Terms of trade shocks, import dependency and debt distress

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Abstract

This paper examines the relationship between terms-of-trade shocks and sovereign debt defaults in import-dependent developing economies. While existing literature highlights a negative relationship between terms-of-trade shocks and defaults for commodity exporters, we find the opposite for commodity importers, where rising import prices can worsen debt distress and increase default risks. We incorporate trade into a sovereign default model to explore this interaction, finding that countries with a high import share are at risk of default when facing rising import prices and deteriorating terms of trade. Additionally, heavily indebted nations risk default even with modest price increases. Our empirical analysis focuses on food as a key terms-of-trade shock, given its limited substitutability with domestic production. Using unexpected harvest shocks as an instrument to isolate food price fluctuations, we focus on Ghana, which defaulted on its external debt in 2022. We find that unexpected food price increases drive up import costs, inflation, trade imbalances, and debt. These results underscore the importance of consumption composition in assessing trade shock impacts.

Keywords: Terms of trade, Sovereign debt default, Commodity price shocks, Debt crisis.
JEL Classification: C32, E21, E23, E31, E32, E43, F34, O11, O19, O55, Q18.

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1 Introduction

Growing concerns are currently being voiced about an imminent debt crisis, particularly in low-income countries, whose debt levels have been increasing over the past decade[2]. As of 2022, the IMF assessed more than half of low-income countries in sub-Saharan Africa to be at high risk of, or already in, debt distress. Zambia became the first African country to default on its sovereign debt in November 2020, following the COVID-19 pandemic. In 2022, both Ghana and Sri Lanka defaulted on their external debt, while Pakistan and Egypt are teetering on the brink of default.[3] In contrast to previous debt crises—such as those of the 1980s, which followed declines in commodity prices—the current crisis has been driven by rising commodity prices, largely due to the COVID-19 pandemic and the war in Ukraine.

This situation is surprising, given the prevailing literature, which shows that rising commodity prices generally improve the fiscal situation of developing countries. This relationship is particularly intuitive for countries that are net exporters of commodities. Drechsel and Tenreyro (2018), for example, demonstrate that for a net commodity exporter, the risk premium depends positively on the debt-to-GDP ratio and negatively on commodity prices. However, this relationship appears to be specific to net exporters. Recent work by Di Pace et al. (2024) demonstrates that terms of trade shocks are not homogeneous, differentiating between import and export price shocks. In this paper, we explore the relationship between terms of trade shocks and sovereign default risk for net-importing countries. For low-income, commodity-dependent net importers, price hikes can be challenging to mitigate, deteriorating the terms of trade and trade balance. This, in turn, adds pressure to repayment capacities, potentially leading to a debt crisis.

To address this issue, we expand upon the foundational work of Arellano (2008) to test the empirically identified mechanisms. Our model focuses on a small open economy where the government allocates consumption between locally produced and imported goods, while also determining how much debt to issue. This allows us to incorporate terms of trade shocks into the model and study how negative shocks affect the probability of default. The model shows that even a slight decline in terms of trade can push heavily indebted nations into a default crisis. We further demonstrate that for highly indebted countries, even small increases in import prices can push them into the default zone. This relationship is influenced by the import share, a proxy for trade openness. The lower the import share, the higher the likelihood of default in response to negative terms of trade shocks. Our analysis also shows that greater openness allows countries to better access financial markets and secure international aid, thereby reducing their default risk. These findings suggest that small, heavily indebted economies with limited openness are particularly vulnerable to terms of trade shocks.

To empirically test this theoretical channel, we focus on food commodity shocks. Many countries currently facing debt distress heavily rely on imported food commodities. In Africa, for instance, numerous nations depend on food imports from countries like Russia and Ukraine.[4]

[2] According to World Bank estimates, by the end of 2020, the total public and publicly guaranteed debt of low-income countries reached approximately $124 billion, representing a substantial increase of around 75% compared to 2010 levels.

[3] To date, Pakistan has successfully secured a preliminary $3 billion funding deal with the International Monetary Fund, aimed at alleviating short-term pressures on its debt situation.

[4] According to the World Bank, as many as 25 African economies import at least one-third of their wheat from these countries, with 15 of them importing more than 50 percent.

Essential commodities such as wheat, rice, maize, and soybeans have low elasticity of substitution and are both primary food sources and intermediate production goods. The recent rise in commodity prices has significantly increased food import bills, particularly in impoverished countries where these commodities play a critical role in their trade balances. For countries already facing debt distress, soaring food prices exert additional pressure, potentially escalating the risk of a food crisis. If debt distress can trigger a food crisis, it is plausible that the surge in food prices has significantly contributed to the current debt landscape.

To isolate the effect of terms of trade on debt distress, we use unexpected harvest shocks as a specific type of terms of trade shock. For example, a crop disease or climate disaster could reduce the quantity of food available, leading to a price increase on the international market. For net-importing countries, this would represent a negative terms of trade shock. In our paper, we build upon the methodologies of De Winne & Peersman (2016) and Peersman (2022) to create an instrumental variable for food price shocks. We identify quarterly unexpected harvest shocks for the four most important food commodities globally: corn, wheat, maize, and soybeans. We use these harvest shocks to identify external food price shocks through a VAR model, updating this methodology with the most comprehensive dataset available. Our analysis focuses on Ghana, a net-importer of these commodities, which defaulted on its external debt in December 2022.

Our results demonstrate how price shocks exacerbated Ghana's economic situation, culminating in its 2022 default. Using the local projection method by Jordà (2005), we estimate impulse response functions (IRFs) for key variables in response to price shocks. The results show that rising commodity prices increased the cost of imports, driving food inflation and, over time, non-food inflation. Since these four commodities also serve as intermediate goods, the effect on non-food prices is more gradual. Overall, inflation rose, primarily due to food inflation, underscoring the independent role of these shocks as inflation drivers. Moreover, the shocks led to a deterioration of Ghana's terms of trade, currency depreciation, and a decline in export earnings. Our investigation also reveals that while price shocks did not significantly impact domestic debt, they contributed to higher external debt and widening interest rate spreads. The rising interest rates indicate Ghana's increased difficulty in repaying its debt, making the evidence consistent with the country's situation in 2022.

In terms of policy implications, our analysis offers a clear framework for understanding the connection between terms of trade shocks and sovereign default in net-importing countries. It underscores the importance of considering the specific structure of consumption goods in assessing a country's vulnerability to shocks and preventing future defaults. Addressing these vulnerabilities is crucial for formulating effective international assistance, especially for highly indebted countries facing food-related emergencies. Future research should focus on the specifics of such assistance, as this extends beyond the scope of our paper.

Literature review. This paper primarily contributes to the literature on sovereign default modeling. Our approach builds on the quantitative models of sovereign default, originating from the influential framework developed by Eaton & Gersovitz (1981), subsequently extended by Aguiar & Gopinath (2006) and Arellano (2008). We extend this framework by incorporating trade, distinguishing aggregate consumption between domestic and imported goods. This enables us to model fluctuations in import prices and terms of trade, both recognized as influential factors in sovereign default, as evidenced by Min (1998) and Cuadra & Sapriza (2006).

Furthermore, existing literature has notably emphasized the significant impact of commodity price fluctuations on a country's probability of default. For instance, in the case of Ecuador, Hatchondo et al. (2007) highlight the critical role of commodity prices in exacerbating macroeconomic conditions, ultimately leading to a sovereign default in 1999. However, most studies have predominantly examined this phenomenon from an export-oriented perspective, as seen in the works of Hilscher & Nosbusch (2010) and Roch (2019). For instance, Drechsel and Tenreyro (2018) use a small open economy model for a net commodity exporter to show that the risk premium depends positively on the debt-to-GDP ratio and negatively on commodity prices. In contrast, our paper shifts focus to the import side, demonstrating that for net commodity importers, the risk premium can depend positively on both the debt-to-GDP ratio and commodity prices. We build on the work of Di Pace et al. (2024), who empirically show that terms of trade shocks are not homogeneous, distinguishing between import and export price shocks. They find that an economy's response to a positive export price shock is not mirrored by its response to a negative import price shock. While they emphasize the greater significance of export price shocks in driving output, we show that import price shocks are more critical in triggering sovereign defaults.

In addition, this paper contributes to the literature on the impacts of world price shocks. Kose (2002) demonstrate that world price shocks significantly drive business cycles in small, open, emerging economies, accounting for approximately 88% of the variations in aggregate output, underscoring their substantial explanatory power. Additionally, studies by Caballero & Panageas (2008) and Calvo et al. (2008) observe that a decline in commodity prices increases the likelihood of sudden stops in capital flows. Building upon this body of research, our empirical analysis focuses specifically on food commodities, that are particularly challenging to substitute, especially for low-income countries. To explore these dynamics, we draw upon the literature on identifying commodity price shocks, as exemplified by the works of De Winne & Peersman (2016) and Peersman (2022).

Finally, Farah-Yacoub et al. (2022) estimate that following a sovereign default, the affected country experiences a persistent deficit in calorie availability. This gap, compared to their synthetic control groups, widens by 4 percentage points a decade after the default occurs, emphasizing how sovereign debt distress can lead to food crises and underscoring the policy significance of this issue, given its potentially enduring consequences.

The remainder of the paper is organized as follows. Section 2 details the framework we use to incorporate trade into a sovereign default model and presents the resulting quantitative analysis. Section 3 describes the construction of the harvest shocks, the estimation methodology, and presents the arguments for using these shocks as an external instrument for terms of trade shocks. Section 4 provides empirical evidence of the mechanisms at hand, using the shocks built before to show that indeed those shocks affect the variables of interest. Finally, Section 5 concludes the paper.

2 Quantitative Analysis

2.1 Environment

Time is discrete and runs forever. There is a benevolent government maximizing utility of the households. It's objective function is given by:

$$\mathrm{E}\sum_{t=0}^{\infty}\beta^t u(C_t) \tag{1}$$

Where C_t aggregates consumption of home C_{Ht} and foreign C_{Ft} goods. We assume constant elasticity of substitution between home and foreign goods. That is:

$$C_t = \left((1-\alpha)^{\frac{1}{\rho}} C_{Ht}^{\frac{\rho-1}{\rho}} + \alpha^{\frac{1}{\rho}} C_{Ft}^{\frac{\rho-1}{\rho}}\right)^{\frac{\rho}{\rho-1}} \tag{2}$$

Intratemporal optimality implies

$$C_{Ht} = (1-\alpha)\left(\frac{P_{Ht}}{P_t}\right)^{-\rho} C_t \tag{3}$$

$$C_{Ft} = \alpha\left(\frac{P_{Ft}}{P_t}\right)^{-\rho} C_t \tag{4}$$

To insure households against shocks, the sovereign can borrow on the world financial market. We assume it can issue bonds in nominal currency, inflation indexed. That is, in period t the sovereign gets $q_{t+1}b_{t+1}p_t$ in exchange for the promise to repay $b_{t+1}p_{t+1}$ next period. We assume inflation-indexed bonds to neutralize the effect of debt dilution and focus on the effect of a change in relative price between home and foreign. In addition, each period the economy receives an endowment y of home good. Hence the government budget constraint is

$$P_{Ht}C_{Ht} + P_{Ft}C_{Ft} + P_{Ht}b_t = P_{Ht}y_t + q_t P_{Ht} b_{t+1} \tag{5}$$

Which is equivalent to

$$C_t = \frac{P_{Ht}}{P_t}\left(y_t + q_t b_{t+1} - b_t\right) \tag{6}$$

That is to say the resources of the government are valued in terms of home prices, relative to total expenditures prices. To make more explicit the role of terms of trade $T_t = \frac{P_{Ht}}{P_{Ft}}$, we can use the definition of the welfare-relevant price index $P_t = \left((1-\alpha)P_{Ht}^{1-\rho} + \alpha P_{Ft}^{1-\rho}\right)^{\frac{1}{1-\rho}}$

$$\frac{P_{Ht}}{P_t} = g(T_t) = \left(\alpha T_t^{\rho-1} + 1 - \alpha\right)^{\frac{1}{\rho-1}} \tag{7}$$

The function $g(T_t)$ encapsulates all the effects of terms of trade on the economy. An improvement of terms of trade raises the value of home resources relative to total expenditures. This has an ambiguous effect on welfare. A deterioration of the terms of trade reduces the consumption value of home endowment. However, if the economy experiences capital outflows, a negative terms of trade shocks reduces the value of debt repayments, which increases welfare.

2.2 Default decisions

Here we assume that the final consumption can be of two types: one when the government does not default and one when the government defaults. We also assume that under the case when the government decides to default, it is excluded from the international credit market and has every period a given probability to regain access to the markets. In addition, in the line of the output loss faced by the government following its default, as modeled by Arellano (2008), we assume that, following its default, the government faces an extra cost in the form of an increase in the price of imports.

Under our terms of trade specification, consumption in each case is characterized by the two following expressions:

- when the government chooses to repay its debt:

$$C_t = g(T_t)(y_t + q_t b_{t+1} - b_t) \tag{8}$$

- when the government chooses to default:

$$C_t^d = g(T_t^d)(y_t + q_t b_{t+1} - b_t) \tag{9}$$

  where $T_t^d \geq T_t$.

The timing of the model is as follows:

1. At the beginning of each period, the government decides whether or not to default on its debt. Let V_t^d denotes the value function when the government chooses to default and V_t^p the value function when the government chooses to repay its debt.
2. Default is optimal whenever $V_t^d > V_t^p$. Every time this condition holds, the government chooses to default and therefore does not pay back its past debt.
3. During the default period, the government is excluded from the international markets and, thus cannot borrow. We also assume that the government faces as another punishment an increase in the price paid for its imports.

The problem is therefore such that the government chooses the optimal policy b_{t+1} to maximize utility. The expected value from the next period onward and the bond prices q_{Ht} will incorporate the fact that the government can choose to default in the future.

The state in this economy is represented by a vector $s = (b_t, T_t)$. Before we proceed, it is important to recall that foreign creditors in this economy have access to the international credit market and are subject to a constant international interest rate denoted as $r^* > 0$. We make the assumption that these creditors are risk neutral and break-even

$$q_t b_{t+1} - \frac{(1-\delta_t)}{1+r^*} b_{t+1} = 0,$$

where δ_t is the probability of default. Notice that when $b_{t+1} \geq 0$, the probability of default is zero since the government is saving. This no arbitrage condition implies that the equilibrium price of a discounted bond is given by:

$$q_t = \frac{(1-\delta_t)}{1+r^*}. \tag{10}$$

The probability of default, δ_t, is endogenous to the model and relies on incentives of the government to repay. The probability of default is a function of both b_{t+1} and T_t, which means that q_t is also a function of those variables. Finally, the gross interest rate is defined as $r_t \equiv 1/q_{Ht} - 1$ and the spread as $r_t - r^*$. With those elements, we can define the recursive competitive equilibrium.

2.3 Recursive competitive equilibrium

Given the state vector $s = (b, T)$, the government's policy functions b', the price functions $q(s)$, and the consumption functions C, we can determine the equilibrium.

Foreign creditors, being risk-neutral and competitive, determine bond prices based on the following condition:

$$q(b', T) = \frac{1-\delta(b', T)}{1+r^*}.$$

Now, let $V^0(b, T)$ be the government's value function at the beginning of the period, with assets b_H and facing terms of trade T. The government decides whether to repay or default to maximize households utility. The value function $V^0(b, T)$ is defined by the following equation:

$$V^0(b, T) = \max_{\{C, b'\}} \{V^p(b, T), V^d(T)\}, \tag{11}$$

where $V^p(b, T)$ represents the value function when repaying, and $V^d(T)$ represents the value function when defaulting. When the government defaults, it enters a state of autarky but has a constant and exogenous chance to regain access to credit markets every period.

The value function of defaulting is given by:

$$V^d(T) = u\Big(g(T^d)y\Big) + \beta \int_{T'} \Big[\theta\ V^0(0, T') + (1-\theta)\ V^d(T')\Big]\ f(T', T)\ dT', \tag{12}$$

where θ is the probability of re-entering the credit market.

On the other hand, when the government has not defaulted, and therefore has repaid its debt, the value function $V^p(b_H, T)$ is given by:

$$V^p(b, T) = \max_{b'} \Big\{u\Big(g(T)(y + q(b', T)b' - b)\Big) + \beta \int_{T'} V^0(b', T')\ f(T', T)\ dT'\Big\}, \tag{13}$$

Therefore, the government chooses b' to maximize utility, with the decision being made period by period. Additionally, to prevent Ponzi schemes, we assume that the government faces a lower bound on debt defined as $b' \geq -z$, not binding in equilibrium.

The policy functions can be characterized by the following sets:

$$A(b) = \{T \in \mathbb{P} : V^p(b, T) \geq V^d(T)\},$$

and

$$D(b) \equiv \tilde{A}(b) = \{T \in \mathbb{P} : V^p(b,T) < V^d(T)\}.$$

where the set $A(b_H)$ represents the optimal set for remaining in the contract, while the set $D(b)$ represents the optimal set for default. Given this information, and denoting the aggregate states of the economy as $s = (b, T)$, we can define a recursive equilibrium as follows:

Definition 1. *The recursive equilibrium for this economy is defined as a set of policy functions for (i) consumption $C(s)$; (ii) government's asset holdings $b'(s)$, repayment sets $A(b)$, and default sets $D(b)$; and (iii) the price function for bonds $q(b', T)$ such that:*
1. Taking as given the government policies, household consumption $C(s)$ satisfies the resource constraint.
2. Taking as given the bond price function $q(b', T)$, the government policy function $b'(s)$, repayment sets $A(b)$, and default sets $D(b)$ satisfy the government optimization problem.
3. Bonds prices $q(b', T)$ reflect the government's default probabilities and are consistent with the creditor's expected zero profits.

Furthermore, default probabilities $\delta(b', T)$ and default sets $D(b')$ are related by the following equation:

$$\delta(b', T) = \int_{D(b'_H)} f(T', T)\, dT'. \tag{14}$$

In other words, when $D(b') = \emptyset$, equilibrium default probabilities are zero because the government does not choose to default for any realization of the import prices when it has assets b'. Similarly, when $D(b') = \mathbb{P}$, default probabilities are equal to one.

The value of remaining in the contract increases with b, while the value of default is independent of b. Assuming bounded support for import price shocks, there exists a level of assets low enough for which $D(b') = \mathbb{P}$. However, since default only occurs when assets are negative, there is a level of b for which the default set is empty.

From equation (14), we can observe that the equilibrium bond price increases with b', indicating that a low discount price for a large loan compensates lenders for the possibility of default. Additionally, bond prices are also dependent on terms of trade shocks.

2.4 Model properties

As discussed earlier, the effect of a terms of trade shock on real consumption, and hence on default incentives is ambiguous. On the one hand, a terms of trade shock acts as an income shock. As made clear by Arellano (2008), this result comes from the concavity of the utility function: a bad income shock increases marginal utility of consumption, and hence makes repayment more costly. On the other hand, a bad terms of trade shock reduces the real value of debt repayment, which decreases default incentives. Yet, with i.i.d. shocks, we can show that under a mild restriction on the concavity of the utility function, the first effect dominates, that is a bad terms of trade shock increases default incentives.

Proposition 1. *Under i.i.d. shocks and CRRA utility with $\sigma > 1$, deteriorated terms of trade increases default incentives. That is, if $T^1 > T^2$ then $T^1 \in D(b) \Rightarrow T^2 \in D(b)$.*

Proof: See appendix A

2.5 Calibration

In the simulations presented below, we employed the Constant Relative Risk Aversion (CRRA) utility function:

$$u(c) = \frac{c^{1-\sigma}}{1-\sigma},$$

where $\sigma = 2$. The risk-free interest rate is set at 1%, which corresponds to the quarterly yield of the US 5-year bond.

We set the probability of re-entry on international markets that is equal to 0.1 which gives an average autarky duration of 4 years.

We assume an AR(1) process for the terms of trade, in logs.

$$\log T_{t+1} = \xi \log T_t + \varepsilon_t,$$

where $E[\varepsilon] = 0$ and $E[\varepsilon^2] = \eta_p^2$. We use the estimates of Schmitt-Grohé & Uribe (2018) for Ghana, $\xi = 0.17$, $\eta_p = 0.09$. We discretized the shock into a 60-state Markov process, employing the method developed by Tauchen & Hussey (1991).

The parameter α is estimated to be around 0.22 and represents the average import share of commodities relative to the total consumption of commodities for Ghana in quantity, based on annual FAO informations regarding production, exports and imports of these four commodities, from 2008 to 2021.

Following Arellano (2008), the punishment is in the following form:

$$T^d = \min(T, \phi)$$

This implies that if the government is already facing bad terms of trade, there is no extra punishment associated to default. As a baseline, we calibrate $\phi = 0.7$.

Overall, the parameters of the model are represented in the table below:

Table 1: Model Parameters.

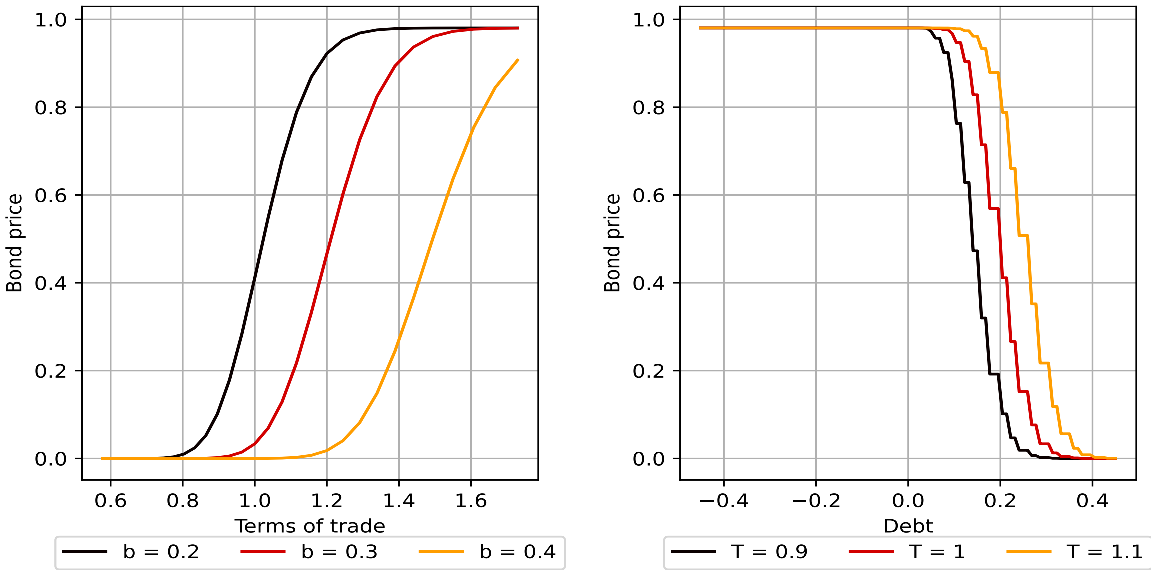
Parameter	**Value**
Risk-free interest rate	$r = 1\%$
Risk aversion	$\sigma = 2$
Stochastic structure	$\xi = 0.17$, $\eta_p = 0.09$
Discount factor	$\beta = 0.96$
Probability of reentry	$\theta = 0.085$
Elasticity of substitution among domestic and foreign goods	$\rho = 2$
Import share	$\alpha = 0.22$
Terms of trade in default	$\phi = 0.7$

By using the parameters as defined in Table 1, we simulate the model and we obtain the following results for the competitive recursive equilibrium. The algorithm to solve the model is discussed in the Appendix C.

2.6 Quantitative results

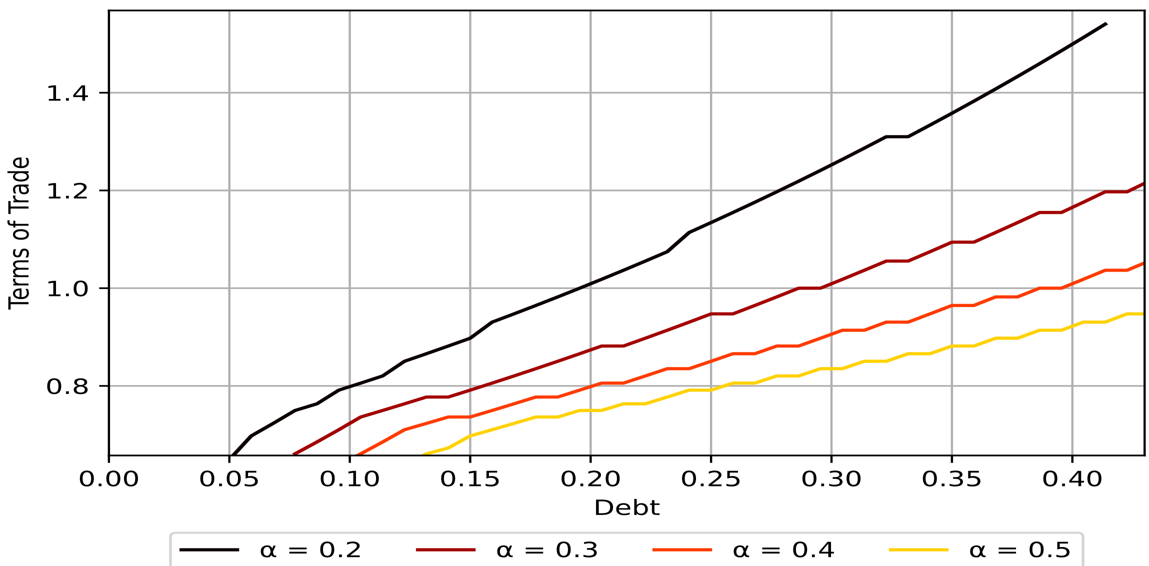
Figure 1 shows the equilibrium price of debt obtained with the quantitative model. It confirms the result obtained with i.i.d. shocks, that is, worse terms of trade increase default incentives. To establish the sensitivity of this result to the trade conditions of the country, figure 2 shows the default frontier, for different values of α, the weight of foreign good in consumption. The more the country relies on the foreign good, the smaller the default set.

Figure 1: Bond price schedule



Note: This figure shows the bond price schedule of the baseline model against terms of trade (left) panel and debt (right panel).

Figure 2: Default frontier



Note: This figure shows the default frontier, for different values of α. Values in the south-east quadrant corresponds to the default set.

Overall, the model demonstrates that the structure of the consumption basket, particularly the import share, plays a crucial role in the relationship between terms of trade and sovereign default. In the next section, we aim to strengthen our results by verifying whether the theoretical channels identified are reflected empirically. To isolate the relationship between terms of trade and debt—both of which are influenced by the business cycle—we focus on the specific case of food. For low-income net importers, a negative terms of trade shock, characterized by rising food prices, can be particularly challenging, as these goods are difficult to substitute through domestic production due to constraints such as land and climate.

3 Supply shocks

In this section, we aim to explore the mechanisms linking terms of trade to sovereign default in net-importer countries, as well as the associated transmission channels. To achieve this, we must isolate terms of trade shocks—specifically, exogenous changes in import prices—from business cycle fluctuations, which could influence the probability of default and repayment capacity. Measuring the impact of terms of trade shocks separately from business cycles is essential for studying this relationship. Given the empirical challenges, we focus on a specific type of terms of trade shock where careful econometric analysis can be conducted: food commodities, specifically rice, maize, soybeans, and wheat. Due to the time lag between planting and harvesting, we can isolate unexpected harvest shocks, which result in a decrease in the quantity of food available in the market and likely lead to an increase in international prices for these commodities. We consider these four commodities together because they are somewhat substitutable; however, their prices tend to move in tandem, and they are not easily substituted with other cereals, as they are staples in the diets of many low-income countries. Thus, for low-income net importers of food commodities, an increase in international food prices—characterized by a significant surge in food commodity prices—will be treated as a negative terms of trade shock. This approach allows us to study the effects of unexpected harvest shocks on various aggregate variables, helping us identify potential transmission channels to sovereign debt.

In the following sections, we will first explain how we construct a measure for exogenous variations in international food commodity prices. Subsequently, we will use this instrumental variable to estimate the impact of an increase in import prices on some selected variables for Ghana. We chose to focus on Ghana because the country defaulted on its external debt in December 2022 and has a high import share. This is particularly true for food, where it is a net importer, including the four aggregated food commodities analyzed. Some additional elements regarding the economic situation of Ghana can be found in Appendix B.

3.1 Construction

To identify exogenous variations in international food commodity prices, we elaborate on De Winne & Peersman (2016) and Peersman (2022) to construct an instrumental variable. Since the instrument's validity relies on satisfying the exogeneity condition, as explain previously, we adopt the approach of De Winne & Peersman (2016).

This involves first constructing a quarterly global food production index, aligning with the annual production cycle and planting and harvesting schedules for specific crop-country pairs. Despite the possibility of commodity prices swiftly reacting to macroeconomic shocks, there remains a delay of at least one quarter between the decision to produce, through planting, and the actual production following the harvest. Consequently, macroeconomic shocks cannot immediately impact harvest volumes; instead, such volumes are influenced only by exogenous shocks to the economy, like unanticipated weather conditions or crop diseases.

More precisely, the procedure starts by using the annual production data for each of four commodities - corn, maize, wheat and soybeans - for 191 countries over the period 1960-2022 that are published by the FAO. For each commodity, the production is converted into edible calories according to an updated version of the conversion parameters estimated by Roberts & Schlenker

(2013). They estimate for each commodity the conversion parameters to go from bushel to pound and from pound to calorie, then rescale the caloric conversion ratios so the average price in 1961-2010 of all four crops equals that of maize. We use the same method, only updated in order to rescale the caloric conversion ratios so the average price in 1961-2022 based on monthly data of all four crops equals that of maize. By multiplying the two conversion coefficients and dividing by the price rescaler, we derive a conversion factor for each individual commodity, facilitating the transition from bushels to calories. Given that our data is denominated in tons, an additional converter is employed to facilitate the shift from tons to calories.

We therefore build on the crop calendar for each country and each of the specified crop developed by De Winne & Peersman (2016) where they are able to determine a specific quarter to which allocate the country's annual production for this specific crop. More details on the determination of the quarter for each pair of crop and country can be found in their paper. We update their calendar according to the "AMIS - GEOGLAM Crop Calendar" that provides an up-to-date calendar for some selecting leading producers for each of the four crops.[5] In addition, compared the crop calendar by De Winne & Peersman (2016), this calendar distingues two categories: "harvest (peak)" and "harvest". De Winne & Peersman (2016) restricts their sample according to some assumptions. Indeed, if a single harvesting season is spread over two subsequent quarters, they allocate the production volume to the first quarter. In addition, if part of the planting and harvesting seasons overlap at the quarterly frequency or if there is more than one harvesting period, or because the crops are harvested almost uniformly throughout the year, they exclude the country's production of their index. We depart from those assumptions and choose to spread the production equally according to all the months labeled as part of the harvesting period, and then aggregate at the quarterly level to have a that reflect how many months in the quarter are labeled as part of the harvesting period. For the countries where the subtility between "harvest (peak)" and "harvest" is available, we consider that a "harvest" month has half of the weight of a "harvest (peak)" month. Overall, this enables to have for each pair of crop and country, a quarterly production quantified in edible calories. The quarterly production data are then aggregated across crops and countries to give a global quarterly production series and converted into an index which takes as reference 2016. Following De Winne & Peersman (2016), we seasonally adjust our index using the U.S. Census Bureau's X-13ARIMA-SEATS seasonal adjustment program. In Peersman (2022), the author focused on the effect of fluctuations in international food prices on euro-area inflation dynamics and therefore, do not include the harvests of European countries in the index. In our case, as Ghana can be considered as a small open economy among the 191 countries and is not considered as a leading producer for any of the selected crops, we do not consider necessary to exclude Ghana from our index computation, as it is unlikely that specific shocks applying only to Ghana would impact the world commodity production and prices. Overall, our quarterly global food production index is represented in Figure 3.

[5] https://www.amis-outlook.org/fileadmin/user_upload/amis/docs/Crop_Calendar/AMIS_Crop_Calendar.pdf

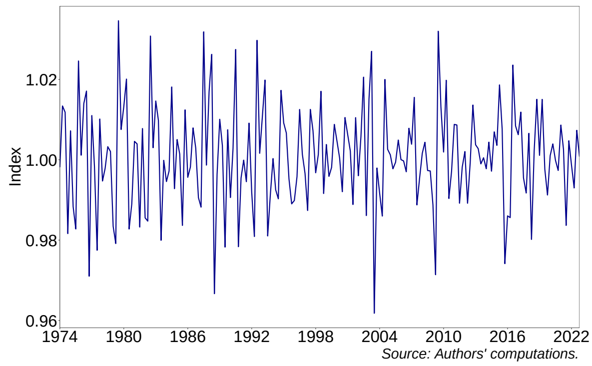


Figure 3: Quarterly global food production index.

In addition, we also follow De Winne & Peersman (2016) and Peersman (2022), and construct a cereal price index based on prices of our four selected commodities: wheat, corn, rice and soybeans. Once again, we use the FAO annual production data for each of the four commodities. This data is aggregated among countries for each specific commodity and year, from 1960 to 2022. For each commodity, we compute the trend production volumes by applying a Hodrick-Prescott filter to annual production data, with smoothing parameter of 100. We then compute the crop's proportion of the annual global production, thereby obtaining the appropriate weight for price calculations. Extending this methodology to each crop, we duplicate the annual global production data for every quarter within a year. This dataset is then merged with quarterly price data for each crop, spanning from 1960 to 2022, sourced from the World Bank Commodity Price Data (The Pink Sheet). For every quarter of each year and for each crop, the share is multiplied by the corresponding quarterly price. Subsequently, the weighted prices are averaged among crops for each quarter of each year. We finally apply seasonal adjustment to the averaged data using the U.S. Census Bureau's X-13ARIMA-SEATS program. Overall, our quarterly cereal price index is represented in Figure 4.

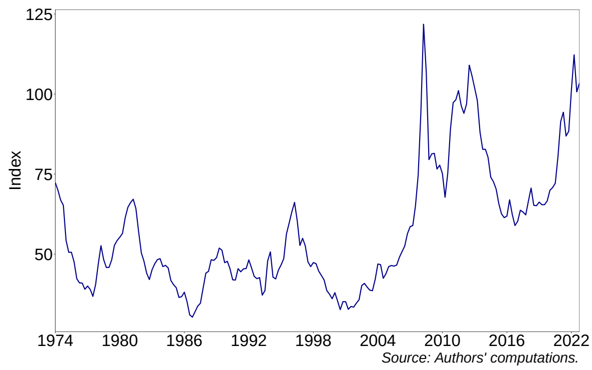


Figure 4: Quarterly cereal price index.

3.2 Estimation

The series of instrumental variables is obtained through the estimation of the subsequent supply shocks equation:

$$y_t = \beta_0 + \beta_1 t + \beta_2 \Psi_t + \sum_{i=1}^{p} \lambda_{i,x} X_{t-i} + \sum_{i=1}^{p} \gamma_i y_{t-i} + \xi_t, \tag{15}$$

where Ψ_t is a vector of the Multivariate El Niño/Southern Oscillation index (MEI), the Oceanic Niño Index (ONI) collected from the National Oceanic and Atmospheric Administration (NOAA) and a dummy variable based on the US National Oceanic and Atmospheric Administration (NOAA) definition of El Niño, and should control for the global weather phenomena.

X_t is a vector of control variables that could have a lagged influence on global food production. It includes the Industrial Production Total Index of the Board of Governors of the Federal Reserve System (US) in order to account for current economic activity, the MSCI World Equity Price Index collected from Refinitiv Eikon, and the G-20 value of the OECD Composite Leading Indicator to account for expected economic activity. These data are available quarterly from 1960 to 2022. In addition, it includes the real crude oil prices from 1974 to 2022, and global oil production from 1973 to 2022, both collected from the U.S. Energy Information Administration. Both the crude oil prices and the global oil production are seasonally adjusted using the U.S. Census Bureau's X-13ARIMA-SEATS seasonal adjustment program. As some variables are potentially based on nominal elements, we also include the US personal consumption expenditures implicit price deflator index collected from the U.S. Bureau of Economic Analysis from 1960 to 2022. Finally, it includes the cereal price index previously explained and the IMF global price of Food index, where those value represents the benchmark prices (period averages in nominal U.S. dollars) which are representative of the global market and are determined by the largest exporter of a given commodity. This includes prices regarding cereals, vegetable oils, meat, seafood, sugar, bananas, and oranges. The IMF Global Price of Food index is also seasonally adjusted using the U.S. Census Bureau's X-13ARIMA-SEATS seasonal adjustment program. Finally the sum represents the lag operator, where we use $p = 6$ in the estimation.

The estimation of this equation is conducted on a quarterly basis from 1974 to 2022, which represents the most extensive dataset available for all the relevant series. Presuming that the information available to local farmers is not more comprehensive than what's encompassed by equation 15, the residuals ξ_t can be interpreted as a sequence of unexpected harvest shocks, that we will refer as supply shocks. These shocks can then serve as an external instrument to identify exogenous shocks in international food commodity prices. The corresponding data is depicted in Figure 5.

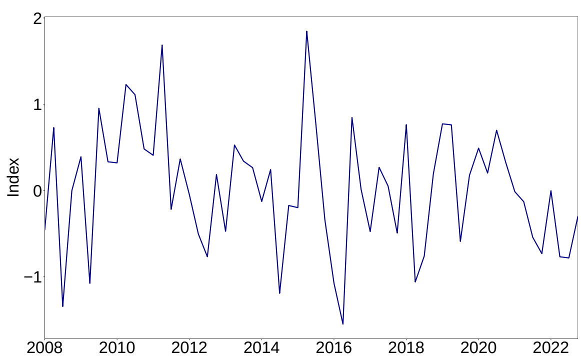


Figure 5: Supply shock.

4 Empirical Evidence

This section presents empirical evidence that serves three main purposes: (i) supporting the upcoming model's predictions, (ii) validating certain aspects of the model's mechanisms, and (iii) emphasizing the pivotal role of our instrumental variable, ξ_t. This variable function as an external instrument to identify shocks in international food commodity prices.

By employing this variable as a shock, we can effectively determine whether there exists empirical support for the notion that food crises can trigger adverse economic conditions leading to debt distress. To accomplish this, we exploit the fact that the information available to producers is no greater than that in equation (15). Consequently, the residuals ξ_t can be treated as a sequence of unforeseen harvest shocks. These shocks then serve as an external instrument, aiding in the identification of shocks in the international food commodity prices.

The use of this instrument is essential. Without it, one could say that countries can anticipate shifts in commodity prices and take measures to hedge against the associated risks. In such a scenario, the link between food crises and debt distress would not be as straightforward. Our approach, therefore, centers on scrutinizing the impact of unanticipated supply shocks on a country's economic and financial conditions, particularly in terms of defaults.[6]

4.1 Commodity prices transmission mechanisms

First, we begin by estimating harvest shocks in the data following the procedure described in equation (15). We then utilize these harvest shocks as an external instrument to price shocks. Once this data is obtained, we analyze its impact on the variables of interest. To quantitatively assess this impact, we estimate the following model:

$$y_{t+h} = \beta_0^h + \beta_1^h \varepsilon_t^p + controls_t + \varepsilon_{t+h}, \tag{16}$$

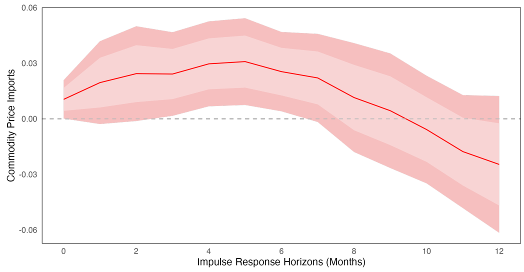
where y_t represents the variable under investigation for which we wish to study the effect of the price shock, ε_t^p denotes the commodity price shock, and ε_t is the residual. In this expression, $controls_t \equiv \sum_{i=1}^{p} \beta_{i,x}^h X_{t-i} + \gamma_1^h trend_t$, where X_t represents a vector of control variables, and $trend_t$ denotes the time trend. The null hypothesis is $\beta_1^h = 0$, and $\beta_1^h \neq 0$ indicates that a negative harvest shock, understood here as a negative supply shock that will lead to a positive price shock, renders supply shocks as having an effect in the variable under consideration. The specific vector of control variables will be discussed for each case we present subsequently. We include four lags ($p = 4$) of control variables.

In order to accurately estimate equation (16) and investigate whether price shocks affect the variables of interest, it is imperative to have an exogenous measure of price shocks to causally analyze their effects. This justifies our reliance on the points outlined in Section 3.1, ensuring that these shocks are plausibly uncorrelated with other macroeconomic shocks, which fulfills the required exogeneity condition.

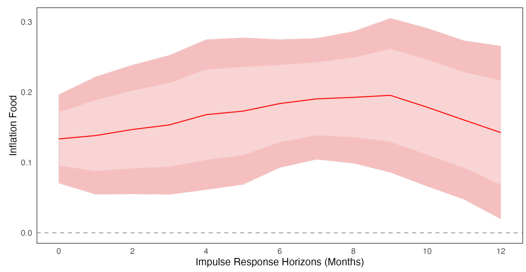
[6]For example, in light of recent events like the Ukraine-War, many analysts were unable to predict their occurrence. Within our model, these events are considered unanticipated shocks. This underlines our focus on understanding the effects of such shocks on a country's economic dynamics, particularly in the context of defaults. For a recent study using the war as an unanticipated event see Afunts et al. (2023).

To estimate the Impulse Response Functions (IRFs) presented next, we utilize the local projection methodology proposed by Jordà (2005). To account for potential cointegration between the variables, the model in equation (16) is estimated in levels, adhering to the recommendations of Sims et al. (1990). An advantage of this approach is its ability to delve into the transmission mechanism in greater detail, particularly the pass-through effect onto the variables of interest.

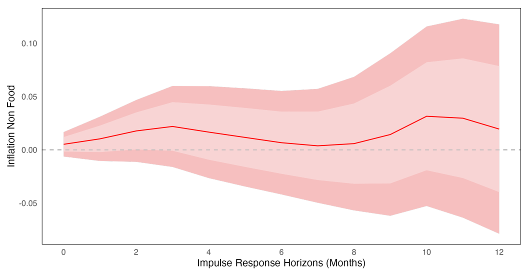
Figure 6 illustrates the outcomes derived from estimating model (16) for each value of $h = 0, 1, ..., 12$, considering a one-unit escalation in price shocks. The figure also includes the 68% and 90% confidence intervals, which are constructed using Newey-West standard errors.



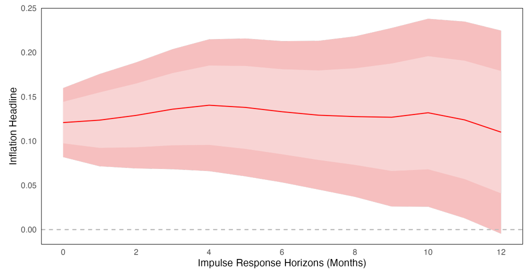
(a) Commodity Price Imports.



(b) Inflation Food.



(c) Inflation Non Food.



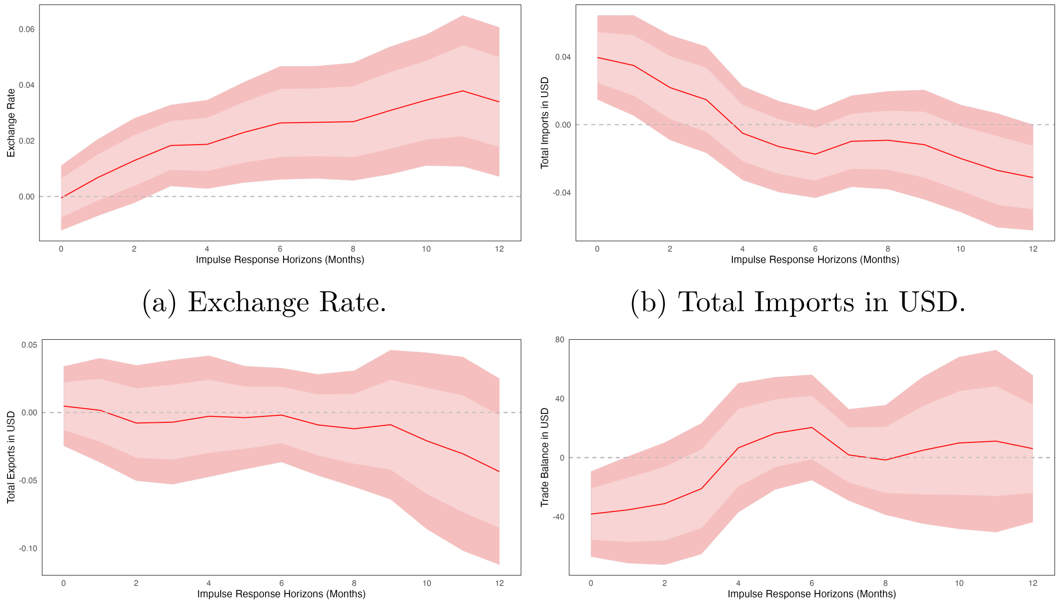
(d) Inflation Headline.

Figure 6: Impact of a Positive Shock in International Food Commodity Prices.

Note: This figure illustrates the Impulse Response Functions (IRFs) of selected prices and inflation following an unforeseen positive supply shock, characterized as an unanticipated increase in commodity prices on the international market. In particular, panel (a) displays $\hat{\beta}_1^h$, estimated from the model: $y_{t+h} = \beta_0^h + \beta_1^h \varepsilon_t^p + controls_t + \varepsilon_{t+h}$. Here, y_t represents the logarithm of Commodity Price Imports, and the control vector X_t encompasses the logarithm of Total Imports in USD, the logarithm of FX Debt Value (the exchange rate), and the lag of the logarithm of Commodity Price Imports. Panel (b) exhibits the estimated $\hat{\beta}_1^h$ from the model specified in equation (16), where y_t is the logarithm of Consumer Price Index (CPI) for Food, and the control vector X_t includes the logarithm of Total Imports in USD and the logarithm of FX Debt Value (the exchange rate). Panel (c) showcases the estimated $\hat{\beta}_1^h$ resulting from estimating the model in equation (16), with y_t representing the logarithm of Consumer Price Index (CPI) for Non-Food items. The control vector X_t encompasses the logarithm of Total Imports in USD and the logarithm of FX Debt Value (the exchange rate). Lastly, panel (d) presents the estimated $\hat{\beta}_1^h$ derived from estimating the model in equation (16), where y_t denotes the logarithm of Headline Consumer Price Index (CPI). The control vector X_t includes the logarithm of Total Imports in USD and the logarithm of FX Debt Value (the exchange rate). The lightly shaded region corresponds to a 68% confidence interval, while the more prominently shaded area indicates the 90% confidence interval. Both intervals are constructed employing Newey-West Standard Errors.

Figure 6 conveys a crucial message: the null hypothesis that price shocks do not influence internal prices in Ghana can be dismissed across multiple time horizons, particularly in the initial months. Notably, the food commodity price shock triggers a progressive and statistically significant surge in commodity price imports. Examining panel (a), we discern that a unit increase in the price shock results in an approximately 3% increase in the commodity price of imports index after 5 months. This impact endures for about six months before losing its statistical significance, underscoring the temporal and diminishing nature of the shock's effect. Panels (b) and (c) illuminate the impacts on Inflation for Food items and Inflation for Non Food items. As anticipated, given the nature of the shock, the transmission to Food Inflation is immediate and persists over the long run, slightly increasing with each passing month. A nearly 20% increase in food inflation emerges after ten months. However, the shock does not appear to result to non-food inflation, as there is no significant effect on the Inflation Non Food. Lastly, Headline Inflation appears to be predominantly influenced by Food Inflation, as it exhibits a similar reaction following the shock, albeit at a comparable magnitude. This observation underscores the significance of these commodities within Ghana's consumption basket. It is worth noting that for the Core and Headline Inflation, a one-unit increase in the price shock continues to have effects even after several months. This persistent influence underscores the lasting nature of the price impact, suggesting the likely presence of indirect consequences stemming from fluctuations in international food commodity prices on the Consumer Price Index (CPI). Overall, these findings demonstrate the discernible influence of international food commodity prices on retail prices.

Moving forward, our analysis delves into the ramifications of the supply shock on Ghana's Terms of Trade.



(a) Exchange Rate.

(b) Total Imports in USD.

(c) Total Exports in USD.

(d) Trade Balance in USD.

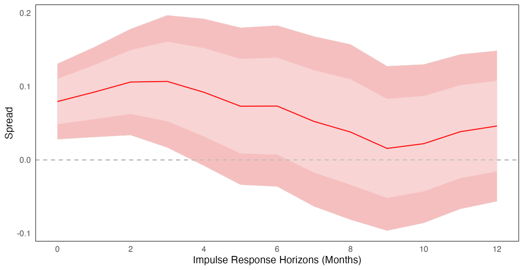
Figure 7: Impact of a Positive Shock in International Food Commodity Prices.

Note: This figure presents Impulse Response Functions (IRFs) reflecting the impact of a positive supply shock on international trade conditions. Panel (a) showcases the estimated $\hat{\beta}_1^h$ derived from estimating the model in equation (16), where y_t is the logarithm of FX Debt Value (the exchange rate). The control vector X_t includes the logarithm of Inflation Food and the logarithm of Total Debt in USD. In panel (b), the estimated $\hat{\beta}_1^h$ is depicted from the model outlined in equation (16), with y_t indicating the logarithm of Import Prices. Here, the control vector X_t includes the logarithm of Inflation Food and the logarithm of Total Debt in USD. In panel (c), $\hat{\beta}_1^h$ is shown, obtained through estimating the model described by equation (16), with y_t representing the logarithm of Export Prices. The control vector X_t encompasses the logarithm of Inflation Food and the logarithm of Total Debt in USD. Finally, panel (d) displays the estimated $\hat{\beta}_1^h$ resulting from estimating the model in equation (16), where y_t denotes the Trade Balance in USD dollars. The control vector X_t encompasses the logarithm of Inflation Food and the logarithm of External Debt in USD. The light shaded area corresponds to a 68% confidence interval, while the darker shaded area indicates the 90% confidence interval, both constructed using Newey-West Standard Errors.

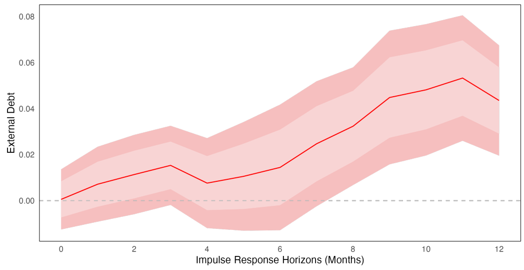
Analyzing Figure 7 brings forth several key insights. First, as a one-unit increase in the price shock increases the price of commodity imports, it implies a decrease in the Ghanaian terms of trade. This leads to a devaluation of the currency, here against the dollar, depicted in panel (a). It appears to be a one-month lag in the USD-GHS exchange rate increase compared to the initial shock, and it rises over time. Panel (b) unveils a significant result: the price shock triggers a substantial increase in the Total Imports in USD, which includes all the country imports. This effect is immediate and gradually decreases over time. This underscores that a price shock in the food sector promptly compels the country to augment its spending on imports at the moment of the shock, before being able to partly switch suppliers and contracts. Considering our focus on food products and their limited substitutability, it becomes clear that an immediate replacement of these items is not feasible, coupled with a depreciation of the currency which makes all imports more expensive. On the opposite, panel (c) shows that the Total Exports in USD dollars does not appear affected by the shock. This result appears particularly interesting as a depreciation of the currency could boost Ghana's exports. In addition, if Ghana's exports of commodities played a significant role in its overall export portfolio, then the price increase could potentially lead to an export boost. Overall, as the response of total exports in USD is unsignificant, this highlights Ghana's status as a net importer of commodities. Finally, panel (d) demonstrates that the trade balance worsens on impact and quickly adjusted back after the shock. Overall, those results underscores Ghana's vulnerability as a net importer of commodities, particularly during periods of surging food prices.

Our central proposition, as we delve into subsequent model development, centers on the cumulative impact of deteriorating trade balance coupled with the low elasticity of substitution inherent in food markets. Our central assumption in the model is that a benevolent government in face of this reality drives the trajectory toward increase public debt, since the increase in prices of goods with low elasticity of substitution as food, will lead to a benevolent government to increase public debt to compensate the adverse economic conditions.[7] The subsequent analysis studies the consequences of those shocks to debt and interest rate spreads and it seems to corroborate to the main assumption used in the modeling part developed in Section 2.

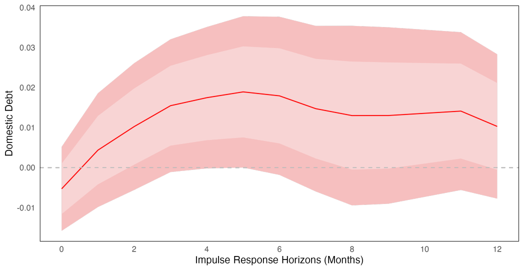
[7]Here, we identify two contributing mechanisms driving increased public debt. Primarily, currency depreciation heightens debt service value. Secondarily, given the low elasticity of substitution in food, a benevolent government might augment debt to counterbalance the adverse international conditions. Those assumptions are crucial in the model development presented in Section 2.



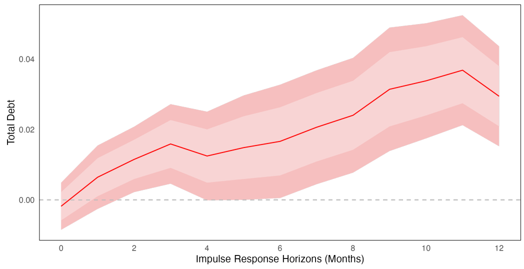
(a) Spread.



(b) External Debt in USD.



(c) Domestic Debt in USD.



(d) Total Debt in USD.

Figure 8: Impact of a Positive Shock in International Food Commodity Prices.

Note: This figure presents the Impulse Response Functions (IRFs) that depict the behavior of debt and spread in response to a positive supply shock. Specifically, in panel (a), we illustrate $\hat{\beta}_1^h$, derived from estimating the model as described in equation (16). Here, y_t represents the logarithm of Spread, and the control vector X_t includes the logarithm of Total Debt in USD and Inflation Food. Panel (b) displays the estimated $\hat{\beta}_1^h$ obtained from the model outlined in equation (16), where y_t refers to the logarithm of External Debt in USD. In this context, the control vector X_t comprises the logarithm of Total Debt in USD and Inflation Food. Moreover, panel (c) depicts the estimated $\hat{\beta}_1^h$ resulting from estimating the model as described in equation (16), with y_t refers to the logarithm of Domestic Debt in USD. In this context, the control vector X_t comprises the logarithm of Total Debt in USD and Inflation Food. Lastly, panel (d) shows the estimated $\hat{\beta}_1^h$ obtained from estimating the model in equation (16), where y_t is the logarithm of Total Debt in USD. The control vector X_t includes the logarithm of Total Debt in USD and Inflation Food. The lighter shaded region corresponds to a 68% confidence interval, while the darker shaded area indicates the 90% confidence interval. Both intervals are constructed using Newey-West Standard Errors.

First, following an unexpected price shock, the spread, which is the difference on debt interest rate between the US and Ghanaian's bonds, increases. This reflects a loss in market confidence in the government's debt repayment capacity. This could be due on impact to the deteriorating international trade position but potentially later on by the depreciation of the currency, which implies that the burden of interest on debt held in foreign currency increases. This could explain why, while domestic debt remains relatively unaffected by food price shocks, external debt exhibits a distinct response. The effect reaches a peak of 20% after 2 months and then gradually decreases. In panel (b), we observe that an increase in the price shock corresponds to a rise in Ghana's external debt. This effect appears with a significant delay, after 2 quarters (6 months), and then increases gradually. The delay and the shape in the response could be explained by the gradual rollover of the current external debt, as low-income country usually borrow on international market at low duration. Furthermore, in panel (c) of Figure 8, we observe a lack of evidence to reject a null effect across initial horizons regarding an effect on the domestic debt. Finally, panel (d) demonstrates an increase in the total debt in USD, driven by the external debt increases. Overall, this suggests Ghana's reliance on international debt markets to support its financial position is substantial. As the spread remains high and the country rollovers its debt, this further increases the cost of external debt. In conclusion, as these interconnected factors mutually reinforce each other, it could potentially lead to a sovereign default similar to Ghana's experience at the end of 2022.

In Appendix D, we conduct the same analysis using quarterly data, revealing that the overall effects closely resemble those highlighted earlier.

In Appendix E, we employ an Oil Supply News Shocks model developed by Känzig (2021) to investigate whether the results presented here may be attributed to the influence of oil shocks. Our analysis reveals no evidence supporting the notion that oil shocks are driving the observed outcomes, as there is no significant effect on the external debt.

Furthermore, in Appendix F, we repeat this investigation using Monetary Policy Shocks, as detailed in the paper by Choi et al. (2022). Once more, we do not find any evidence indicating that this is the underlying mechanism responsible for the observed results. While an increase in the external debt can be seen on impact, the effect fades after one month, compared to our results where this effect is significant and persistent over the long-run.

Overall, we use these empirical findings to support the modeling developed in the previous section, and as shown, they align with the predictions of our quantitative model. We view these empirical results as a valuable complement to the theoretical framework presented earlier.

5 Concluding remarks

The conjunction of the COVID-19 crisis, the conflict in Ukraine, and surging global commodity prices has severely impacted the world's poorest countries. A significant number of nations have found themselves in debt distress, with some opting to default in recent years. Unlike previous debt crises, the current situation arises from soaring commodity prices, disproportionately affecting import-dependent economies. This is surprising given the established literature linking rising commodity prices to positive outcomes for emerging markets, particularly net-exporters. In this context, it becomes clear that an increase in commodity prices should be viewed not as a positive terms of trade shock, but rather as a negative one for these countries.

To further explore how the distinction between being an importer or exporter affects the relationship between terms of trade and sovereign default, we develop a sovereign default model within a small open economy framework that incorporates trade dynamics. A benevolent government in a commodity-importing country must decide how to allocate consumption between domestic and imported goods while determining the level of debt to issue. The relationship between domestic and imported goods is influenced by the import share. Our model yields two main results: (i) import-dependent countries with low debt levels can default when confronted with significant negative terms of trade shocks; and (ii) highly indebted countries can be pushed into the default zone even by small decreases in terms of trade, which correspond for example to minor increases in import prices. These outcomes particularly hinge on the import share, serving as a proxy for trade openness, and predominantly impact nations with substantial debt and limited openness.

To empirically test our results, we utilize unexpected harvest shocks as a specific terms of trade shock. This shock is particularly detrimental for net-importing countries, as it leads to price increases in the international market, thereby easing the debt constraints of net-exporters. We emphasize the necessity of examining shifts in terms of trade separately from global economic cycles to identify their direct effects on debt-related issues. In this regard, we focus on food commodities and employ the concept of harvest shocks, which are crucial for understanding the impacts of food crises. Such shocks involve unexpected variations in food commodity supply and are essential for comprehending how terms of trade prices affect the economic conditions of net-importing countries.

Applying this methodology to Ghana, which defaulted in 2022, we find three key results: (i) when commodity prices rise unexpectedly, there is an increase in the cost of imports and overall inflation; (ii) price shocks elevate import costs and, due to currency depreciation, diminish Ghana's export earnings; and (iii) while price shocks do not significantly affect domestic debt, they do lead to increased external debt and wider interest rate spreads. This last finding indicates Ghana's heavy reliance on international markets, with higher interest rates suggesting a growing likelihood of difficulty in debt repayment.

In terms of policy implications, our approach sheds light on the heterogeneity characterizing the relationship between terms of trade shocks and debt crises. It highlights the need to monitor both the export and import sides to provide effective assistance to countries and mitigate the risk of sovereign default, particularly for nations that are net-importers of food commodities, as debt crises can be triggered by food-related emergencies. For highly indebted countries facing food crises, international assistance emerges as a critical avenue for relief.

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Appendix

A Proofs

A.1 Proof of Proposition 1

Take $T^1 > T^2$ and $T^1 \in D(b)$. Assuming i.i.d. shocks, we have $q(T,b) = q(b)$ and $\mathrm{E}[v(T',b)|T] = \mathrm{E}[v(T',b)]$, so $T^1 \in D(b)$ writes as:

$$u\left(g(T^1)y\right) + \beta \mathrm{E}v^d(T') > u\left(g(T^1)(y + q(b_1)b_1 - b)\right) + \beta \mathrm{E}v^o(T', b_1) \tag{17}$$

Then $T^2 \in D(B)$ if and only if

$$\begin{aligned} u\left(g(T^1)(y + q(b_1)b_1 - b)\right) + \beta \mathrm{E}v^o(T', b_1) - u\left(g(T^2)(y + q(b_2)b_2 - b)\right) - \beta \mathrm{E}v^o(T', b_2) \\ > u\left(g(T^1)y\right) + \beta \mathrm{E}v^d(T') - u\left(g(T^2)y\right) - \beta \mathrm{E}v^d(T') \end{aligned} \tag{18}$$

Utility maximization implies that

$$u\left(g(T^1)(y + q(b_1)b_1 - b)\right) + \beta \mathrm{E}v^o(T', b_1) > u\left(g(T^1)(y + q(b_2)b_2 - b)\right) + \beta \mathrm{E}v^o(T', b_2) \tag{19}$$

So if

$$u\left(g(T^1)(y + q(b_2)b_2 - b)\right) - u\left(g(T^2)(y + q(b_2)b_2 - b)\right) > u\left(g(T^1)y\right) - u\left(g(T^2)y\right) \tag{20}$$

Then the inequality (18) holds true. Using the CRRA functional form we have, and assuming $\sigma > 1$ we obtain

$$g(T^1)^{1-\sigma}\left((y + q(b_2)b_2 - b)^{1-\sigma} - y^{1-\sigma}\right) < g(T^2)^{1-\sigma}\left((y + q(b_2)b_2 - b)^{1-\sigma} - y^{1-\sigma}\right) \tag{21}$$

Since $T^1 \in D(b) \Rightarrow q(b')b' - b < 0 \ \forall b'$, we can simplify to

$$\left(\frac{g(T^1)}{g(T^2)}\right)^{1-\sigma} < 1 \Longleftrightarrow g(T^1) > g(T^2) \tag{22}$$

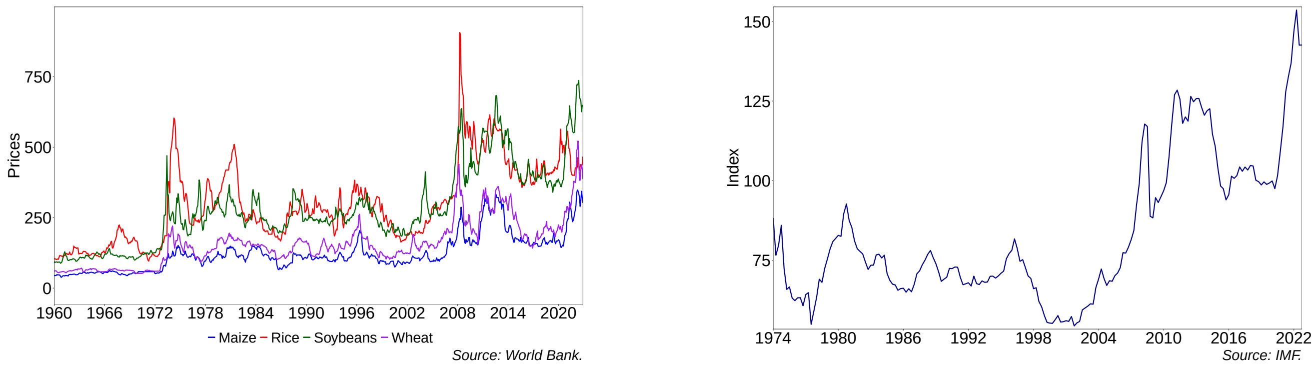
Which is true since $g(.)$ is an increasing function. Hence, the inequalities (18) holds true.

B Motivation facts

Ghana defaulted on its external debt in December 2022, following a series of events, as depreciation of its currency, which lost more than 50% of its value from January to October 2022. This subsequent event led to an increase in the debt burden of around \$6bn.[8] Some general observations we can do about Ghana's economy that make it a good laboratory for the present paper are as follows:

[8] After the default the Ghana goal is to reduce its external debt repayment of \$20bn by half to secure a loan deal from the IMF to be able to restructure its debt.

Observation 1: Increase in the commodity prices. Amidst the economic vulnerabilities inflicted by the COVID-19 crisis, particularly impacting low-income and emerging nations, the beginning of the Ukraine-Russia war in February 2022 introduced new challenges for these countries. The war was associated by an overall and unprecedented rise of commodity prices, as shown in Figure 9b. When we narrow our focus to four specific commodities - rice, maize, wheat and soybeans - we can see that the prices reached in 2022 are among the highest observed since 1960 - Figure 9a.

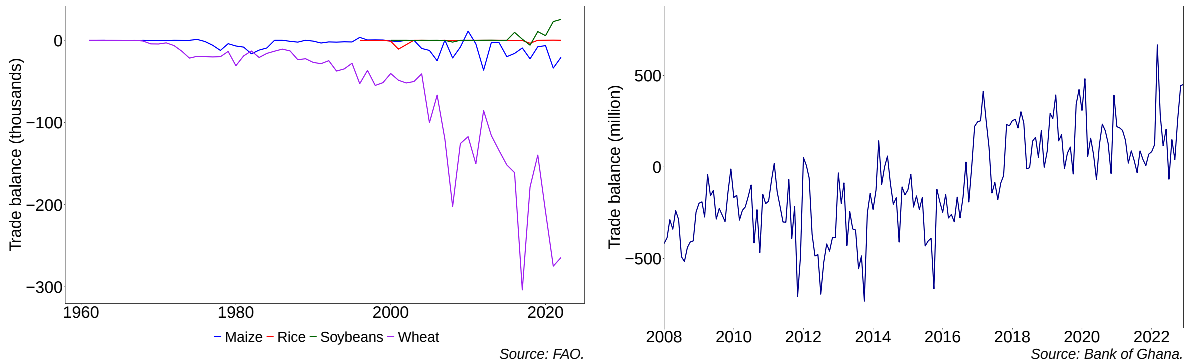


(a) Prices of four selected commodities.

(b) Global price of Food Index.

Figure 9: Evolution of Prices and Global Food Price Index.

Observation 2: Ghana is a net-importer of commodities. For countries that are net-importers of those commodities, and given the low elasticity of substitution regarding those goods, such an increase can have massive economic consequences. Over the past few decades, Ghana has consistently been a net importer of at least three out of the four specified commodities. Over the four commodities, Ghana was a net-importer until 2011, and once again in 2018. Since 2015, out of the four commodities, it has experienced a positive trade balance only in some years regarding soybeans. This is the case even though there has been a positive change in its trade balance in recent years, as illustrated in the accompanying Figure 10.

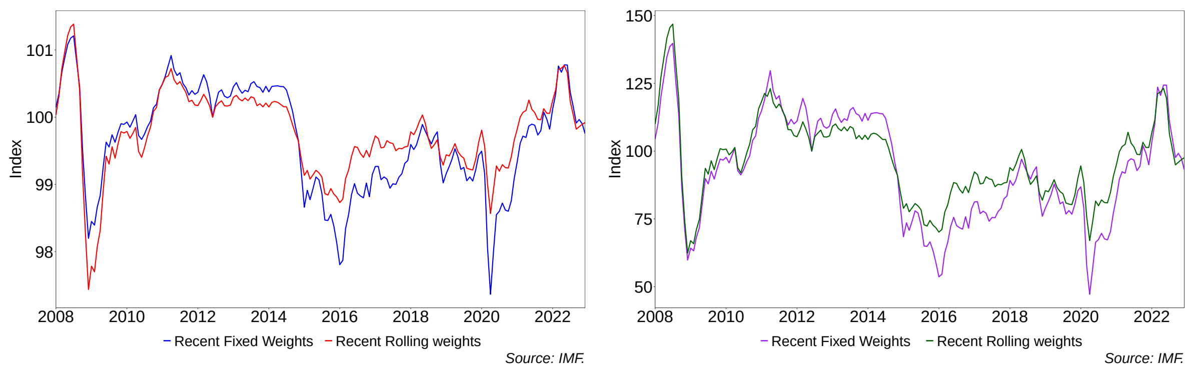


(a) For selected commodities.

(b) Overall.

Figure 10: Ghana's trade balance (USD).

Given its trade situation and the increase in commodity prices, Ghana's import terms of trade increased in 2022, as captured by the commodity import price index of individual commodities shown in Figure 11.



(a) Individual commodities weighted by ratio of imports to GDP.

(b) Individual commodities weighted by ratio of imports to total commodity.

Figure 11: Comparison of commodity import price index.

Observation 3: Surge in inflation. In a historic turn of events, Ghana experienced its first instance of debt default in December 2022. Our analysis suggests that the substantial surge in commodity prices, along with its repercussions on Ghana's economy, could provide partial insight into the factors that led the country to a state of sovereign default by year's end. Indeed, an increase in import prices for a net-importer first translates into an increase of inflation, especially to food items when it comes to commodity prices. Certainly, in 2022, Ghana experienced a remarkable and unprecedented rise in its overall inflation rate, as shown in Figure 12. Notably, this trend was most pronounced in the food sector, where prices surged by over 60%. As import price increases, the country theoretically try to decrease its import. However, when it comes to food and commodities, the elasticity of substitution is usually low, as the market is concentrated among a small number of exporters and prices are determined on international markets.

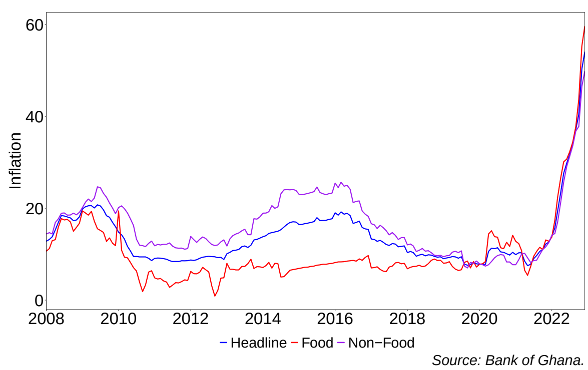


Figure 12: Ghana's year-on-year inflation.

Observation 4: Depreciation of the currency. As import price increases, the trade balance in value of the country deteriorates. It also implies that the country's currency depreciates. This effect appears to be even stronger in a context of gradual increase in Fed's interest rate since February 2022 due the worldwide increase in inflation. This makes the dollar more attractive, especially in periods of high uncertainty, which accentuates the safe-haven property of the dollar. Consequently, Ghana's currency, the Ghanaian cedi, has experienced depreciation against the dollar throughout 2022, as depicted in Figure 13.

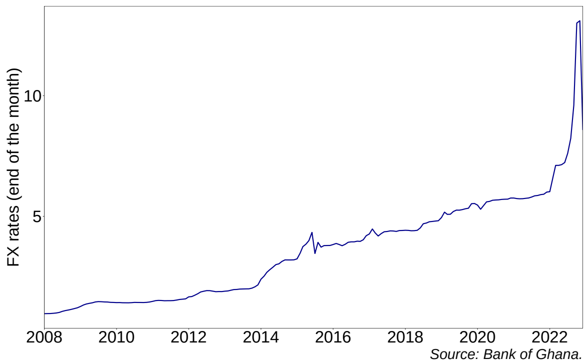
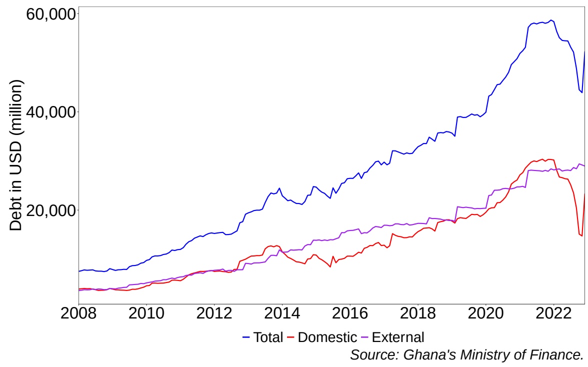
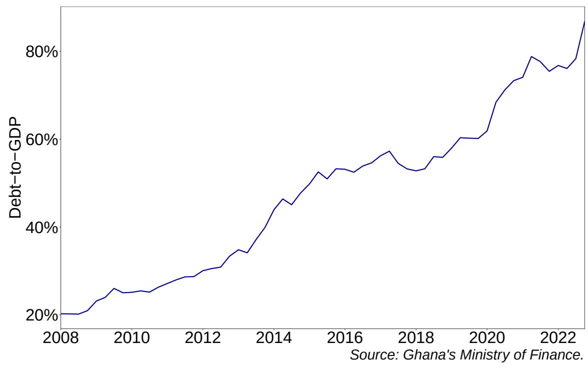


Figure 13: Exchange rate against the dollar (end of the month).

Observation 5: Increase in public debt. For Ghana, a depreciation of its currency also implies an increase of the service of its debt, as almost half of the debt is denominated in dollar, as shown in Figure 14.



(a) Ghana's public debt (USD millions).



(b) Ghana's debt (in percent of GDP).

Figure 14: Ghana's debt.

Observation 6: Increase in spread. As a consequence, there is an increase in the interest rates faced by Ghana on its debt as it raises some concern regarding the government's ability to repay the debt in the future, as shown in Figure 15.

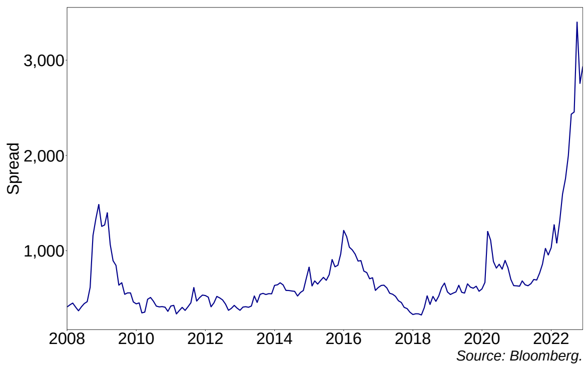


Figure 15: Ghana's spread.

During the year 2022, a self-fulfilling mechanism was feared by international markets regarding Ghana. First, it is due to the fact that a significant proportion of the country's debt is denominated in dollars. In the case of Ghana, this represents more than half of its debt in the early 2022, as shown in Figure 14 (ending in September 2022). Its debt has massively increased in the recent years, going from almost 20% of GDP in 2008 to above 80% of GDP in 2022, as shown in Figure 14. Therefore, a depreciation raises the burden of the government's debt that is held in foreign currencies. As the cedi's value diminishes, the equivalent amount in local currency required to service the debt increases, intensifying the debt burden. However, while the debt burden continues to grow, market starts to loss confidence in the ability of the government to reimburse its debt, which increases the interest rates on government debt's, as depicted on Figure 15. This increases the external debt, leading to another depreciation of the currency. Overall, these two elements reinforce each other and can lead to a sovereign default, precisely what Ghana faced by the end of 2022.

C Algorithm

1. Set up the calibrated value of the parameters summarized in the table above and define the grids of assets, which in our case consist of 400 grids equally spaced between -100 and 100, representing respectively the minimum and maximum value of b;

2. Discretize the Markov process into a 60- state space vector using the idea of Tauchen & Hussey (1991);

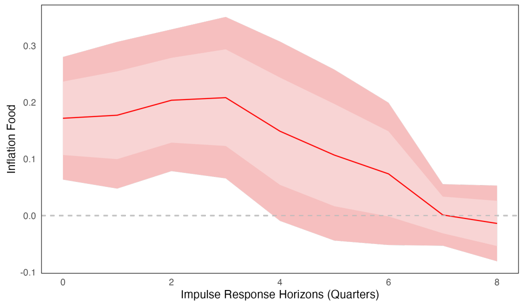
3. Give some initial guess for the bond price schedule such as $q^0(b,T) = 1/(1+r)$;

4. Given $q^0(b,T)$, solve the optimal policies functions for consumption $C(b,T)$, asset holdings $b'(b,T)$, repayment sets $A(b)$, and default sets $D(b)$ through value function iteration. Define the consumption in the two states (default and not default), create the initial guess for all value functions involved in the process - default and not default, give some guess for the expected value given current state - expected value when in default, not in default and when the government had defaulted in the previous period and regain the credit markets. Iterate until convergence for a given q^0;

5. Using these sets of default and sets of repayment, compute bond price schedule $q^1(b,T)$ such that lenders break even and compare it to the price schedule of the previous iteration $q^0(b,T)$. If a convergence step is met, $\max\{q_H^0(b,T) - q_H^1(b,T)\} < \varepsilon$, you are done, otherwise come back to the step 4.

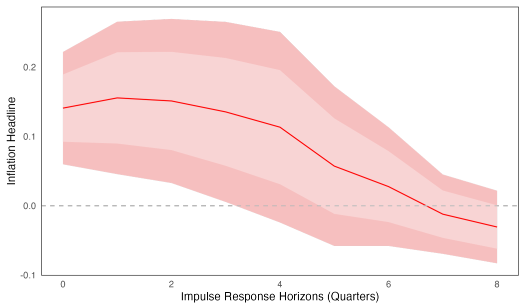
D Impulse Response Functions using quarterly data

(a) Commodity Price Imports.



(b) Inflation Food.

(c) Inflation Non Food.

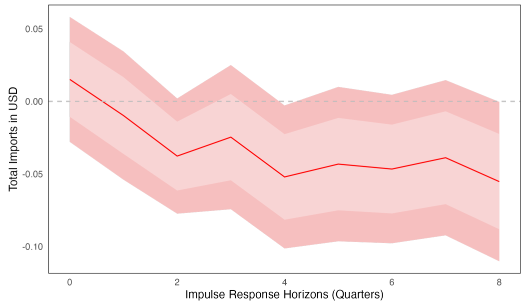


(d) Inflation Headline.

Figure 16: Impact of a Positive Shock in International Food Commodity Prices.

Note: This figure illustrates the Impulse Response Functions (IRFs) of selected prices and inflation following an unforeseen positive supply shock, characterized as an unanticipated increase in commodity prices on the international market. In particular, panel (a) displays $\hat{\beta}_1^h$, estimated from the model: $y_{t+h} = \beta_0^h + \beta_1^h \varepsilon_t^p + controls_t + \varepsilon_{t+h}$. Here, y_t represents the logarithm of Commodity Price Imports, and the control vector X_t encompasses the logarithm of Total Imports in USD, the logarithm of FX Debt Value (the exchange rate), and the lag of the logarithm of Commodity Price Imports. Panel (b) exhibits the estimated $\hat{\beta}_1^h$ from the model specified in equation (16), where y_t is the logarithm of Consumer Price Index (CPI) for Food, and the control vector X_t includes the logarithm of Total Imports in USD and the logarithm of FX Debt Value (the exchange rate). Panel (c) showcases the estimated $\hat{\beta}_1^h$ resulting from estimating the model in equation (16), with y_t representing the logarithm of Consumer Price Index (CPI) for Non-Food items. The control vector X_t encompasses the logarithm of Total Imports in USD and the logarithm of FX Debt Value (the exchange rate). Lastly, panel (d) presents the estimated $\hat{\beta}_1^h$ derived from estimating the model in equation (16), where y_t denotes the logarithm of Headline Consumer Price Index (CPI). The control vector X_t includes the logarithm of Total Imports in USD and the logarithm of FX Debt Value (the exchange rate). The lightly shaded region corresponds to a 68% confidence interval, while the more prominently shaded area indicates the 90% confidence interval. Both intervals are constructed employing Newey-West Standard Errors.

(a) Exchange Rate.



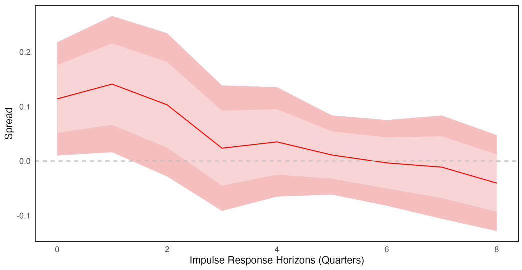
(b) Total Imports in USD.

(c) Total Exports in USD.

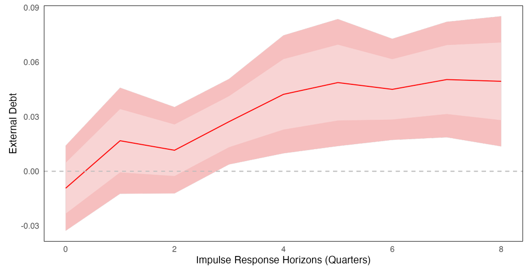
(d) Trade Balance in USD.

Figure 17: Impact of a Positive Shock in International Food Commodity Prices.

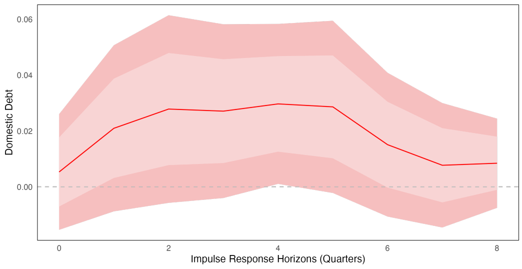
Note: This figure presents Impulse Response Functions (IRFs) reflecting the impact of a positive supply shock on international trade conditions. Panel (a) showcases the estimated $\hat{\beta}_1^h$ derived from estimating the model in equation (16), where y_t is the logarithm of FX Debt Value (the exchange rate). The control vector X_t includes the logarithm of GDP at constant prices and the logarithm of FX Debt Value (the exchange rate). In panel (b), the estimated $\hat{\beta}_1^h$ is depicted from the model outlined in equation (16), with y_t indicating the logarithm of Import Prices. Here, the control vector X_t includes the logarithm of GDP at constant prices and the logarithm of Total Debt in USD. In panel (c), $\hat{\beta}_1^h$ is shown, obtained through estimating the model described by equation (16), with y_t representing the logarithm of Export Prices. The control vector X_t encompasses the logarithm of GDP at constant prices and the logarithm of Total Debt in USD. Finally, panel (d) displays the estimated $\hat{\beta}_1^h$ resulting from estimating the model in equation (16), where y_t denotes the Trade Balance in USD dollars. The control vector X_t encompasses the logarithm of GDP at constant prices and the logarithm of External Debt in USD. The light shaded area corresponds to a 68% confidence interval, while the darker shaded area indicates the 90% confidence interval, both constructed using Newey-West Standard Errors.



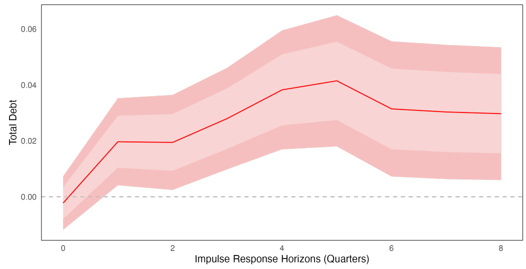
(a) Spread.



(b) External Debt in USD.



(c) Domestic Debt in USD.

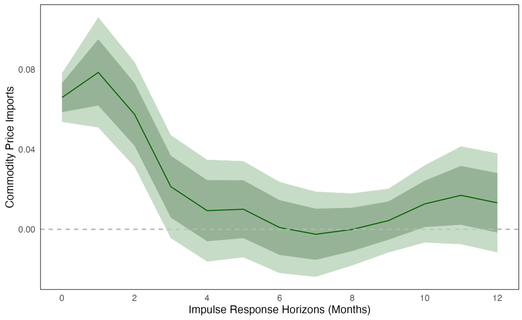


(d) Total Debt in USD.

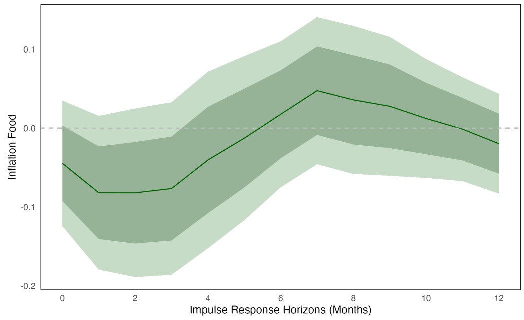
Figure 18: Impact of a Positive Shock in International Food Commodity Prices.

Note: This figure presents the Impulse Response Functions (IRFs) that depict the behavior of debt and spread in response to a positive supply shock. Specifically, in panel (a), we illustrate $\hat{\beta}_1^h$, derived from estimating the model as described in equation (16). Here, y_t represents the logarithm of Spread, and the control vector X_t includes the logarithm of Total Debt in USD and the logarithm of GDP at constant prices. Panel (b) displays the estimated $\hat{\beta}_1^h$ obtained from the model outlined in equation (16), where y_t refers to the logarithm of External Debt in USD. In this context, the control vector X_t comprises the logarithm of Total Debt in USD and the logarithm of GDP at constant prices. Moreover, panel (c) depicts the estimated $\hat{\beta}_1^h$ resulting from estimating the model as described in equation (16), with y_t refers to the logarithm of Domestic Debt in USD. In this context, the control vector X_t comprises the logarithm of Total Debt in USD and the logarithm of GDP at constant prices. Lastly, panel (d) shows the estimated $\hat{\beta}_1^h$ obtained from estimating the model in equation (16), where y_t is the logarithm of Total Debt in USD. The control vector X_t includes the logarithm of Total Debt in USD and the logarithm of GDP at constant prices. The lighter shaded region corresponds to a 68% confidence interval, while the darker shaded area indicates the 90% confidence interval. Both intervals are constructed using Newey-West Standard Errors.

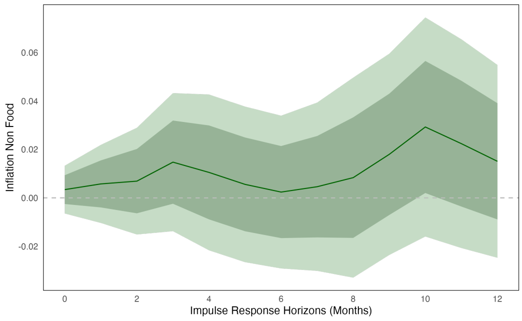
E Oil Supply News Shocks



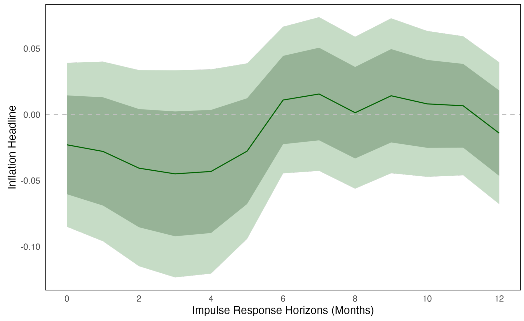
(a) Commodity Prices.



(b) Inflation Food.



(c) Inflation Non Food.

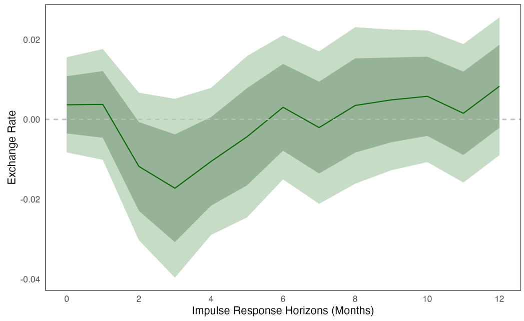


(d) Inflation Headline.

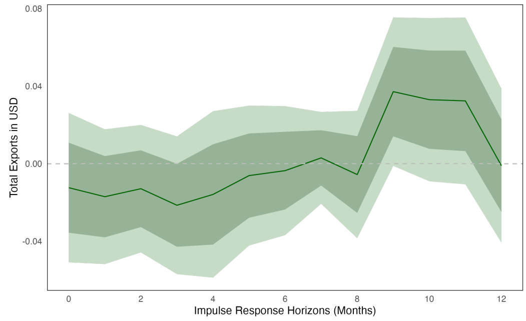
Figure 19: Impact of a Positive Shock in Oil Supply Shock News in International Food Commodity Prices.

Note: This figure illustrates the Impulse Response Functions (IRFs) of selected prices and inflation following an unforeseen positive oil supply shock as developed by Känzig (2021). In particular, panel (a) displays $\hat{\beta}_1^h$, estimated from the model: $y_{t+h} = \beta_0^h + \beta_1^h \varepsilon_t^p + controls_t + \varepsilon_{t+h}$. Here, y_t represents the logarithm of Commodity Price Imports, and the control vector X_t encompasses the logarithm of Total Imports in USD, the logarithm of FX Debt Value (the exchange rate), and the lag of the logarithm of Commodity Price Imports. Panel (b) exhibits the estimated $\hat{\beta}_1^h$ from the model specified in equation (16), where y_t is the logarithm of Consumer Price Index (CPI) for Food, and the control vector X_t includes the logarithm of Total Imports in USD and the logarithm of FX Debt Value (the exchange rate). Panel (c) showcases the estimated $\hat{\beta}_1^h$ resulting from estimating the model in equation (16), with y_t representing the logarithm of Consumer Price Index (CPI) for Non-Food items. The control vector X_t encompasses the logarithm of Total Imports in USD and the logarithm of FX Debt Value (the exchange rate). Lastly, panel (d) presents the estimated $\hat{\beta}_1^h$ derived from estimating the model in equation (16), where y_t denotes the logarithm of Headline Consumer Price Index (CPI). The control vector X_t includes the logarithm of Total Imports in USD and the logarithm of FX Debt Value (the exchange rate). The lightly shaded region corresponds to a 68% confidence interval, while the more prominently shaded area indicates the 90% confidence interval. Both intervals are constructed employing Newey-West Standard Errors.

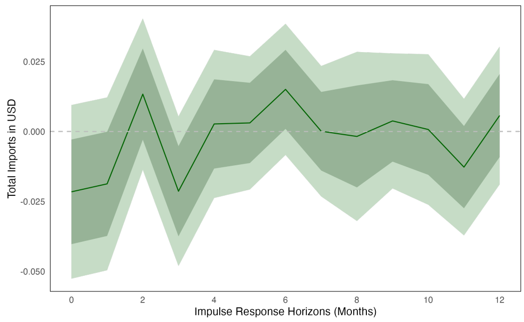
In this figure, it is evident that negative oil supply news shocks have an increasing effect on import commodity prices, while no discernible effect can be said about the effect on inflation. In other words, when it comes to inflation for food items, non food items, and headline inflation, we cannot dismiss the hypothesis that oil supply news shocks may not significantly affect these variables.



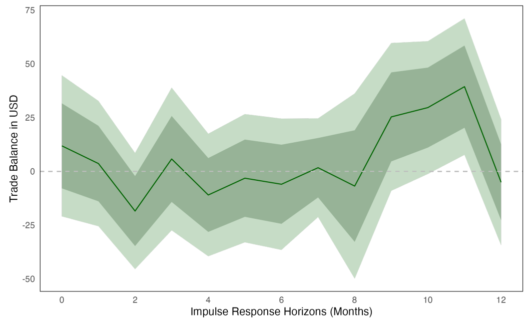
(a) Exchange rate.



(b) Total Exports in USD.



(c) Total Imports in USD.

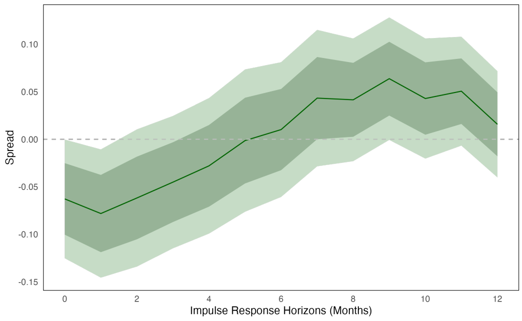


(d) Trade Balance in USD.

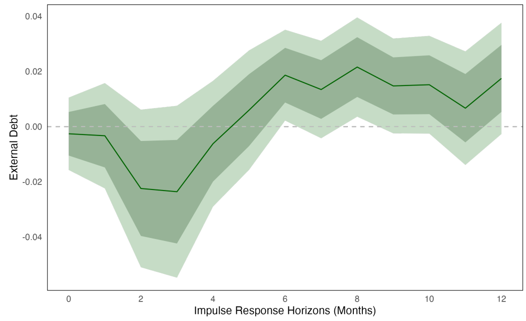
Figure 20: Impact of a Positive Shock in Oil Supply Shock News.

Note: This figure illustrates the Impulse Response Functions (IRFs) on international trade conditions following an unforeseen positive oil supply shock as developed by Känzig (2021). Panel (a) showcases the estimated $\hat{\beta}_1^h$ derived from estimating the model in equation (16), where y_t is the logarithm of FX Debt Value (the exchange rate). The control vector X_t includes the logarithm of Inflation Food and the logarithm of Total Debt in USD. In panel (b), the estimated $\hat{\beta}_1^h$ is depicted from the model outlined in equation (16), with y_t indicating the logarithm of Import Prices. Here, the control vector X_t includes the logarithm of Inflation Food and the logarithm of Total Debt in USD. In panel (c), $\hat{\beta}_1^h$ is shown, obtained through estimating the model described by equation (16), with y_t representing the logarithm of Export Prices. The control vector X_t encompasses the logarithm of Inflation Food and the logarithm of Total Debt in USD. Finally, panel (d) displays the estimated $\hat{\beta}_1^h$ resulting from estimating the model in equation (16), where y_t denotes the Trade Balance in USD dollars. The control vector X_t encompasses the logarithm of Inflation Food and the logarithm of External Debt in USD. The light shaded area corresponds to a 68% confidence interval, while the darker shaded area indicates the 90% confidence interval, both constructed using Newey-West Standard Errors.

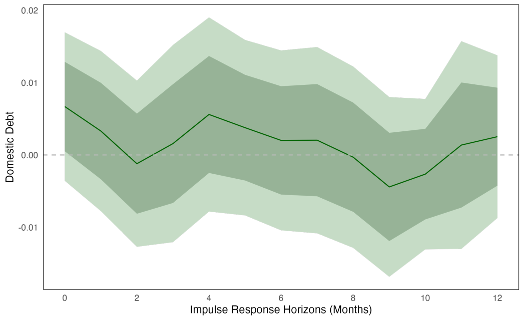
Here, it is evident that the oil supply new shocks seems to have no impact in the variables that represents the international situation of the country.



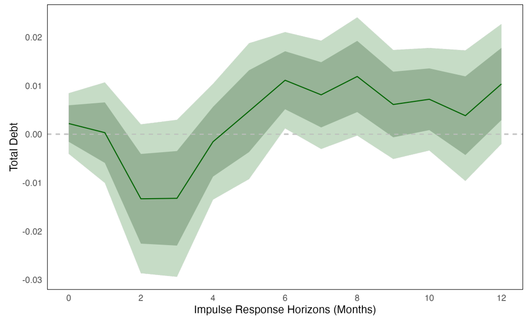
(a) Spread.



(b) External Debt in USD.



(c) Domestic Debt in USD.



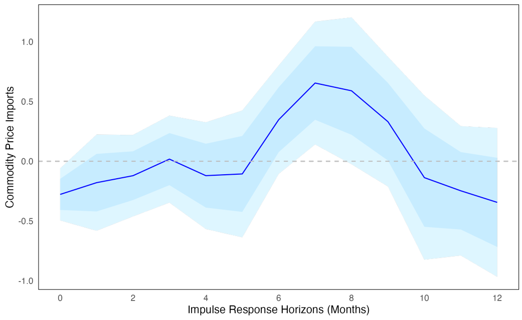
(d) Total Debt in USD.

Figure 21: Impact of a Positive Shock in Oil Supply Shock News.

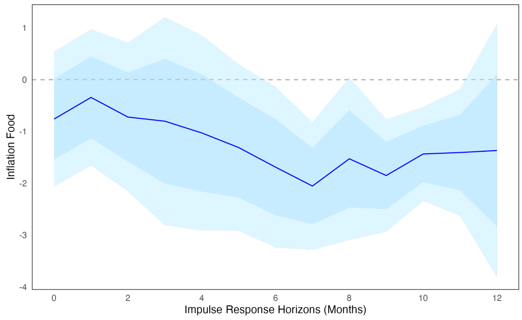
Note: This figure illustrates the Impulse Response Functions (IRFs) for debt and spread following an unforeseen positive oil supply shock as developed by Känzig (2021). Specifically: Specifically, in panel (a), we illustrate $\hat{\beta}_1^h$, derived from estimating the model as described in equation (16). Here, y_t represents the logarithm of Spread, and the control vector X_t includes the logarithm of Total Debt in USD and Inflation Food. Panel (b) displays the estimated $\hat{\beta}_1^h$ obtained from the model outlined in equation (16), where y_t refers to the logarithm of External Debt in USD. In this context, the control vector X_t comprises the logarithm of Total Debt in USD and Inflation Food. Moreover, panel (c) depicts the estimated $\hat{\beta}_1^h$ resulting from estimating the model as described in equation (16), with y_t refers to the logarithm of Domestic Debt in USD. In this context, the control vector X_t comprises the logarithm of Total Debt in USD and Inflation Food. Lastly, panel (d) shows the estimated $\hat{\beta}_1^h$ obtained from estimating the model in equation (16), where y_t is the logarithm of Total Debt in USD. The control vector X_t includes the logarithm of Total Debt in USD and Inflation Food. The lighter shaded region corresponds to a 68% confidence interval, while the darker shaded area indicates the 90% confidence interval. Both intervals are constructed using Newey-West Standard Errors.

The only observable effect we can discern here is the initial impact on the spread in the periods immediately following the shock. However, this effect diminishes and becomes negligible after a couple of months. As for other variables, particularly in terms of the external debt situation, we cannot dismiss the null hypothesis that the effect is zero. Even in the context of the spread, the effects appear to be minor.

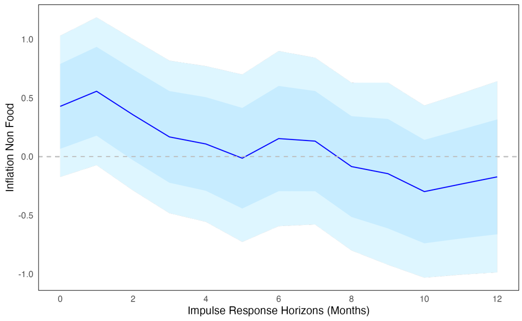
F Monetary Policy Shocks



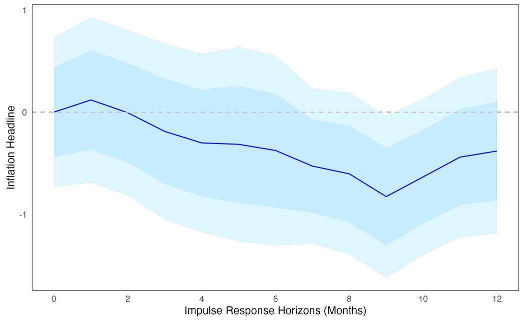
(a) Commodity Price Imports.



(b) Inflation Food.



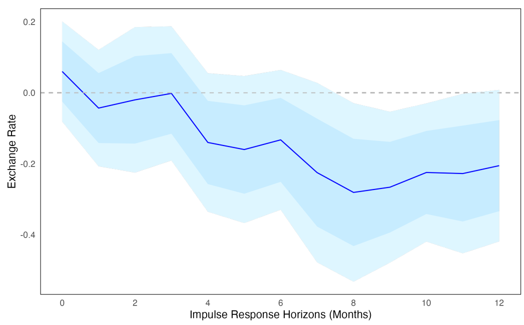
(c) Inflation Non Food.



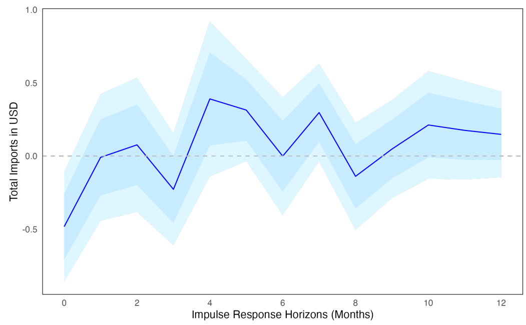
(d) Inflation Headline.

Figure 22: Impact of a Contractionary Monetary Policy Shock in the United States.

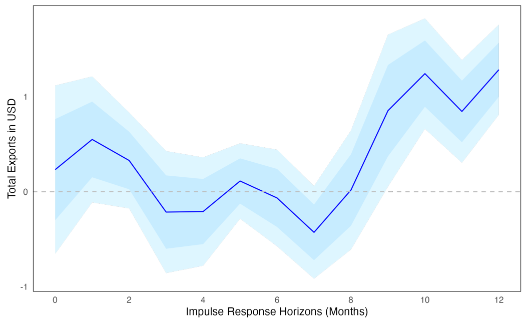
Note: This figure illustrates the Impulse Response Functions (IRFs) of selected prices and inflation following an unforeseen contractionary monetary policy shock as developed by Choi et al. (2022). In particular, panel (a) displays $\hat{\beta}_1^h$, estimated from the model: $y_{t+h} = \beta_0^h + \beta_1^h \varepsilon_t^p + controls_t + \varepsilon_{t+h}$. Here, y_t represents the logarithm of Commodity Price Imports, and the control vector X_t encompasses the logarithm of Total Imports in USD, the logarithm of FX Debt Value (the exchange rate), and the lag of the logarithm of Commodity Price Imports. Panel (b) exhibits the estimated $\hat{\beta}_1^h$ from the model specified in equation (16), where y_t is the logarithm of Consumer Price Index (CPI) for Food, and the control vector X_t includes the logarithm of Total Imports in USD and the logarithm of FX Debt Value (the exchange rate). Panel (c) showcases the estimated $\hat{\beta}_1^h$ resulting from estimating the model in equation (16), with y_t representing the logarithm of Consumer Price Index (CPI) for Non-Food items. The control vector X_t encompasses the logarithm of Total Imports in USD and the logarithm of FX Debt Value (the exchange rate). Lastly, panel (d) presents the estimated $\hat{\beta}_1^h$ derived from estimating the model in equation (16), where y_t denotes the logarithm of Headline Consumer Price Index (CPI). The control vector X_t includes the logarithm of Total Imports in USD and the logarithm of FX Debt Value (the exchange rate). The lightly shaded region corresponds to a 68% confidence interval, while the more prominently shaded area indicates the 90% confidence interval. Both intervals are constructed employing Newey-West Standard Errors.



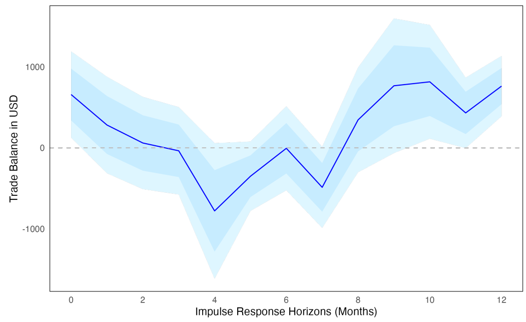
(a) Exchange rate.



(b) Total Imports in USD.



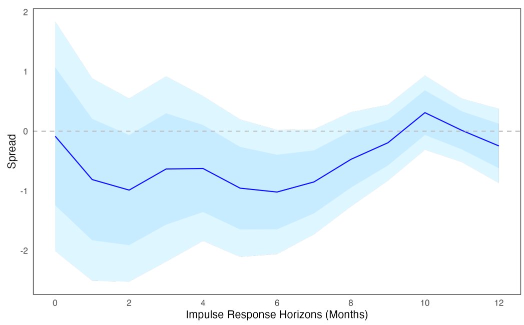
(c) Total Exports in USD.



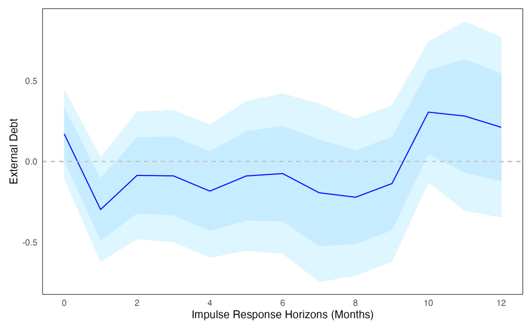
(d) Trade Balance in USD.

Figure 23: Impact of a Contractionary Monetary Policy Shock in the United States in International Food Commodity Prices.

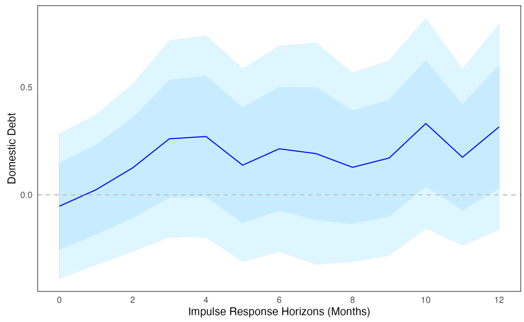
Note: This figure illustrates the Impulse Response Functions (IRFs) on international trade conditions following a contractionary monetary policy shock as developed by Choi et al. (2022). Panel (a) showcases the estimated $\hat{\beta}_1^h$ derived from estimating the model in equation (16), where y_t is the logarithm of FX Debt Value (the exchange rate). The control vector X_t includes the logarithm of Inflation Food and the logarithm of Total Debt in USD. In panel (b), the estimated $\hat{\beta}_1^h$ is depicted from the model outlined in equation (16), with y_t indicating the logarithm of Import Prices. Here, the control vector X_t includes the logarithm of Inflation Food and the logarithm of Total Debt in USD. In panel (c), $\hat{\beta}_1^h$ is shown, obtained through estimating the model described by equation (16), with y_t representing the logarithm of Export Prices. The control vector X_t encompasses the logarithm of Inflation Food and the logarithm of Total Debt in USD. Finally, panel (d) displays the estimated $\hat{\beta}_1^h$ resulting from estimating the model in equation (16), where y_t denotes the Trade Balance in USD dollars. The control vector X_t encompasses the logarithm of Inflation Food and the logarithm of Total Debt in USD. The light shaded area corresponds to a 68% confidence interval, while the darker shaded area indicates the 90% confidence interval, both constructed using Newey-West Standard Errors.



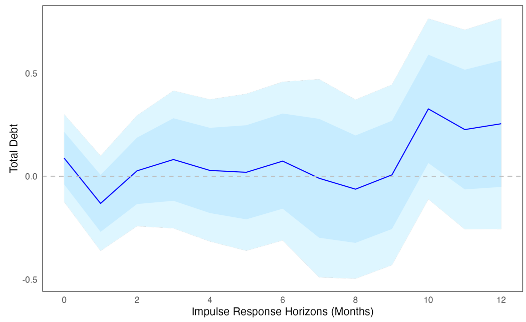
(a) Spread.



(b) External Debt in USD.



(c) Domestic Debt in USD.



(d) Total Debt in USD.

Figure 24: Impact of a Contractionary Monetary Policy Shock in the United States.

Note: This figure illustrates the Impulse Response Functions (IRFs) for debt and spread following a contractionary monetary policy supply shock as developed by Choi et al. (2022). Specifically: Specifically, in panel (a), we illustrate $\hat{\beta}_1^h$, derived from estimating the model as described in equation (16). Here, y_t represents the logarithm of Spread, and the control vector X_t includes the logarithm of Total Debt in USD and Inflation Food. Panel (b) displays the estimated $\hat{\beta}_1^h$ obtained from the model outlined in equation (16), where y_t refers to the logarithm of External Debt in USD. In this context, the control vector X_t comprises the logarithm of Total Debt in USD and Inflation Food. Moreover, panel (c) depicts the estimated $\hat{\beta}_1^h$ resulting from estimating the model as described in equation (16), with y_t refers to the logarithm of Domestic Debt in USD. In this context, the control vector X_t comprises the logarithm of Total Debt in USD and Inflation Food. Lastly, panel (d) shows the estimated $\hat{\beta}_1^h$ obtained from estimating the model in equation (16), where y_t is the logarithm of Total Debt in USD. The control vector X_t includes the logarithm of Total Debt in USD and Inflation Food. The lighter shaded region corresponds to a 68% confidence interval, while the darker shaded area indicates the 90% confidence interval. Both intervals are constructed using Newey-West Standard Errors.