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The effects of the oil price and temperature on food inflation in Latin America

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Abstract

The impacts on food prices of temperature, the oil price, the exchange rate and wages in the agricultural industry were examined via a structural vector autoregression model and panel Granger causality test, using monthly data between January 2003 and December 2020 for Latin American countries. The paper concerns how much the determinants affect food prices. Empirical findings show that the oil price and temperature can be significant factors for reducing food inflation. According to the result of variance decomposition, in general, a considerable part of food inflation was explained by the exchange rate, but its effect did not show any significant change in the long term. The impacts of the oil price and temperature were limited in the early months, but they created larger changes over time. Impulse response function and the Granger causality test also indicated that exchange rate was a crucial dynamic in explaining food inflation in all countries except Ecuador. This country successfully mitigated the negative effect of the exchange rate, but the oil price and temperature had an impact on food inflation. All results indicate that both monetary and fiscal policies are essential to control food prices. These countries can accomplish this by conventional policies or by radical institutional changes. Nevertheless, the oil price and temperature are external dynamics, and crucial in creating alternative policies to control food inflation.

Keywords Food prices · Oil price · Temperature · Structural VAR

JEL Classification C5 · G1 · Q1 · Q4

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1 Introduction

The main purpose of this paper is to analyze the effects of temperature, the oil price, the exchange rate and wages in the agricultural industry on food prices in Latin American countries by implementing a SVAR model and a panel Granger causality test. The countries included are Argentina, Colombia, the Dominican Republic, Ecuador, Mexico and Uruguay. It was assumed that the determinants can strongly influence food prices. Global warming and climate change are assumed to be an important indicator of food prices. Changes in temperature can have a significant impact on food prices. The oil price plays a crucial role in agricultural production, industrial production and daily life. This determinant can strongly influence energy prices and costs in the agricultural industry. It can directly or indirectly influence production dynamics, fertilization and the transportation cost of foods. Hence, it can affect price changes in an economy. The exchange rate has been an important macroeconomic indicator of currency crises and chronic inflation in Latin American countries. It is expected that depreciations in the exchange rate can influence the prices of imported intermediate and final goods. It is an indicator of rising costs in developing countries and hence to changes in food prices. Wages are the main components of labor costs. Large increases can also lead to rising prices. It is expected that wages in the agricultural industry can influence the cost of production and the supply of foods and can cause changes in food prices. These four determinants—temperature, the oil price, the exchange rate and wages in the agricultural industry—were taken into account for the analysis. The main objective of this paper is to investigate the roles of the chosen variables in rising food prices. The first question concerns how much these determinants affect food prices. The second explores which determinant shows the stronger impact and the extent of their effects on food prices. The last question deals with the main political implications. This work provides answers to these questions. The purpose of the paper is to estimate the impact of temperature and the oil price on food inflation in developing countries. For this aim, Latin American countries, which are highly depended on agricultural production, were selected for the analysis. People in developing and underdeveloped countries have to spend a large part of their income for foods. These countries need to deal with poverty and high food prices. The method and the results of the empirical research create a significant novelty for environmental and inflation problems in these countries. This paper contributes to its field by implementing a SVAR model, assessing new assumptions beside new determinant such as wages in agricultural industry and showing how temperature and the oil price can be defining factors of food inflation.

The high inflation problem and rising food prices have been a heavy burden for many countries. In the last decades, research into rising food prices has become popular. Topics have usually focused on food prices because they can impact not only on the macroeconomic indicators of a country, but also on poverty, food security, hunger, waste management, consumer behaviors for reaching health and organic foods, and even social unrest (Bellemare, 2015; Hendrix & Haggard, 2015; Lazaroiu et al., 2019, 2020; Pocol et al., 2021; Solaymani, 2018). Latin American countries have been facing chronic inflation for decades. Their inflation levels based on consumption goods have been an important issue to research (Cavallo, 2013). These countries are still developing economies and less industrialized. Income and inequality have high dependency on natural resources (Alvarado et al., 2021; Tillaguango et al., 2021). Their manufacturing industries are still in a progressing stage compared with developed countries. The agricultural industries occupy an important position in these economies. Food prices are a significant indicator of the well-being of a

Table 1 Inflation and food inflation in Latin American countries

Countries	2003		2010		2020	
	Inflation	Food inflation	Inflation	Food inflation	Inflation	Food inflation
Argentina	4.4	11.1	9.8	6.8	44.3	47.5
Colombia	5.9	6.4	3.4	4.6	2.6	6.9
Dominican Rep	52.4	73.4	5.8	5.5	7.5	9.7
Ecuador	2.7	1.75	4.5	6.7	−0.5	−1.2
Mexico	4.7	7.2	3.4	4.4	4.8	6.4
Uruguay	9.2	16.1	8.1	9.6	8.2	7.8

Data were derived from Food and Agriculture Organization (FAO)

population. Thus, food inflation can deepen poverty in developing economies, especially in Latin America (Avalos, 2015; Dávila, 2010; Valero-Gil & Valero, 2008). Hence, food prices have become important in research. It is accepted that they can be a significant component of inflation (Montes-Rojas & Toledo, 2021; Garcimartín et al., 2021; Gómez et al., 2012; Moore et al., 2012). Cruz et al. (2011) used dynamic panel techniques and stated that inflation was affected by international food prices in Mexico—a country dependent on imported foods. Furthermore, it has been assumed that because of economic integrations into the developed economies, food prices can erode purchasing power and give way to rising inflation (Otero, 2011). Thus, resolving inflation problems are often a part of the policies designed by central banks (Ginn & Pourroy, 2020). Table 1 shows inflation based on the consumer price index and food inflation in the countries under consideration. As can be seen from the data, food inflation generally remained higher than overall inflation. This demonstrates that food inflation is a major factor in inflation in these countries. Furthermore, the table shows inflation in most of Latin American countries to be higher than that in developed countries. Hence, finding the factors driving food inflation can help policy makers, researchers and investors to understand market dynamics in these countries, and identify solutions for reducing inflation problems. Moreover, this research can also set an incentive for other developing countries to research the causes of food inflation in their own economies.

Climate change creates large fluctuations in temperature that can impact on food inflation in developing countries (Mawejje, 2016). It was indicated that temperature can cause boost environmental degradation (Khan et al., 2022a, 2022b, 2022c). Latin American countries are still developing economies. Products related to agriculture constitute a significant proportion of exports in the region. In 2016, it was estimated that exports of foods and beverages made up approximately 36.4% of total exports of commodities in Argentina, 17.1% in Colombia, 14.1% in the Dominican Republic, 49.8% in Ecuador, 7.2% in Mexico and 61.6% in Uruguay.[1] It is known that emerging countries are lacking in nutrition, and as food prices rise around the world, it can negatively affect poor populations who spend a large part of their income on foods. Food sovereignty and security are important matters for developing countries, including Latin American countries (Giunta, 2014; Mekonnen et al., 2021). Hence, understanding the indicators of food prices in Latin American countries, which are vulnerable to inflation, can serve as a guide for creating environmental policies for other countries.

[1] Data was derived as BEC from UN Comtrade Database.

Natural resources are important in supporting developing countries to maintain their welfare and technology standards (Tang et al., 2022; Xie et al., 2022; Zakari et al., 2022). Energy is an essential input of economic growth, production and sustainability (Khan et al., 2022a). It is also a crucial factor for the agricultural industry, in particular, for developing countries. Although Latin American countries have oil production capacity, they do not rank among the top producer countries. Oil is a vital international commodity, and all countries need this energy resource. International demand and supply can easily change oil prices around the globe. The oil price is accepted as a determinant that can increase stress on inflation (Köse & Ünal, 2021). The agricultural industry needs this energy resource for fertilizing, production and transportation. It plays an important role in commodity prices. There appears to be a significant relationship between the oil price and food prices (Olayungbo & Hassan, 2016; Pal & Mitra, 2017). Chowdhury et al. (2021) indicated that a positive change in world energy prices caused a high and long-lasting effect on world food prices. Hence, it is expected that increases in the oil price can impact on food inflation in Latin American countries.

There is often a direct link between exchange rate and food inflation in emerging economies (Mahmoudinia, 2021). As Latin American countries are still developing economies, they are dependent on imports of goods for production. It is assumed that these countries are still too far from technological frontier to meet all of their needs for agricultural production themselves. These countries are also at risk from chronic macroeconomic problems which make them more defenceless to changes in the exchange rate. Currency crises and high inflation are prominent in Latin American countries (Agarwal & Vandana, 2021; Carrasco & Ferreiro, 2013; Damill et al., 2015). Hence, it is considered that the exchange rate can have a pass-through effect on food inflation in these countries. The labor cost is also a variable that can have an impact on inflation. The most important dynamic in labor cost is wages. Thus, wages in the agricultural industry can stimulate food inflation. The acceleration in food inflation can also reduce the purchasing power of workers. This will cause a persistent inflation if more wages are bargained for by workers.

This work is the first effort that scrutinizes the relationship between temperature, the oil price, the exchange rate, wages in the agricultural industry and food inflation. Furthermore, the research is first to implement a SVAR model to find answers to questions for Latin American countries. The paper mainly aimed to estimate the effects of the oil price and temperature on food inflation in Latin American countries. It was found that exchange rate was an important dynamic, but its effect did not increase significantly over the months. High fluctuation in the exchange rate can be solved by fiscal or monetary policies. The oil price and temperature are external factors. Ecuador accepted the US dollar as official currency. Thus, it could mitigate the impact of the currency on food inflation. Nevertheless, the oil price and temperature remained as a problem. Hence, governments in the developing countries should implement policies those could reduce the impact of the oil price and temperature on food inflation, if they would like to mitigate the negative effects of energy and climate change.

This paper is structured as follows: In Sect. 2, previous works that have considered food inflation by taking the selected variables into account and the originality of the current work are introduced. In Sect. 3, assumptions are discussed, and data collection is explained. In Sect. 4, a SVAR model is implemented and the results of the analysis examined. In Sect. 5, political implications are laid out. In Sect. 6, the paper is concluded.

2 Previous research and the current work

2.1 Previous research

There have been many works that explained inflation in many countries. On the issue of food inflation, the chosen Latin American countries are still cases to be studied. Thus, all related works are considered in this section. Previous works have implemented many methods and techniques, including different dates and variables. In this section, previous works are laid out, considering the relationship between food prices and temperature, the oil price, the exchange rate, wages and other related variables.

Nam (2021) investigated the impact of climate uncertainty on global commodity markets, using a time-varying factor-augmented VAR (FAVAR) with stochastic volatility in a mean model for the period from February 1965 to October 2017. The result can be summarized; thus, climate uncertainty generally increases global food prices. Kunawotor et al. (2021) used the two-step system generalized method of moments (GMM) estimation technique to analyze the effect of extreme weather conditions on food prices in Africa for the period 1990–2017. It was pointed out that although the impact of weather conditions was not significant, drought and flood could have a positive and statistically significant impact on food inflation. Mukherjee and Mukherjee and Ouattara (2021) implemented a panel VAR model to estimate the effects of temperature shocks on inflation in developed and developing countries over the period 1961–2014. The results showed that temperature shocks caused inflationary pressures. In particular, in developing countries, the effects persisted for several years after the initial shock. Abril-Salcedo et al. (2020) applied a smooth transition nonlinear model and generalized impulse response functions to evaluate the relationship between extreme weather conditions such as El Nino and food prices in Colombia for monthly periods between March 1962 and December 2018. It was found that weather shocks are transitory and asymmetric on food inflation. An El Nino shock had a significant effect on food inflation.

Agyei et al. (2021) applied dynamic panel data models to examine how COVID-19 influenced food prices in sub-Saharan Africa from March to September in 2020. It was estimated that COVID-19 gave rise to increasing food prices. Furthermore, the exchange rate, inflation and oil prices had significant effects on food prices. Dalheimer et al. (2021) investigated the relationship between global oil turmoil and food prices in sub-Saharan Africa using a SVAR model for the period between January 2006 and June 2019. It was found that, contrary to US and global corn markets, African corn markets were less sensitive to the effects of oil-specific demand shocks. However, rising food prices can be attributed to oil-supply shortages. Mokni and Ben-Salha (2020) researched the causal relationship between the oil price based on the WTI and the world food prices, implementing an asymmetric causality in quantiles approach for the monthly period between January 1960 and September 2019. It was found that the oil price impacts upon food prices under all food market conditions. Sarwar et al. (2020) examined pass-through effect of the oil price on food and non-food prices in Pakistan via a nonlinear autoregressive distributed lag (NARDL) model using data from 1993/Q3 to 2019/Q4. The result indicated that the oil price influenced both food prices and non-food prices, but its effect was much stronger on non-food prices. Taghizadeh-Hesary et al. (2019) analyzed the linkages between energy prices and food prices in various Asian economies for the period 2000–2016 via a panel VAR model. The results indicated that the oil price significantly influenced food prices. Ahmadi et al. (2016) used a SVAR model to examine the volatility of commodities in terms of oil price movements between April 1983 and May 2014. The analysis was separated into two subsamples: the period before and after 2006 for agricultural commodities and changes in US ethanol production policy; and also before and after 2008 for metals. The results showed that the volatility of commodities to oil price shocks differed significantly according to the periods in question. Variance decomposition showed that the explanatory role of oil shocks became stronger after the 2008 crisis. Estrades and Terra (2012) investigated Uruguay, a country that exports foods and imports oil, using a computable general equilibrium (CGE) model focusing on the years 2006–2008. It was found that rising food prices had a positive effect on the economy. However, benefits accrued through the export of commodities were reduced because of shocks in the oil price, and, of course, any increase in food price impacts most on the poorest populations. Nair and Eapen (2012) examined the causes of inflation in twelve commodities in India between January 2008 and July 2010 using a commodity-wise analysis. In this work, most of the commodities were affected by domestic supply constraints. It was found that whereas the domestic food prices were affected by increases in the oil price, the effect of imports remained limited.

Tolepbergen (2022) studied the persistence properties of the monthly inflation and its components such as general inflation, food inflation and non-food inflation in Kazakhstan for the monthly period between January 2001 and November 2021. A fractionally integrated approach was applied. It was found that a shift in monetary policy toward inflation targeting regime impacted on inflation. It was found that non-food inflation was cointegrated with the depreciation in nominal exchange rate. Eregha (2022) examined asymmetric response of domestic prices to official exchange rate and parallel exchange rate movements in oil-dependent country, Nigeria, by using a nonlinear ARDL model for the period 1995/Q1-2019/Q1. It was estimated that general and food prices symmetrically responded to parallel exchange rate movements than official rate movements. Samal and Goyari (2022) examined the role of monetary policy shocks on food inflation in India for the monthly period between January 2009 and December 2019 by using a quantile regression analysis. It was pointed out that contractionary monetary policy stabilized food inflation across the quantiles. It was also mentioned that exchange rate and transportation play a significant role in promoting food inflation. Bhattacharya and Jain (2020) investigated the effectiveness of monetary policy in stabilizing food inflation in both developed and developing economies via a panel VAR analysis for the periods between 2006/Q1 and 2016/Q2. It was found that any unexpected monetary tightening has a positive and significant effect on food inflation. Akanni (2020) studied linkages between the exchange rate and food prices via a VAR model for Nigeria, using weekly data between January 2010 and January 2019. The paper found evidence that the exchange rate and food prices were directionally interdependent. Wong and Shamsudin (2017) studied on the impact of the oil price, real GDP and the exchange rate on food price fluctuations in Malaysia. An unrestricted NARDL model was implemented using quarterly data between 2000/Q1 and 2016/Q2. According to this work, there was a long-term asymmetric relationship between food price fluctuation and the exchange rate and real GDP. In the short term, these two determinants had a significant impact on food price movement, whereas the effect of the oil price was insignificant. It was suggested that policymakers consider the exchange rate factor instead of the oil price. Sasmal (2015) examined why food inflation rises while economic growth is increasing in India, using a two-sector general equilibrium model, considering samples from the 1970s to 2010s. It was found that although the effect of the exchange rate on food inflation was significant, it was not robust. Aron et al. (2014) implemented OLS methods to estimate exchange rate pass-through to consumer prices in South Africa using monthly data between December 2001 and December 2007. The study indicated that the exchange rate significantly influenced food components. Works that explain how wages in the agricultural industry affect food prices have remained limited. However, it is possible to find related research recently conducted. Hassan and Kornher (2022) implemented both a standard vector error correction model (VECM) and ARDL method to explain the relationship between farm wages and rice prices. For research, monthly data from 1994 to 2014 were utilized. This work basically focused on how rice price shocks transmitted to wages. The results indicated that rice price shocks do not affect wages in the short term. In the long term, food prices were less influential on farm wages, but the effect of urban wages was stronger. Recent works are summarized in Table 2.

2.2 The current work

Although some of the works discussed above considered the determinants behind food inflation, new research needs to be undertaken, taking into account new indicators. This work contains significant originalities. Firstly, a group of countries was included in the analysis, with a large data sample. Then, a macro-based analysis was implemented. When previous research is considered, it can be seen that papers for the developing economies, especially for Latin America, are very limited. This work serves to fill this gap. To our knowledge, this is the first work to have conducted research using a SVAR model for Latin American countries. This paper utilizes new data, such as temperature and wages in the agricultural industry. Most existing works that have studied the main indicators of food prices omitted these two variables. However, temperature and wages can serve as significant factors behind food inflation in Latin American countries. It proved challenging to determine wages in the agricultural industry for all Latin American countries, which in turn limited the number of countries in the research. Although this also limited time periods, the sample was still broad enough to conduct our research. This is crucial data that indicates the impact of labor costs on food inflation. Taking account all these determinants, the role played in food inflation by both global and domestic indicators could be assessed. Our findings can serve as a case study for other emerging economies. In addition, they can be a guide for policy makers and researchers seeking to mitigate food inflation for the sake of macroeconomic stability and economic development.

3 Assumptions and data collection

3.1 Assumptions

In this work, there are four main indicators influencing food prices in the selected Latin American countries. The first is temperature. Agricultural products can play a large part in inflation and can also be the main component of food inflation. Agricultural production in these countries is a large part of the economy, especially in exports. Thus, average changes in temperature, which is a strong indicator of climate change, influence productivity in the agricultural industry (Bandara & Cai, 2014; Bradbear & Friel, 2013; Tan et al., 2021). This variable was added into the analysis because it was assumed that weather conditions are a significant factor behind the changes in food prices. In particular, if temperature significantly affects food inflation, then it can be said that there is a link between food prices and climate change.

Table 2 Summary of recent empirical studies

Authors	Countries	Variables	Methodology	Findings
Nam (2021)	Global	Climate uncertainty, global commodity markets	FAVAR	Climate uncertainty generally increases global food prices
Kunawotor et al. (2021)	Africa	Extreme weather events, headline inflation, food inflation	GMM	Drought and flood could have a positive and statistically significant impact on food inflation
Mukherjee and Ouattara (2021)	27 developed and 80 developing countries	Inflation, real GDP, government spending, money supply, temperature change	Panel VAR	Temperature shocks caused inflationary pressures
Abril-Salcedo et al. (2020)	Colombia	Food prices, El Nino shocks	Smooth transition nonlinear model and generalized impulse response functions	Weather shocks are transitory and asymmetric on food inflation
Agyei et al. (2021)	Sub-Saharan Africa	Exchange rate, inflation, crude oil price, food prices, cases of COVID-19	Dynamic panel data	The exchange rate, inflation and oil prices had significant effects on food prices
Dalheimer et al. (2021)	Sub-Saharan Africa	Crude oil production, global economic activity, oil price, food price	SVAR	Rising food prices can be attributed to oil-supply shortages
Mokni and Ben-Salha (2020)	Global	Crude oil price, world food price	Asymmetric causality in quantiles approach	The oil price impacts upon food prices under all food market conditions
Sarwar et al. (2020)	Pakistan	Crude oil price, food and non-food prices, output gap	NARDL	The oil price influenced both food prices and non-food prices
Tolepbergen (2022)	Kazakhstan	General inflation, food inflation, non-food inflation	Fractionally integrated approach	Shift in monetary policy toward inflation targeting regime impacted on inflation
Eregha (2022)	Nigeria	CPI, food inflation, money supply, oil price, domestic output, official and parallel exchange rates, interest rate	Nonlinear ARDL	General and food prices symmetrically responded to parallel exchange rate movements
Samal and Goyari (2022)	India	Food price, transportation cost, exchange rate, repo rate, economic output	Quantile regression analysis	Contractionary monetary policy stabilized food inflation across the quantiles

Table 2 (continued)

Authors	Countries	Variables	Methodology	Findings
Bhattacharya and Jain (2020)	Seven developed and nine developing economies	Food inflation, GDP, consumption, investment, CPI, policy rate, exchange rate	Panel VAR	Any unexpected monetary tightening has a positive and significant effect on food inflation
Akanni (2020)	Nigeria	Food prices, exchange rate	VAR	Exchange rate and food prices were directionally interdependent
Hassan and Kornher (2022)	Bangladesh	Food prices, farm wages, industrial and construction wages	VECM and ARDL	In the long term, food prices were less influential on farm wages, but the effect of urban wages was stronger

Energy contributes a large part to the agricultural industry in terms of production, transportation and daily consumption. It is to be expected that rising prices in energy sources can also impact on food prices (Ibrahim & Said, 2012; Zmami & Ben-Salha, 2019). It is clear that oil is necessary for the production process in developing countries. Latin American countries are still too far from technological frontiers to catch up with developments in sustainable and alternative energy resources (Murshed et al., 2022). Thus, the oil price has been included in the analysis since it can exert a dramatic impact on price levels in developing economies. Davidson et al. (2016) estimated that there were long-term partial elasticities for food inflation with respect to international food prices, exchange rates and the oil price in the UK. Baek and Koo (2010) used a cointegration analysis and stated that energy prices had a long-term relationship with food prices in the USA. Therefore, it is assumed that the oil price can also be a major determinant of food inflation in Latin American countries.

Increases in exports of foods can lead to rising foods prices in the domestic economy, and this can work to reduce poverty in a country. Thus, the exchange rate is taken to be a crucial factor that not only changes the cost of imported goods but can also affect export performance (Clapp & Moseley, 2020). Copula functions were designed by Reboredo and Ugando (2014) to examine the comovement between several food prices and the US dollar. It was found that there was a significant relationship between these two determinants. However, it was emphasized that depreciations in the exchange rate stimulated the price of soybeans. Kataranova (2010) also estimated that depreciations in the exchange rate exerted a considerable impact on food prices in Russia. Hence, it was assumed that the exchange rate would be an important determinant of food prices in Latina America.

Developing countries still have labor-intensive economies. Thus, workers are expected to occupy a major position in the cost of production. High wage costs can also push commodity prices up. This can be a stimulating factor behind rising inflation. In the case of food inflation, it is important to consider wages in the agricultural industry (Guha & Tripathi, 2014). This variable is one of the factors of cost that can stimulate food prices. Thus, wages in the agricultural industry were included in the analysis.

This work is important because developing countries are facing with food inflation problem that can be driven by climate change, energy needs, monetary and fiscal policies. Food inflation gained more importance around the globe in recent years. This problem is more crucial for developing economies, which need to spend a large part of their income for obtaining nutrition. In particular, it is very little known regarding the impact of the selected determinants on food inflation in Latin American countries. Scrutinizing the determinants of food inflation can guide governments, policy makers and authorities to develop new solutions to deal with this problem.

3.2 Data collection

Various sources were used to collect data on a monthly basis between January 2003 and December 2020. In selecting the sample, the common period that creates a larger time span at most was considered. Wages are an important component of labor costs, which can directly impact upon inflation. If food inflation is taken into account, then wages in the agricultural industry should be examined in terms of their effect on prices. This was the most challenging variable to be collected. The common point for wages in the agricultural industry is from January 2003. This was accepted as the starting point for collecting other variables too.

Agricultural production is vulnerable to climate change. One of the most important variables that can be used is temperature. Latin American countries occupy different geographical parts of the continent. However, the main problem the whole continent faces is global warming and climate change. Global warming has become a serious environmental issue that affects human activities and economic interactions around the world. The results of this global problem are shared with many countries (et al., 2021b). The production of foods can be strongly influenced by fluctuations in temperature. The failure of crops can cause countries to face poverty and economic slowdown. Including this variable into the analysis will at least answer our question as to the extent that food inflation is influenced by fluctuations in the temperature. These data were collected from the FAO climate indicator and presented as temperature changes.

There are two main global oil prices usually used in energy research. These are Brent (Europe) and West Texas Intermediate (WTI). Although it can be assumed that these prices are correlated, only the WTI oil price was considered for this research. It was assumed that this price could represent the oil price in Latin America because of its close location. These data were collected from the Federal Reserve Bank of St. Louis. The category was the monthly crude oil price (WTI) based on US dollars per barrel.

Exchange rates can change prices in markets. It is common for Latin American countries to experience chronic inflation and high fluctuations in the exchange rate. The agricultural industry accounts for a considerable level of exports. Moreover, these countries are developing countries, which means a dependency on imports. The exchange rate should be derived to analyze its impact on food inflation. All data were derived from investing.com. However, Ecuador ceased using its currency because of broad dollarization in the country. The US dollar was accepted as its official currency from 2000. For this country, DXY was taken into account.

These countries are still technologically behind the developed countries. This makes their agricultural industries more important for economic progress. Wage bargaining can be implemented in countries where manufacturing industries are developed, which can decrease the elasticity of wages. However, in agriculture, workers are more vulnerable to climate, temperatures and other related factors. They are often self-employed. Thus, it is assumed that wages tend to be more flexible and their impact on food inflation can easily fluctuate. Wages in agriculture were derived from the ILO earnings of employees by economic activity in agriculture for each country. Missing data were interpolated to conduct this research.

Food prices are a main indicator of inflation for developing countries. Assessing the determinants of food prices will help central banks to follow inflation targeting policies and mitigate the effects of food prices on inflation. The data were derived from FAO consumer prices, food indices (2015 = 100).

These data are described as follows:

temp: Temperature change.

oil: WTI oil price (US dollars).

er: Nominal exchange rate (per US dollar).

w: Wages in the agricultural industry (local currency).

fp: Food price (2015 = 100).

4 Empirical analysis

4.1 Unit root test results

To check the stationarity of the variables in a robust manner, two alternative unit-root tests, augmented Dickey–Fuller (ADF, 1981) and Phillips–Perron (PP, 1988), were used.

Table 3 shows the unit-root test results. According to the ADF and PP unit-root tests, the results for four variables were obtained at a 5% significance level. Their integrated orders were analyzed with the breakpoints' unit-root test suggested by Vogelsang and Perron (1998). The breakpoints' unit-root test results show that the integrated order of these variables is one. The unit-root test results indicate that the integrated order for all series except temperature change is one at a 5% level. On the other hand, the integrated order for temperature change is zero at 5% significance. These results show that all series except temperature change are stationary in the logarithmic first difference, and in the level at 5% significant level.

4.2 SVAR model

The SVAR model is a developed form of a vector autoregressive (VAR) model. This model has advantages compared with others that apply single equations. A SVAR model can create additional identifying assumptions for structuring contemporary relationships between endogenous variables. These assumptions can be shaped by economic theory, institutional knowledge and other constraints (Köse & Ünal, 2021). A SVAR model structures economic assumptions to analyze contemporaneous links between determinants via structural factorization (Bernanke, 1986; Blanchard & Watson, 1986; Sims, 1986). The innovation terms of a VAR model or the orthogonalization of the reduced-form residuals can be implemented recursively (Cholesky decomposition) or non-recursively (structural factorization). Orthogonalization by Cholesky decomposition indicates a causal chain that is imposed rather than learning about causal relations from variables. This solution can make sense with a plausible interpretation for recursive ordering (Kilian, 2013). A SVAR model needs identifying assumptions that help the correlations to be causally interpreted. These assumptions can cover the entire VAR so that a SVAR model allows only a specific causal link to be explored (Stock & Watson, 2001).

The SVAR(p) specification for the short run A-B model can be designed as follows:

$$A\left(I_k - A_1L - A_2L^2 - \dots\dots\dots\dots A_pL^p\right)y_t = Ae_t = Bu_t$$

where

$\boldsymbol{L}$: Lag operator,

$\boldsymbol{e_t}$: Error terms of standard VAR model,

$\boldsymbol{u_t}$: Error terms of structural VAR model,

k: Number of variables in the model,

$\boldsymbol{A}$ and $\boldsymbol{B}$: Restriction matrices.

The order condition requires $k^2 + k(k-1)/2$ restrictions for identification in the short run A-B model. The identifying restrictions are described as follows:

Shocks to all variables do not contemporaneously affect temperature change, the oil price, and wage shocks. In that sense, these shocks are exogenous. While they

Table 3 Unit-root test results

Variable	Argentina				Colombia			
	ADF		PP		ADF		PP	
	t-statistic	*p*-value	Adj. *t*-Statistic	*p*-value	*t*-statistic	*p*-value	Adj. *t*-Statistic	*p*-value
temp	− 12.2266	0.0000	− 12.2051	0.0000	− 2.8666	0.0511	− 9.0053	0.0000
er	3.7101	1.0000	3.9969	1.0000	− 0.9762	0.7618	− 0.9762	0.7618
Δ*er*	− 13.4940	0.0000	− 13.5230	0.0000	− 14.3505	0.0000	− 14.3522	0.0000
w	− 0.3383	0.9156	− 0.0360	0.9534	− 1.7564	0.4014	− 1.7190	0.4203
Δ*w*	− 4.4940	0.0003	− 7.6208	0.0000	− 9.8252	0.0000	− 68.6230	0.0001
fp	3.2524	1.0000	5.8547	1.0000	− 1.0405	0.7388	− 1.2121	0.6695
Δ*fp*	− 2.0668	0.2585	4.4574	0.0003	− 7.9846	0.0000	− 7.2362	0.0000
Variable	Dominican Rep				Ecuador			
	ADF		PP		ADF		PP	
	t-statistic	*p*-value	Adj. *t*-Statistic	*p*-value	*t*-statistic	*p*-value	Adj. *t*-Statistic	*p*-value
temp	− 5.3073	0.0000	− 8.4911	0.0000	− 4.2555	0.0007	− 6.2885	0.0000
er	− 0.9503	0.7704	− 2.7062	0.0746	− 2.1226	0.2361	− 2.2404	0.1928
Δ*er*	− 5.2539	0.0000	− 16.4264	0.0000	− 5.0200	0.0000	− 14.5167	0.0000
w	− 1.1748	0.6854	− 1.3264	0.6174	− 1.1929	0.6777	− 1.51585	0.5238
Δ*w*	− 6.2738	0.0000	− 7.6253	0.0000	− 6.1984	0.0000	− 5.9359	0.0000
fp	− 2.5629	0.1025	− 3.4217	0.0112	− 1.9320	0.3171	− 1.9625	0.3034
Δ*fp*	− 5.1993	0.0000	− 7.1546	0.0000	− 3.2274	0.0198	− 9.6561	0.0000
Variable	Mexico				Uruguay			
	ADF		PP		ADF		PP	
	t-statistic	*p*-value	Adj. *t*-Statistic	*p*-value	*t*-statistic	*p*-value	Adj. *t*-Statistic	*p*-value
temp	− 6.3820	0.0000	− 10.1254	0.0000	− 12.7767	0.0000	− 12.7343	0.0000
er	− 0.7834	0.8214	− 0.7639	0.8267	0.0738	0.9631	0.1014	0.9652
Δ*er*	− 13.7255	0.0000	− 13.7153	0.0000	− 12.0626	0.0000	− 12.1204	0.0000
w	0.0792	0.9634	0.2806	0.9768	−1.3235	0.6186	−3.0388	0.0330
Δ*w*	− 2.7599	0.0660	− 6.1795	0.0000	− 7.2771	0.0000	− 50.6340	0.0001
fp	− 0.9725	0.7630	− 0.7335	0.8347	− 0.4162	0.9028	− 1.3597	0.6015
Δ*fp*	− 8.0019	0.0000	− 11.1260	0.0000	− 4.2560	0.0007	− 11.4784	0.0000
oil	− 3.0335	0.0334	−2.6133	0.0918				
Δ*oil*	− 9.8770	0.0000	− 10.5147	0.0000				

Exogenous variable is only constant. Appropriate lag length for ADF test has been selected using Akaike information criterion (AIC) for a maximum lag of 12 periods. Appropriate Newey–West bandwidth for PP unit-root tests is selected using Bartlett kernel. Δ is the first-order difference operator

contemporaneously affect food inflation, since the exchange rate is a price for imported intermediate goods, they can cause rising costs in food production, which also directly affect inflation. The oil price plays an important role in the trade balance. Thus, oil price shocks contemporaneously affect both exchange rate and food inflation shocks. Food inflation shocks are affected contemporaneously by all of the other variables' shocks. Food inflation was assumed to be the most endogenous factor in the SVAR model.

The results of the unit-root test imply that the all series are stationary in the logarithmic first difference at a 5% level of significance, except changes in temperature. This is stationary in the level at a 5% significance level. The short-run analysis was conducted using the SVAR model in stationary form. Under these restrictions, a structural VAR model with A and B matrices can be specified as below:

$$\begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & a_{32} & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \\ a_{51} & a_{52} & a_{53} & a_{54} & 1 \end{bmatrix} \begin{bmatrix} e_t^{temp} \\ e_t^{\Delta oil} \\ e_t^{\Delta er} \\ e_t^{\Delta w} \\ e_t^{\Delta fp} \end{bmatrix} = \begin{bmatrix} b_{11} & 0 & 0 & 0 & 0 \\ 0 & b_{22} & 0 & 0 & 0 \\ 0 & 0 & b_{33} & 0 & 0 \\ 0 & 0 & 0 & b_{44} & 0 \\ 0 & 0 & 0 & 0 & b_{55} \end{bmatrix} \begin{bmatrix} u_t^{temp} \\ u_t^{\Delta oil} \\ u_t^{\Delta er} \\ u_t^{\Delta w} \\ u_t^{\Delta fp} \end{bmatrix}$$

The optimal lags of the VAR model for each country are determined by using Akaike information criteria. Before constructing the SVAR model, identification needs to be checked. There are 5 variables in our SVAR model. To satisfy exact identification, $2K^2 - \frac{1}{2}K(K+1)$=35 restrictions are needed, where K is the number of variables. However, for this study, there are 40 restrictions. This shows that the SVAR model has an over-identification problem and the preponderance of over-identification for this model must be controlled. According to the likelihood ratio test (LR), H_0, which indicates that over-identification is valid, it is not rejected at a 5% level for each country. These results mean that over-identification is not a problem for the model.

4.3 Variance decomposition

Table 4 shows the results of forecast error variance decomposition analysis for food inflation in the selected Latin American countries. The table shows a 12-month period for each country. In Argentina, the most important determinant in explaining changes in food prices was the exchange rate. In the first month, the impact of the exchange rate on food inflation was 6.2%. Its effect rose to 32% in the 4th month and this did not change significantly until the 12th month. In the first month, the impact of the oil price on food inflation was approximately 2% and this effect became weaker in the following periods. The temperature did not have a strong effect in the first month, but its influence increased to 2.5% in the 12th month. Wages were the second important determinant in the long term. Its impact rose from 0.6% to 3.5% between the first and the 12th month. The impact of food inflation by itself was 91% in the first month, but this declined to 59.1% in the 12th month. This indicates that expectations of food inflation decreased over the period.

In Colombia, the most important explanatory factor for food inflation was the oil price. In the first month, its impact was around 1.1% but this increased to approximately 3.1% in the 12th month. The effect of temperature change remained limited. The exchange rate and wages exerted weak effects—below 1% in the first month, rising to 2.6% and 2.9%, respectively, in the 12th month. Sticky inflation was marked in Colombia, indicating resistance to change. The effects of food inflation in explaining itself did not drop below 90% over the time period.

In the Dominican Republic, the impact of the exchange rate on food inflation was 10.1% in the first month. In the 12th month, its effect increased significantly to approximately 30.6%. This was the strongest variable on food inflation. The second strongest variable was the oil price. Its effect was very weak—almost zero—in the first month. However, the effect of the oil price exerted a 7% influence on food inflation in the 12th month. The

Table 4 Results of variance decomposition for food inflation

Period	Argentina					Colombia				
	temp	*oil*	*er*	*w*	*fp*	*temp*	*oil*	*er*	*w*	*fp*
1	0.25	2.00	6.18	0.62	90.94	0.01	1.15	0.10	0.63	98.10
4	1.41	1.24	31.82	1.13	64.40	0.07	2.79	2.52	1.16	93.47
8	2.39	1.10	32.66	3.62	60.23	0.36	3.10	2.56	2.78	91.20
12	2.55	0.95	33.84	3.52	59.14	0.46	3.15	2.57	2.90	90.92
Mean	1.83	1.23	29.45	2.59	64.90	0.24	2.70	2.15	2.08	92.82
Period	Dominican Rep					Ecuador				
	temp	*oil*	*er*	*w*	*fp*	*temp*	*oil*	*er*	*w*	*fp*
1	2.33	0.06	10.15	0.62	86.84	0.03	7.25	0.07	0.00	92.65
4	5.00	2.84	31.59	0.56	60.01	2.82	9.82	0.68	1.08	85.60
8	5.22	3.35	31.21	0.91	59.30	7.68	10.66	2.07	1.21	78.38
12	6.95	7.04	30.63	1.14	54.24	8.63	10.91	2.27	1.37	76.82
Mean	5.12	3.39	28.61	0.79	62.09	5.50	9.94	1.24	1.10	82.22
Period	Mexico					Uruguay				
	temp	*oil*	*er*	*w*	*fp*	*temp*	*oil*	*er*	*w*	*fp*
1	4.46	0.00	1.44	0.19	93.90	3.45	0.02	2.73	0.94	92.86
4	5.90	1.74	4.69	0.46	87.21	4.67	0.79	4.66	3.12	86.77
8	9.30	2.70	6.69	1.32	79.98	5.98	0.91	5.13	5.38	82.59
12	9.02	4.40	6.89	2.68	77.01	6.54	0.93	5.01	8.18	79.33
Mean	7.74	2.35	5.15	1.12	83.64	5.37	0.78	4.67	4.72	84.46

impact of temperature change increased from 2.3% to 6.9% between the first month and the 12th. Wages in the agricultural industry caused weak effect around 1.1% in the 12th month. A large part of food inflation was explained by itself, but its role decreased over the months. The share was initially 86.8%, then fell to 54.2%.

Food inflation was strongly influenced by the oil price in Ecuador. The impact of the oil price was approximately 7.2%, whereas those of others remained around zero in the first month. In the 12th month, the effect of the oil price on food inflation was 10.9%. After the oil price, temperature change was the largest explanatory factor of food inflation. Its effect was approximately 8.6% in the 12th month. The exchange rate and wages had a more limited impact on food inflation. In the same period, their impacts were 2.3% and 1.4%, respectively. Although food inflation was also largely explained by itself, its effect decreased from 92.6% to 76.8% over the period.

The impact of the exchange rate on inflation Mexico was significant—1.4%—whereas those of the oil price and wage were around zero in the first month. After the 8th month, there was no significant change; its effect was 6.7% in the 8th month and 6.9% in the 12th month. The oil price had a 4.4% impact on food inflation in the 12th month, and temperature change 9.0%. Over the period, the impact of wages increased but remained limited compared with the other determinants. Its effect stood at 2.7% in 12th month. The impact of food inflation fell from 93.9% to 77% between the first month and the 12th. This variable indicated a resistance to change and the pattern of sticky inflation.

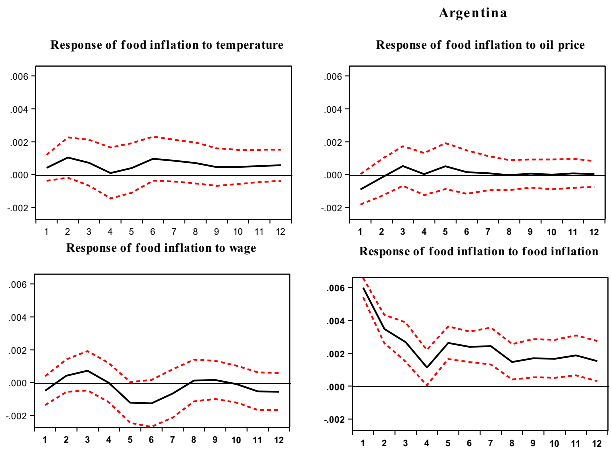

Fig. 1 Response of food inflation to structural one-standard-deviation positive innovations in Argentina

Food inflation in Uruguay was also largely influenced by the exchange rate—around 2.7%—whereas the other variables such as the oil price and wage had weaker effects—below 1% in the first month. Temperature change had a significant impact of around 6.5% on food inflation in the 12th month. Wages played an important role in explaining inflation. Its effect rose to 8.2%. The effect of the oil price remained more limited in this country. As a last point, Uruguay also showed a chronic pattern of sticky inflation. This means that food inflation is also a driving factor behind itself. Its explanatory power decreased from 92.9% to 79.3% over the 12th month period.

4.4 Impulse response function

In this section, there are sets of figures that indicate the response of food inflation to structural one-standard-deviation positive innovations. The impulses are temperature, the oil price, the exchange rate and wages in the agricultural industry. The response is food inflation. The figures analyze whether the responses were significant, and to what extent, over the period. Figure 1 gives information about Argentina. In this country, the response of food inflation to the exchange rate was positive and significant over the period. Its significance increased markedly around the second month. Although it decreased in later periods, the response remained significant. The response of food inflation to itself was strongly significant. Its effect started very highly. Although the impact decreased until the 4th month, it rose again and continued as positive over the following months. The responses of other variables to food inflation did not show any significance, and this did not change.

In Fig. 2, the response of food inflation to wages in the agricultural industry for Colombia was negative and insignificant. It became positive and significant in the 5th month but then became negative and insignificant again. A similar situation can be seen for the exchange rate. It became statistically significant around the third month then continued to be so for the whole time period. The response of food inflation to itself was positive and significant until the fourth month. In subsequent months, it became insignificant.

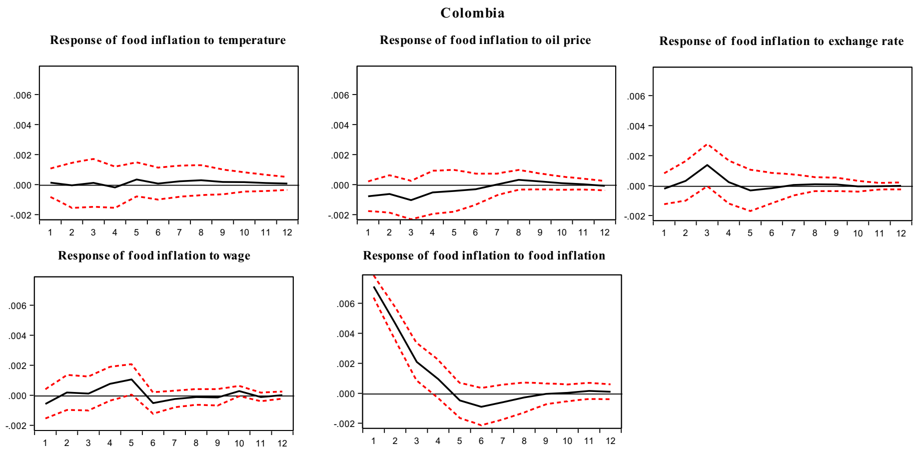

Fig. 2 Response of food inflation to structural one standard deviation positive innovations in Colombia

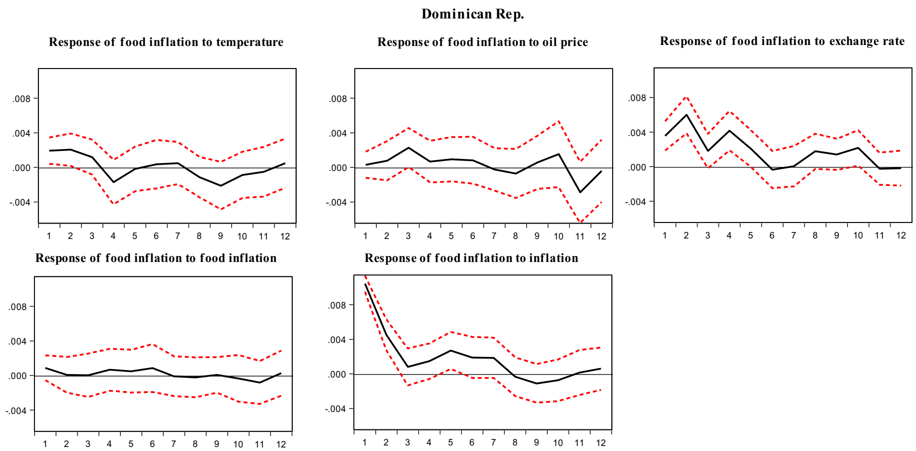

Fig. 3 Response of food inflation to structural one-standard-deviation positive innovations in the Dominican Republic

Figure 3 indicates that the response of food inflation to temperature for the Dominican Republic was positive and statistically significant. After the second month, the effect faded and became insignificant. The response of food inflation to the exchange rate was positive and statistically significant. Although its impact changed over the months, it remained positive and significant until the fifth month. The response of food inflation to itself started as positive and statistically significant. After the third month, the response became insignificant.

The responses of food inflation to the variables are given for Ecuador in Fig. 4. All responses were insignificant except for food inflation. The response was positive and significant, but its effect decreased over the months and became insignificant after the third month.

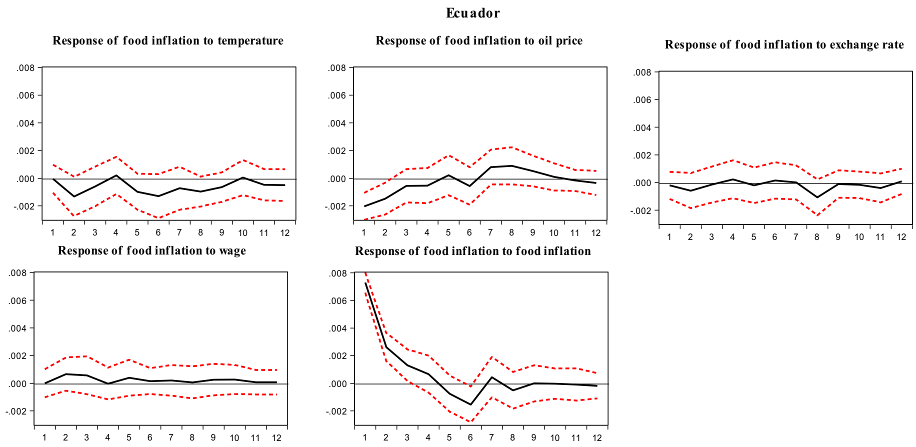

Fig. 4 Response of food inflation to structural one-standard-deviation positive innovations in Ecuador

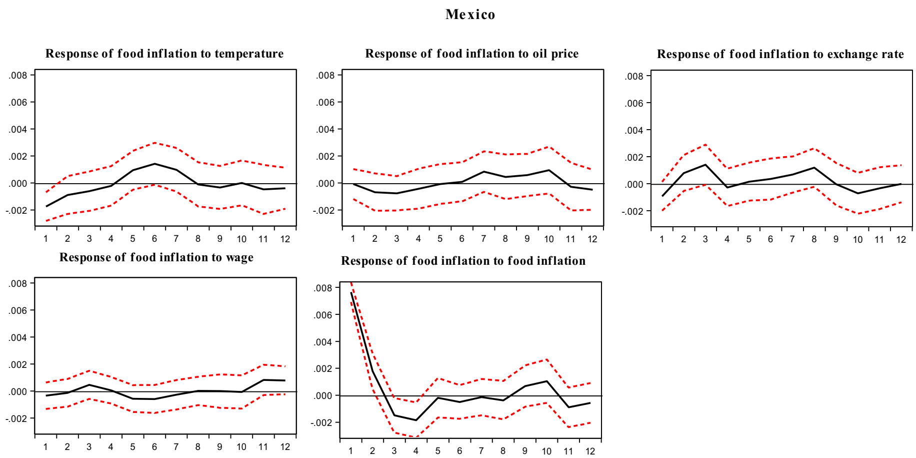

Fig. 5 Response of food inflation to structural one-standard-deviation positive innovations in Mexico

As can be seen in Fig. 5, the response of food inflation to all variables was insignificant over the whole period in Mexico. The response of food inflation to itself was similar as in the other countries. The response was positive and significant but lost its significance after the second month.

As shown in Fig. 6, the response of wage to food inflation was positive and significant in the third month in Uruguay. It was also significant around the ninth month but became insignificant again. Food inflation followed a similar pattern to other Latin American countries. The response of food inflation was positive and statistically significant until the second month. Then, it became insignificant. Although it again became positive and significant between the fifth and the seventh months, thereafter, it returned to insignificance.

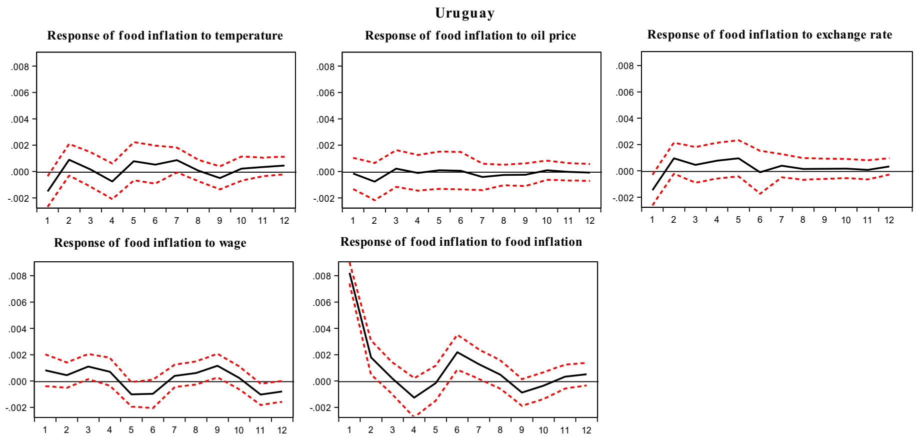

Fig. 6 Response of food inflation to structural one-standard-deviation positive innovations in Uruguay

4.5 Panel Granger causality test results

In this section, the bootstrap panel Granger non-causality test proposed by Emirmahmutoglu and Kose (2011) was implemented. The methodology is robust in a heterogeneous mixed panel under cross-section dependency. The methodology of Emirmahmutoglu and Kose (2011), an extension and improvement of Toda and Yamamoto (1995), uses the level VAR model with extra dmax lags to test Granger causality between variables in heterogeneous mixed panels. Thus, this test can be applied to panels for stationary, non-stationary, cointegrated and non-cointegrated series. Emirmahmutoglu and Kose (2011) used the Fisher's (1932) test statistic in order to test the Granger non-causality hypothesis in heterogeneous panels. However, the limit distribution of the Fisher test statistic is no longer valid in the presence of cross-section dependence among countries. Therefore, Emirmahmutoglu and Kose (2011) obtained the empirical distribution of the test statistic using the bootstrap method. The probability values for panel statistics are derived from bootstrap distributions; this methodology considers cross-section dependency.

Testing cross-section dependence, LM test statistics using Breusch and Pagan (1980), Pesaran (2004) and Baltagi et al. (2012) can be applied. These three tests may be computed from panel and pool equations estimated by least squares and instrumental variables. The results from the cross-sectional dependences are shown in Table 5. These results demonstrate that the null hypothesis of no cross-sectional dependence is rejected at a 1% level of significance for all variables in Latin American countries.

The results of the Granger causality test are given in Table 6. The results indicate that null hypothesis "the exchange rate does not Granger cause food inflation" can be rejected at a 5% significance level for all countries except Ecuador. However, there is evidence for rejecting null hypothesis “the oil price does not Granger cause food inflation" only for Argentina at a 5% level of significance. Finally, it was found that empirical analysis supports Granger causality from wage to food inflation at a 10% level for Argentina and at a 1% level for Uruguay.

The Fisher test statistic value combining the p-values of countries is derived to assess an overall hypothesis for six countries. The bootstrap distribution of Fisher test statistics is obtained from 10,000 replications, and bootstrap critical values are received at the 1%, 5%,

Table 5 Cross-section dependence test

Test	Temperature		Oil price		Exchange rate	
	Statistic	*P*-value	Statistic	*P*-value	Statistic	*P*-value
Breusch–Pagan LM	278.80	0.0000	3225.00	0.0000	278.80	0.0000
Pesaran-scaled LM	48.16	0.0000	586.06	0.0000	48.16	0.0000
Baltagi, Feng, and Kao						
Bias-corrected scaled LM	48.15	0.0000	586.05	0.0000	48.15	0.0000
	Wage		Food price			
	Statistic	*P*-value	Statistic	*P*-value		
Breusch–Pagan LM	31.62	0.0072	1181.84	0.0000		
Pesaran-scaled LM	3.03	0.0024	213.04	0.0000		
Baltagi, Feng, and Kao						
Bias-corrected scaled LM	3.02	0.0025	213.02	0.0000		

Table 6 Granger causality test results

	temp		*oil*		er		*w*	
	Wald	*p*-value	Wald	*p*-value	Wald	*p*-value	Wald	*p*-value
Argentina	2.901	0.234	6.299	0.043**	46.598	0.000*	5.018	0.081***
Colombia	0.869	0.648	0.472	0.790	9.126	0.010*	3.736	0.154
Dominican	1.069	0.586	3.938	0.140	46.723	0.000*	0.354	0.838
Ecuador	3.943	0.139	0.255	0.880	0.686	0.710	0.035	0.983
Mexico	1.197	0.550	0.880	0.644	8.831	0.012**	4.067	0.131
Uruguay	1.575	0.209	1.815	0.178	6.723	0.010*	6.621	0.010*
Fisher test statistic	13.105		15.296		121.272*		22.403	
Bootstrap critical values								
1%	34.798		41.119		54.417		35.439	
5%	27.531		33.423		43.997		29.185	
10%	23.796		29.743		39.524		25.562	

Dependent variable is food price. Lag orders are selected by minimizing the Schwarz Bayesian criteria

* Indicate significance at the 1% level

** Indicate significance at the 5% level

*** Indicate at the 10% level

and 10% levels based on these empirical distributions. The limit distribution of the Fisher test statistic is no longer valid in the presence of cross-section dependence in the mixed panels. Under cross-section dependency in mixed panels, the bootstrap method can be used to find the empirical distributions of the Fisher test. Results indicate that the Fisher test statistic is higher than asymptotic Chi-square critical values for only the exchange rate. This finding proves that the exchange rate has an effect on food inflation for these countries.

5 Results and discussion

The paper generally indicates that food inflation in Latin American countries can be influenced by temperature, the oil price and monetary and fiscal policies. Therefore, these countries should design new policies to control food inflation. First, these countries should focus on climate change policies. Agriculture is highly sensitive to temperature changes. Shocks can increase the fragility of food production and cause crop failures and falls in output. This can result in food shortages and inflation. The illustration of the econometric methodology is given in Fig. 7. In Table 4, forecast error variance decomposition analysis shows that most of Latin American countries are susceptible to temperature changes. In particular, food inflation in the Dominican Republic, Ecuador, Mexico and Uruguay was strongly influenced by this determinant. The impact of temperature changes on food inflation increased more than that of the exchange rate in the long term. This result shows that these countries are vulnerable to weather conditions and might be deeply affected by climate change in the long term. Whereas the effect of the exchange rate did not change strongly in the long term, temperature change did. Hence, these countries should focus on the production of foods that are more resistant to temperature change. They should plant more durable crops. New sowing techniques and alternative crops can be efficient policy (Dagar et al., 2021a). Governments should support investment that can mitigate the effects of climate change and design policies to reduce the inflationary effect of food prices. Hence, tightening policies to reduce inflationary effects must play a role. Following these policies is crucial since climate change is not only a regional issue but also a global one. Dependency on international trade increases the vulnerability of Latin American countries because of the economic importance to them of food exports.

Second, these countries are not large producers of oil. Food inflation can be directly influenced by the global oil price. Industrialization, production, fertilization and daily life require energy resources. As can be seen in Table 4, forecast error variance decomposition shows that the oil price constituted a considerable component of food inflation in all countries, although this effect was more limited in Uruguay. The analysis proves that the impact of the oil price becomes stronger in the long term. Whereas the effect of the exchange rate does not show significant change, that of the oil price gains power over time. Hence, it can be said that Latin American countries are weak in the face of changes in the oil price. These countries need to find ways to reduce the inflationary effect of the oil price. These economies are still developing and are some distance from the technological frontier of the developed countries. The sustainable resources should be developed to cover energy needs and eliminate the impact of the oil price on food

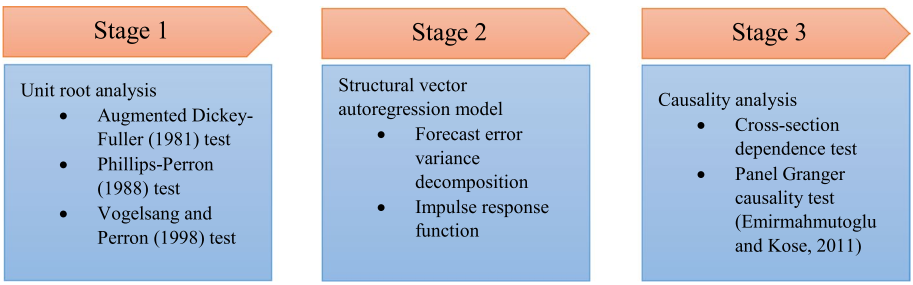

Fig. 7 Illustration of the econometric methodology

inflation. Sustainable energy transition can improve economic performance of the countries. Favoring investments toward renewable energy can suggested as an action plan. Each country should design plans to ensure affordable and secure sustainable energy transition (Khan et al., 2022). Governments can provide incentives in green and renewable energy by waiving a portion of costs and should design an inclusive environmental and economic energy policy (Khan et al., 2021). Reducing oil dependency within the agricultural industry and daily transportation can help mitigate the costs of delivery and production (et al., 2021a). Governments should diversify the energy needs by ensuring the replacement of conventionally used energy resources with relatively clean and alternative energy resources (Dagar et al., 2021b; Murshed et al., 2021). The adoption of renewable energy can provide clean and low-cost production, reliability and sustainability benefits for society. Governments, policy makers or authorities are advised to facilitate policies for renewable and sustainable energy technologies.

Other measures should be based on monetary and fiscal policies to reduce the impact of the exchange rate and labor costs on food inflation. The exchange rate is directly related to monetary policy. Central banks should inject price stability into the market by reducing fluctuations in the exchange rate. In general, as can be seen in Table 4, analyses indicate that in all countries except Ecuador, the exchange rate constitutes a considerable component of food inflation. Figures 1 and 3 show that the response of food inflation to exchange rate was positive and statistically significant in Argentina and the Dominican Republic. Table 6 proves that exchange rate impacts on food inflation in all countries except Ecuador. Latin American countries should create macroeconomic stability that can lessen the influence of the exchange rate on inflation. In addition, these countries might also follow policies to decrease the import component of foods vulnerable to currency depreciations. In this way, the effect of the exchange rate can be reduced. Our analysis indicates that food inflation is not strongly influenced by wages. This might be due to disorganized labor in the agricultural industry. Wages can be affected by market conditions that may mitigate their effect on food inflation. According to variance decomposition analysis, although their effect was weak, wages had an increasing impact on food inflation. Moreover, in some countries, such as Argentina, Colombia and Uruguay, this variable yielded significant results in impulse response and Granger causality tests. This shows that wage increases should be examined. Governments could set wages in the agricultural industry through collective bargaining. Government intervention into the market might be necessary to reduce the effect of wages on food inflation. Policies should be designed to decrease the cost of production and increase productivity.

Overall, this work shows that Latin American countries can control the impact of exchange rates and wages on inflation. These issues are more related to the domestic policies followed by central banks and governments. They can deal with inherent problems using conventional tools. The impacts of the oil price and temperature are not directly related to these policies. These are global issues and not easy to deal with. Governments can follow policies to create stability by adopting fiscal and monetary measures. However, the effects of the oil price and temperature will doubtless continue. The case of Ecuador serves to explain this condition. When the country created a new institutional change by officially accepting the US dollar as its national currency (because of chronic inflation), the impact of the exchange rate lost its power over inflation. As can be seen in empirical analyses, the country reduced its inflation problem, which had been stimulated by currency fluctuations. Nevertheless, even with the exchange rate brought under control, the impacts of the oil price and temperature are distinguishable. In addition, these problems also tend to decrease the efficiency of political tools used by central banks and governments, making it difficult to fully realize political objectives. As a result, creating alternative policies is crucial to the elimination of problems caused by food inflation and food price hikes.

6 Conclusion and policy implications

World has been facing with a rising trend in food inflation. The problem of food inflation gained attention of authorities because this problem can be a driving factor of general inflation and uncertainty and also decrease the welfare of poor people. When it comes to the developing countries, the problem of food inflation can be more serious as their economies and spending are more depended on agricultural industry. The theoretical foundation of this work is based on the assumptions that temperature, the oil price, the exchange rate and wages in the agricultural industry can significantly influence food inflation. Hence, the impacts of the selected variables were analyzed using a SVAR model for monthly periods between January 2003 and December 2020. Certain Latin American countries were included in the analysis. These countries' economies are still developing and a large part of their exports consist of agricultural products.

Forecast error variance decomposition, impulse response function and panel Granger causality tests were implemented to examine the indicators of food prices. Although a variety of implications can be derived from these analyses, these countries faced similar problems related to the oil price and temperature. According to the result of variance decomposition, the effects of the oil price and temperature on food inflation increase in the long term. Although exchange rates constituted a large element of food inflation, its impact did not indicate strong change over time. Wages remained a relatively weak operator on food inflation, but its effect increased later on. Impulse response function and Granger causality tests showed that the exchange rate is the outstanding dynamic in all of the selected countries. All of them except Ecuador were impacted by changes in the exchange rate. Macroeconomic instability is a common threat. These economies are sensitive to depreciations in the exchange rate. The case of Ecuador carries a strong political implication. These countries have the ability to control the effects of the exchange rate and can create tightening policies by conventional economic tools. A stable exchange rate and low costs of production can bring stability to food prices. It seems that Ecuador distinguished itself from the other countries by creating a radical institutional change in its exchange rate system by accepting the US dollar as official currency. This helped the country pursue a tightening monetary policy. This seems in empirical analyses to lessen the effect of the exchange rate on food inflation. However, the importance of the oil price and temperature remained important factors which increasingly effected food inflation.

The most important political implication that can be gleaned from this work is that Latin American countries can control their exchange rate to reduce its effect on food inflation by conventional tools or by a radical institutional change. Wages and exchange rates are susceptible to internal policies and can be influenced by fiscal and monetary measures. However, it is not easy to mitigate the effects of the oil price and temperature. Hence, these countries need to follow policies that make them less vulnerable to climate change and energy resources. To achieve this, alternative policies should be designed. Such new policies can eliminate the problems caused by food inflation.

There are some limitations in the paper. Six Latin American countries could be selected for the analysis because of data availability. In future, if there are reliable data for more countries, the research can be extended. There are four variables included into the analysis.

More variables can be taken into account for other Latin American countries. In particular, it is difficult to find data for agricultural industry. Future researches can also be separated according to the specific agricultural product. The more countries develop the more energy consumption and demand increase. Oil can cause environmental, social and economic problems. Thus, it would be favorable to conduct future research that particularly tackles the problem of climate change and environmental concerns caused by fossil fuels used in agricultural industry. In addition, during the COVID-19 period, the world faced with surging inflation and food prices. The impact of COVID-19 on food inflation can be considered for future research.

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Declarations

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