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The Changing Drivers of Food Inflation – Macroeconomics, Inflation, and War

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Abstract

The inflation surge in recent years is having profound social, economic, and political consequences. In particular, food price increases strongly affect low-income segments of the population. What makes this period so unusual is the breadth of price pressures that are affecting both low and high-income countries. In essence, this means that price movements increasingly synchronize across borders. This study examines price developments across countries and over time and investigates the driving factors behind current inflation trends and food price hikes. Our analysis reveals that a complex mix of causes has led to the soaring food prices seen in 2021-2022. The spread of COVID-19 produced disruptions in the world's supply chains, pushing the cost of producing and transporting food upward. The increase in fertilizer and energy prices has further exacerbated production costs for agricultural products. Droughts in parts of Africa, Asia, and the Americas damaged harvests, and fueled prices. The war in Ukraine and the associated trade blockade of grain exports created additional supply shortages. Additional pressures included speculative activities in financial markets, which were already at play before the Russia-Ukraine war. In spite of all these increases in costs, inflation could perhaps have been kept under control by immediate, sufficiently restrictive monetary policies by Central Banks. Most likely, the main cause of the strong inflationary surge in several countries seems to have been the failure of some Central Banks to rapidly intervene to counteract the effects of overall price increases including key staples. Soaring inflation is continuing to make vulnerable countries hungrier and poorer and, therefore, prompt actions necessary to help them.

Keywords: food inflation, exchange rate fluctuations, supply and demand shocks, financial speculation

JEL Codes: C32, E31, Q02, Q17

1. Introduction

The world economy is currently facing significant challenges: high inflation, food and energy insecurity, elevated debt levels, tightening financial conditions, volatility in capital flows and exchange rates, and the intensification of geopolitical tensions. The sharp and persistent rise in inflation, which started in 2021 and grew to distressing dimensions in 2022, is continuing to cause concerns, above all, for the world's poor. High inflation erodes the purchasing power of individuals and families, increases material and social deprivation, and widens social inequalities, thus deepening absolute poverty and increasing food and energy penury (Brewer et al. 2023; Menyhert, 2022).

The micro-economics of food price volatility, such as supply and demand shocks, are extensively researched (e.g. Mustafa et al., 2024; Kalkuhl et al., 2016; Tadesse et al., 2014). For instance, Kalkuhl et al. (2016) curated a comprehensive collection of studies on food price volatility and its implications for food security. Their work provides evidence of the intensified linkages between food, energy, and financial markets and the role of speculation affecting price fluctuations. It further discusses policy responses to mitigate excessive price volatility. Tadesse et al. (2014) identified three groups of price change determinants in the period 1986-2009: root causes or exogenous shocks, such as extreme weather events; conditional causes linked to market conditions and political environment; and internal causes or endogenous shock amplifiers, such as speculative activities and food stocks. Thus, both national and international policy actions are needed to cope with price swings. Robles et al. (2009) documented that changes in supply and demand fundamentals could not fully explain the 2007-2008 food crisis, but rising expectations, speculation, hoarding, and hysteria played a role in the increasing price volatility. Less research is available about the joint effects of macro-economic and micro-economic drivers of food price inflation and, in particular, for the current complex global economic situation.

Former studies have spotlighted that inflation in less developed countries is linked to the food and agricultural sector. For example, Durevall et al. (2013) showed that, in the long run, international food prices and exchange rate dynamics triggered inflation in Ethiopia, while, in the short run, domestic food supply shocks and inter-seasonal fluctuations strongly affected inflation. Nguyen et al. (2017) found that in the past, the main drivers of inflation in Sub-Saharan Africa have been domestic supply shocks and shocks to the exchange rate and monetary factors. In recent years, the influence of these shocks has lessened, while the role of domestic demand pressures and global shocks has significantly risen (IMF, 2022; Okou et al., 2022). The recent literature, with a few exceptions, is mostly silent on the drivers of food price changes. Adjemian et al. (2023) divided the path of domestic food prices in the US into supply and demand determinants. The authors documented that even though supply-side factors explain most of the recent price changes, the demand-side factors, and especially the money supply, have recorded a stronger correlation with food price increases than in the past.

We believe that the causes of the 2022 price hikes are complex and should be carefully investigated, as the global food crisis will not be over when international prices go back to normal (Kornher and von Braun 2024).

The purpose of this study is, hence, to fill the gap in the research and identify the determinants and drivers of global food prices measured by the FAO food price index. This index can be considered a gauge for world food price inflation. The global perspective is novel and is important to assess since international price movements represent a major threat to worldwide food security, and they matter significantly for the world's poor, who increasingly lose the capacity to access healthy diets and good nutrition (FAO et al. 2023; FAO 2022). Price hikes, in fact, while amplifying the incidence of poverty, lead poor people to reduce calorie intake and the quality of their diets.

This study contributes to the current debate in several directions. First, we discuss the different causes of inflation. Second, the study provides thorough overview of price dynamics across countries and time in order to contextualize the issue of inflation and detect important characteristics and features. Third, we discuss the relevance of the different drivers of inflation during the recent inflation spike and examine the importance of these drivers for changes in the FAO food price index between 2000 and 2022 using the Engle and Granger estimations.

The study is organized as follows. Section 2 briefly touches on the theory of inflation. Section 3 provides an overview of recent inflation developments. Section 4 discusses the causes of general inflation and food price inflation in 2021-2022. Section 5 presents the econometric analysis and Section 6 concludes.

2. Inflation determinants in theory

There are several causes for changing prices of goods and services in an economy (Stevenson and Wolfers, 2020; Abel et al., 2019). As opposed to a price increase of a single good or service, inflation refers to a generalized increase in the overall price level, while the inflation rate denotes the percentage change (or growth rate) in the price level from one period to another. Inflation can be caused by internal factors of an economy, for which we speak of internal inflation or external factors, for which we talk of imported/exported inflation.

2.1 Internal triggers

a) Cost-driven inflation. This is caused by a rise in production costs (supply shock). For example, an increase in the price of raw materials, such as crude oil, leads to higher prices for a range of oil-based inputs (e.g., plastics, rubber, fertilizers, transports) and will induce a producer to directly transfer the surge in production costs to the prices of final products. Production costs can also increase because of rises in wages or drops in productivity. In all cases, when a producer experiences an increase in production costs to keep profit unchanged (profit = revenues - costs), he/she has to raise sales prices.

b) Demand-driven inflation. This is caused by an excess of internal demand. The excess occurs when the demand for goods and services outstrips the production capacity (i.e., the supply). For example, if households experience an increase in income due to, for instance, expansive fiscal policies, they will demand more goods and services. If it is not possible to increase production by the same amount, prices will tend to rise. Consumers will compete to get the few goods in circulation, which causes widespread price increases.

c) Liquidity-driven inflation. This is triggered by an excessive rise in liquidity (i.e., money in circulation, measured by monetary aggregates). When Central Banks introduce more money than the goods and services to be produced, inflation is generated. Milton Friedman (1970) famously said, “Inflation is always and everywhere a *monetary phenomenon* in the sense that it is and can be produced only by a more rapid increase in the quantity of money than in output.”

d) Rising inflation expectations. The inflation expectations describe the rate at which average prices are expected to increase across the whole economy next year (Stevenson and Wolfers, 2020). When market operators envisage higher inflation, this may push suppliers to raise their prices, thus fueling inflation. If everyone expects prices to rise—for instance, by 2% over the next year—businesses will want to raise prices by (at least) 2%, and workers and their unions will want similar-sized raises in wages. Because businesses, consumers and workers incorporate inflation expectations into their forward-looking pricing behavior,[1] (Obstfeld, 2022) high or low inflation projections can be a self-fulfilling prophecy (Kydland and Prescott,

[1] This behaviour, which can be influenced by several factors (e.g. wage bargaining power of workers), is known as ‘wage-price spiral’ and ‘second round effects’ (United Nations, 2023).

1977; Neri et al. 2022). Inflation expectations are measured by surveys (e.g., the University of Michigan Surveys), by professional forecasts, and by analyzing financial market data (in particular inflation swaps). Inflation expectations remain a key variable that is difficult to measure in most African countries.

2.2 External triggers

a) Imported/exported inflation. Imported inflation occurs if price levels in a country increase due to a sharp increase in demand for foreign goods and services. For example, because Egypt imports large quantities of grain, an increase in the price of this raw material causes an increase in the domestic prices of final products that use grain as input (e.g., bread). Egypt, therefore, imports inflation and the grain supplying countries export inflation.

b) Cost-driven imported inflation. The dynamics of nominal exchange rates can also create (cost-driven) inflation. In particular, when a country has a weak (or depreciated) currency, more money is needed to buy foreign products (i.e., the domestic price of foreign-made goods increases), thus boosting inflation. There are further indirect effects that cause national producers to raise their prices when the value of the domestic currency goes down. In particular, for businesses that rely on imported inputs: a weak currency raises the cost of imported inputs, and this leads to higher prices of final products. For businesses that compete with imported products: a weak currency increases the price of goods made by foreign competitors; therefore, national producers can raise their prices, given the lower international competition.[2]

In any case, independently from internal and external triggers, Central Banks have the power and the duty to counteract most of the effects of specific cost increases on general prices through monetary policy actions.

[2] This pattern is consistent with recent research, which finds that cost-push shocks propagate more strongly to inflation when it is rising steeply than when it is subdued, i.e. the Phillips curve is non-linear (Lindé et al., 2023). See also Hazell et al. (2022) for an analysis of the slope of the Phillips curve.

3. Recent inflation trends

Figure 1 shows the dynamics of the inflation rate at the world level in both aggregate (world) and disaggregate components (developed and developing economies). Developing economies are divided into three subgroups: African, American, and Asian countries. African countries have experienced the highest inflation rates over time, followed by developing American and Asian economies. Developed countries show an inflation rate that is always below the world average. The reason for the lower inflation rate of developed countries with respect to developing countries can be mainly ascribed to the stronger economic structure, the sharper technology-driven efficiency (i.e., high productivity reduces production costs and, therefore, prices), and more credible monetary policies[3] present in advanced economies, compared to developing economies. In 2021-2022, the growth rate in the price level peaked at more than 20% in developing African countries and above 15% in developing American countries. Lower rates have been recorded for developing Asian and developed economies (see Figure 1). Inflation is nonetheless a global phenomenon, due to a likely growing role for global factors affecting price dynamics.

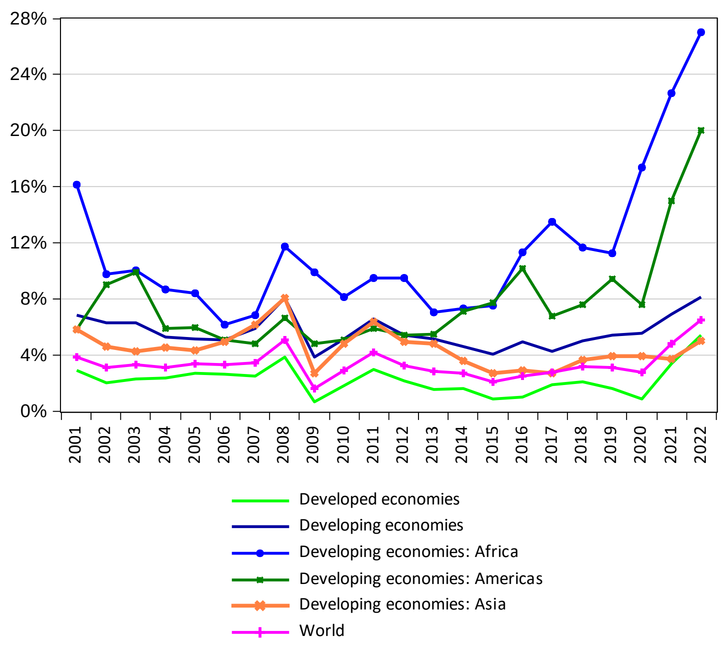

Figure 1: Inflation rate for groups of countries (Annual growth rate in %)

Note: Inflation CPI based. Country groups: World, Developing Economies and Developed Economies. Developing Subgroups: Africa, Asia, Americas.
Source: Elaborations on UNCTADSTAT (2024) https://unctadstat.unctad.org/wds/TableViewer/tableView.aspx

[3] In advanced economies, interest rates, the main tool of monetary policy, are generally set in a transparent and predictable way following clear principles like the Taylor rule or gradualism, thus allowing the private sector to understand the intentions of monetary policy makers (Reis, 2022).

Figure 2 displays headline and core inflation[4] for OECD countries considered together from January 1990 until November 2022. It is worth noting that the differences between the two lines indicate the increase in prices due to energy and food products. This increase was particularly marked in 2007-2008, 2011-2012 and 2021-2022. In view of the more severe effects of headline inflation on the poor (e.g., nutrition and health effects), even in the short-term (Kornher et al., 2023; Usman et al. 2022, FAO et al. 2023), policy makers and Central Banks should be as concerned with headline inflation, as with core inflation.

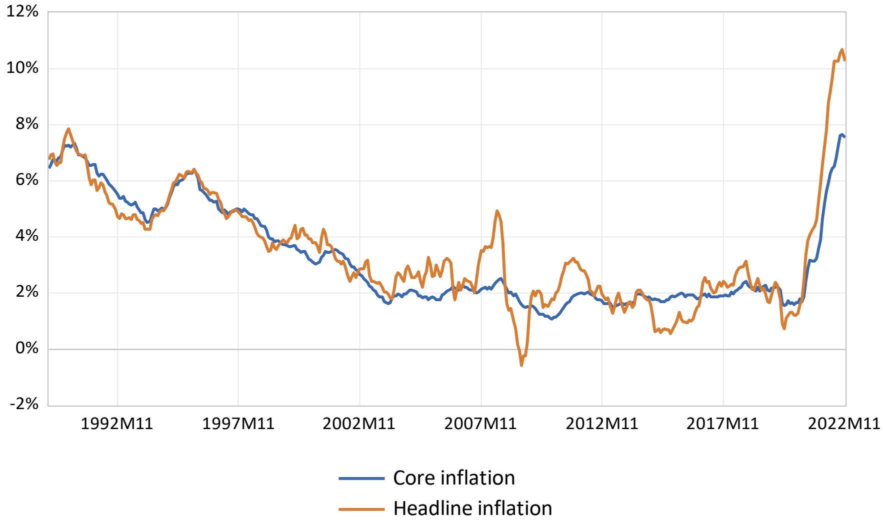

Figure 2: Inflation in OECD countries (Year-on-year CPI inflation rate)

Note: All items (headline) & all items less food and energy (core).
Source: Elaboration on Refinitiv-Datastream (2023).

Figure 2 sketches the patterns of headline, core, food, and energy inflation rates, broken down into advanced economies, emerging developing economies, and low-income economies. All different types of inflation have been generally higher in the late 20th century (1980-1999) and very recently (2021-2022). Also notable is that inflation has been particularly elevated in emerging developing and low-income countries.[5]

The dynamics of prices have always attracted significant attention for their impact on the stability of the real economy (in terms of output, employment, investments, consumption, and poverty), for the evaluation of the transmission mechanisms of monetary policy, and for the relationship that an economy has with the rest of the world (exchange rates, economic integration). High inflation is, in fact, associated with lower economic growth, an increased likelihood of financial crises, reduced investor confidence, erosion of public sector balance sheets, more indigence, income inequality, and social unrest (IMF, 2022; Linke et al., 2021; Ha et al. 2019a; Espinoza et al. 2012; Mishkin 2008; Crowe, 2006).

[4] Headline inflation considers the overall prices of a country's basket of consumer goods and services; core inflation excludes the prices of food and energy from the basket, which are more volatile than other products.
[5] See also Ha et al 2019b.

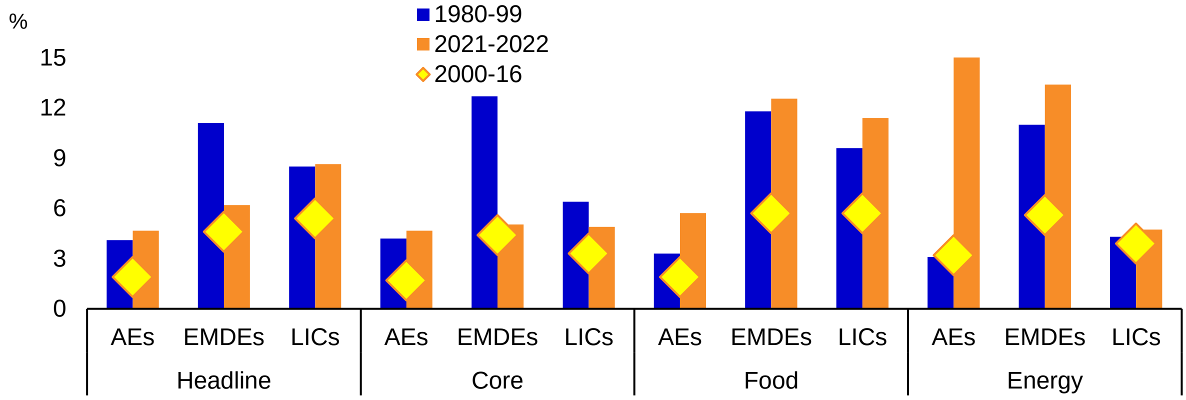

Figure 2: Different types of inflation (Median values in %)

Note: AEs (Advanced Economies), EMDEs (Emerging developing economies), LICs (Low-Income Economies).
Source: The World Bank database (2023).

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The extent of inflation is not felt equally across economies: low and middle-income countries tend to be more vulnerable to high inflation than developed, richer countries. The reason is due to the different composition of their income and consumption baskets. The World Bank Group (2022) has estimated that the lowest-income households in emerging and developing economies spend roughly 50% of their income on food, while the highest-income households spend only 20% (Figure 4). Therefore, the current surge in food and energy prices could hurt the poor most. While high-income households can easily switch from higher-quality goods to lower-quality goods in difficult times or take advantage of discounts on bulk sales, poor households do not have many options. This would increase undernourishment and wasting risks for children of poor and landless rural households. Currently, food inflation in Africa is shrinking portions, with sellers reducing the size of several products to allow people to buy. In Nigeria, for instance, it is possible to buy small packets of shampoo and washing powder and ''smallie'' pizzas and meals. Retailers often see shrinking products as a better option than raising prices—a phenomenon known as "shrinkflation" (The Economist, 2022).

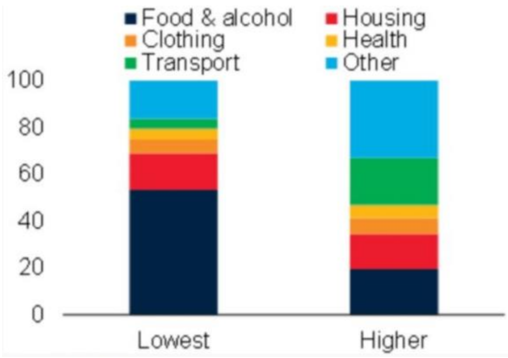


Figure 3: Composition of consumption expenditure, by income group in emerging and developing countries (% of total consumption in 2021)

Note: The sample includes 90 emerging markets and developing economies (24 are low-income countries). The lowest consumption segment refers to the bottom half of global distribution (i.e., the 50th percentile and below); the higher consumption segment corresponds to the 91st percentile and above. "Housing" includes energy and other utilities. "Transport" includes purchases of new vehicles, as well as motor fuel. "Other" includes furnishings, personal care, and finance and insurance services.
Source: The World Bank (2022).

Figure 5 illustrates the inflation rates at a finer disaggregated level across the world for the years 2019, 2022 and 2023. In 2019, Libya, Mali, Burkina Faso, Chad, Niger, Benin, Saudi Arabia, and Iraq recorded negative inflation rates (deflation; shown in bright green). Argentina, Venezuela, Liberia, Zimbabwe, South Sudan, Sudan, and Iran registered more than 25% of inflation (shown in red). Most European countries, the US, and Canada experienced contained inflation rates between 0-3% (shown in dark green). Low inflation rates in 2019 were partly owed to reduced economic growth in that year. By contrast, in 2022, the number of countries experiencing inflation between 10-25% (shown in blue) and above 25% (shown in red) grew. In particular, Argentina, Venezuela, Suriname, Sierra Leone, Ghana, Sudan, Ethiopia, Angola, Zimbabwe, Iran, Yemen, Turkey, Moldova, and Sri Lanka recorded the most extreme price surges (Figure 5). A similar dramatic scenario has characterized 2023. While in October 2021, only 20 out of 146 countries in the world registered inflation rates above 10%, in October 2022, this number more than tripled, with 68 out of 146 countries (most of which are developing economies) registering inflation rates above 10% (UN, 2023). In November and December 2022, Zimbabwe, Venezuela, and Lebanon showed the largest percentages of hyperinflation (Figure 5). With the exception of Moldova and Rwanda, all the countries reported in Figure 5 faced steep depreciation of their national currencies against the US dollar in 2022.

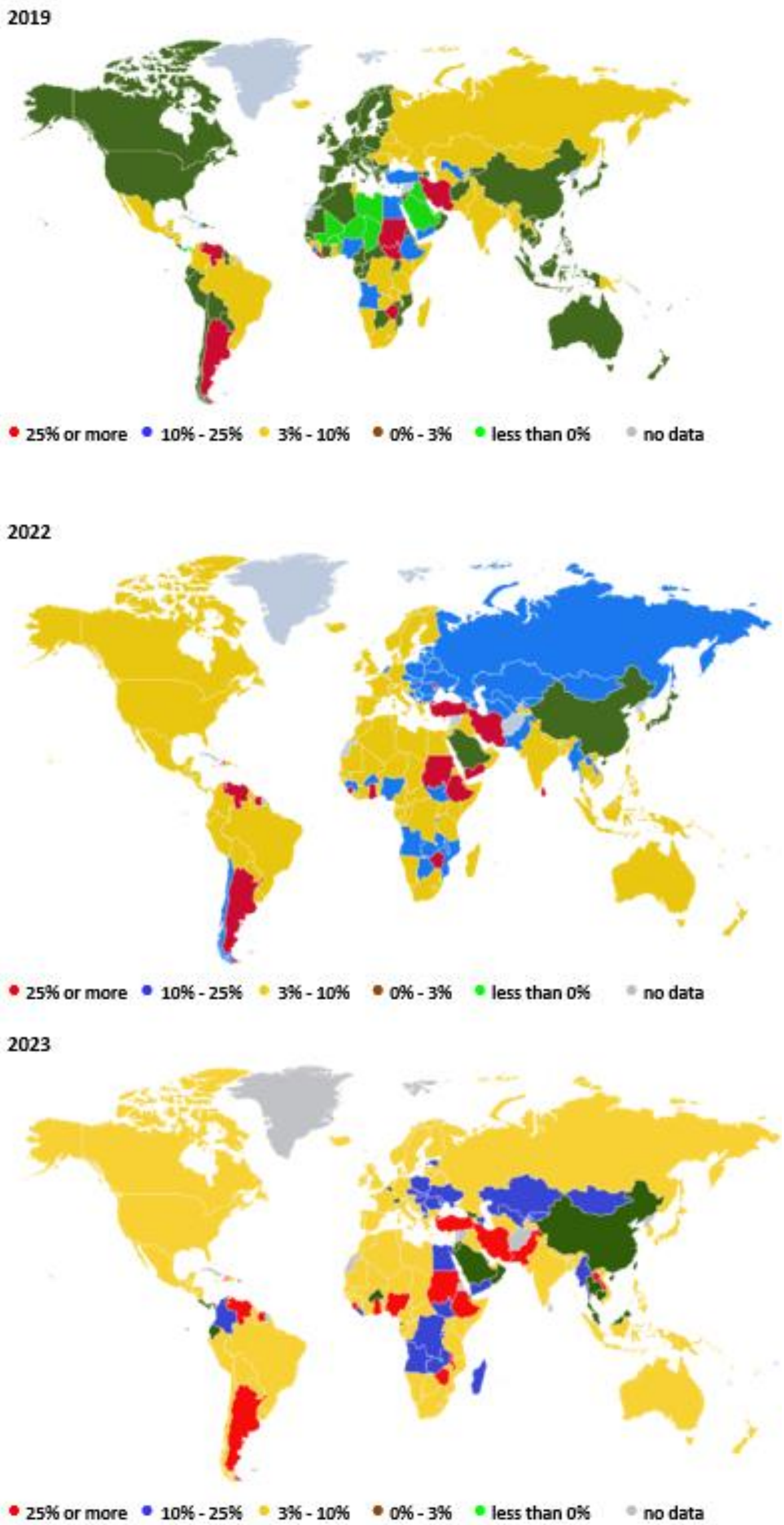


Figure 4: Inflation rate world maps for 2019, 2022, and 2023 (Average consumer prices)

Source: Elaboration on IMF (2024).

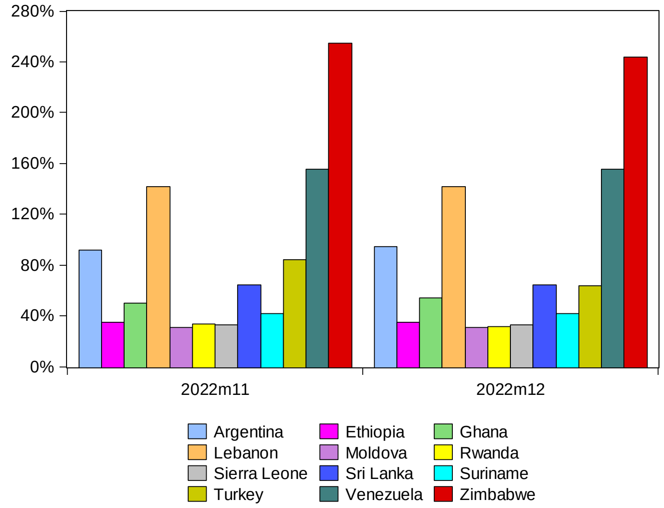


Figure 5: Countries with an inflation rate of more than 30% in November and December 2022

Source: Elaboration on IMF (2023a).

4. Inflation determinants in practice

4.1 Global and domestic drivers

The reasons for the steep rise in inflation in 2021 and 2022 are multifaced and result from a confluence of multiple inflationary forces and shocks. Examples of these influences include major supply chain and logistical disruptions due to the COVID-19 pandemic[6] first and the Russian-Ukrainian war later, rising global demand following the partial worldwide economic recovery in 2021, policy stimuli (both the generous pandemic-relief fiscal measures and expansive monetary policies), elevated inflation expectations, the eroding value of national currencies against the US dollar, and speculative trading in commodities (see policy brief by Kornher et al., 2022). The start of the war in Ukraine in February 2022 amplified pre-existing stresses in global commodity markets, pushing prices up. The cost of oil and gas rose by a third as Western countries imposed sanctions on Russia, a major producer and exporter of both commodities. Food prices also increased to historic heights (see Figure 5), pushed up by input costs, in particular a rise in fertilizer[7] and transportation costs. For instance, between January 2021 and 2022, prices of NPK (nitrogen, phosphorus, and potassium), and phosphate rock have more than doubled. Meanwhile, prices of DAP (di-ammonium phosphate) and TSP (triple super-phosphate) increased by 58% and 74%, respectively, over the same period. Russia's blockades of grain exports from Ukraine—the fifth-largest exporter of wheat (Russia was, until recently, the world's top exporter)—put further pressure on prices. A series of extreme climatic events in 2021-2022 also reduced production of some agricultural products. For example, Brazil experienced the worst drought in a century and the worst frost in 20 years, a four-season drought hit Ethiopia and Kenya, India saw a lack of rain and extreme temperatures, and climatic challenges in America's wheat belt and in the Beauce region of France contributed to worldwide concerns.

In each country, all these factors impacted inflation dynamics in varying proportions (United Nations, 2023). For example, inflation in Sub-Saharan Africa was mainly pushed by elevated global food prices (Figure 6), especially wheat, maize, rice, and sorghum, accompanied by national depreciations (IMF, 2022). Except for Ethiopia and Ghana, where the excess in domestic demand—due to expansionary fiscal policies—has contributed to price pressure, in all other African countries, the major drivers of inflation have been external factors (Okou et al. 2022). In advanced economies, like the EU, both supply chain disruptions and rises in agricultural input prices and energy prices (Figure 7) were also associated with increased rates of inflation (Kornher et al. 2023). In Latin America, price pressures became stronger because

[6] While there is a growing number of studies that have explored the impact of lockdown measures on food security (e.g., Adjognon et al., 2021; Kansiime et al., 2021, Laborde et al., 2021; Harris et al., 2020), less attention has been devoted to the impact of Coronavirus policy response on price dynamics. Dietrich et al. (2021) have documented that more stringent policy responses to contain the spread of COVID-19 have increased food prices for integrated markets in low- and middle-income countries, but not for segmented markets.

[7] In December 2022, prices for urea, a compound used in the production of nitrogen-based fertilizer, ran to more than $500 per tonne—down from $1050 in April 2022, but still much more than the $400 price in 2021.

of expansive monetary policies consequent to the pandemic response, wage indexation and, in some cases, strong aggregate demand. In Chile, pandemic-related financial support, together with pension withdrawals, heightened consumer spending significantly, fueling inflation. In Colombia, instead, inflation surged, mainly due to higher oil and commodity prices (United Nations, 2022).

A further element to note when examining 2021-2022 prices is that several economies underwent a faster and stronger pass-through of external shocks into domestic prices. Indeed, in the past, the pass-through of producer prices to goods inflation usually took about 2 years and was often cushioned by profit margins (i.e., firms absorbed some of the cost increases to avoid presenting too high prices to the consumers). Haile et al. (2017), for instance, have documented a transmission from international wheat prices to domestic Ethiopian prices at downstream markets (flour and bread prices) of about one year for restoring half equilibrium price. Currently, the pass-through to inflation has been very rapid, lasting only around half a year, and on average, it has been more intense than in the past, with firms maintaining and, in some sectors, even increasing their profit margins (Lagarde, 2022). The reason is that when inflation is high everywhere, and supply is constrained, firms can more easily pass on cost increases to customers without losing market share to their competitors. Okou et al. (2022) have estimated a pass-through from global to local food prices close to unity for the Sub-Saharan African countries.

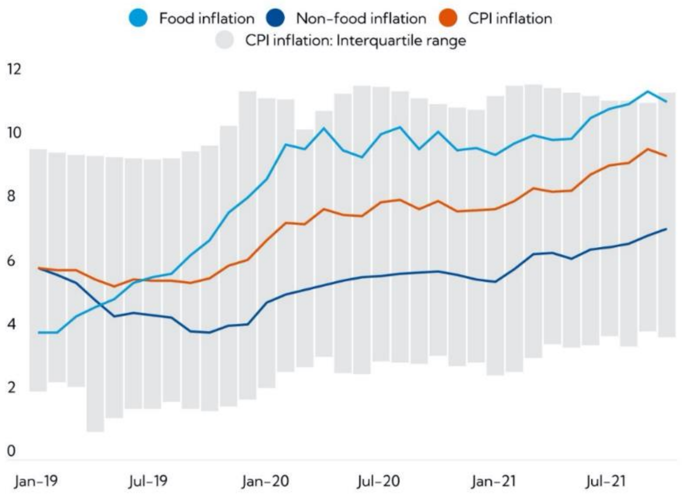


Figure 6: Types of inflation in Sub-Saharan Africa (January 2019-July 2021)

Note: Food inflation in Sub-Saharan Africa has contributed to the spike in overall consumer price inflation.
Source: IMF (2022a).

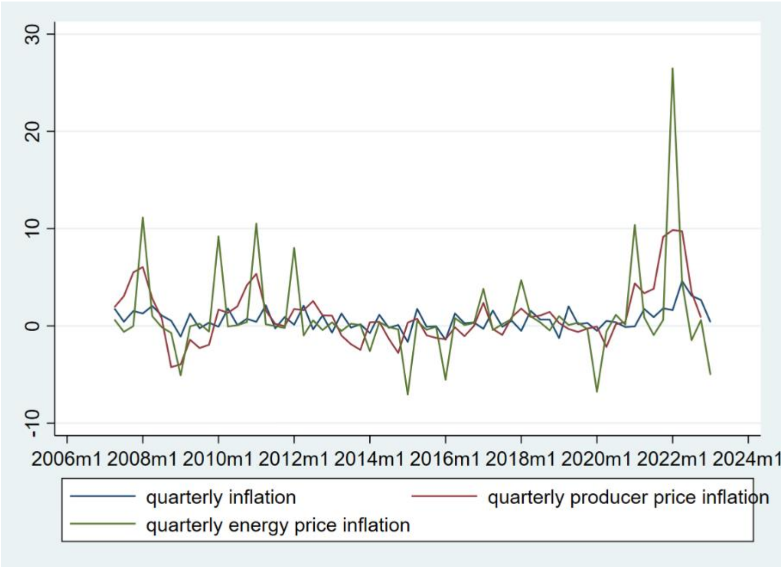


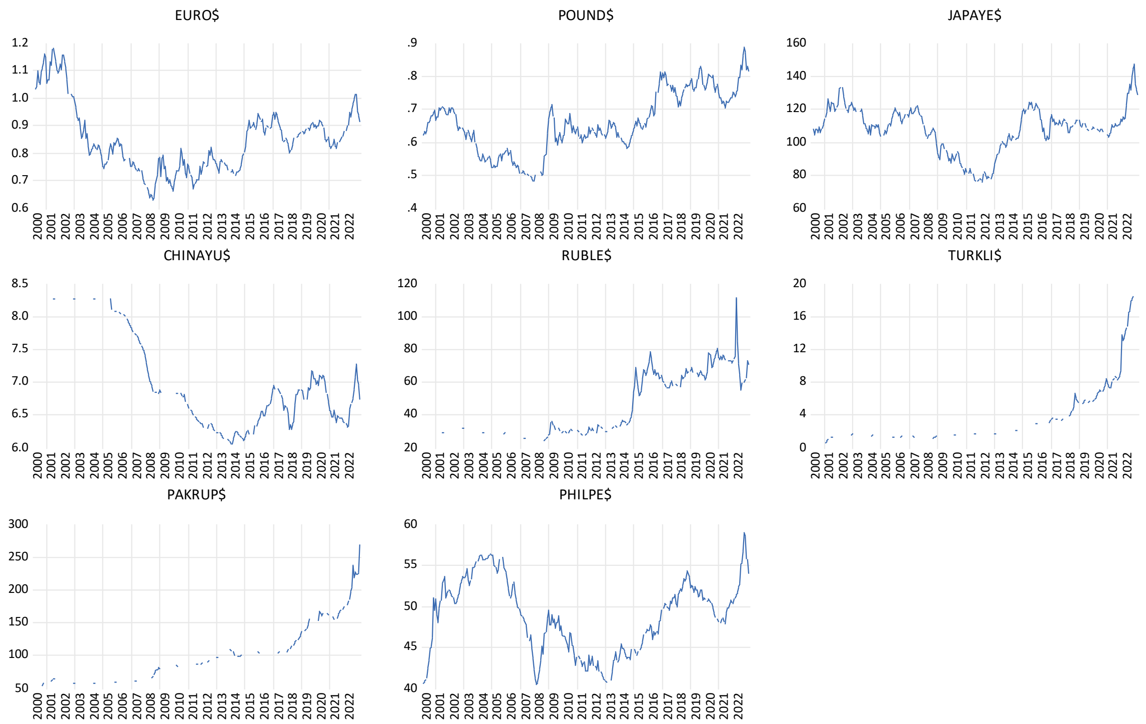
Figure 7: EU average inflation and agricultural producer price inflation

Source: Elaboration on Eurostat (2023).

4.2 The role of exchange rates

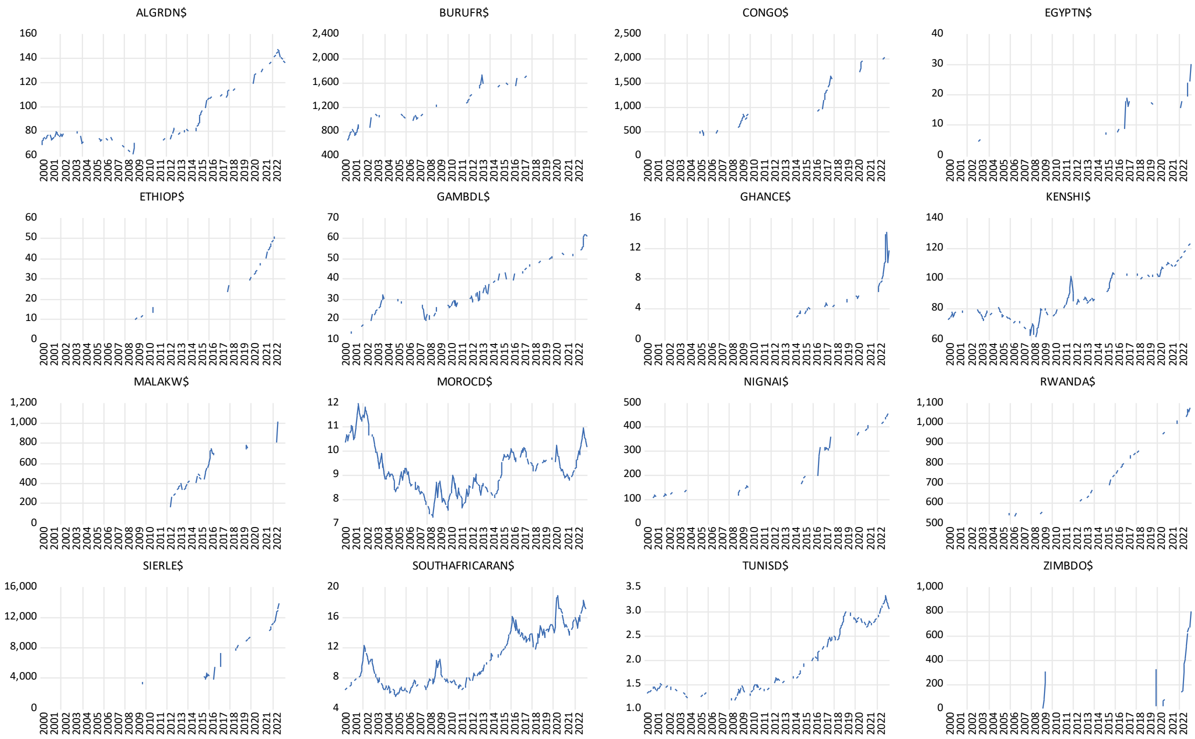
The inflationary pressures of 2021-2022 have been accompanied by eroding values of national currencies. In particular, the US dollar appreciated against almost all currencies in 2022, with a few exceptions (Figure 8).

Panel A. Select countries



Note: Domestic currency necessary to buy 1 US$. Euro, British pound, Japanese yen, Chinese yuan, Russian ruble, Turkish lira, Pakistani rupia, Philippine pesos.

Panel B. African countries



Note: Domestic currency necessary to buy 1 US$. Algeria, Burundi, Congo, Egypt, Ethiopia, Gambia, Ghana, Kenia, Malawi, Marocco, Nigeria, Rwanda, Sierra Leone, South Africa, Tunisia, and Zimbabwe.

Panel C. Southern America Countries

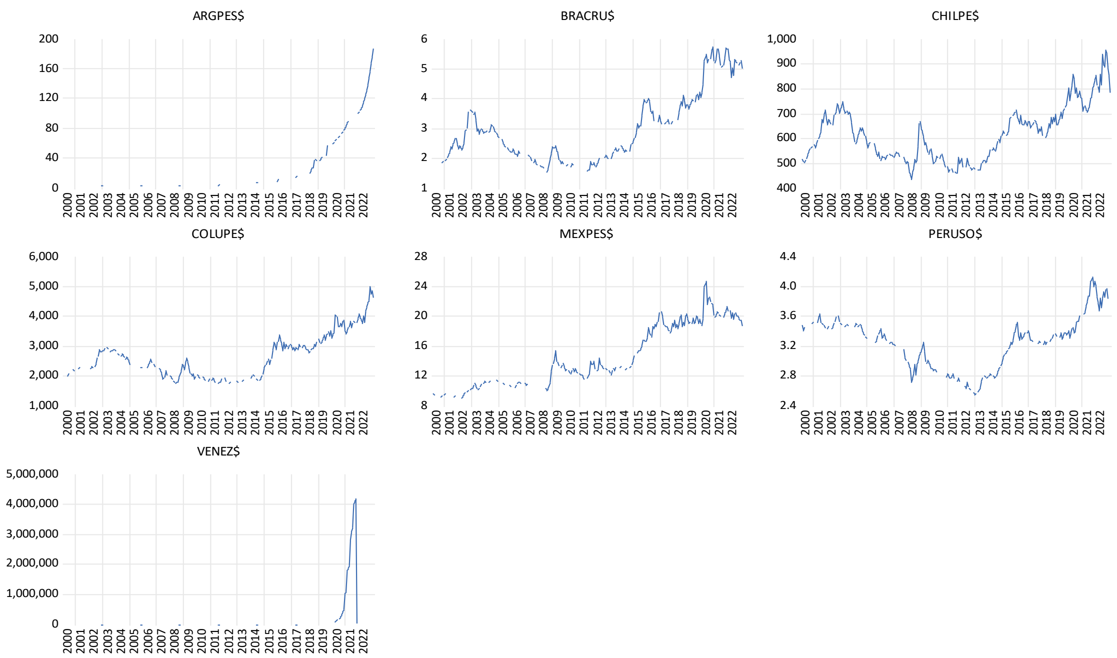


Figure 8: Bilateral exchange rate (Domestic currency, per US$)

Note: Domestic currency necessary to buy 1 US$. Argentina, Brazil, Chile, Colombia, Mexico, Peru, and Venezuela.
Source: Elaborations on Refinitiv-Datastream (2023).

The strengthening of the US dollar appears sharper when looking at the mean value of the fourth quarter (Q4) in 2022 compared to the same quarter in the previous year (see Figure 9). The greenback has gained value against all currencies at the world level, with the following exceptions: it has depreciated against the Russian ruble (by 15.27%), the Mexican peso (5.59%), the Brazilian real (6.78%), and the Peruvian sol (3.45%). The currencies with the highest depreciations against the US dollar were the Ghanaian cedi (110.2%), the Turkish lira (79.54%), the Argentine peso (58.07%), the Venezuelan bolivar (46.28%), and the Egyptian pound (44.79%).

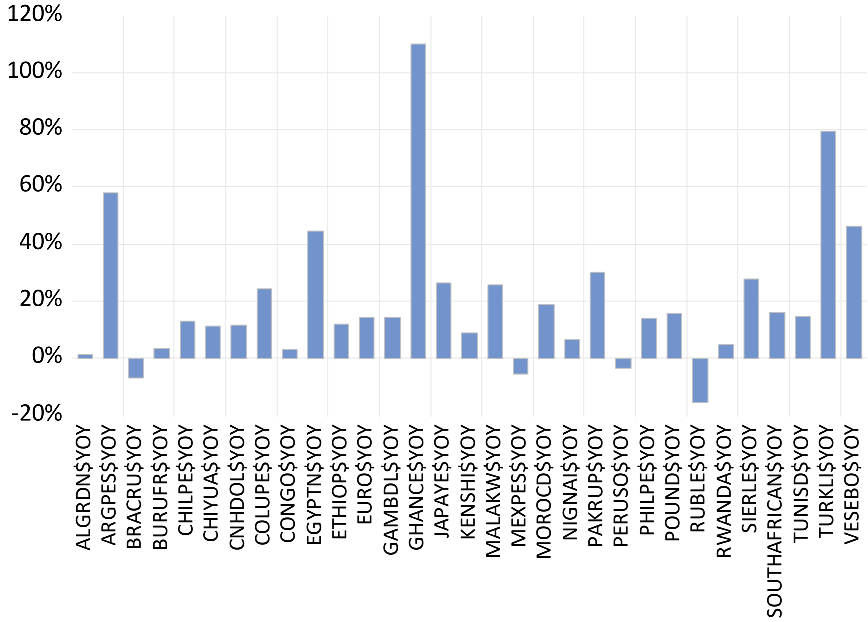


Figure 9: Select exchange rates against the US$ (Q4 2022- Q4 2021 % change)

Note: A value below zero implies a domestic appreciation, and a value above zero signals a domestic depreciation against the US dollar.
Source: Elaborations on Refinitiv-Datastream (2023).

A strong US dollar can generate severe economic problems in the global South. Poorer countries tend to borrow in the US currency and when it appreciates, debts become heftier. Commodity prices are quoted in US dollars and, when the currency strengthens, they become more expensive. Hence, a dollar appreciation tends to boost import prices and makes food imports more expensive—especially for developing countries. Hence, there is an increased risk that millions of people could experience acute food insecurity and hunger. For instance, Egypt imports 86% of its whole wheat and 26% of its maize from Russia and Ukraine, and in 2022, the Egyptian pound went down by 18% compared to 2021. Similarly, the Turkish lira depreciated by 27% against the dollar in 2022 and the country is one of the largest wheat importers in the world.

There are three main sources of the US dollar's appreciation in 2022. First, the food and energy price shocks fueled by the Russian-Ukrainian war produced an improvement in the US terms-of-trade, given the country's status as an energy exporter. Conversely, energy-importing countries, such as Japan and the Eurozone, recorded terms-of-trade deteriorations. This is consistent with the purchasing power parity theory, so price hikes are accompanied by real exchange rate depreciations necessary to restore the external balance (i.e., the equilibrium between exports and imports).

A second source of the US dollar's appreciation has been the different pace of monetary policy tightening at the global level. Fighting inflation can be "complex and simple" at the same time (Lagarde, 2022). It is complex because in periods of high volatility, countries can go through multiple shocks that cause soaring and persistent inflation. It is also simple because the only way to avoid these shocks is to adopt a tighter monetary policy. Otherwise, expansive measures would further fuel inflation expectations. Thus, Central Banks everywhere started raising interest rates in 2022. However, the US Federal Reserve raised interest rates higher and faster than all other Central Banks, except for Brazil and Mexico, both of which began the tightening maneuvers before the US. The ample interest rate differentials have been related to larger depreciations against the US dollar since it became a good target for a "carry trade" (i.e., selling a low-yielding currency to buy a high-yielding dollar and seizing the difference). Put differently, the Federal Reserve increased its interest rates causing an inflow of capital from investors and an appreciation of the US dollar of 24 percent between May 2021 and October 2022.

A third driver of the dollar appreciation has been fear and economic uncertainty due to geopolitical tensions, the Covid-19 health crisis, and the anxiety of a possible global recession that pushed financial operators to invest in US assets perceived as safe investments (the so-called "flight to safety dynamics").

Table 1: Exchange rate arrangements

Currency Board	**Conventional peg**	**Stabilized arrangement**	**Crawl-like arrangement**	**Pegged with horizontal bands**	**Other managed arrangement**	**Floating**	**Free Floating**
Djibouti	Belize, Benin, Burkina Faso, Cameroon, Côte d'Ivoire, Congo Rep, Eritrea, Gabon, Mali, Namibia, Niger, Senegal, Togo	Algeria, Bolivia, Egypt, Gambia, **Lebanon**, Nigeria, Sudan, **Suriname,** Tanzania,	**Argentina**, Burundi, Congo, **Ethiopia, Ghana,** Malawi, Mozambique, Philippines, **Rwanda,** Tunisia (with flexibility toward euro), Zambia	Morocco	Kenya, Liberia, **Sierra Leone**, **Venezuela, Zimbabwe**	Angola, Argentina, Brazil, Colombia, India, Indonesia, **Moldova,** Pakistan, Paraguay, Peru, **Sri Lanka, Turkey**, Uganda, Uruguay	Chile, Japan, Mexico, Russia, Somalia, UK, US, Euro area

Regime Types: ♦ **Hard pegs** ♦ **Soft pegs** ♦ **Floating regime** ♦ **Residual**

Source: Elaborations based on IMF (2023b): Annual Report on Exchange Arrangements and Exchanger Restrictions 2022.

Table 1 sketches the official exchange rate arrangements, as reported by the latest IMF Annual Report. It has been documented that fixed exchange rates are generally associated with low inflation and growth, while flexible exchange rates are related to high inflation and economic growth (Ghosh et al., 1996). Fixed pegs have been considered an anti-inflationary tool because they point to discipline and commitment. When the pegs are credible, they produce a confidence effect that leads to a higher willingness to hold domestic currency, thus reducing

Box 1. Exchange rate regimes and inflation: It is important to underscore the point that each country at the global level has a specific exchange regime. While it is common to reference fixed and floating exchange rates, regimes can assume a range of typologies, from hard and soft pegs to target zones, to free or dirty floats with heavy, light, or no intervention. The fixed-floating dichotomy, in fact, can mask important differences among exchange rate regimes. Regimes can be classified according to the publicly stated commitment of the country's Central Bank, the so-called *de jure* classification, or according to the observed behaviour of the country's exchange rate, the so-called *de facto* classification. The *de jure* classification uses the IMF's *Annual Report on Exchange Arrangements and Exchange Restrictions*, while the *de facto* classification is based on a survey of IMF desk officers for each country.

any inflationary consequence of an eventual money supply expansion. Floating regimes instead tend to increase productivity and raise economic growth. According to the IMF (2022b), countries with pegs have experienced lower inflation than those with flexible exchange rates in 2022. Monthly median inflation averaged 5½ among peggers compared to 9½ among floaters between January and July 2022. It should be noted, however, that countries that have frequent parity changes, while notionally preserving a peg, are not able to grasp all the benefits associated with fixed exchange regimes. Table 1 shows in bold those countries that recorded the highest inflation rates at the world level in 2022 and their official regimes. These countries have officially declared that they adopt soft pegs, other managed arrangements, or floating regimes. However, some—such as Egypt—have changed their arrangements several times.

To scrutinize the relationship between exchange rates and inflation, we initially calculated the correlation point between the exchange rates of a selected group of countries vis-à-vis the US dollar and the national inflation rate based on Consumer Price Index (CPI) for the period 2000:M1-2023:M1 and the subperiod 2019:M1-2023:M1 (see Table 2). Then, we constructed a time-varying correlation (i.e., a trailing correlation with a 5-year rolling window for all OECD countries, the EU group, and selected countries) for the same sample period (2000:M1-2023:M1) (see Figure 11). One benefit of this rolling window correlation is that it makes it possible to visualize the correlation between two series over time. The results, as illustrated in Figure 11, reveal some interesting points. First, the correlation between exchange rate and inflation evolves over time and can assume a positive or negative sign both in developing and advanced countries. Second, the correlation between the two series is positive and has raised significantly during the 2022 price spike, except for Mexico. This indicates that in period of high inflation, the two series tend to show higher co-movements. Third, in 2022, food inflation shows a higher correlation with exchange rates than core, headline and energy inflation. Fourth, correlation for Kenya is the lowest among the considered countries or country-groups.

Table 2: Correlation between bilateral exchange rates with respect to US$ and national inflation

	2000-2023				2019-2023			
	CPI	CPI SA	CPI CORE	CPI CORE SA	CPI	CPI SA	CPI CORE	CPI CORE SA
EU EURO$	0.154	0.156	0.185	0.190	0.754	0.756	0.800	0.804
UK POUND$	0.191	0.190	0.338	0.338	0.546	0.547	0.489	0.486
US DXY$	0.116	0.116	0.349	0.350	0.459	0.462	0.525	0.528
ETHIOPIA	0.605	0.596			0.916	0.920		
EGYPT	0.367	0.367	0.348	0.349	0.858	0.849	0.922	0.917
GHANA	0.636	0.636			0.932	0.932		
GAMBIA	0.691	0.689			0.782	0.777		
KENYA	-0.157	-0.160			0.682	0.673		
NIGERIA	0.553	0.547	0.696	0.699	0.949	0.951	0.967	0.970
CHILE	-0.016	-0.012	0.072	0.073	0.745	0.748	0.737	0.714
TURKEY	0.903	0.904	0.918	0.920	0.940	0.944	0.946	0.951
MEXICO	-0.143	-0.143	-0.172	-0.173	-0.125	-0.128	-0.044	-0.049

Source: Elaborations on Refinitiv-Datastream (2023).

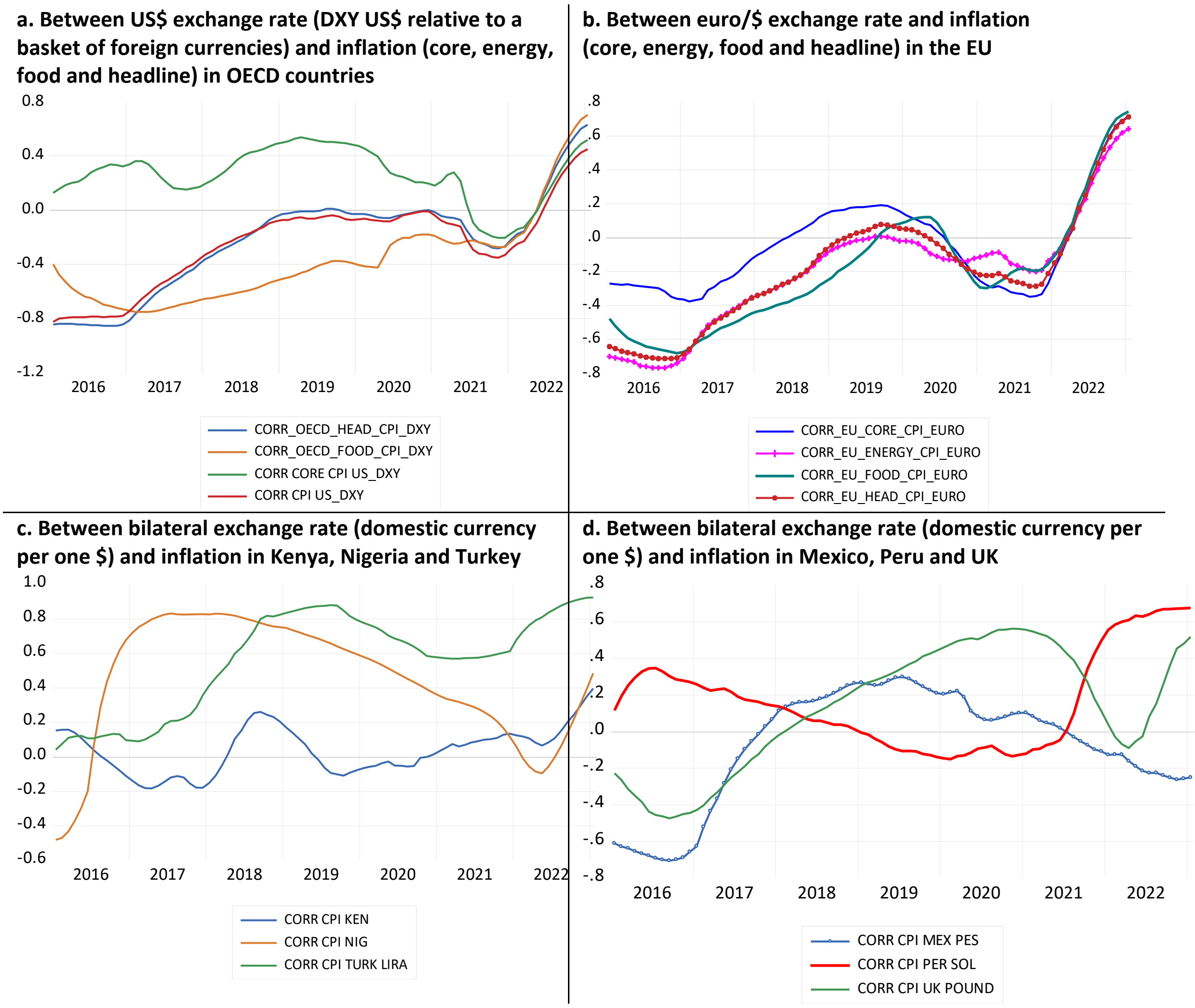


Figure 10: Five-year trailing correlations

Source: Elaborations on Refinitiv-Datastream (2023).

5. Contribution of different inflation drivers to international food price increases

After having scrutinized price dynamics across countries and time, we zoom out our analysis to quantify the impact of the different determinants of food prices at the global level. To do this, we model the monthly FAO food price index as a function of demand, supply, monetary, and climate variables, as well as other shocks from January 2000 to December 2022. For the subsamples involving price crises, this is done from January 2008 to December 2022 and from January 2019 to December 2022.

In particular, as a measure of global demand, we considered the monthly world container index that tracks the freight costs of a 40-foot container via eight major routes to and from the US, Europe, and Asia. The index is a good proxy of global demand at monthly frequency since it presents a high positive correlation (of about 80%) with the world GDP, which is generally considered with quarterly or annual data. An increase in the world container index implies a surge in worldwide demand. With a few exceptions (Carriere-Swallow et al., 2023), increased shipping costs and their role in driving inflation have been overlooked in the academic literature.

To account for the fact that trade in food commodities is made in US$, we have incorporated the nominal US effective exchange rate[8] (i.e., the US$ against a basket of currencies). The US dollar is considered the key—or vehicle—currency at the global level. Because the currency is used in all international transactions and invoicing, its movements affect the global economy through, trade, inflation, and financial conditions. As mentioned, a change in the dollar exchange rate can modify the demand and supply for agricultural commodities and, thus, change their prices.[9]

The multifaceted linkage between the US exchange rate and the FAO food price index can be visualized by examining Figure 11, which also reports the FAO food price index comprising cereals. The graph highlights the world's three major food price spikes registered in the 21st century: the first in 2007-2008, the second in 2010-2012 and the third in 2021-2022. These three food crises are different. During the first two spikes, as food prices surged, the value of

[8] To avoid any endogeneity issues between the exchange rate and the FAO food price index, we have calculated the correlation between the FAO index and the US soft and hard wheat prices and found a correlation above 90%. This renders the US nominal effective exchange rate a proper explanatory variable. We have further ascertained that the weight compositions between the nominal effective exchange rate and the FAO index are entirely different.

[9] An exchange rate appreciation (depreciation) could positively or negatively affect food prices. A dollar depreciation tends to reduce the commodity price in domestic currencies for countries with floating exchange rates, thus increasing commodity demand and, in turn, prices. Conversely, a dollar appreciation makes exports less competitive and decreases the demand for commodities, causing dollar denominated international commodity prices to diminish. The effect is neutral for countries that have a currency pegged to the US$, such as Oman, Saudi Arabia, Eritrea, and Hong Kong.

the US dollar weakened. The depreciation of the US dollar and the accompanying appreciation of other currencies made imports cheaper and facilitated net food-importing by developing countries that could purchase food at a lower price. The current 2021-2022 price spike has been characterized instead by a strong US dollar and significant exchange rate adjustments.

We have further added crude oil prices, since their fluctuations are transmitted to food inflation through production input costs (including processing, transportation, and distribution). Moreover, a surge in oil prices provides an incentive to produce biofuels, which generates pressure on food commodity prices. Therefore, food prices and oil prices are expected to be positively related. We have also inserted fertilizer prices, as they impact on production and thus on food prices. Fertilizer prices could be added since they show a correlation with oil prices below 80%.

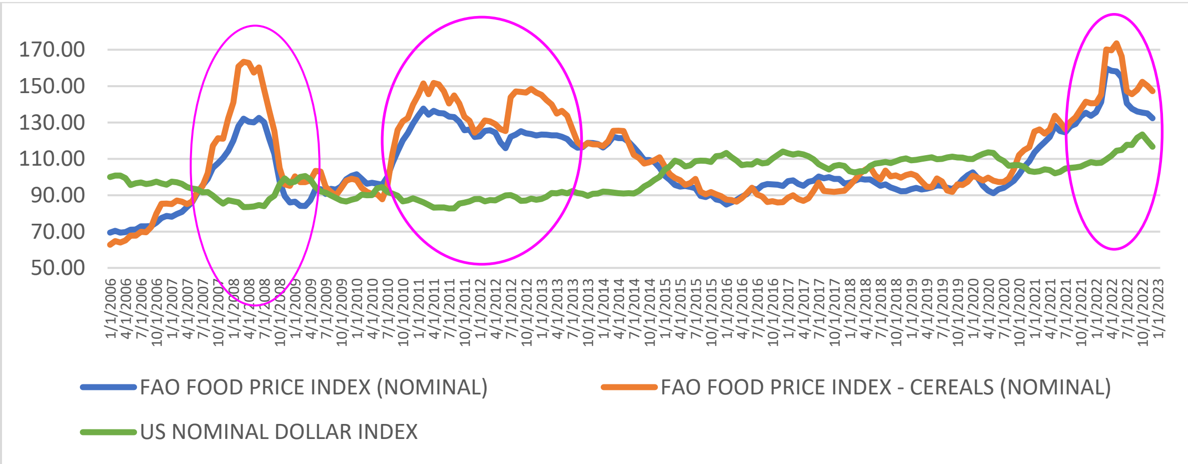


Figure 11: Dynamics of food prices and US dollar exchange rate (January 2006-December 2022)

Source: Elaborations on Refinitiv-Datastream (2023).

To capture the monetary stance, we have included the US monetary aggregate M2 (growth rate of M2 stock), which gives an indication of liquidity in the system. A surge in M2 would suggest a monetary expansion which generates inflation. We have also added the long-term interest rate, measured as market yield on US Treasury securities at a 20-year constant maturity or US Treasury yield, adjusted to constant maturity (20 Years). A treasury's yield is the return an investor expects to receive each year over its term to maturity. Interest rates can influence commodity prices with a positive or negative impact, as explained by Frankel (2006, 2012, 2013). For instance, the prices of storable commodities would rise as interest rates fall because, by decreasing the cost of carrying inventories, lower rates stimulate inventory demand for commodities. Conversely, a rise in interest rates reduces inventory demand since it increases the cost of carrying inventories. This, in turn, lessens commodity prices. Treasury yields could also reflect saving habits, therefore when yields raise, saving increases and consumption decreases with a consequent contraction in prices. Theory suggests that the long-term interest rate has a positive relationship to future inflation expectations (Hardisty, 2006). When investors believe inflation will be high, they require a higher yield to compensate for the loss in the purchasing power of money. Long-term Treasury yields[10] have recorded a declining trend over time from 2000 until the years of the global pandemic, pointing to lower inflation expectations up to the coronavirus outbreak when investors panicked, and global markets were thrown into chaos (Baldridge and Curry, 2023).

Since food commodity markets have registered progressive financialization over time, we have considered a speculation index constructed as the ratio between trading volume and open interests, following Bessembinder and Seguin (1993), Robles et al. (2009), and Algieri et al. (2017). Trading volume captures commodity futures trading within a time frame. Open interests refer to the total number of futures contracts—long (purchased contracts outstanding) or short (sold contracts outstanding)—for the main grain commodities (wheat, maize, and soybean) in a delivery month or market that has been entered into and not yet liquidated by an offsetting transaction or fulfilled by delivery of the commodity. Bessembinder and Seguin (1993) have explained that open interests primarily reflect hedging activity while trading volume mirrors speculative traders. Hence, an index increase would signal an intensification in speculative activities.

We have enhanced the model with weather anomalies measured by the Southern Oscillation Index (SOI). Weather anomalies have an important influence on the world's production and price of agricultural commodities. A rise in SOI, associated with La Niña events,[11] points to increasing droughts throughout the mid-latitudes, where much of wheat, maize and soybeans are produced, thus damaging yields (Iizumi et al. 2014; Algieri, 2016; Brunner, 2002) and driving up prices. For this reason, La Niña episodes have historically been associated with global food crises.

In addition to that, we have accounted for seasonal effects by entering seasonal dummy variables in order to control for their additive effects on prices.[12] The descriptive statistics and the correlation matrix for our considered variables are reported in Table A1 and Table A2 in the technical appendix, respectively.

To investigate if a long-run relationship between the variables of interest and the FAO food price index exists, we use the co-integrating regression analysis. The empirical analysis involved a few steps. First, we have tested the stationarity of our variables adopting the Augmented Dickey-Fuller (ADF) and Phillips and Perron (PP) tests. The results of the tests[13] indicate that all variables have I (1) order of integration (i.e., they are not stationary in level

[10] Another relevant measure is the yield spread: the difference between treasury yields on 10-year and 3-month rates. The higher the yields on 10-year relative to short-term rates, the better the economic outlook. The rise of the yield spread indicates expectations of a strong economy and a greater desire to spend today in order to avoid paying higher prices in the future, which, in turn, drives up the prices of raw materials.
[11] See, for instance, Hodgson, C., Campbell, C. (2022) "Climate graphic of the week: Rare 'triple dip' La Niña threatens more floods and drought." Financial Times. 23 September 2022.
[12] In a few specifications, we have also entered US grain exports to proxy for the world monthly supply of agricultural goods, which is not available on a monthly frequency. The results are available upon request.
[13] Not reported for reasons of space, but available upon request.

and become stationary after their first differences). The only exception is for the weather variable (SOI) that is already stationary in levels. Then, we performed the Trace and Maximum Eigenvalue tests (Table A3) to evaluate the existence of cointegrating relationships among the targeted variables following Johansen and Juselius (1990). The Trace and Maximum Eigenvalue tests indicate that there is one cointegrating (i.e., long-run) relationship, as the null hypotheses of r = 0 against the alternatives r > 0 is rejected at conventional significance levels (Table A3). Therefore, we can proceed with the Engel and Granger two-step procedure (1987) to investigate the dynamic impact of different macro variables on food prices[14].

The long-run equilibrium relation can be expressed as follows, with the methodology and full regression results shown in the technical appendix A1 and Table A4.

$$\ln food\ p = \underset{(0.484)}{2.56} - \underset{(0.099)}{0.198} \ln neer + \underset{(0.025)}{0.123} \ln world\ cont + \underset{(0.020)}{0.179} \ln fertil + \underset{(6.96e-05)}{2.20e-04} \ln m2 +$$

$$- \underset{(0.027)}{0.106} \ln i + \underset{(0.033)}{0.214} \ln spec + \underset{(0.027)}{0.290} \ln oil$$

$T = 276, R^2 = 0.936$
(standard errors in parentheses)

We can say that, in equilibrium, an increase of 1% in crude oil or fertilizer prices will lead to a rise in food prices of about 0.3% and 0.2%, respectively (as long as all other variables are constant). Similarly, an increase in world demand by 1% produces upward pressure on food prices by 0.12%. Speculation also affects food prices with an elasticity of 0.21, implying that financial speculators are overwhelming agricultural commodities markets and fueling global food price inflation, likely resulting in a perverse effect on hunger and food security. This result supports previous analyses by Kornher et al. (2022), Chadwick (2017), von Braun et al. (2014), von Braun (2008), and others. Expansive monetary policies contribute to amplifying food prices, while a 1% appreciation of the dollar or a 1% rise in long-term interest rates determines a contraction of prices by 0.198 and 0.106%, respectively.

The short-run relationship that explains the change in food prices (Δy_t) by the past changes of the explanatory variables (X_t and Z_t) and the correction term, is displayed in Table 3. The findings suggest that demand factors (proxied by the world container index), supply factors (proxied by oil price, fertilizer price), liquidity factors (M2), fiscal stance (spread) and exchange rate have all impacted the short-run food price dynamics. In addition, climate anomalies (SOI) and geopolitical tensions related to the Russia-Ukraine war have reinforced food price fluctuations. The speed of convergence of food prices to equilibrium is 3.48%. Therefore, in the short-run, food prices are adjusted by 3.48% of the past month's deviation from equilibrium. Put differently, it takes about 20 months for food prices to restore half of the

[14] Engle-Granger can be used when there is only one cointegrating vector and when there are two or more covariates. Vector Error Correction Model (VECM) can be used if there are one or more cointegrating vectors.

deviation from the equilibrium after a shock.[15] This slow speed of adjustment of food prices reveals that prices present some stickiness, possibly due to constraints, uncertainty, and inefficiency in the market that produce difficulties for prices to adjust according to the law of demand and supply.

The model is well-specified. The disturbances have no serial correlation, and the stability conditions are satisfied.[16] As a supplementary analysis, we have considered the interest rate spread—calculated as the difference between the Treasury Bond at ten years and the T-bill at three months—and the results are confirmed (see Appendix Table A7).

Table 3: Cointegration analysis: Short-run dynamics

OLS, using observations 2000:06-2022:12 (T = 271)
Dependent variable: DLn FAO food price

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	0.00190584	0.00125323	1.521	0.1295	
$ NEER	−1.05194	0.106721	−9.857	<0.0001	***
Fertilizer index	0.0703543	0.0195177	3.605	0.0004	***
M2 change	3.84804e-05	1.95615e-05	1.967	0.0502	*
Crude oil price	0.0461634	0.0119400	3.866	0.0001	***
SOI index	0.000284943	0.000134382	2.120	0.0349	**
US Treasury yield	−0.0476233	0.0200214	−2.379	0.0181	**
Speculation index	0.0108760	0.00536378	2.028	0.0436	**
Dummy war	0.0402934	0.0104929	3.840	0.0002	***
World container index	0.0656064	0.0202605	3.238	0.0014	***
Speed of adjustment	−0.0348248	0.0176525	−1.973	0.0496	**

Mean dependent var	0.003418	S.D. dependent var	0.026627
Sum squared resid	0.104840	S.E. of regression	0.020158
R-squared	0.450296	Adjusted R-squared	0.426859
F(11, 258)	19.21306	P-value(F)	5.70e-28
Log-likelihood	677.1414	Akaike criterion	−1330.283
Schwarz criterion	−1287.102	Hannan-Quinn	−1312.943
rho	0.301630	Durbin-Watson	1.393113

*Note: All variables are in ln difference, except for M2. * p < 0.1, ** p < 0.05, *** p < 0.01*

We have further estimated the subsample covering the first and second food price crises in the period 2008/01-2012/12 and the subsample 2019/01-2022/12 by embracing the most recent economic, geopolitical and health developments. These results are presented in the Appendix Tables A5 and A6. Table 4 presents the standardized regression coefficients (found by multiplying each regression coefficient by the standard deviation of the associated explanatory variable and dividing it by the standard deviation of the dependent variable) for all the estimations (the entire period 2000-2022 and the subsamples). Because some regression coefficients have different measurement units, a direct comparison is difficult; a

[15] This is based on the formula $T = ln(2)/r$, where T refers to the time needed to achieve half of the initial deviation from equilibrium and r is the adjustment parameter, ln(2)/0.0348=19.9.

[16] For reasons of space, we do not report the results of diagnostic tests, but they are available from the authors upon request.

small coefficient may be more important than a larger one; hence, standardization eliminates the problem of different scales of the original series (Siegel and Wagner, 2022).

Table 4 shows that, in the long run (2000-2022), input costs have contributed the most to increasing world food prices; in particular, crude oil prices and fertilizers have played a major role. Other important drivers have been speculative activities and global demand, followed by US Treasury yields, the monetary stance, and the nominal effective exchange rate. In contrast, in the short run and for the entire sample, the most prominent impact on global food prices is exerted by the exchange rate, followed by input cost, speculation, weather anomalies, global demand, and the Russia-Ukraine war. Analysis of the 2008-2012 and 2019-2022 subsamples reveals that monetary policies and weather anomalies did not have a significant impact on prices during the first two food crises, while all identified drivers turned out to be significantly important during the pandemic period and the war crisis. In addition, the effect of exchange rate dynamics has been more pronounced in 2008-2012 than in 2019-2022, while other factors—in particular speculation, input costs, and weather anomalies—have been more marked in recent years. Finally, differently from the period 2008-2012, the sign of the US Treasury yields (long-term interest rate) carries a positive value in 2019-2022. The reason could be ascribed to the inverted yield curve registered in the last period of the sample. The impact of different shocks on food prices is reported in the Appendix, Figure A1.

Table 4: Standardized regression coefficients

	2000-2022 long-run	2000-2022 short-run	2008-2012	2019-2022
$ NEER	-0.0622**	**-0.502*** **	**-0.5962*** **	-0.3413***
World container	0.1720***	0.098***	0.2320***	0.2448***
Fertilizer	0.2686***	0.172***	0.1270*	0.3605***
M2 change	0.0701***	0.104*	0.0868	**0.5184*****
US Treasury yield	-0.1377***	-0.118**	-0.1775**	0.2029**
Speculation	0.1724***	0.114**	0.1261**	0.2245***
Crude oil price	**0.4743*** **	0.216***	0.2608***	0.4825***
SOI index		0.109**	0.1226	0.2217**
Dummy war		0.049***		0.3214***

*Note: * p < 0.1, ** p < 0.05, *** p < 0.01*

6. Discussion

Inflation is back and is causing a global economic storm. General price increases have squeezed living standards across the world. Food and energy prices have rocketed to new historic highs amid the global pandemic and the Russia-Ukraine war. Troublingly, the mounting surge in international food prices and inflation is posing new challenges in terms of food insecurity, with the most vulnerable economies and people particularly hard hit. In this study, we have first examined the theoretical causes of inflation and which of these factors dominated during the current food price spells. Then, we have explored the main features of inflation development across countries and time. Our analysis reveals that inflation patterns are more intertwined in an integrated world and are more synchronized across borders.

Moreover, inflation has moved from seeming temporarily elevated to being a persistent problem with double-digit figures.

Although the inflationary pressures of 2021-2022 have been driven by a combination of factors—mainly linked to tight supply-demand conditions and the eroding value of national currencies—in each country, these factors impacted inflation dynamics in varying proportions. For instance, inflation in Sub-Saharan Africa and other African countries was mainly driven by elevated global food prices, accompanied by national depreciations. In Western countries, the major drivers of inflation were supply chain disruptions and rises in global commodity prices. Price pressures in Latin America were triggered by expansive monetary policies as a consequence of the pandemic response, wage indexation, and, in some cases, strong aggregate demand. Additionally, several economies experienced a faster and stronger pass-through of external shocks into domestic prices. This means that while in the past, the pass-through of producer prices to final goods for consumers typically took about two years, this time the price transmission was very rapid (about half a year) and, on average, it was more intense than in the past, with some firms even increasing their profit margins.

To get a better understanding of the relative importance of different drivers, we have analyzed international food price dynamics between 2000 and 2022 including the 2008-2011 and the current food crisis empirically. The results of the econometric analysis show that demand factors (proxied by the world container index), supply factors (proxied by oil and fertilizer prices), liquidity factors (M2), fiscal stance (spread), climate drivers, exchange rates, and geopolitical tensions have all impacted the food price dynamics. High oil and fertilizer prices have fueled the costs of food production with reverberations on prices. Our estimates indicate that an increase in oil and fertilizer prices by 1% has led to a rise in global food prices by about 0.22% and 0.17%, respectively. In poorer countries, where farmers use fertilizer more cautiously, its reduced use due to increased prices may further lessen harvests, adversely affecting prices. Ocean freight rates, as measured by the world container index (a measure of shipping costs), have increased world food prices, and their impact has been more pronounced, especially in the post-pandemic period. The findings have also highlighted that geopolitical frictions have exacerbated food prices, and speculative activities in agricultural commodity markets have nonetheless contributed to upward pressure on food inflation. Moreover, loose monetary and fiscal measures weighing on economic activity have fed into higher food prices. Due to climate change, temperature anomalies have adversely affected agricultural production and, hence, prices. The third year of the La Niña weather phenomenon—with its severe droughts in the US, Argentina, and Europe—has elevated prices by 0.22% for a 1% increase in the SOI index.

We also analyzed different periods of food price spells separately. There are some differences between the food crises in 2008-2012 and the recent one. In particular, the impact of energy prices (oil and fertilizers) has been more pronounced in the recent spike. The actions of monetary policy and speculative activities have also been stronger in 2022 compared to 2008-

2012. Instead, the role of the exchange rate has reduced its effect, due to the inverted correlation between price and dollar registered in the 2008-2012 period. Rises in food prices revert very slowly: it takes about 20 months for food prices to restore half of the deviation from the equilibrium after a shock. This slow speed of adjustment of food prices reveals that prices present some stickiness, possibly due to constraints, uncertainty, and inefficiency in the market that produce difficulties for prices to adjust according to the law of demand and supply. As a supplementary analysis, we have considered the interest rate spread calculated as the difference between the T-Bond at ten years and the T-bill at three months and the results are confirmed.

Policy actions are required to tackle the current crisis and help the vulnerable, but this is not an easy task. Without careful calibration, the world economy could face a "hard landing" involving a recession and acute food insecurity. In order to bring about a "soft landing," whereby inflation is curbed without any downturn and food insecurity is not exacerbated, it is essential to remove food export restrictions to guarantee global food provisions. In this direction, multilateral efforts are needed to smoothen geopolitical tensions, prevent fragmentations, and consolidate trade systems to avoid market disruptions. It is relevant to enhance cooperation across nations for stock releases. Countries with significant grain reserves (EU, the U.S., China, India) should release food stocks to counter acute shortages in international food markets and reduce speculative tendencies. Policymakers should remain vigilant and monitor speculative activities in financial markets. Additionally, policymakers must strengthen the financial safety net to build resilience against future shocks and encourage the voluntary withdrawal from speculation in food by banks and other financial institutions. This should become a criterion of sound corporate environmental, social and governance (ESG) behavior.

Since monetary policies have to remain focused on bringing inflation down, fiscal policies should be framed to support only vulnerable households; this is necessary to avoid fiscal actions that move in the opposite direction with respect to monetary policy. To reduce the longer-lasting adverse effects of commodity price hikes, it is also important to ensure strong macro-fiscal institutions that can buffer commodity price volatility. For countries in great trouble, such as Tunisia, Somalia and Egypt, there would be the need for an IMF bail-out. Central banks often focus on the core rate of inflation, it could be useful in exceptional periods of extreme events and geopolitical turmoil to carefully monitor headline inflation and calibrate proper actions. Future research could extend the analysis to Sub-Saharan Africa and specific countries.

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Technical appendix

A1. Engle and Granger methodology

The Engle and Granger test consists in first estimating the "co-integrating regression", i.e. the long-run relationship, using OLS, and then test if the residuals in the estimated equation are stationary. If they are stationary, there is a stationary cointegrating relationship. Formally:

$$ln\, y_t = \alpha_1 + \sum_{j=1}^{n} \beta_j ln\, X_{j,t} + u_t \qquad (1)$$

y_t is the FAO food price index and X_t is a $(nx1)$ vector of all explanatory I(1) variables. In our model *n* is equal to 7, namely:

$$X_t \;= (exchange\ rate_t, world\ container_t, oil\ p_t, fertilizer_t\ , m2_t\ , tresury\ yield_t, speculation_t\ )$$

u_t is the idiosyncratic error term that is assumed to be independently and identically distributed over time.
If there is a linear combination of y_t and X_t that is stationary (that is I(0)), then y_t and X_t are cointegrated. This implies that the estimated residuals are stationary, so that

$$\hat{u}_t = ln\, y_t - \hat{\alpha}_1 - \sum_{j=1}^{n} \hat{\beta}_j ln\, X_{j,t} \quad (2)$$

with

$\hat{\beta}_j =$ is the long-run coefficient

The short-run relationship between y_t and X_t with an error correction specification is expressed as

$$\Delta ln\, y_t = \alpha_2 + \sum_{k=1}^{n} \hat{\gamma}_k \Delta ln\, X_{k,t} + \sum_{p=1}^{q} \hat{\delta}_p\, Z_{p,t} + \pi_1\, \hat{\mu}_{t-1} + \varepsilon_t \qquad (3)$$

where Z_t includes the I(0) variable weather anomaly index and the dummy war, explicitly:

$$Z_t \;= (weather\ anomaly\ index_t, dummy\ Russia\ blockade_t)$$

α_2= constant term
γ_k= short-run coefficients, measure the immediate impact of a change in $X_{k,t}$ will have on a change in y_t
δ_p= short-run coefficients, measure the immediate impact of a change in $Z_{q,t}$ will have on a change in y_t
π_1= coefficient of the estimated lagged residual of equation 1 is the feedback effect, or the adjustment effect, or error correction coefficient and shows how much of the disequilibrium is being corrected.
$\hat{u}_{t-1}$ = error correction term. We use lagged residual because is the error made in the previous period is used to correct the imbalance in the current period of time.
ε_t= white noise error term

Equation 3 can be reorganized as:

$$\Delta ln\, y_t = \alpha_3 + \sum_{k=1}^{n} \hat{\gamma}_k \Delta ln\, X_{k,t} + \sum_{p=1}^{q} \hat{\delta}_p\, Z_{p,t} + \pi_1\, (ln\, y_{t-1} - \hat{\alpha}_1 - \sum_{j=1}^{n} \hat{\beta}_j ln\, X_{j,t-1}) + \varepsilon_t \quad (4)$$

Equation 4 has a nice economic interpretation: y can wander away from its long-run (equilibrium) path in the short-run, but will be pulled back to it by the error correction mechanism over the longer term.

A2. Additional tables and figures of the empirical analysis

Table A1: Descriptive statistics

	FAO food price	$ NEER	World container index	Fertilizer index	M2 change	US Treasury yield	Speculation index	Crude oil price
Mean	4.502	4.716	5.014	4.780	60.033	1.249	1.571	4.068
Median	4.556	4.734	4.932	4.758	42.500	1.330	1.580	4.131
Maximum	5.073	4.914	5.855	5.855	1013.800	1.926	2.221	4.969
Minimum	3.921	4.533	4.006	3.826	-164.400	0.058	0.905	2.922
Std. Dev.	0.305	0.096	0.425	0.458	97.240	0.398	0.246	0.499
Skewness	-0.397	-0.229	0.127	-0.006	5.834	-0.616	-0.043	-0.375
Kurtosis	2.036	1.773	1.947	2.931	50.941	2.850	2.758	2.158
Jarque-Bera	18.012	19.655	13.552	0.057	28097.90	17.778	0.761	14.686
Probability	0.000	0.000	0.001	0.972	0.000	0.000	0.684	0.001
Observations	277	275	277	275	277.000	277	277	277

Note: All variables are in ln, except for M2

Table A2: Correlation matrix, 2000-M01/2022-M12

	FAO food price	$ NEER	World container index	US Treasury yield	Fertilizer index	Crude oil price	Southern oscillation index	Speculation	M2 change
FAO food price	1								
$ NEER	-0.383	1							
World container index	0.575	0.350	1						
US Treasury yield	-0.626	-0.082	-0.764	1					
Fertilizer index	0.798	-0.360	0.311	-0.273	1				
Crude oil price	0.836	-0.645	0.245	-0.330	0.761	1			
Southern oscillation index	0.374	-0.134	0.101	-0.021	0.365	0.290	1		
Speculation index	0.320	0.057	0.335	-0.462	0.161	0.154	-0.102	1	
M2 change	0.128	0.186	0.297	-0.452	-0.047	-0.105	0.020	0.110	1

Table A3: Johansen test

Rank r	Eigenvalue	Trace test	p-value	Lmax test	p-value
0	0.216	173.74	[0.0059]	64.011	[0.0010]
1	0.127	109.73	[0.3081]	35.871	[0.4215]
2	0.095	73.861	[0.5874]	26.373	[0.6841]
3	0.080	47.488	[0.7416]	22.056	[0.6126]

4	0.047	25.432	[0.9030]	12.754	[0.8885]
5	0.034	12.678	[0.9030]	91.630	[0.8166]
6	0.013	35.146	[0.9312]	33.769	[0.9089]
7	0.0005	0.13767	[0.7106]	0.13767	[0.7106]

Number of equations = 8, since we have eight I(1) variables.
Case 3: Unrestricted constant Log-likelihood = 3023.52
(including constant term: 2277.15) The lag order is determined based on the Akaike Information Criterion (AIC). Sample: 2000:01 - 2023:01

Table A4: Cointegrating regression

Cointegrating regression OLS, using observations **2000:01-2022:12** Sample adjusted (T = 276)
Dependent variable: ln FAO food price

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
constant	2.56306	0.483767	5.298	<0.0001	***
$ nominal effective exchange rate (NEER)	−0.198383	0.0995343	−1.993	0.0473	**
World container index	0.123493	0.0246106	5.018	<0.0001	***
Fertilizer index	0.179019	0.0203812	8.784	<0.0001	***
M2 change	0.000220102	6.96205e-05	3.161	0.0018	***
US Treasury yield	−0.105731	0.0266670	−3.965	<0.0001	***
Speculation index	0.214495	0.0337916	6.348	<0.0001	***
Crude oil price	0.290078	0.0273270	10.62	<0.0001	***
S1	−0.0245554	0.0238442	−1.030	0.3041	
S2	−0.0850305	0.0267055	−3.184	0.0016	***
S3	−0.0557721	0.0243270	−2.293	0.0227	**
S4	−0.106873	0.0277813	−3.847	0.0002	***
S5	−0.0520559	0.0244804	−2.126	0.0344	**
S6	−0.134692	0.0299768	−4.493	<0.0001	***
S7	−0.0727181	0.0251764	−2.888	0.0042	***
S8	−0.0978467	0.0265336	−3.688	0.0003	***
S9	−0.0229446	0.0238385	−0.9625	0.3367	
S10	−0.0681697	0.0253232	−2.692	0.0076	***
S11	−0.0754090	0.0265312	−2.842	0.0048	***

Mean dependent var	4.499655	S.D. dependent var	0.304816
Sum squared resid	1.616622	S.E. of regression	0.079467
R-squared	0.936499	Adjusted R-squared	0.932034
F(18, 256)	209.7457	P-value(F)	8.0e-142
Log-likelihood	316.0514	Akaike criterion	−594.1027
Schwarz criterion	−525.3841	Hannan-Quinn	−566.5240
rho	0.828958	Durbin-Watson	0.343584

Note: All variables are in ln, except for M2. S stands for monthly season.

Table A5: Subsample analysis, 2008-2012

OLS, using observations **2008/01-2012/12** (T = 60)
Dependent variable: DLn FAO food price
HAC standard errors, bandwidth 2, Bartlett kernel

	Coefficient	*Std. Error*	*t-ratio*	*p-value*
const	−0.00303108	0.00287977	−1.053	0.2975

Fertilizer index	0.0596942	0.0323339	1.846	0.0707	*
Crude oil price	0.0806153	0.0233212	3.457	0.0011	***
SOI index	0.000440042	0.000327459	1.344	0.1850	
US Treasury yield	−0.101952	0.0413946	−2.463	0.0172	**
Speculation index	0.0179962	0.0100890	1.784	0.0804	*
World container index	0.0953470	0.0210139	4.537	<0.0001	***
$ NEER	−1.44871	0.216479	−6.692	<0.0001	***
M2 change	7.57544e-05	5.69001e-05	1.331	0.1890	

Mean dependent var	0.001191	S.D. dependent var	0.038934
Sum squared resid	0.025655	S.E. of regression	0.022429
R-squared	0.713143	Adjusted R-squared	0.668145
F(8, 51)	20.18139	P-value(F)	2.48e-13
Log-likelihood	147.5843	Akaike criterion	−277.1687
Schwarz criterion	−258.3196	Hannan-Quinn	−269.7958
rho	0.227026	Durbin-Watson	1.533318

Note: All variables are in ln difference, except for M2 and SOI.

Table A6: Subsample analysis, 2019-2022

OLS, using observations **2019/01-2022/12** (T = 48)
Dependent variable: DLn FAO food price
HAC standard errors, bandwidth 2, Bartlett kernel

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	0.00631943	0.00221921	2.848	0.0075	***
Fertilizer index	0.158099	0.0368448	4.291	0.0001	***
M2 change	0.000106046	1.61778e-05	6.555	<0.0001	***
Crude oil price	0.0881774	0.0238531	3.697	0.0008	***
SOI index	0.000752884	0.000344498	2.185	0.0361	**
US Treasury yield	0.0611602	0.0296559	2.062	0.0471	**
Speculation index	0.0222713	0.00616222	3.614	0.0010	***
Dummy war	0.0359552	0.00963732	3.731	0.0007	***
World container index	0.125919	0.0421235	2.989	0.0052	***
$ NEER	−0.820269	0.207420	−3.955	0.0004	***

Mean dependent var	0.008423	S.D. dependent var	0.032232
Sum squared resid	0.011361	S.E. of regression	0.018555
R-squared	0.745674	Adjusted R-squared	0.668605
F(10, 33)	20.63198	P-value(F)	1.96e-11
Log-likelihood	119.3246	Akaike criterion	−216.6493
Schwarz criterion	−197.0232	Hannan-Quinn	−209.3710
rho	−0.199047	Durbin-Watson	2.385245

Note: All variables are in ln difference (D Ln), except for M2 and SOI.

Table A7: Alternative estimation with interest rate spread (difference between 10-years T-bond and 3-months T-bill)

OLS, using observations 2000/01-2022/12 (T = 276)
Dependent variable: L_FAO_FOOD_P_NOM

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	2.02409	0.535599	3.779	0.0002	***
World container index	0.203310	0.0172314	11.80	<0.0001	***
Fertilizer index	0.173015	0.0202880	8.528	<0.0001	***
M2 change	0.000387321	5.53590e-05	6.997	<0.0001	***

Spread 10Y-3M	0.0266377	0.00504160	5.284	<0.0001	***
Speculation index	0.208563	0.0303485	6.872	<0.0001	***
Crude oil price	0.291383	0.0280633	10.38	<0.0001	***
$ NEER	−0.202231	0.105996	−1.908	0.0575	*
S1	−0.0278803	0.0228875	−1.218	0.2243	
S2	−0.0855736	0.0252250	−3.392	0.0008	***
S3	−0.0604866	0.0232629	−2.600	0.0099	***
S4	−0.115888	0.0256905	−4.511	<0.0001	***
S5	−0.0653469	0.0232023	−2.816	0.0052	***
S6	−0.136311	0.0280402	−4.861	<0.0001	***
S7	−0.0715965	0.0241737	−2.962	0.0033	***
S8	−0.0925459	0.0254550	−3.636	0.0003	***
S9	−0.0172432	0.0229670	−0.7508	0.4535	
S10	−0.0602425	0.0244486	−2.464	0.0144	**
S11	−0.0734046	0.0252864	−2.903	0.0040	***

Mean dependent var	4.499655	S.D. dependent var	0.304816
Sum squared resid	1.497662	S.E. of regression	0.076487
R-squared	0.941172	Adjusted R-squared	0.937035
F(18, 256)	227.5355	P-value(F)	4.7e-146
Log-likelihood	326.5609	Akaike criterion	−515.1218
Schwarz criterion	−506.4032	Hannan-Quinn	−517.5431

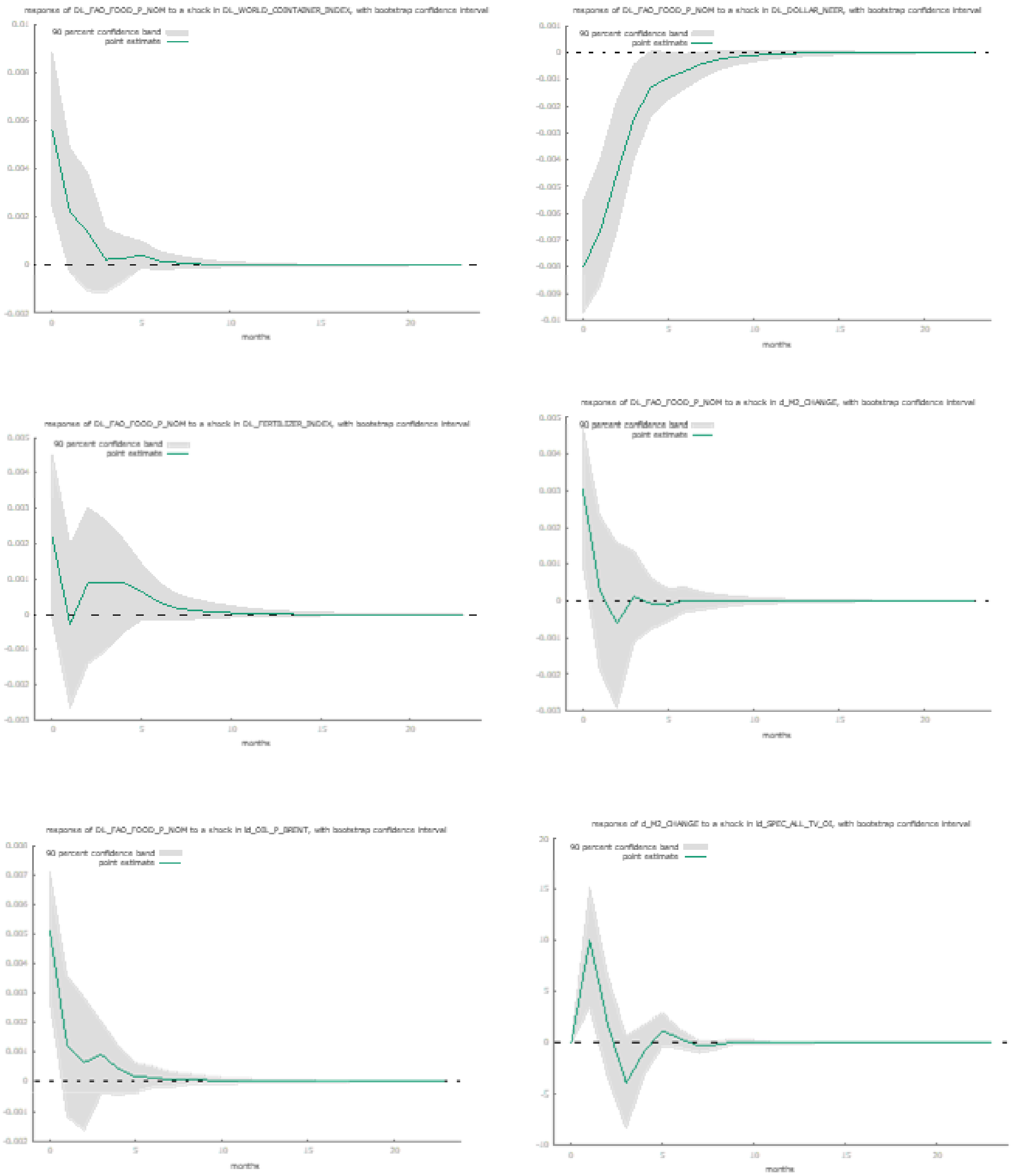
Shot run

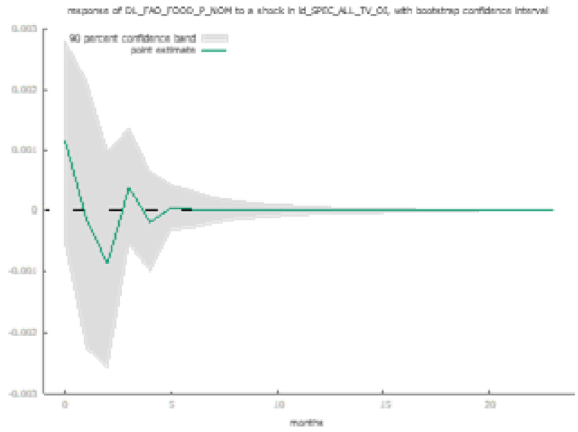
OLS, using observations 2000/02-2022/11 (T = 274)
Dependent variable: DL_FAO_FOOD_P_NOM
HAC standard errors, bandwidth 4, Bartlett kernel

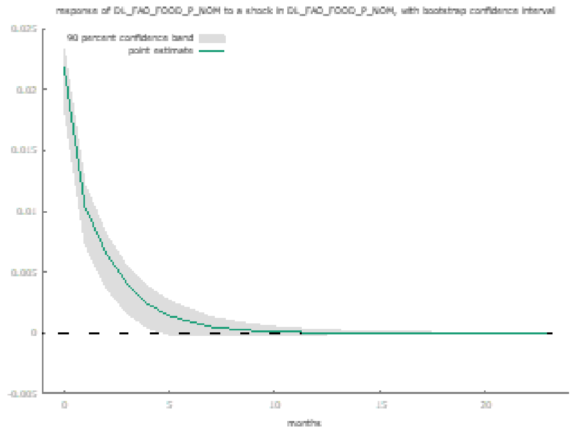
	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	0.00172811	0.00108829	1.588	0.1135	
Fertilizer index	0.0947700	0.0193493	4.898	<0.0001	***
M2 change	0.000159550	2.35415e-05	6.777	<0.0001	***
Crude oil price	0.141163	0.0180667	7.813	<0.0001	***
SOI index	7.42190e-06	0.000146111	0.05080	0.9595	
Speculation index	0.0231482	0.00305721	7.572	<0.0001	***
War	0.0193263	0.00874570	2.210	0.0280	**
World container index	0.0943348	0.0158628	5.947	<0.0001	***
$ NEER	−0.661137	0.0894444	−7.392	<0.0001	***
Spread 10Y-3M	0.0117471	0.00479717	2.449	0.0150	**
Speed of adjustment	−0.366453	0.0442123	−8.288	<0.0001	***

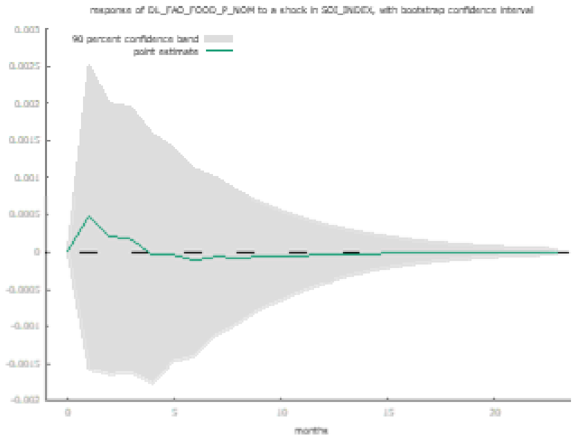
Mean dependent var	0.003437	S.D. dependent var	0.026444
Sum squared resid	0.073297	S.E. of regression	0.016726
R-squared	0.616070	Adjusted R-squared	0.599951
F(11, 262)	28.26294	P-value(F)	1.44e-38
Log-likelihood	738.2235	Akaike criterion	−1152.447
Schwarz criterion	−1109.090	Hannan-Quinn	−1135.044

Figure A1: Different shocks on FAO food prices




response of DL_FAO_FOOD_P_NOM to a shock in ld_SPEC_ALL_TV_OI, with bootstrap confidence interval
90 percent confidence band
point estimate
months


response of DL_FAO_FOOD_P_NOM to a shock in DL_FAO_FOOD_P_NOM, with bootstrap confidence interval
90 percent confidence band
point estimate
months


response of DL_FAO_FOOD_P_NOM to a shock in SDI_INDEX, with bootstrap confidence interval
90 percent confidence band
point estimate
months