). Trade openness, export structure, and labor productivity in developing countries: Evidence from panel VAR approach. *Structural Change and Economic Dynamics*, *60*, 194–205.

Krugman, P. R. (1981). Intraindustry specialization and the gains from trade. *Journal of Political Economy*, *89*(5), 959–973.

Long, M. A., Gonçalves, L., Stretesky, P. B., & Defeyter, M. A. (2020). Food insecurity in advanced capitalist nations: A review. *Sustainability*, *12*(9), 3654.

Martí, L., Puertas, R., & García, L. (2014). The importance of the Logistics Performance Index in international trade. *Applied Economics*, *46*(24), 2982–2992.

Melitz, M. J. (2003). The impact of trade on intra-industry reallocations and aggregate industry productivity. *Econometrica*, *71*(6), 1695–1725.

Munir, S., & Kiani, A. K. (2011). Relationship between trade openness and inflation: Empirical evidences from Pakistan (1976—2010). *The Pakistan Development Review, 50*(4), 853–876.

Murphy, K. M., & Shleifer, A. (1997). Quality and trade. *Journal of Development Economics*, *53*(1), 1–15.

Orjuela-Castro, J., & Adarme-Jaimes, W. (2018). Evaluating the supply chain design of fresh food on food security and logistics. In J. C. Figueroa-García, E. R. López-Santana, & J. I. Rodriguez-Molano (Eds.), *Communications in Computer and Information Science: Vol. 915. Applied Computer Sciences in Engineering* (pp. 257–269).

Romer, D. (1993). Openness and inflation: Theory and evidence. *The Quarterly Journal of Economics*, *108*(4), 869–903.

Roodman, D. (2009). How to do Xtabond2: An introduction to difference and system GMM in Stata. *The Stata Journal, 9*(1), 86–136.

Runge, C. F., Senauer, B., Pardey, P. G., & Rosegrant, M. W. (2003). *Ending hunger in our lifetime: Food security and globalization*. The Johns Hopkins University Press.

Smith, L. C., & Haddad, L. J. (2000). *Explaining child malnutrition in developing countries: A cross-country analysis* (Research Report No. 111). International Food Policy Research Institute.

Sun, Z., & Zhang, D. (2021). Impact of trade openness on food security: Evidence from panel data for Central Asian countries. *Foods*, 10(12), 3012.

Ullah, S., Akhtar, P., & Zaefarian, G. (2018). Dealing with endogeneity bias: The Generalized Method of Moments (GMM) for panel data. *Industrial Marketing Management, 71*, 69–78.

Wilms, R., Mäthner, E., Winnen, L., & Lanwehr, R. (2021). Omitted variable bias: A threat to estimating causal relationships. *Methods in Psychology*, *5*, 100075.

Wintoki, M. B., Linck, J. S., & Netter, J. M. (2012). Endogeneity and the dynamics of internal corporate governance. *Journal of Financial Economics, 105*(3), 581–606.

Wong, S. A. (2009). Productivity and trade openness in Ecuador's manufacturing industries. *Journal of Business Research*, *62*(9), 868–875.