Trade Risk and Food Security*

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Abstract

International trade provides critical access to food for many countries, yet food-importing countries often continue to protect agriculture and sustain production even where productivity is low. Given the potentially devastating cost of losing access to food, this paper studies the extent to which the risk of trade disruptions can account for these patterns. We document that reliance on staple imports is systematically associated with higher food insecurity, particularly in poorer countries. Consistent with this pattern, we document that during the Ukraine–Russia war Ethiopian districts more exposed to disrupted imports experienced sharper declines in food security. To interpret these patterns, we develop and estimate a 71-country, multi-sector general equilibrium model with stochastic trade costs and non-homothetic preferences. In the model, importers must commit to suppliers before shocks are realized, which leads them to self-insure by re-shoring production or shifting to more reliable but costlier partners. Stress-testing current global trade patterns under plausible tail risk, we show that food importers retreat most from trade, reallocate resources to agriculture, and face higher food insecurity. We analytically characterize and quantify optimal agricultural protection as insurance against unreliable imports, but show that productivity growth can substitute for protection by reducing exposure to risk. Our results highlight that trade risk fundamentally alters the gains from openness and the motives for optimal policy protection.

JEL classification: E10, F10, F60, I30, O11, O41.

Keywords: food security, trade, risk, structural change, productivity.

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1 Introduction

Given the large differences in agricultural productivity across countries, trade has emerged as a key channel for securing reliable access to food for large populations in importing countries. For example, in Djibouti and Jordan 100 percent of their cereal consumption needs in 2018 were accounted for by imports of cereals.[1] International trade yields welfare gains not only by allowing countries in the long run to exploit comparative advantage but also by hedging idiosyncratic production shocks in the short run. Yet, despite these potential gains, many food-importing countries systematically protect their domestic agricultural sectors and sustain production even where productivity is strikingly low.

One channel that could help explain this pattern is concern about rare but severe trade disruptions. Even if such tail risks are infrequent, their potentially catastrophic consequences make dependence on foreign suppliers especially fraught when the good in question is essential for survival. These risks have long shaped food security policy and have become increasingly salient with rising shipping disruptions, growing trade policy uncertainty, geopolitical tensions, and climate-related shocks. Indeed, food security is a major policy objective for international organizations (it is one of the United Nations Sustainable Development Goals) and for national governments, many of which subsidize domestic agriculture (Anderson et al., 2011). In this paper, we examine the extent to which the risk of trade disruptions, given the potentially severe cost of losing access to food, can help account for the widespread protection of domestic agriculture in food-importing countries.

To investigate this question, we combine new empirical evidence with a global quantitative model. We study how the risk of trade disruptions jeopardises food security, shapes global trade flows and sectoral production patterns, and can rationalize protective agricultural policies – even in the absence of political economy considerations. We show that food trade disruptions are infrequent, but recurring and sizable, and that countries that depend more on imported food staples exhibit higher food insecurity. Exploiting the 2022 Ukraine–Russia war, we illustrate that trade shocks increase food insecurity in more exposed districts in Ethiopia, and we document that food importers protect agriculture more. To interpret this evidence, we develop and estimate a 71-country, multi-sector general equilibrium model in which importing firms choose suppliers before uncertain trade costs are realized. The model features stochastic shocks to trade costs and non-homothetic preferences with food as a necessity, introducing a precautionary motive to re-shore production or shift to more reliable but costlier sources. We analytically characterize and quantify optimal protec-

[1] See FAOSTAT, Food Security Indicators, 'Cereal Import Dependency Ratio," https://www.fao.org/faostat.

tive policies in agriculture, highlighting their insurance role against food import disruptions.

We use the model to stress-test today's global trade patterns under an empirically grounded tail-risk scenario. We find that all countries retreat from trade, but the largest adjustments occur in economies with high food import dependence and high food expenditure shares. These countries reallocate toward domestic agriculture, face sharper increases in food prices, and suffer greater welfare losses. Our results offer a novel explanation for why many low-income countries continue to produce food domestically despite low agricultural productivity. We show that although private importers internalize trade risk when sourcing, they under-weigh it because they do not account for general equilibrium price effects, leading to excessive aggregate exposure. Policies such as production subsidies and import tariffs can help re-align incentives to insure domestic consumers against unreliable imports. In contrast to protective policies, we also find that productivity-enhancing reforms in agriculture can provide insurance by reducing trade exposure directly, thereby lowering the need for protection.

This paper contributes to a growing literature that reconsiders the benefits and costs of openness in the presence of trade risk. While standard models emphasize the gains from specialization and access to variety, our analysis shows that the prospect of trade disruption can act as a powerful force shaping production patterns, trade flows, and food security—especially in low-income, food-importing countries. By explicitly modeling trade risk, we provide a framework for understanding why countries may resist deep integration, and why agricultural production persists even where productivity is low.

To motivate our analysis, we document salient features of the data on the relation between trade risk, food security, and policy. First, using historical data on food import volumes across countries over the period 1961-2023, we document that trade disruptions – measured as a 20 percent year-over-year drop – are infrequent but recurring events, with a 9.5 percent chance of occurring across all country-years. Second, using recent cross-country data, we show that greater reliance on cereal imports is associated with higher food insecurity, especially among poorer importers. Third, we provide micro-level evidence on the effect of trade disruptions for food security, exploiting the exogeneity of the Ukraine-Russia war as a major trade disruption event that limited access to critical food imports for Ethiopian consumers. Employing a shift-share approach, and utilizing geographic variation in import penetration prior to the war, we find that districts in Ethiopia more exposed to imports from the conflict countries experienced a significantly larger decline in food security. Fourth, using data on the nominal rate of assistance we find, perhaps surprisingly, that net food importers systematically protect domestic agriculture more than exporters.

Motivated by this evidence, we develop a multi-country multi-sector general equilibrium model of international trade risk and structural change to study the impact of the risk of trade disruptions on food security, sectoral patterns of production and trade, welfare, and optimal policy. A key conceptual novelty of the model is the interaction of stochastic trade costs, i.e., risk in the trading technology, with non-homothetic preferences featuring food as a necessity. Importantly, in our framework, we explicitly model sourcing decisions as made prior to the realization of trade shocks, which leads to a novel ex-ante risk-return trade-off channel for importers. We show analytically that the sourcing of imports depends not only on the production and trade cost advantage of a trading partner, but also on the associated risk premium of the partner. Our theory implies a pre-cautionary trade motive: in an effort to self-insure, importers may choose to substitute "cheaper" imports in favor of domestic production (re-shoring) or imports from more expensive but less risky trading partners (friend-shoring).

To quantify our theory, we consider a global economy populated by 70 countries and the rest of the world, with two traded sectors in each country – agriculture and manufacturing – and one non-traded sector, services. We estimate our global sectoral trade model, including sector-country trade costs, to match the patterns of sectoral bilateral trade flows, sectoral production and expenditures, and relative prices, with data from the Food and Agricultural Organization (FAOSTAT), the Trade in Value Added Database of the OECD (TiVA), and the World Bank's International Comparison Project (ICP). In our main quantitative experiment we assess the effect of tail trade risk, i.e., low-probability, high-impact food trade disruptions. We empirically ground the food trade disruption probability at 10 percent, drawing on the historical incidence of food import disruptions (as in the macroeconomics rare disaster literature, e.g., Barro and Ursúa, 2012) and the estimated effects of recent spikes in the geopolitical risk (Caldara and Iacoviello, 2022) and trade policy uncertainty (Caldara et al., 2020) indices. This experiment allows us to stress test current patterns of production and trade, and study the welfare effects of risk and its implications.

The results are stark. We find that risk induces all countries to limit their participation in trade, especially those exposed most to trade initially. Intuitively, countries retreat from trade as a self-insurance mechanism against the chance of losing access to imported goods, particularly critical ones like food. Food importers shift their sourcing toward domestic agricultural production, in proportion to their initial agricultural trade deficits. On average, the share of labor in agriculture in food importing countries increases by 7.9 percent. We find that the risk of losing access to essential food imports raises food insecurity, manifested in lower consumption and higher prices. Trade risk reduces welfare, because of the higher food insecurity and the lower trade participation, which induces them to economize on the benefits

offered by international trade. We show that the risk "costs" of globalization undermine the traditional gains from trade found in models that abstract from uncertainty, particularly for large food importers.

We use our framework to study optimal tariffs on imports and domestic production subsidies, policy levers governments often use to protect domestic agriculture. We first characterize optimal tariffs under risk in a one-sector version of our model, and contrast them to those without risk. This allows us to analytically show that there are three motives for policymakers to impose tariffs under risk. First, to manipulate the terms of trade in favor of their country by exploiting the country's market power in world markets. This motive is also present, and in fact stronger, in the no-risk case where countries endogenously trade more. Second, to use tariff revenue as insurance for domestic consumers in bad (high marginal utility) states of the world. Third, to secure enough consumption for domestic households in the event of a trade disruption, by shifting spending ex-ante from unreliable risky imports to safer domestic production, a pre-cautionary insurance motive. While in equilibrium private importers internalize the trade risk when ordering varieties, they under-weigh the risk because they do not account for the price effects and aggregate exposure of their choices. The planner internalizes both the overall risk exposure and the pecuniary general equilibrium externality, and raises the tariff to cut back further on orders of risky goods. We quantify optimal tariffs and subsidies in our estimated model for all countries. Consistent with the data, we find that it is the countries with higher trade deficits in agriculture that are more likely to protect their domestic agricultural sectors.

While our multi-country trade model with risk and our optimal policy analysis have more general applicability for understanding global trade under uncertainty, the sectoral layer delivers key insights for structural change and development. We illustrate the structural change implications of our theory in three steps. First, we show that with standard CES preferences (abstracting from non-homothetic terms), the retreat from trade and the shift to domestic agricultural production are considerably attenuated for large food importers. This shows that non-homotheticities are important in mediating the effects of trade risk, particularly for countries that rely heavily on imports of agricultural goods. Second, we show that conditional on trade imbalances, risk disproportionately shifts resources towards domestic agricultural production in countries with high expenditure shares on food. The implication is that trade risk is a larger obstacle to trade and structural change for countries at earlier stages of their structural transformation process. This occurs because the utility cost of downside risk is greater for countries closer to subsistence, prompting stronger self-insurance retreat from trade. Third, we show that potential domestic agricultural productivity improvements – that often accompany the development process – in lower income

importing countries, can endogenously mitigate exposure to trade risk and alleviate the need for protective policies.

There are four distinctive features of our analysis relative to the literature. First, we study trade risk, that is, shocks to the trading technology itself, which in a bilateral trading relationship manifests as aggregate uninsurable risk. This differs from idiosyncratic production shocks or sectoral shocks that the literature has previously emphasized. Second, to study risk per se, sourcing decisions are made before the realization of the trade shocks, which implies that importers have to determine trading relationships ex-ante. This allows them to internalize the risk and self-insure by producing more domestically and shifting imports towards less risky trading partners, rationalizing the notions of "re-shoring" and "friend-shoring." To put things into perspective, our results differ markedly from an environment in which production and trade respond to trade shocks ex-post. Third, our model has important implications for countries at different stages of economic development. It is well documented that lower-income countries allocate disproportionate shares of consumption expenditure to food and production to agricultural goods. In our theory, other things equal, lower income countries self-insure more against trade risk with more domestic production of agricultural goods. This occurs because our environment features decreasing relative risk aversion, due to the interaction of the non-homothetic preferences with the standard risk aversion. As a result, our risk mechanism offers a distinct channel, relative to the literature, of why poor countries may choose to isolate and endogenously trade less, despite their low productivity in agriculture. Fourth, we study optimal policies analytically and quantitatively and illustrate the additional insurance role of such policies, and rationalize observed protection of agriculture – absent political economy motives.

Our paper contributes to a wide range of literature in international trade and macro-development. The long-run welfare gains from international trade, associated with specialization, comparative advantage and varieties, are well understood and quantified in a large class of trade models under certainty (Eaton and Kortum, 2002; Arkolakis et al., 2012). Relative to this literature we show that considering the risk of trade disruptions can undermine the benefits of globalization, especially for heavily-reliant food importers. There is a large trade literature that shows that international trade can be beneficial in diversifying risk, when productivity shocks are country-specific in nature (Cole and Obstfeld, 1991; Costinot et al., 2016). We complement this work by showing that when the risk is to the trading technology of essential consumption goods it can threaten the welfare gains from trade.

Our paper contributes to a growing literature in international trade that studies the effect of risk on international trade patterns and aggregate outcomes. Our paper relates to the work

of Burgess and Donaldson (2012), Caselli et al. (2020), and Allen and Atkin (2022) who also introduce uncertainty in multi-sector models of trade with multiple locations.[2] In contrast, we study the role of trade risk per se with global sourcing decisions chosen before stochastic trade costs are realized, giving rise to a risk-return trade off for importers. Kleinman et al. (2025) also examine the role of risk across countries, and countries' resilience through ex-ante investments in import and export capacity (e.g., logistics, transport, customer capital). We differ in our emphasis on tail trade risk per se; the distinct channel of resilience through ex-ante re-shoring and friend-shoring; our explicit analytical and quantitative characterization of optimal protective policies; and importantly the role of risk for essential goods, structural change, and development.

Our framework also relates to the literature on production networks and the propagation of shocks (Acemoglu et al., 2012; Carvalho et al., 2021) and especially studies emphasizing multi-sourcing and resilience investments in supply chains (Elliott et al., 2022; Grossman et al., 2023). Closest to us in mechanism, were input sourcing decisions are made prior to shocks, is Castro-Vincenzi et al. (2024), who study how firms diversify their supply chains in the face of climate risk. Relative to this literature our focus is the global food trade network, where aggregate trade disruptions –rather than production shocks– propagate across trading partners and induce precautionary reallocation toward "friendlier" partners and domestic agriculture. A key component of our analysis is the characterization of optimal policies.

Our paper contributes to a large literature in macro-development that studies structural change — that is, the shift from agriculture to manufacturing and services, a stylized feature of the process of development (Herrendorf et al., 2014). An important literature in growth and development studies mechanisms that could generate a structural transformation of the economy, e.g., Kongsamut et al. (2001), Ngai and Pissarides (2007), Acemoglu and Guerrieri (2008), Boppart (2014), Comin et al. (2021). We use the preference structure of Comin et al. (2021) to generate structural change income effects. There is also a large literature that examines the interaction of international trade and structural change in an open economy, e.g., Matsuyama (1992), Tombe (2015), Teignier (2018), Lewis et al. (2022), Sposi et al. (2021), Gollin et al. (2025). However, none of this work incorporates the role of risk. Chen et al. (2024) also study the role of food security risk for structural transformation, investigating the income-expenditure tension between rural and urban households within a country and the role for domestic insurance policies. In contrast, we focus on how trade risk affects food security, the global pattern of production and trade, and characterize protectionist policy interventions.

[2]Our paper is also related to other studies of the role of risk in international trade, such as Handley and Limão (2022), Esposito (2022), Gervais (2018), and Kramarz et al. (2020), among others.

Our focus on food security speaks directly to the literature on agriculture and macro-development. There are several papers that study why agricultural productivity is low in developing countries, and yet such a large share of the population is employed in agriculture — see, for instance, Restuccia et al. (2008), Caselli (2005), Lagakos and Waugh (2013), Adamopoulos and Restuccia (2014), Gollin et al. (2014), Brooks and Donovan (2020), Donovan (2021), Adamopoulos and Restuccia (2022), among others. We contribute to this literature by studying the role of international trade risk in shaping the sectoral allocation of labor and productivity within and across countries mediated by food security considerations. While we emphasize the risk associated with losing access to essential imported goods in consumption, Brooks and Donovan (2025) study at the micro-level the risk of losing access to key inputs in agricultural production such as fertilizer.

Our work relates to the literature that studies the motives behind observed protectionist policies. Hsiao et al. (2024) study how agricultural policies respond to domestic and foreign climate-induced production shocks, and rationalizes them through a redistributive motive across domestic interest groups. In our framework shocks are to trade costs, and we provide a non-political insurance rationale for agricultural protection—showing that protection can be optimal even without the political economy motives. Becko et al. (2025) show how geopolitical alignment motives can lead to raise optimal tariffs beyond the traditional terms-of-trade manipulation incentives. While we also show that protective tariffs can optimally be above their terms-of-trade levels, in our environment the amplification effect comes from the insurance role policy plays in maintaining food security in the face of trade risk.

Finally, there is also a strand of the literature that has studied the effect and policy implications of trade disruptions. For instance, the works of Baqaee et al. (2022), Attinasi et al. (2023), Baqaee et al. (2023) have been recently investigating the effect of trade disruptions in various contexts such as the Ukraine-Russian war and U.S.-China decoupling. Similarly, Leibovici and Santacreu (2023) study the effects and policy implications of shortages of critical goods in an open economy. In contrast to our work, these studies examine the implications of trade disruptions ex-post, abstracting from the effect of risk.

The paper proceeds as follows. Section 2 presents aggregate stylized facts on food insecurity and micro-level causal evidence from Ethiopia during the Ukraine-Russia war. Section 3 develops our model of international trade risk and structural change. Section 4 presents the estimation of the model and Section 5 the main quantitative results. In Section 6 we extend the model to include risk-taking incentives and analyze the role for policy interventions. Section 7 concludes.

2 Evidence on Trade Risk, Food Insecurity, and Policy

We lay out in four steps the motivating evidence on the vulnerability associated with importing food and countries' policy behavior. First, we document the incidence of large food import disruptions, and heightened risks in recent years. Second, we show that reliance on food imports is systematically related to food insecurity across countries. Third, exploiting the exogeneity of the Ukraine-Russia war as a major food trade breakdown event, we study its causal effects on the food security of a developing country where food represents an important component of consumption. Fourth, we document that – perhaps surprisingly – food importers protect agriculture more than exporters.

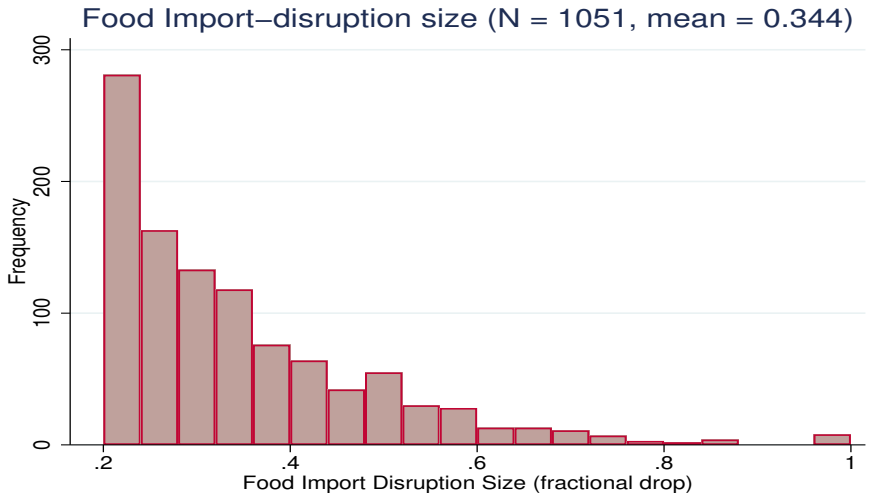
2.1 Food Trade Risks

Trade risk refers to uncertainty about shocks that disrupt trade flows between countries. Unlike country-specific production shocks (e.g., a drought), which trade can help insure against, trade risk is a bilateral shock. We focus on food, an essential consumption good, for which international sourcing disruptions can have important implications not only for food security and welfare, but also for patterns of production and trade, as well as policy. We begin by documenting the incidence and magnitude of historical food trade disruptions, and place these in the context of heightened geopolitical and policy risks in recent years.

Food trade disruptions. To identify food trade disruptions empirically, we use annual data from the Food and Agricultural Organization (FAO) on the volume of food imports by country over 1961-2023, covering every country in the world with available data.[3] We define a food trade disruption as a year-over-year decline in food imports of 20 percent or more. This threshold is chosen to capture trade disruptions as infrequent but significant food import downturn events. Following the macroeconomics rare-disasters literature (e.g., Barro and Ursúa, 2012), we calculate the chance of a food trade disruption as the ratio of the number of trade disruption entries relative to the total number of country-year observations. With a 20 percent year-over-year decline in import volume as the threshold for a trade disruption, we identify 1,051 such events in the data. With a total number of year-country pair observations of 11,034, the estimated annual trade disruption probability is 9.53% ($= 1,051/11,034$). Figure 1 shows the histogram of trade disruption events over 1961-2023 over all countries,

[3]The data are from the "Trade Indices" of the FAOSTAT database, series *Import Quantity Index (2014-2016=100)*, which covers all crops and livestock products. Downloaded from https://www.fao.org/faostat/en/#data/TI, May 23, 2025.

Figure 1: Histogram of Trade Disruptions



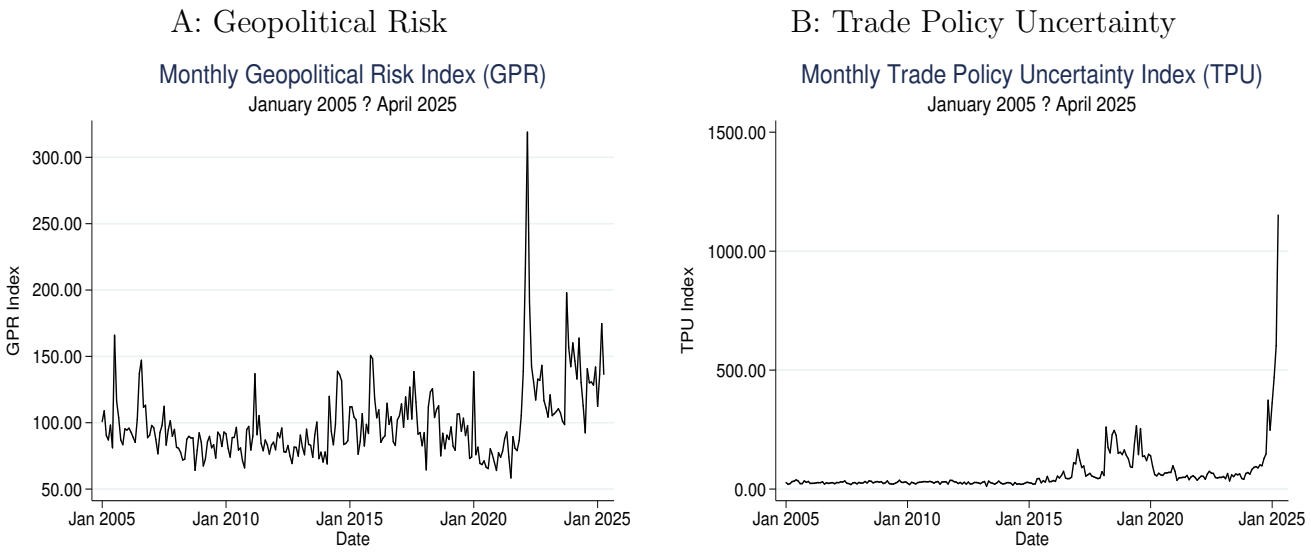
Notes: Food import disruption frequencies by size. Data on volume of imports for crops and livestock products from FAOSTAT, all countries, 1961-2023. A food import disruption is measured as a proportionate decline in the food import quantity index of 20% or more.

with an average drop in the volume of imports of 34% in these events. This implies that even though rare, food trade disruptions, are recurring events.

Heightened recent risks. In recent years, geopolitical risks and trade policy uncertainty are on the rise, with direct implications for food trade. We consider the global geopolitical risk index (GPR) from Caldara and Iacoviello (2022), and the trade policy uncertainty index (TPU) from Caldara et al. (2020).[4] Both the indices are textual analysis based-metrics of the frequency of occurrences of geopolitical tensions and trade policy instability from newspaper articles in major newspapers. In Figure 2.1 we plot the monthly GPR in Panel A and TPU in Panel B, for the last 20 years. As can be seen the geopolitical risk index spikes at the onset of the Ukraine-Russia war due to the hightened geopolitical volatility of the period since 2022. The trade policy uncertainty index initially spikes in the second half of the 2010s during the US-China trade tensions, followed by a sharp spike since the end of 2024 associated with the US trade policy re-alignment.

[4]The GPR index is available at https://www.matteoiacoviello.com/gpr.htm and the TPU index at https://www.matteoiacoviello.com/tpu.htm. Both downloaded May 22, 2025.

Figure 2: Risk Indices



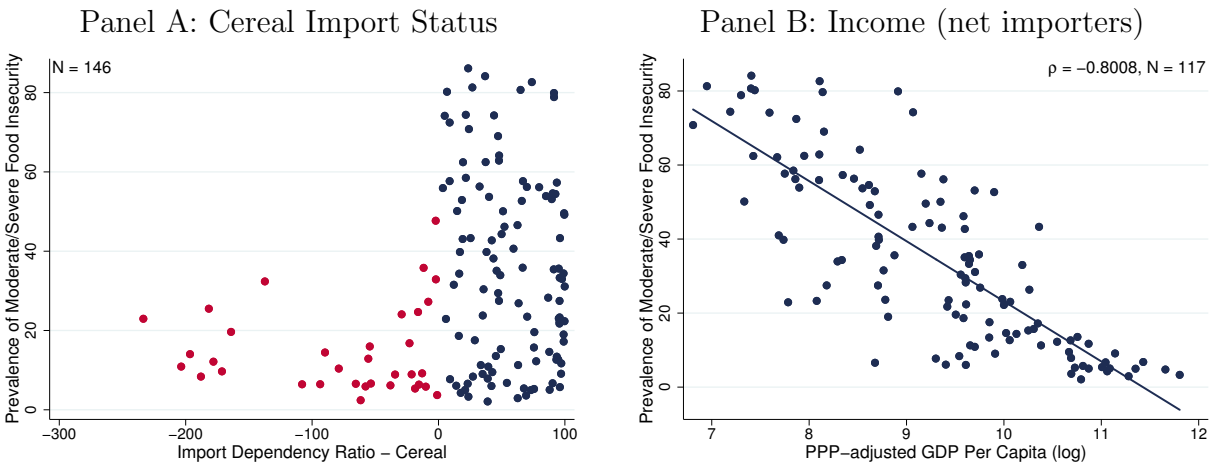
Notes: Monthly GPR and TPU indices, January 2005-April 2025.

2.2 Food Insecurity and Trade Across Countries

After establishing that large food trade disruptions are both real and recurrent, we next ask whether dependence on imports is systematically linked to food insecurity across countries. Using cross-country data, we document that food importing is extensive and associated with higher food insecurity. The Food and Agricultural Organization (FAO) constructs comparable measures of perceived food insecurity across countries using survey answers that question respondents about their families' experiences and challenges in accessing food. We use the prevalence of moderate to severe food insecurity in the population (percent) reported by FAOSTAT, which does not rely on the use of a particular set of prices.

In Figure 2.2, Panel A we plot the prevalence of food insecurity against the import dependency ratio for cereals, the most common staple foods. The import dependency ratio is measured as the ratio of imports minus exports, over domestic absorption. Positive values for the import dependency ratio represent net importers of cereals, while negative values represent net exporters. The scale on the horizontal axis in Panel A indicates that many countries rely heavily on imports of cereals to meet domestic demand, by as much as 100 percent. In Panel A the net importers are the blue points, while the net exporters are the red points. On average, net importers face more than double the food insecurity of net exporters (35.3 vs. 14.9 percent). This mean disparity, however, confounds considerable dispersion within the group of net importers. While exporters are close to the low mean, some

Figure 3: Food Insecurity Across Countries



Notes: Each point in the scatter plots represents a country. The y-axis measures the prevalence of moderate to severe food insecurity in the population. The x-axis measures the import dependency ratio for cereals (Panel A) and log - real GDP per capita (Panel B).

importers are very food insecure while others not at all. As Figure 2.2, Panel B indicates, the variation within the group of net importers is systematically negatively correlated with the level of development, whereby lower-income importing countries face higher insecurity than higher-income ones.[5]

In Appendix A we consider two alternative metrics of food insecurity from FAOSTAT, the prevalence of undernourishment in the population, and the relative volatility of consumer food prices to general prices. Both metrics paint a similar picture as the experiential measure above, being on average higher for cereal importers than for exporters, along with more dispersion for importers. We also show that the relationship between food insecurity, under each metric, and import dependency is present even after controlling for real GDP per capita.

2.3 Micro-Evidence from the Ukraine-Russia War

While the cross-country patterns above establish a correlation between food insecurity and reliance on food imports, they do not identify a causal impact of trade disruptions. To examine whether actual trade shocks affect food security at the micro level, we exploit the

[5]Data on the prevalence of moderate to severe food insecurity, the cereal import dependency ratio, and real GDP per capita in PPP adjusted international dollars, for all countries and all years are obtained from FAOSTAT, "Food Security and Nutrition/Suite of Food Security Indicators," https://www.fao.org/faostat. Downloaded December 7, 2024. Figures are based on averages of these variables over 2014-2022.

exogeneity of the Ukraine-Russia war–a major trade disruption event–that sharply reduced access to key food staples in parts of Africa. Ukraine and Russia are both major exporters of food staples, particularly to Eastern Africa. We focus on Ethiopia, a large Eastern African economy, and use geographic variation in pre-war import exposure across districts to assess the war's impact on food insecurity.

Empirical approach We use a shift-share approach and estimate the following district-level specification of the change in food security on the exposure to the war shock, measured as a weighted average-across crops-of the drop in imports and penetration prior to the war,

$$\Delta\text{Food Insecurity}_{it} = \beta \sum_{c} \text{Import Exposure}_{ci0} \cdot \text{Trade Shock Size}_{cit} + u_{it}$$

where c is a crop index, i is the district index, and 0 refers to the period prior to the shock. Our district-level measure of food insecurity is the share of district households that report insecurity about access to food.[6]

The size of the trade shock for crop c in district i is the absolute change in the quantity of per capita imports of that crop from Ukraine and Russia, normalized by the level of per capita consumption of that crop in district i prior to the trade shock, i.e., $\text{Trade Shock Size}_{cit} = \frac{\Delta IMP^{UR}_{ct}}{C_{ci0}}$. Our crop-district measure of pre-war import exposure is the product of the share of crop c in the total food expenditures of district i, and the share accessed through markets,

$$\text{Import Exposure}_{ci0} = \text{Food Consumption Share}_{ci0} \times [1 - \text{Own Production Share}_{ci0}] .$$

Data We use micro data for Ethiopia from the World Bank's *High Frequency Phone Survey 2020-2023*, conducted through rotating interviews over the period 2020-2023. These are national, longitudinal, high-frequency surveys where households are interviewed on a variety of socio-economic conditions, including food security. The high-frequency phone surveys are implemented through the Living Standards Measurement Study - Integrated Survey on Agriculture (LSMS-ISA) program, and as a result the two surveys can be connected at the household level. We leverage detailed consumption and production data from the 2018-2019 in-person LSMS survey for Ethiopia to estimate initial measures of exposure prior to the pandemic and the war.

We construct district measures of exposure to the war shock for two major imported agricultural goods by Ethiopia from Ukraine and Russia—wheat and sunflower oil, and use

[6] To the extent that there are time-invariant differences across districts, the first differencing absorbs these district fixed effects.

Table 1: Estimated Effects of Ukraine-Russia War on Food Security

	Dependent Variable (change in share):	
	(1)	(2)
	Fewer Kinds of Foods	Ate Less Food
War Import Disruption	-0.124***	-0.054
	(-3.28)	(-1.20)
Observations	298	298
$F - stat$	10.78	1.44
R^2	0.03	0.02

Note: Each column shows the estimate from an OLS regression of the exposure to the import disruption shock from the Ukraine-Russian war on the change in the share of households that are food insecure at the district-level. The measure of food insecurity in column (1) is whether households "ate fewer kinds of foods" and in column (2) whether they "ate less than they should." The sample is a balanced panel of districts. t-statistics in parentheses, *** represents significance at the 1% ($p < 0.01$) level.

median household shares by district from the 2018-2019 LSMS survey prior to the war. We focus on two measures of food insecurity from the questionnaires in the high frequency phone interviews from 2020 and 2023. The first measure is about the variety of foods consumed ("ate only few kinds of foods"), and the second measure is about the total amount of food eaten ("ate less than thought they should"). We have a balanced panel of households for 2020 and 2023.

Results Our shift-share approach relies on relative exposure to estimate the causal effect of the war across districts. Standard errors are clustered at the district level. The results for each of our two food insecurity measures are shown in Table 1.

We find that households in districts facing larger exposure to the drop in imports from the conflict countries experience a significant increase in food insecurity relative to households in less exposed districts, through a reduction in dietary variety. Column (1), on the kinds of foods eaten, shows that the war shock coefficient is negative (import drop increases food insecurity) and statistically significant at the 1 percent level. The share of food-insecure households associated with a one-standard-deviation change in the war-induced shock is 0.16 standard deviations lower. Column (2), on the amount of food eaten, is also negative but the effect is not statistically significant. These findings together suggest that while households in districts more exposed on average did not go hungry, they did have to switch

Nominal Rate of Assistance, 2000-2011

		GDP per capita		
	All countries	$< \$5,000$	$\$5,000 - \$15,000$	$> \$15,000$
Net importer	44.52%	32.16%	43.47%	54.12%
Net exporter	4.14%	-1.96%	9.43%	11.81%

Note: Data from World Bank.

to less variety in their diet.

The results thus far suggest that reliance on food imports leaves households vulnerable to exogenous trade shocks. A natural question is how governments respond to this vulnerability. We turn next to evidence on protective policies toward domestic agriculture.

2.4 Protective Policies

Despite their reliance on food imports, many countries often actively protect domestic agriculture. In practice, protective policies take the form of production subsidies to farmers or tariffs on imports of agricultural goods. In fact, the imposed tariffs on agricultural goods are often higher than in other industries (Huang et al., 2018). To document policy patterns across importing and exporting countries, we use data on a summary measure of agricultural protection, the nominal rate of assistance, compiled and maintained by (Anderson et al., 2011) for the World Bank. The nominal rate of assistance, is measured as the difference between the domestic farm-gate price and the world price of agricultural good, over the world price. Anything driving a wedge between farm-gate price and world price (excluding transport costs, distribution costs) is in the nominal rate of assistance, and thus captures distortions to farmer prices from: (i) domestic subsidies; (ii) border measures. If this rate is positive, it is a subsidy and if it is negative it is a tax. The nominal rate of assistance is available by country and by agricultural product over several years. In Table 2.4 the average nominal rate of assistance over 2000-2011 by import status and bracket of real GDP per capita. Net importers protect agriculture more than net exporters regardless of level of income. This observation may appear paradoxical at first glance given the dependence on food imports.

Motivated by the cross-country and micro-level evidence on the vulnerability associated with food imports, we next ask a broader question: how does the risk of trade shocks affect ex-ante patterns of sectoral production and trade across countries? To answer this question, in the next section, we develop a structural model to study the aggregate implications of

trade risk. Through the lens of our model, we also show that trade risk can rationalize why food importing countries may choose ex-ante to protect domestic agriculture to achieve food security.

3 A Model of Trade Risk and Structural Change

We develop a multi-country, multi-sector model of international trade with structural change, where suppliers of goods make sourcing decisions subject to risk. The global economy consists of N countries, indexed by $n \in \{1, ..., N\}$, with J sectors in each country, indexed by $j \in \{1, ..., J\}$. Each sector in each country produces a domestic sectoral variety that is sold both domestically and internationally. In addition, each sector in each country produces a sectoral good that is consumed domestically by aggregating the domestic sectoral variety with sector-specific varieties from every other country. Critically, the international sourcing of varieties is subject to trade risk. Sectoral goods are then aggregated into a final good that is consumed by households. Final goods are produced using a non-homothetic technology, leading to a systematic relation between the composition of consumption baskets and the level of economic development. Thus, each country is populated by the following agents: a producer of a domestic sectoral variety in each sector, a producer of sectoral goods in each sector, a producer of final goods, and a representative household.

3.1 Risk and timing

We begin by describing the source of risk and the timing of decisions in our model, and then proceed to describe each of the agents in the following subsections.

Trade risk As in standard models of international trade, international purchases are subject to trade costs that we model as bilateral sector-specific iceberg trade costs. These trade costs affect the sourcing decisions of producers of sectoral goods. But in contrast to standard models of international trade, international sourcing in our model is subject to trade risk. We model trade risk as connectivity shocks between countries that manifest in bilateral iceberg trade costs being stochastic.

Let S denote the set of possible states of the world, and let $s \in S$ denote an individual state of the world. Moreover, let $\pi(s)$ denote the probability that state $s \in S$ is realized. Given the only fundamentals subject to risk in our model are trade costs, we have that states of the world index trade costs: If state s is realized, importing one unit of sectoral

variety j from country n into country i requires purchasing $\tau_{in}^{j}(s) \geq 1$ units. Let $\mathcal{T}(s) = \left\{\tau_{in}^{j}(s)\right\}_{i\in N, n\in N}^{j\in J}$ be the array of all bilateral trade costs and sectors in state s.

To reduce the dimensionality of this object, note that the trade shocks can be further decomposed into a bilateral component and a sector-specific component:

$$\tau_{in}^{j}(s) = \overline{\tau}_{in}(s)\overline{\tau}^{j}(s).$$

Thus, if trade relations between countries i and n collapse, this can be captured by $\overline{\tau}_{in}(s) \to \infty$. If, on the other hand, trade in sector j collapses globally, this can be captured by $\overline{\tau}^{j}(s) \to \infty$.

Timing We study a static one-period model, where the period consists of two sub-periods: Before and after the trade cost shock is realized. We now describe the timing of events, and in the following subsections describe each stage in detail.

The following take place simultaneously before the shock is realized:

- **Producers of domestic sectoral varieties**: Hire labor, produce varieties, and sell them to producers of sectoral goods. Profits (losses) are transferred to (paid by) the household.
- **Producers of sectoral goods**: Purchase sectoral varieties domestically and internationally subject to risk.
- **Households**: Supply labor to producers of domestic sectoral varieties; earn labor income.
- **Market for labor clears**: Supply of labor from households equals demand for labor by producers of domestic sectoral varieties, pinning down the equilibrium wage in each country.
- **Market for domestic sectoral varieties clears**: Supply of domestic sectoral varieties equals demand for them by producers of sectoral goods across all countries, pinning down the equilibrium price of varieties in each sector and country.

The following take place simultaneously after the shock is realized:

- **Producers of sectoral goods**: Produce sectoral goods given trade cost realizations and sell them to producers of final goods. Profits (losses) are transferred to (paid by) the household.

- **Producers of final goods**: Produce final goods by purchasing sectoral goods. Profits (losses) are transferred to (paid by) the household.
- **Households**: Earn profits from all domestic producers; use total earnings to purchase final goods to be used for consumption.
- **Market for sectoral goods clears**: Supply of sectoral goods equals demand for sectoral goods by producers of final goods, pinning down the equilibrium price of sectoral goods.
- **Market for final goods clears**: Supply of final goods equals demand for final goods by households, pinning down the equilibrium price of final goods.

3.2 Producers of domestic sectoral varieties

Producers of domestic sectoral varieties in sector j of country i are endowed with a technology for producing differentiated country-specific varieties in sector j. The technology is constant returns to scale and uses only labor as an input:

$$y_i^j = z_i^j \ell_i^j,$$

where y_i^j is the total amount of the domestic sectoral variety that country i produces in sector j to be sold to all countries (including domestically), ℓ_i^j denotes the labor used to produce this variety, and z_i^j is a sector-specific productivity level in country i.

Producers of domestic sectoral varieties are representative within each sector and country. Thus, they choose labor to maximize profits subject to the production technology, taking the price and wages as given. All these choices and their respective payoffs take place prior to the realization of the shocks. Their problem is given by:

$$\max_{\ell_i^j} \pi_i^j = p_i^j y_i^j - w_i \ell_i^j$$

subject to

$$y_i^j = z_i^j \ell_i^j.$$

3.3 Producers of sectoral goods

In each country i, a sectoral good j is produced by a representative sectoral good producer using an Armington aggregator across country-specific sectoral varieties. The production

technology features constant elasticity of substitution (CES) and is given by:

$$Y_i^j(s) = \left[\sum_{n=1}^{N} \left[q_{in}^j(s)\right]^{\frac{\eta_j - 1}{\eta_j}}\right]^{\frac{\eta_j}{\eta_j - 1}}$$

where $q_{in}^j(s)$ is the quantity of the sectoral variety from sector j produced in country n consumed in i when shocks $s \in S$ are realized. The elasticity of substitution across varieties from different countries within a sector is $\eta_j > 0$. With $\eta_j > 1$, varieties from different countries are more substitutable than under Cobb-Douglas.

For quantity $q_{in}^j(s)$ of variety n in sector j to arrive and be consumed in country i in state of the world $s \in S$, the country of origin n has to produce and ship the following amount:

$$\widetilde{y}_{in}^j = q_{in}^j(s)\tau_{in}^j(s),$$

since iceberg costs imply that $\tau_{in}^j(s) - 1$ per unit melt in transit. Therefore, sectoral producers in country i have to place a *deterministic* order of $\widetilde{y}_{in}^j$ units prior to the realization of the shock to receive a *stochastic* quantity $q_{in}^j(s)$ that depends upon the realization of the state of the world.

The sectoral good producer in sector j and country i chooses how much to order of each variety, taking into account that the quantities delivered depend on the trade cost shock. As a result, they order varieties under trade cost risk by solving the following problem:

$$\max_{\{\widetilde{y}_{in}^j\}_{n=1}^N} \mathbb{E}\left\{u'\left[c_i(s)\right]\left[\Pi_i^j(s) = P_i^j(s)Y_i^j(s) - \sum_{n=1}^{N} p_n^j \widetilde{y}_{in}^j\right]\right\}$$

subject to

$$Y_i^j(s) = \left[\sum_{n=1}^{N}\left[\frac{\widetilde{y}_{in}^j}{\tau_{in}^j(s)}\right]^{\frac{\eta_j - 1}{\eta_j}}\right]^{\frac{\eta_j}{\eta_j - 1}},$$

where P_i^j is the sectoral price of good j in country i, and $u'\left[c_i(s)\right]$ weighs payoffs across states of the world according to the marginal utility of the owner of the firm, that is, the domestic representative household.

3.4 Producers of final goods

Within each country is a final good producer that aggregates sectoral goods and sells them as a final good to consumers. The production technology is defined implicitly by a non-homothetic CES function, as in Comin et al. (2021),

$$\sum_{j=1}^{J} b_i^j \left[\frac{Q_i^j}{Y_i^{\epsilon_j}} \right]^{\frac{\sigma-1}{\sigma}} = 1$$

where Y_i is the final good in country i, and Q_i^j is the amount of sectoral good j consumed in country i. b_i^j is a sectoral parameter that weights the contribution of sectoral good j to the final good in country i. The non-homotheticity parameter for sectoral good j, ϵ_j, controls the relative income elasticities of demand across goods. If $\epsilon_j = 1 \; \forall j$, then the technology is a standard CES technology with unit income elasticities of demand across all sectors.

The problem of final good producers is then given by:

$$\max_{Y_i(s), \left\{Q_i^j(s)\right\}_{j=1}^{J}} \Pi_i(s) = P_i(s) Y_i(s) - \sum_{j=1}^{J} P_i^j(s) Q_i^j(s)$$

subject to

$$\sum_{j=1}^{J} b_i^j \left[\frac{Q_i^j(s)}{Y_i^{\epsilon_j}(s)} \right]^{\frac{\sigma-1}{\sigma}} = 1.$$

Note that, given that all decisions and payoffs of the final good producers take place after the shocks are realized, its choices are not subject to risk. Yet, they do depend on the realized state of the world.

3.5 Households

In each country i there is a representative household that has monotonic preferences over consumption of the final good. We let preferences be sensitive to risk, so we model them as being of the constant relative risk aversion (CRRA) class, given by:

$$u\left(c_i\right) = \frac{C_i^{1-\gamma}}{1-\gamma}$$

where C_i denotes per capita consumption, and $\gamma > 0$ denotes the household's degree of relative risk aversion.

Households are endowed with L_i units of labor, which we also interpret as the total population of country i. The representative household in each country owns all firms, and as a result is entitled to their profits.

The representative household's budget constraint in country i in state of the world s is:

$$P_i(s)C_i(s) = w_i L_i + \Pi_i(s) + \sum_{j=1}^{J} \Pi_i^j(s) + \sum_{j=1}^{J} \pi_i^j$$

where the left-hand side denotes expenditures on final goods. The right-hand side consists of total labor income, which is independent of the state of the world given it is accrued prior to the realization of the shock, plus the total profits transferred from all firms.

3.6 Equilibrium

A competitive equilibrium in the world economy consists of prices and allocations such that the following conditions hold in each country i:

- Given prices and wages, households choose consumption optimally
- Given prices, producers of domestic varieties choose inputs and production optimally
- Given prices, producers of sectoral goods choose inputs and production optimally
- Given prices, producers of final goods choose inputs and production optimally
- Market for labor clears prior to the shock: $L_i = \sum_{j=1}^{J} \ell_i^j$
- Market for domestic sectoral varieties clears prior to the shock: $y_i^j = \sum_{n=1}^{N} \widetilde{y}_{ni}^j$
- Market for sectoral goods clears after the shock: $Q_i^j(s) = Y_i^j(s) \ \ \forall s$
- Market for final goods clears after the shock: $C_i(s) = Y_i(s) \ \ \forall s$

Throughout, we let wages in one country to be the numeraire (the United States in the quantitative analysis).

3.7 How risk affects international sourcing decisions

From the problem of the importer (sectoral good producer) we can show analytically that there is an ex-ante risk-return trade-off governing international sourcing decisions.

The solution to the importer's problem in sector j, in country i, with respect to variety n is characterized by a set of first order conditions:

$$\left(\widetilde{y}_{in}^{j}\right)^{-\frac{1}{\eta_j}} \mathbb{E}\left\{u'\left(C_i\right) P_i^j \left(Y_i^j\right)^{\frac{1}{\eta_j}} \left(\tau_{in}^j\right)^{\frac{1-\eta_j}{\eta_j}}\right\} = p_n^j \mathbb{E}\left[u'(C_i)\right].$$

Note that we omit the dependence of the variables on the realization of state of the world s whenever variables are within the expectations operator.

We denote the variety-specific trade cost term, weighted by the sectoral revenue term:

$$\varphi_{in}^j \equiv P_i^j \left(Y_i^j\right)^{\frac{1}{\eta_j}} \left(\tau_{in}^j\right)^{\frac{1-\eta_j}{\eta_j}}.$$

Then, the first-order conditions can be re-written as:

$$\left(\widetilde{y}_{in}^{j}\right)^{-\frac{1}{\eta_j}} \mathbb{E}\left\{u'(C_i)\varphi_{in}^j\right\} = p_n^j \mathbb{E}\left[u'(C_i)\right]$$

or, equivalently, as:

$$\left(\widetilde{y}_{in}^{j}\right)^{-\frac{1}{\eta_j}} \mathbb{E}\left(\varphi_{in}^j\right) \mathbb{E}\left\{\frac{u'(C_i)}{\mathbb{E}\left[u'(C_i)\right]} \frac{\varphi_{in}^j}{\mathbb{E}\left(\varphi_{in}^j\right)}\right\} = p_n^j. \tag{1}$$

Then, the definition of the covariance operator implies we can rewrite the expression as:

$$\begin{aligned}\mathbb{E}\left\{\frac{u'(C_i)}{\mathbb{E}\left[u'(C_i)\right]} \frac{\varphi_{in}^j}{\mathbb{E}\left(\varphi_{in}^j\right)}\right\} &= \mathbb{E}\left\{\frac{u'(C_i)}{\mathbb{E}\left[u'(C_i)\right]}\right\} \mathbb{E}\left\{\frac{\varphi_{in}^j}{\mathbb{E}\left(\varphi_{in}^j\right)}\right\} + \mathbb{C}\left\{\frac{u'(C_i)}{\mathbb{E}\left[u'(C_i)\right]}, \frac{\varphi_{in}^j}{\mathbb{E}\left(\varphi_{in}^j\right)}\right\} \\ &= 1 + \mathbb{C}\left\{\frac{u'(C_i)}{\mathbb{E}\left[u'(C_i)\right]}, \frac{\varphi_{in}^j}{\mathbb{E}\left(\varphi_{in}^j\right)}\right\} \equiv 1 + \mu_{in}^j\end{aligned}$$

where $\mathbb{C}$ denotes the covariance operator, and μ_{in}^j is the covariance of the household's marginal utility with the weighted bilateral sector-specific trade cost term, which can be interpreted as the risk premium. Then we can re-write the set of first-order conditions of the sectoral good producer as:

$$\left(\widetilde{y}_{in}^{j}\right)^{-\frac{1}{\eta_j}} \mathbb{E}\left(\varphi_{in}^j\right)\left(1 + \mu_{in}^j\right) = p_n^j$$

This set of equations is key for characterizing sourcing decisions under risk. Sectoral producers equate the expected marginal product to the marginal cost of ordering a unit of imported variety n. As in the case of certainty this choice depends on the marginal cost of production

in n (which captures productivity advantage), and the trade cost of delivering the variety from country n to country i. Under risk, however, this choice also depends on the covariance of the household's marginal utility of consumption and the trade cost term, the risk premium μ_{in}^j. If μ_{in}^j is positive and high then this implies that the trade costs are low when the marginal utility of consumption is high, implying that the variety from country n is less risky, and other things equal the importer would want to source more of this variety.

Given this characterization, the relative demand for orders in country i and sector j, for the varieties of countries k and n is given by,

$$\frac{\widetilde{y}_{ik}^j}{\widetilde{y}_{in}^j} = \left(\frac{\frac{p_k^j}{\mathbb{E}\left(\varphi_{ik}^j\right)\left(1+\mu_{ik}^j\right)}}{\frac{p_n^j}{\mathbb{E}\left(\varphi_{in}^j\right)\left(1+\mu_{in}^j\right)}} \right)^{-\eta_j}$$

This implies that country i in sector j will order relatively more from the country that has a lower cost of production (lower p_n^j), a lower expected weighted trade cost (higher $\mathbb{E}[\varphi_{in}^j]$), and is less risky (higher μ_{in}^j). The last of these is what is specific to the choice under trade risk, not present in standard analyses of import choices.

If $i = k$, then this condition says that with risk, the sectoral producer can shift spending from risky imported varieties to safer domestic ones despite the productivity advantage of foreign producers, capturing the idea of "re-shoring." Intuitively, the shift to domestic production is a self-insurance mechanism against trade risk (pre-cautionary motive). However, this insurance can be costly from a macroeconomic perspective, if the country has low productivity in agriculture.

The risk premia affect not only the extent of trade (domestic vs. foreign) but also the composition of trade, that is who you trade with. Our model implies that an importer might be willing to source goods from a country that is more expensive but less risky, capturing the idea of "friend-shoring."

4 Estimation

Our strategy to quantify the role of trade risk is as follows. First, we estimate the model without risk to the observed sectoral patterns of production and trade, described in this section. Then, we introduce risk and examine how it affects sectoral production, trade, food security and welfare, as described in Section 5.

Our quantitative implementation has three sectors in each country: agriculture ($j = a$),

manufacturing ($j = m$) and services ($j = s$). We estimate the equilibrium of the model across 71 countries (including a rest-of-the-world aggregate), that have data available and a population of at least one million.

We use consistent data across countries for the year 2018 from multiple sources. Bilateral trade flows by sector across all country pairs come from the Trade in Value Added (TiVA) database of the OECD. We use data from the Food and Agricultural Organization of the United Nations (FAOSTAT) on product-by-product imports, exports and production to estimate for each country total agricultural trade imbalances. Sectoral expenditure data and prices by country are sourced from the World Bank's International Comparison Program. Finally, we use additional aggregate data by country, such as population counts, from the World Bank's World Development Indicators.

Pre-determined parameters We set a number of the parameters to values used in previous studies. The set of predetermined parameter values we choose along with their description are provided in Table 4. The elasticity of substitution across varieties within sectors η_j is set to 6 for both agriculture and manufacturing. Broda and Weinstein (2006) estimate an average elasticity across industries at the 3-digit level ranging from 7 (1972-1988) to 4 (1990-2001). Their reported average numbers are higher at the 5-digit level and for commodities. Simonovska and Waugh (2014) find trade elasticities at the macro level around 4. Another key elasticity in our model is the elasticity of substitution across broad sectors σ. Duarte and Restuccia (2010) estimate an elasticity of 0.4 between manufacturing and services. Sposi et al. (2022) estimate an elasticity across agriculture, manufacturing, services in final consumption of 0.23. In Comin et al. (2021), the point estimate from the CEX (with fixed effects) is 0.31, and across countries (with fixed effects) it is 0.50. Herrendorf et al. (2013) estimate a higher elasticity of around 0.85-0.89. Given the range of values we choose the elasticity of substitution across sectors to be 0.50, which implies that sectors are complements. We normalize the non-homotheticity parameter in manufacturing to 1, and choose the one in agriculture $\varepsilon_a = 0.10$, which implies that food is a necessity good. This choice is consistent with the estimate of Comin et al. (2021) across countries, with sector and country fixed effects. Finally, we set the coefficient of relative risk aversion in the household's utility function to 2, as standard in macro studies.

Multi-country estimation Given the predetermined parameters described above, the model parameters that remain to be estimated for each country are: (i) sectoral productivities z_i^j; (ii) bilateral sector-specific trade costs τ_{in}^j; (iii) sectoral good preference parameters by country b_i^j; (iv) population size by country L_i. We measure L_i directly from the data

Predetermined parameters

Parameter	Value	Description
γ	2	Risk aversion
$\{\eta_j\}_{j\in\{a,m\}}$	6	Elasticity within sectors (substitutes)
σ	0.50	Elasticity across sectors (complements)
ε_m	1.00	Mfct. Non-homotheticity
ε_a	0.10	Agr. Non-homotheticity

by each country's population. We then estimate the above parameters to match each country's bilateral trade flows across sectors (including domestic purchases), sectoral expenditure shares, and sectoral relative prices.

We implement this estimation approach by deriving a system of analytical expressions in the economy without risk that maps estimable parameters to data targets, and we use this system to back out the parameters of the model. In particular, the estimated parameters imply the model with no risk matches all target moments exactly. Then, our estimation approach implies the estimated model matches cross-country sectoral production patterns and aggregate GDP per capita despite not targeting these moments directly.

We now illustrate how the parameters can be backed out directly from feeding data into analytical expressions implied by the solution of the model. For instance, we back out relative productivities from relative sectoral prices and relative domestic absorption rates (measured as production less trade),

$$\frac{z_i^k}{z_i^j} = \frac{P_i^j}{P_i^k}\left(\frac{\theta_{ii}^j}{\theta_{ii}^k}\right)^{\frac{1}{1-\eta_j}}$$

We back out trade costs from relative import shares and income,

$$\frac{\theta_{in}^j}{\theta_{ii}^j} = \left(\frac{w_n/z_n^j}{w_i/z_i^j}\right)^{1-\eta_j}\left(\tau_{in}^j\right)^{1-\eta_j}$$

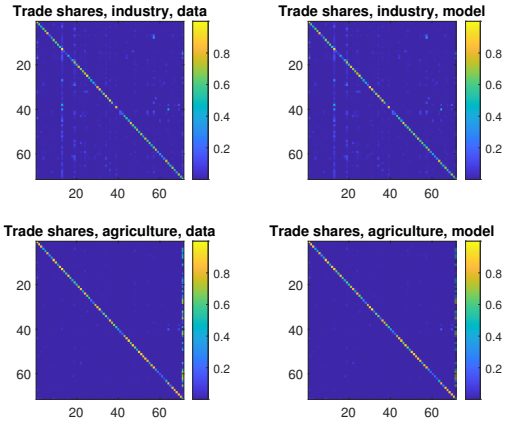
Back out sectoral preference weights from relative sectoral expenditure shares, relative prices and income,

$$\left(\frac{e_i^j}{e_i^k}\right)^{\frac{1}{\sigma}}\frac{P_i^j}{P_i^k} = \frac{b_i^j}{b_i^k}\left[\frac{w_i}{P_i}\sum_{r=1}^{J}\varepsilon_r e_i^r\right]^{\frac{(1-\sigma)}{\sigma}(\varepsilon_j-\varepsilon_k)}$$

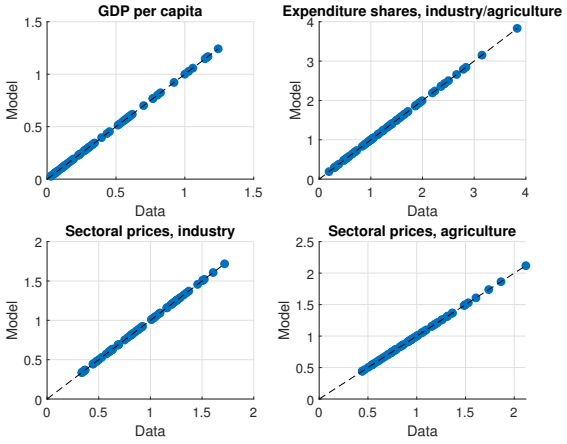
One issue that arises for implementing our estimation approach is that trade is balanced

Figure 4: Target Moments: Model vs. Data

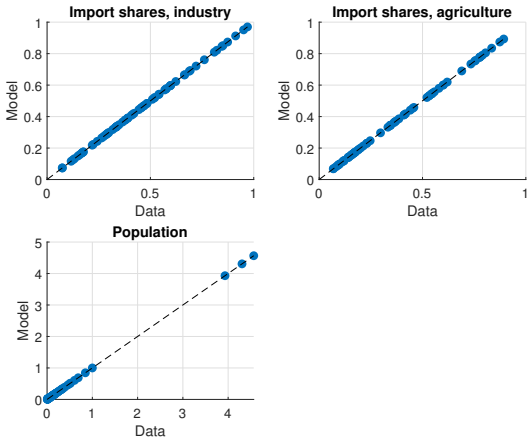
Panel A: Bilateral Trade Shares



Panel B: Sectoral Shares, Prices, GDP per capita

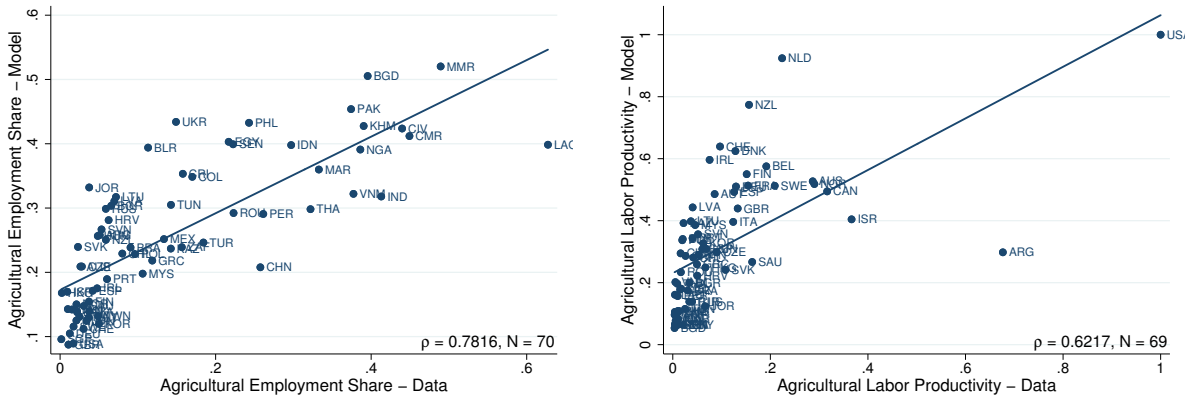


Panel C: Import Shares, Population



Notes: Comparing targeted moments from model without risk to the data.

Figure 5: Non-Target Moments: Model vs. Data



A: Agric. Employment Share B: Agric. Labor Productivity

Notes: The data values for "Agric. Employment Share" and "Agric. Labor Productivity" are taken directly from the World Development Indicators, with the latter measured as agricultural value added per worker. The model values are the ones implied by the trade equilibrium of the estimated model. Agricultural labor productivity in both model and data are relative to the US.

at the country level in our model, whereas this is not the case in the data. To execute our estimation approach and to ensure that the estimated parameters reproduce the target moments exactly, we rebalance the trade flow data to ensure trade is balanced in the aggregate. We do so while ensuring that agricultural sectoral imbalances are preserved.

Our estimation approach exactly matches the targeted data. In Panels A, B and C of Figure 4 we plot the equilibrium moments implied by the model against those targeted in the data. In addition, our estimation procedure is successful in lining up with non-targeted moments directly from the data. In Figure 4 we plot the share of employment in agriculture (Panel A) and agricultural labor productivity (Panel B) implied by the estimated model against the values of these variables in the data. The data values are from the World Development Indicators and agricultural labor productivity is measured as agricultural value added per worker. Agricultural productivity in both the data and the model are reported relative to the United States.

5 Quantitative Results

We use the estimated model to quantitatively assess the effects of trade risk on trade flows, sectoral patterns of production, food insecurity and welfare across countries. In our main experiment, we quantify the effects of the chance of an abrupt trade disruption, which we

model as a low-probability high-impact event in which countries risk reverting to autarky. We think of this exercise as a stress test of current patterns of sectoral production and trade under tail trade risk. In Appendix C, we quantify the effects of the observed volatility in real shipping freight rates, as a specific risk factor that directly maps into the stochastic trade costs in our model. Given the recurrent fluctuations of real freight rates, this experiment captures the role of one type of cyclical trade risk.

5.1 Main Experiment

We introduce trade risk into our baseline estimated model and solve for the new competitive equilibrium. We then compare this equilibrium with risk to the benchmark outcomes under a riskless open economy. Specifically, we consider two possible states of the world: with probability π, the global economy remains open and bilateral sector-specific trade costs equal their estimated values; with probability $1-\pi$, countries revert to autarky, i.e., $\tau_{ij} \to \infty$ for all i, j.

We estimate the trade disruption probability in international food trade, $(1-\pi)$, by drawing on the historical incidence of import disruptions and the recent spikes in the geopolitical risk and trade policy uncertainty indices, documented in Section 2.1 above.[7] We first estimate the effect of geopolitical risk and trade policy uncertainty on the probability of import disruptions in food trade over the entire period 1985-2023. We then combine the estimated conditional probabilities with the geopolitical risk and trade policy uncertainty indices since 2022, to calculate the predicted chance of a food trade disruption, over a period of elevated risks. The details of our estimation are in Appendix B. The predicted probability of a trade disruption from the jointly estimated model is 10.5 percent. Based on this, along with the historical incidence of import disruptions of 9.5 percent documented in Section 2.1, we anchor the probability of trade breakdown in our main experiment at 10 percent ($\pi = 0.90$).

We begin by reporting average effects by food import status—on trade flows, sectoral production, food security, and welfare. We then explore cross-country heterogeneity in these effects, leveraging differences in trade patterns, sectoral productivities, GDP per capita, population size, and sectoral expenditure shares. In particular, we examine how the impact of tail risk varies with the magnitude of countries' agricultural trade imbalances.

[7] This hybrid approach blends the macroeconomics rare-disasters literature (e.g., Barro and Ursúa, 2012) with the more recent geopolitical risk and trade policy uncertainty indices literatures (Caldara and Iacoviello, 2022; Caldara et al., 2020).

Table 2: Average Effects of Trade Risk

	Food Importers		Food Exporters	
	BE	**w/ Risk**	**BE**	**w/ Risk**
Aggregate Import Share (%)	34.7	-13.8	32.6	-11.3
Agricultural Labor share (%)	21.1	+7.9	29.8	-2.2
Food Insecurity (ratio)				
Food Consumption (open/closed)	–	1.65	–	1.13
Rel. Food Price (closed/open)	–	2.21	–	0.66
Welfare costs of risk (%)	–	-11.4	–	-7.0

Note: Average effects from tail trade risk, for food importers (first two columns) and food exporters (next two columns). "BE" refers to the levels in the estimated benchmark open economy without risk. "w/ Risk" refers to the change from the introduction of tail trade risk relative to the benchmark economy. Levels and changes are weighted averages within import status groups, where the weights are the relative magnitude of the countries' agricultural trade imbalances.

5.2 Average effects of trade risk

Table 2 reports the average effects of tail trade risk by food import status in the riskless open benchmark economy ("BE"), distinguishing between net food importers and net food exporters. The first and third columns show the average levels of key outcomes in the benchmark economy for each group, while the second and fourth columns show average changes induced by the introduction of risk. All statistics are weighted averages across countries within each group, using weights based on the relative magnitude of each country's agricultural trade imbalance.

The changes in the aggregate import share in response to trade risk, for both importers and exporters, indicate that risk discourages international trade. This withdrawal from trade acts as a form of self-insurance: countries, driven by a precautionary motive, internalize trade risk by reducing trade in order to mitigate the potential costs of entering a bad state.

This in turn, has important implication for the sectoral composition of the economy. In particular, trade risk raises domestic agricultural production for net importers of agricultural goods, with the share of labor in agriculture increasing by 7.9 percentage points on average. Conversely, it reduces agricultural production among net exporters, who no longer need to produce as much for export—resulting in a decline of 2.2 percentage points on average.

We report the effect of trade risk on two metrics of food insecurity: the dispersion of food consumption and the dispersion in the relative price of food. We define consumption dispersion as the ratio of consumption levels in the "good" state—where the economy remains

open—to the "bad" state—where the economy reverts to autarky and goods fail to arrive. Price dispersion is defined analogously, as the ratio of relative food prices between the bad and good states. Table 2 shows that trade risk increases both types of dispersion by lowering consumption and raising prices in the bad state. Intuitively, border closures are costly because the expected goods do not arrive. As a result, trade risk directly undermines food security, particularly for net importers of food.

We measure the welfare costs of trade risk as the compensating equivalent change in consumption that would make households in the open, riskless economy as well off as those in the economy with risk. Specifically, we ask: by how much would consumption in the open economy without risk need to adjust for utility to match that in the economy with risk? The last row of Table 2 shows that trade risk leads to substantial welfare losses, which are larger on average for net food importers. In our framework, these losses arise both from increased food insecurity—which directly lowers utility—and from the reduced benefits of trade, as countries engage less in international exchange. The magnitude of welfare losses depends on how intensively countries trade in the riskless benchmark. Since food security is also more volatile for importers, they experience especially large declines in welfare.

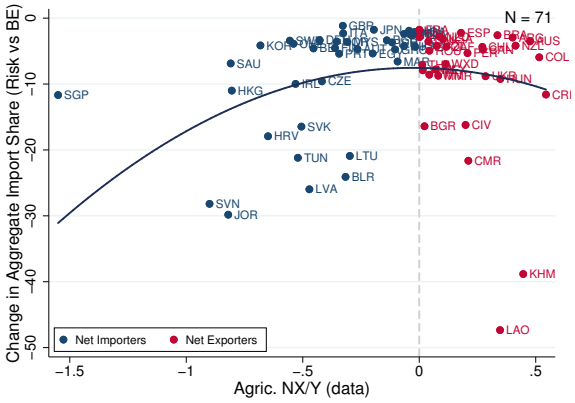
5.3 Cross-country effects of trade risk

After examining the average effects of trade risk by agricultural import status, we next report the changes in trade patterns, production, food security, and welfare for all countries. The country-level results reflect the rich heterogeneity in sectoral productivities and expenditures, trade patterns, income, and population across the 71 countries in our dataset. Given the role of agricultural trade imbalances in our framework, we report the results for the key variables of interest against each country's agricultural net exports as observed in the data and reproduced in the model without risk, using a series of scatter plots. This allows us to discern cross-country patterns in how the effects of trade risk vary with the extent of trade exposure.

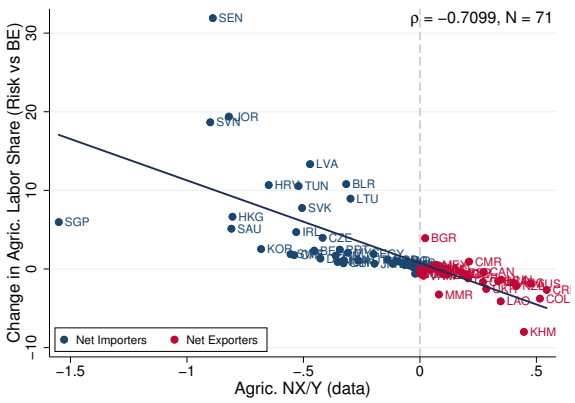
Aggregate Import Share Figure 6, Panel A plots the country-by-country change in the aggregate import share between the equilibrium with risk and the riskless open benchmark economy, against each country's agricultural net exports–to–output share in the data (i.e., in the benchmark economy). The figure compares, at the country level, how import shares respond to the introduction of trade risk. In all cases, countries reduce their overall trade relative to the riskless economy. Importantly, the largest reductions occur among countries that were most actively engaged in trade—whether as large net importers or large net

Figure 6: Imports and Sectoral Composition

A. Change in Aggregate Imports



B. Change in Agricultural Employment



Notes: "Change in Aggregate Import Share (Risk vs BE)" and "Change in Agric. Labor Share (Risk vs BE)" refer to the country-by-country difference between the equilibrium in the economy with risk and that of the riskless open benchmark economy, for the import share and the agricultural employment share respectively. "Agric. NX/Y (data)" is the agricultural net exports to output ratio in the data (benchmark economy).

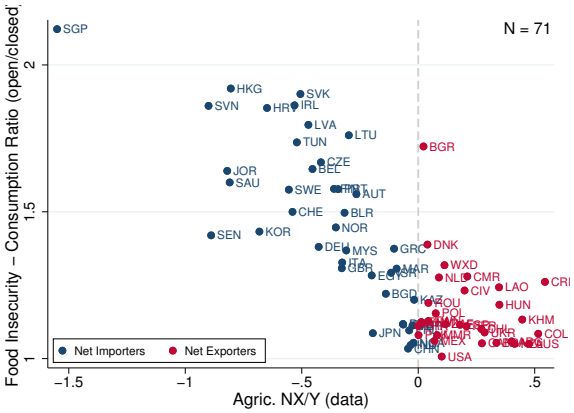
exporters—producing an inverted U-shaped relationship between trade exposure and the impact of risk.

Agricultural Employment Share Figure 6, Panel B shows the country-by-country change in the equilibrium share of employment in agriculture between the economy with risk and the riskless open economy. With trade risk, all countries that are net importers in the benchmark economy increase their agricultural employment share, while all net exporters reduce it. This reallocation reflects a precautionary response: countries that rely heavily on food imports shift labor toward domestic production to insure against the risk of losing access to foreign supply. Conversely, net exporters no longer face the same demand from abroad and scale back agricultural activity. Moreover, these changes are systematically related to the size of agricultural trade imbalances: the countries that experience the largest increases in agricultural employment are those with the largest net import positions, highlighting the importance of the misalignment between the domestic expenditure share and the domestic output share in agriculture.

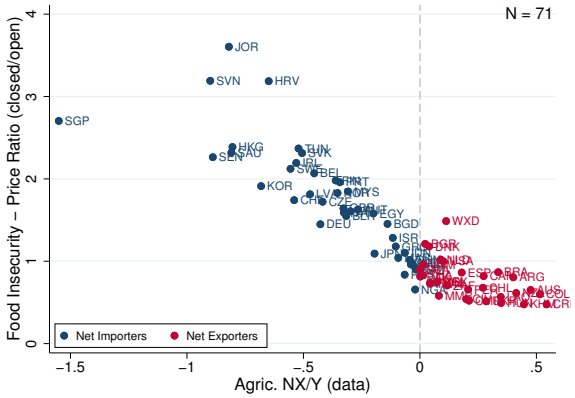
Food Insecurity We examine two metrics of food insecurity generated by the model. The first is a measure of consumption dispersion, defined as the ratio of consumption in the good state—i.e., when the economy remains open—to consumption in the bad state, when the economy reverts to autarky. The second is a measure of price dispersion, defined as the ratio

Figure 7: Food Insecurity

A. Consumption Dispersion



B. Relative Price Dispersion

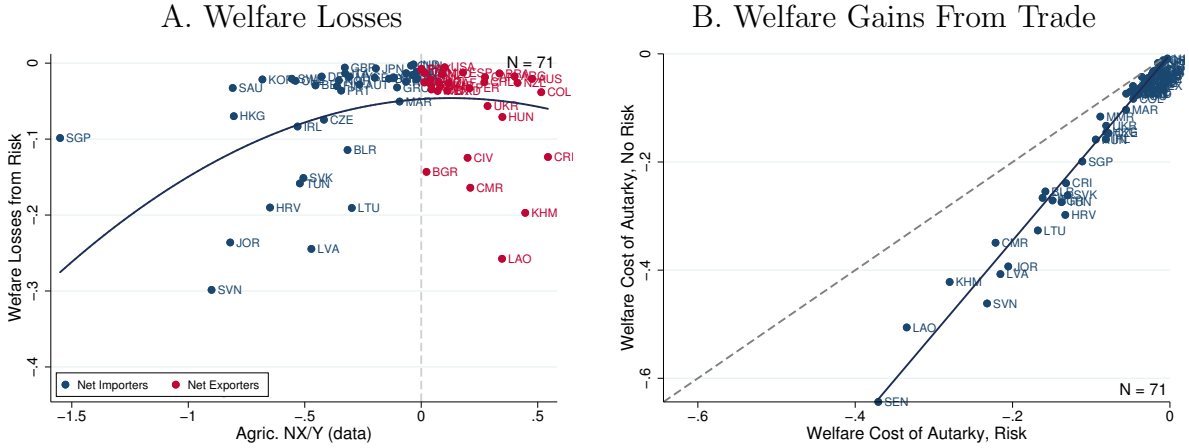


Notes: "Consumption Ratio (open/closed)" refers to the ratio of consumption if the good (open economy) state occurs relative to if the bad state (autarky) occurs. "Price Ratio (closed/open)" refers to the ratio of the relative price of agricultural goods in the bad relative to the good state. "Agric. NX/Y (data)" is the agricultural net exports to output ratio in the data (benchmark economy).

of the relative price of agricultural goods in the bad state to that in the good state. Figure 7 plots these two measures—consumption dispersion in Panel A and price dispersion in Panel B—against each country's agricultural trade imbalance. Introducing trade risk worsens food security outcomes under both metrics for all countries. However, both the average level of food insecurity and its within-group dispersion are higher among net importers than among net exporters. This reflects the fact that when risk materializes, importers lose access to foreign food supply and must rely on insufficient domestic production, resulting in sharp declines in consumption and spikes in food prices. We note that the higher level and dispersion of food insecurity for importers our model produces in the face of trade risk are qualitatively consistent with the evidence in Figure 2.2 we documented in Section 2.2.

Welfare Losses We measure each country's welfare loss from trade risk as the compensating equivalent change in utility between the equilibrium of the riskless open economy and that of the economy with risk. Figure 8, Panel A plots these country-level welfare losses against agricultural trade imbalances. Risk leads to welfare losses for all countries relative to the riskless open economy, with the largest losses occurring in countries most actively engaged in trade. These losses vary with both the extent of food insecurity introduced by risk and the scale of the reduction in international trade. The withdrawal from trade, in turn, implies forfeiting the gains from openness captured by the model—comparative advantage, specialization, and access to a broader range of imported goods.

Figure 8: Welfare



Notes: "Welfare Losses from Risk" refers to the compensating equivalent change in utility between the economy with risk and the riskless open benchmark economy. "Agric. NX/Y (data)" is the agricultural net exports to output ratio in the data (benchmark economy). "Welfare Cost of Autarky, No Risk" and "Welfare Cost of Autarky, Risk" refer to the country-by-country welfare losses from moving from on open economy to autarky under no risk and under risk respectively.

Risk and the Welfare Gains from Trade We next examine how trade risk affects the welfare gains from international trade. These gains are measured as the compensating equivalent change in consumption that would make a household in a given country indifferent between the economy with trade risk and one with permanent autarky. That is, we ask how much consumption a country would be willing to sacrifice to avoid transitioning to a world in which trade is fully and permanently shut down. This welfare cost of autarky captures the potential gains from trade. We then compare these gains in the economy with trade risk to those in the riskless benchmark economy. It is important to distinguish this measure from the welfare cost of risk discussed earlier, which reflects the drop in consumption needed to make households in the riskless open economy as well off as in the economy with risk. While both are expressed in consumption-equivalent terms, they capture distinct counterfactuals: one reflects the value of access to trade, the other captures the cost of uncertainty surrounding that access.

In Figure 8, Panel B we plot the cross-country welfare losses from moving to autarky in the riskless benchmark economy (vertical axis) against the losses from moving to autarky in the economy with risk (horizontal axis). We add a solid best-fit line and a dashed 45-degree line. If the welfare gains from openness were the same with and without risk, then all countries would lie on the 45-degree line. However, as is clear from the figure, all countries fall below the 45-degree line, implying that the welfare gains from openness are smaller under

risk for all countries.

There are two reasons why the welfare gains from trade are lower under risk. First, even if countries do not adjust how much they trade, their expected welfare gains decline due to the possibility of losing access to imported goods—an especially costly outcome for essential sectors. Second, in the presence of risk, countries internalize this possibility and reduce their trade engagement as a form of self-insurance. As a result, both the direct cost of uncertainty and the endogenously reduced trade flows lower the measured gains from openness. These risk-related frictions may discourage countries from fully integrating into global markets.

While all countries experience smaller gains from trade under risk than in its absence, the slope of the trend line indicates that these effects are not uniform. The countries with the largest declines in welfare gains from openness are those that reduce their trade participation the most in response to risk, regardless of their agricultural trade imbalance. This relationship can be seen by comparing Figure 8, Panel B to Figure 6, Panel A. Intuitively, these are the countries that, in a risk-free world, stood to gain the most from trade.

6 Optimal Policies

The analysis so far has shown how private agents respond to trade risk: importers internalize the possibility of disrupted food supplies by sourcing less from abroad and producing more domestically. Yet, in practice, governments in food-importing countries — paradoxically — reinforce this retreat from trade through tariffs on food and subsidies to domestic farmers, as documented in Section 2.4. Can such protective policies be rationalized within our model? If private agents already internalize trade risk, might there be a misalignment between private and public evaluations of risk that creates additional motives for governments to intervene?

To address these questions, we proceed in two steps. First, we study a one-sector version of our model and analytically characterize optimal tariffs under risk, contrasting them with the policies governments would choose in a riskless economy. This highlights the additional insurance incentives for protection that emerge when governments face the risk of losing access to imported food. Second, using the full estimated model, we quantify optimal tariffs and subsidies country by country.

6.1 Optimal Policy Problem

We now turn to the normative question of how a country exposed to trade–cost risk should set policy to maximize domestic welfare. In our framework, trade risk affects both the level

and variability of consumption across states, creating scope for policy to influence outcomes through its impact on ex ante sourcing decisions and the resulting allocation of resources across states of the world.

We focus on the unilateral problem of a domestic policymaker who can set a uniform ad valorem import tariff—applied to agricultural imports—or, equivalently, a production subsidy for domestic agriculture. The policymaker takes the rest of the world's behavior as given and recognizes that any policy choice will influence sourcing and production decisions before trade–cost shocks are realized, and thereby the pattern of consumption and prices after the shocks occur.

Formally, the policymaker in country i chooses policy instrument t to

$$\max_{t} \ \mathbb{E}_s \left[\frac{C_i(s)^{1-\gamma}}{1-\gamma} \right],$$

subject to the decentralized equilibrium conditions described in Section 3. Here $C_i(s)$ denotes state–contingent per–capita consumption, which depends on labor income, tariff revenues rebated or subsidy-financing taxes charged to households, and firm profits, all relative to the state–contingent price of final goods.

The objective assigns higher weight to states in which marginal utility is high. Through its effect on sourcing and production, the policy instrument t shapes both the average level of consumption and its dispersion across states. In the subsections that follow, we characterize the optimal policy in a tractable special case and then quantify its magnitude in the estimated multi–country model.

6.2 Analytical characterization of optimal tariff

We begin by characterizing unilateral optimal policy analytically in a one-sector version of our model that only abstracts from the multi–sector layer and the associated non–homothetic preferences of the full model. All other features remain as in the baseline framework: CES aggregation of domestic and imported varieties, iceberg trade costs are stochastic, sourcing decisions are made before the realization of shocks. We also focus here exclusively on uniform ad valorem import tariffs, with tariff revenues rebated lump-sum to the representative household. This allows us to provide a sharp characterization of the forces shaping policy incentives. In the quantitative section we numerically solve for both tariffs and production subsidies in the full model.

We highlight the key equations here, with the full derivation provided in Appendix **??**.

Let M_i denote total imports of country i, α_{in} the ex–ante import share from country n, and $\widehat{\theta}_{in}$ the risk–adjusted share of global demand for variety n. The planner's first–order condition for the optimal tariff t can be written as

$$\mathbb{E}_s\left[\frac{u'(C_i(s))}{\mathbb{E}_s[u'(C_i(s))]}\left(\frac{dY_i(s)}{dt}-\frac{1}{P_i(s)}\frac{dM_i}{dt}\right)\right]=0,$$

where $Y_i(s)$ is state–contingent output and $P_i(s)$ is the price of the final good. The planner chooses the optimal tariff taking as given the structure of the world economy and accounting for the equilibrium responses of global prices and domestic quantities to the tariff. Using the equilibrium sourcing responses of the final good producer and the changes in the prices of imported varieties to the tariff, we can trace the effect of the tariff on the aggregate output index and total imports,

$$\frac{dY_i(s)}{dt}=-\eta\cdot Y_i(s)^{\frac{1}{\eta}}\cdot M_i\cdot\sum_{n\neq i}\alpha_{in}\cdot\chi_{in}(s)\cdot\left(1-\widehat{\theta}_{in}\right),$$

$$\frac{dM_i}{dt}=\frac{1}{1+t}\left\{(\eta-1)\sum_{n\neq i}p_n\tilde{y}_{in}\widehat{\theta}_{in}-\eta M_i\right\}.$$

where $\chi_{in}(s)$ is the risk-adjusted delivered-cost weight for source n in state s. Substituting $\frac{dY_i(s)}{dt}$ and $\frac{dM_i}{dt}$ into the planner's condition yields the optimal tariff under risk,

$$1+t^{risk}=\frac{\left[(\eta-1)\sum_{n\neq i}\alpha_{in}\widehat{\theta}_{in}-\eta\right]\cdot\mathbb{E}_s\left[\frac{u'(C_i(s))}{\mathbb{E}_s[u'(C_i(s))]}\frac{1}{P_i(s)}\right]}{\eta\cdot\mathbb{E}_s\left[\frac{u'(C_i(s))}{\mathbb{E}_s[u'(C_i(s))]}\cdot Y_i(s)^{\frac{1}{\eta}}\cdot\sum_{n\neq i}\alpha_{in}\cdot\chi_{in}(s)\cdot\left(\widehat{\theta}_{in}-1\right)\right]}. \tag{2}$$

According to the optimal tariff formula under risk (2), there are three motives for country i to impose tariffs. First, to manipulate the terms of trade in favor of country i (first term in the numerator), by exploiting the country's market power captured in the optimal tariff by $\widehat{\theta}_{in}$ and α_{in}. Note, that this motive is not unique to the case under risk, as it is also present, and in fact stronger, in the no-risk case where country i endogenously trades more.

The second motive for tariffs under risk is to use tariff revenue as insurance for domestic consumers in bad (high marginal utility) states of the world (second term in the numerator). The state–contingent value of tariff revenue is measured by the term $\mathbb{E}_s[u'(C_i(s))/P_i(s)]$ relative to its mean. Even though tariff revenues are fixed in nominal terms ex ante, their real value varies across states. When revenue is worth more in bad states—because prices are lower or marginal utility is higher—this channel increases the optimal tariff relative to the no–risk case, as the policy provides a form of consumption insurance. This channel however

is fairly weak, given that less trade happens ex-ante with risk.

The third is a pre-cautionary insurance motive for tariffs (the denominator): is to secure enough consumption for domestic households in the event of a trade disruption, by shifting spending ex-ante from unreliable risky imports to safer domestic production.[8] This substitution from imports to domestic production reduces exposure to the trade risk, and can be thought of as the pre-cautionary insurance motive of the tariff. While in equilibrium private agents (final good producers) internalize the trade risk when ordering varieties, they underweigh the risk because they do not take into account the effects of their sourcing choices on market prices and aggregate risk exposure. The planner internalizes both the overall risk exposure and the pecuniary general equilibrium externality, and raises the tariff to cut back further on orders of risky goods.

In the absence of trade risk, $P_i(s)$ and $u'(C_i(s))$ are constant across states and $\widehat{\theta}_{in} = \theta_{in}$. As we show in Appendix **??**, The optimal tariff formula in the absence of risk reduces to,

$$1 + t^{no-risk} = \frac{(\eta - 1)\sum_{n \neq i} \alpha_{in}\theta_{in} - \eta}{\eta \cdot \sum_{n \neq i} \alpha_{in}\theta_{in} - \eta},$$

which we show is the expression for the optimal tariff in an Armington model with market power. In this benchmark, the only force shaping the optimal tariff is the classic terms–of–trade motive: the ability to improve the relative price of imports by restricting demand when the country has monopsony power. Trade risk generally lowers $\widehat{\theta}_{in}$ relative to the no–risk share θ_{in}, weakening this channel. In addition, as explained above the optimal tariff under risk highlights the insurance role of tariffs through tariff revenue and pre-cautionary deterrence of imports.

6.3 Quantifying Optimal Policies

We now quantify the optimal trade and industrial policies in the full estimated model. The exercise solves the planner's problem for each country, using the full multi–country, multi–sector environment and the trade–risk process analyzed in Section 5. We consider two instruments separately: a uniform ad valorem import tariff on agricultural goods and a uniform production subsidy to domestic agriculture. In both cases, revenues or costs are rebated or financed lump sum to the representative household, and the behavior of the rest of the world is held fixed.

[8] Strictly speaking, the denominator is the marginal deadweight loss weighted by state utility. Under risk, imports shrink in bad states anyway, so the extra distortion from a tariff is smaller precisely when marginal utility is high. That makes the tariff more attractive relative to no risk.

Table 3: Optimal import tariffs by agricultural trade status

Country	No risk, autarky	No risk, open	Risk	Difference (risk – no risk)
Net importer of food (L)	0.00%	14.4%	28.3%	13.9%
Net exporter of food (H)	0.00%	13.7%	19.7%	6.0%

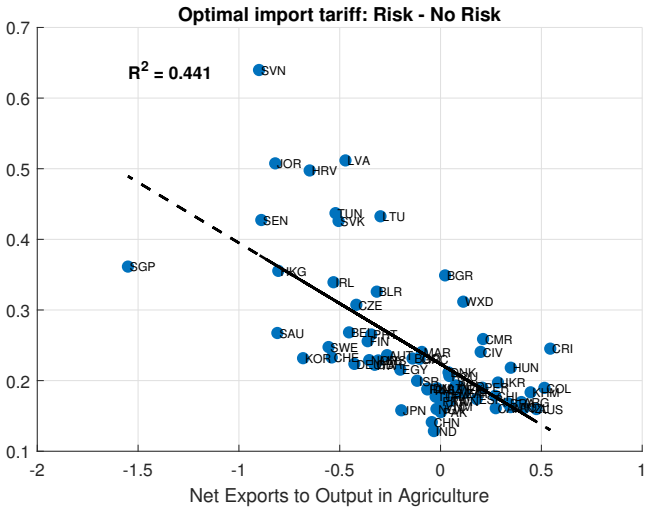


Figure 9: Change in optimal import tariff (risk – no risk) vs. agricultural net exports

Table 3 reports optimal import tariffs for net food importers and exporters under three environments: autarky without risk, open economy without risk, and open economy with risk. The final column shows the difference between the risk and no–risk open–economy tariffs. In the absence of risk, optimal tariffs are sizeable in both groups, reflecting the standard terms–of–trade motive. Introducing trade risk raises the optimal tariff in both cases, but the increase is substantially larger for net importers of food (13.9 percentage points) than for net exporters (6.0 percentage points). This pattern is consistent with the analytics in Section 6b: the insurance value of tariff revenue and the pattern of distortions across states are more important for countries that rely heavily on food imports.

Figure 9 plots the change in the optimal tariff between the risk and no–risk cases against the net exports to output ratio in agriculture. Countries with larger agricultural trade deficits raise tariffs more under risk, consistent with the insurance and distortion channels identified in the analytics. The slope is negative, and the R^2 is 0.44, indicating that a sizeable fraction of the cross–country variation in the change in optimal tariffs is explained by initial agricultural trade imbalances.

We next turn to production subsidies to domestic agriculture. Table 4 reports optimal subsidies in the same three environments. In the no–risk benchmark, net importers have positive optimal subsidies while net exporters have negative subsidies (i.e., taxes on produc-

Table 4: Optimal production subsidies by agricultural trade status

Country	No risk, autarky	No risk, open	Risk	Difference (risk – no risk)
Net importer of food (L)	0.00%	2.9%	7.1%	4.2%
Net exporter of food (H)	0.00%	−1.8%	−0.4%	1.4%

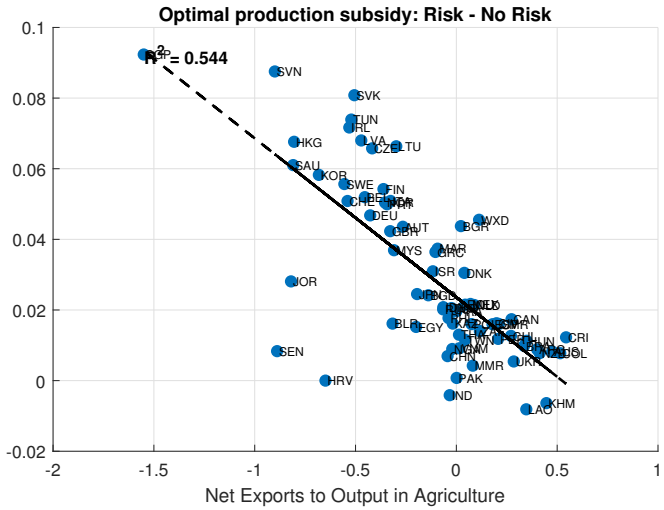


Figure 10: Change in optimal production subsidy (risk – no risk) vs. agricultural net exports

tion), reflecting their comparative advantage patterns. Under risk, optimal subsidies increase for net importers and move toward zero for net exporters. For net importers, the increase of 4.2 percentage points reflects the fact that higher domestic production provides insurance against the possibility of losing access to imports. For net exporters, the insurance value of additional domestic production is smaller, so the increase is more muted.

Figure 10 shows the relationship between the change in optimal subsidies and agricultural net exports. As with tariffs, countries with larger agricultural trade deficits increase subsidies more under risk, and the fit is somewhat tighter here ($R^2 = 0.54$).

Taken together, these results confirm the qualitative predictions from the analytical characterization: the presence of trade risk strengthens the case for protective policies in food–importing countries. The increases in optimal tariffs and subsidies under risk are economically meaningful, especially for countries with large agricultural trade deficits, and the magnitudes vary systematically with the trade structure.

Comparison to observed protective polices In Section 2.4 we documented that the Nominal Rate of Assistance (NRA), a summary measure of protection in agriculture, is systematically higher in net food importing countries than it is in net exporting countries.

The NRA includes both the border and industrial policies we study here. Our qualitative and quantitative findings here with respect to optimal tariffs and optimal subsidies to farmers are consistent with actual protective policies. The estimated gap in policies between food importers and exports we find for each individual policy we study, while sizable, is smaller than the one documented in Table 2.4. However, we note that: (i) the set of countries in our quantitative analysis does not overlap with the set of countries in Table 2.4; (ii) the NRA, while inclusive of border and subsidy policies, covers other protective policies as well; and (iii) there could be other forces, shaping observed policies across countries other than optimality, such as political economy reasons or excess risk taking incentives by private agents.

7 Implications for Structural Change and Development

So far we have studied the role of risk for trade, sectoral production and policy, for a large set of countries that differ in several dimensions. Importantly, however, these countries differ in the role that agriculture plays in their economies—both in terms of consumption, as captured by the expenditure share on food, and in terms of production, as captured by agriculture's share of value added in GDP and employment. A well-known feature of the development process is the accompanying structural transformation, whereby countries at early stages allocate a high share of expenditure to food and a large share of production to agriculture, whether measured by output or employment (e.g., Herrendorf et al., 2014). Our model highlights important implications of trade risk for structural change and development. By shifting the sectoral composition of the economy away from comparative advantage, trade risk can delay structural transformation and thereby slow down development. To study these issues here we: (a) examine the role that non-homothetic preferences – the key mechanism generating structural change – play in generating the effects of trade risk; (b) isolate how the effects of trade risk differ across countries vary in their agricultural expenditure shares; (c) study how improvements in agricultural productivity, often a precursor to structural change, can shape the effects of trade risk and achieve food security.

7.1 The Role of Non-Homothetic Preferences

Our multi-sector model features non-homothetic preferences across sectors. The non-homothetic preferences can generate structural change implications by shifting expenditure and production across sectors. Here we examine whether non-homothetic preferences are an important factor in mediating the effects of trade risk across countries that differ with respect to their engagement in food trade. To answer this question we re-estimate the model with CES pref-

erences, abstracting from non-homotheticities (that is $\epsilon_j = 1$ for all j), to match the same data targets as in our baseline estimation. Then, we introduce the same tail trade risk in the economy with CES preferences as in the main experiment in Section 5.1 for the baseline economy. We contrast, under CES preferences, the equilibrium outcomes in the economy with risk to the estimated economy.

In Figure 11, we plot the change in consumption food security (Panel A), the agricultural employment share (Panel B), and the aggregate import share (Panel C), from the introduction of risk, for both under the CES preferences and under the baseline (non-homothetic) preferences. We plot changes in each variable against the magnitude of countries' agricultural trade imbalances in the data.

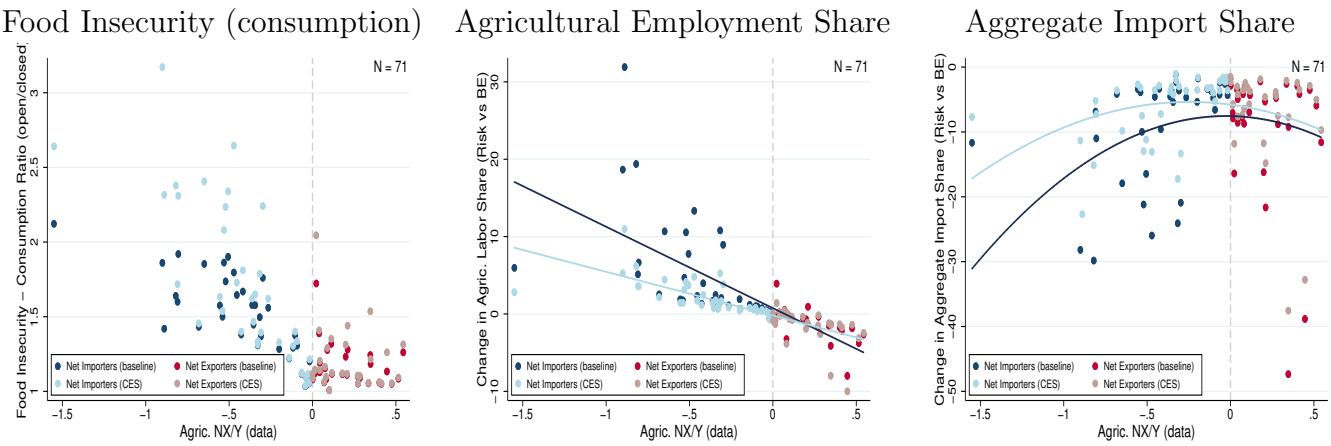
Two observations emerge. The first is that the direction of the effects from the introduction of trade risk, for net importers and net exports of food, does not hinge on the non-homothetic preferences. All countries reduce their participation in trade, food insecurity rises for all – particularly importers, net food importers (exporters) increase (reduce) their agricultural production. From a macroeconomic perspective, these observations highlight the important role of trade risk for all goods that are highly traded, beyond food.

The second observation is that under CES preferences the effects on the sectoral allocation of labor and the aggregate import share are quantitatively more muted, particularly for food importers (compare dark to light blue observations in panels B and C). The non-homothetic preferences, which imply that food is a "necessity" good, result in an amplified response of agricultural production and aggregate trade to the introduction of trade risk, for the countries that heavily import agricultural goods. As Panel A shows though, food insecurity is higher under CES preferences for large food importers. Intuitively, under non-homothetic preferences – because food is a necessity – the largest importers of food endogenously retreat more from international trade and shift more to domestic agricultural production, and as a result are less vulnerable to food insecurity. Under CES where these effects are smaller large food importers are more exposed and face higher food insecurity from an abrupt trade disruption. This illustrates that non-homotheticities are important in mediating the effects of trade risk, especially for importers of essential consumption goods.

7.2 Trade Risk Across Food-Expenditure Shares

We now examine the effects trade risk across the agricultural expenditure share spectrum, focusing on our baseline model with non-homothetic preferences, studied in Section 5.1. This allows us to highlight a key feature of the model. In our framework, countries at

Figure 11: Comparison of Non-homothetic Preferences to CES

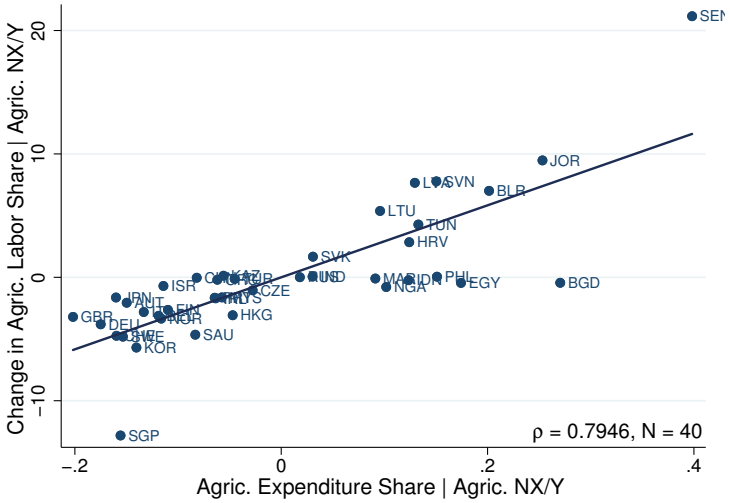


Notes: Each figure compares the difference between the equilibrium metric in the economy with risk and that of the riskless open benchmark economy, for the baseline model with non-homothetic preferences against the counterparts with CES preferences. "Agric. NX/Y (data)" is the agricultural net exports to output ratio in the data.

early stages of development—other things equal—are more likely to self-insure by increasing domestic production, as they are closer to subsistence and thus face a higher utility cost from downside risk. This behavior arises because the model features decreasing relative risk aversion: relative risk aversion is higher at lower income levels. Technically, this is driven by the interaction between standard constant relative risk aversion and the non-homothetic preferences embedded in the model. As a result, our framework offers a rationale for why lower-income countries tend to insulate themselves more from international trade by engaging less in it, despite their low productivity in agriculture.

To show this, we focus on net importers of agricultural goods, all of which tend to increase their share of domestic food production in response to trade risk. In Figure 12, we plot the change in the agricultural employment share between the equilibrium with risk and the one without risk for all net-importing countries, against their food expenditure shares—controlling for agricultural trade imbalances. Specifically, we partial out the effect of agricultural imbalances by plotting the residualized values of both the change in agricultural employment and the food expenditure share, based on partial regressions of each variable on agricultural imbalances (the Frisch–Lovell–Waugh approach). Figure 12 shows that food importers at earlier stages of structural change—those with higher food expenditure shares—shift more strongly toward domestic agricultural production in the presence of trade risk.

Figure 12: Agricultural expenditure share and the shift to domestic production



Notes: "Change in Agric. Labor Share (Risk vs BE)" refers to the country-by-country difference between the equilibrium agricultural employment share in the economy with risk and that of the riskless open benchmark economy. "Agriculture: Expenditure Share" is the agricultural expenditure share in the riskless economy.

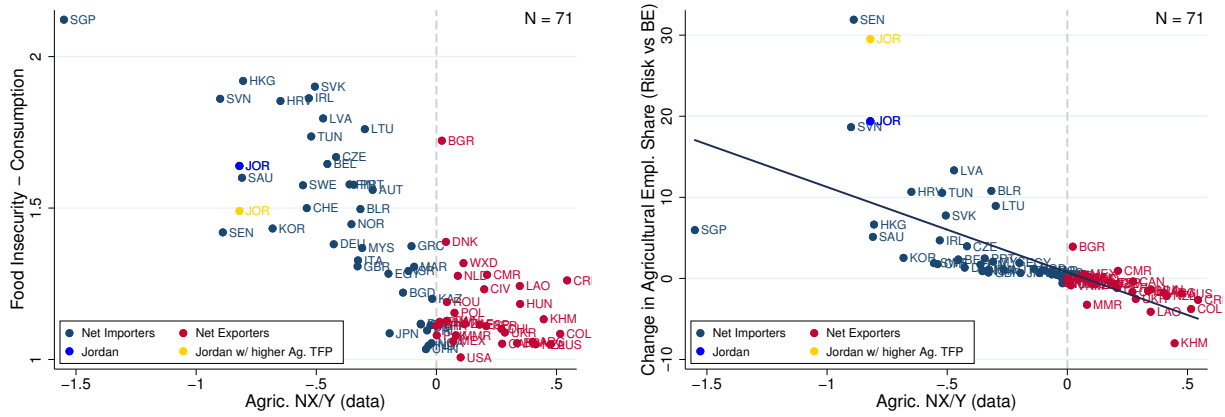
Take, for example, Jordan and Hong Kong—both net importers of agricultural goods with similar agricultural net import–to–output ratios of around 80 percent. However, Jordan's expenditure share on food is twice that of Hong Kong. While both countries shift toward domestic production following the introduction of trade risk, the shift is much more pronounced for Jordan: the share of employment in agriculture rises by 19.4 percentage points in Jordan, compared to 6.6 percentage points in Hong Kong. In other words, conditional on agricultural trade imbalances, countries with higher food expenditure shares respond more strongly to trade risk because they stand to lose more from a trade disruption—particularly when the affected good is a necessity like food.

7.3 Agricultural Productivity Improvements

In practice, policymakers often pursue food security by protecting domestic agriculture through measures such as production subsidies or import tariffs, studied here in Section 2.4 and Section 6. We use our model to ask whether improvements in agricultural productivity, can serve as an alternative to such protective policies in achieving food security.

We conduct a counterfactual experiment in which, holding all else constant, we increase total factor productivity (TFP) in agriculture for one country—Jordan—and recompute the equilibrium under trade risk. To account for the country's potential for agricultural

Figure 13: Agricultural Productivity Improvement: Jordan



A: Food Insecurity (consumption)

B: Agric. Employment Share

Notes: "Change in Agric. Labor Share (Risk vs BE)" refers to the country-by-country difference between the equilibrium agricultural employment share in the economy with risk and that of the riskless open benchmark economy. "Food Insecurity (consumption)" refers to the ratio of consumption if the good (open economy) state occurs relative to if the bad state (autarky) occurs. "Agric. NX/Y (data)" is the agricultural net exports to output ratio in the data (benchmark economy).

productivity growth, we draw on modeled estimates of potential yield from the Global Agro-Ecological Zones (GAEZ) project of the Food and Agricultural Organization, as analyzed in Adamopoulos and Restuccia (2022). These estimates reflect the maximum attainable output per unit of land, based on the land's geographic characteristics (soil, climate, topography), the biological requirements of each crop, and assumptions about water access and input use. They are constructed by agronomic experts using simulation models that assess how effectively the land could be exploited under improved agricultural practices. Aggregating across pixels in Jordan at a 5-arc minute resolution (roughly 10×10 kilometers), the potential yield across 18 major crops under mixed input conditions is estimated to be 100% higher than Jordan's current actual yield over the same crops.

Building on the potential yield evidence, we conduct a counterfactual experiment in which we increase agricultural productivity in Jordan by 100%, holding all other model parameters fixed. Figure 13 shows the resulting changes for Jordan in terms of food insecurity (Panel A) and the share of employment in domestic agriculture (Panel B). The yellow "JOR" symbol indicates the new equilibrium values under higher productivity. We find that this potential, spatially grounded productivity improvement substantially reduces food insecurity, as measured by consumption dispersion, from 1.64 to 1.49. It also enables Jordan to expand domestic food production, with the share of labor in agriculture increasing by 10 percentage

Table 5: Average Effects of Trade Risk with Agricultural Productivity Improvements

	Food Importers		Food Exporters	
	GAEZ	**Baseline**	**GAEZ**	**Baseline**
Aggregate Import Share (%)	-11.4	-13.8	-8.5	-11.3
Agricultural Labor share (%)	+9.0	+7.9	+0.5	-2.2
Food Insecurity (ratio)				
Food Consumption (open/closed)	1.59	1.65	1.14	1.13
Rel. Food Price (closed/open)	1.71	2.21	0.63	0.66
Welfare costs of risk (%)	+10.3	-11.4	+1.9	-7.0

Note: Average effects from tail trade risk, for food importers (first two columns) and food exporters (next two columns). "Baseline" refers to the changes in the baseline economy from the introduction of risk. "GAEZ" refers to the effects from the introduction of risk when agricultural productivities in all countries increase to their GAEZ potential levels. Changes are weighted averages within import status groups, where the weights are the relative magnitude of the countries' agricultural trade imbalances.

points, from 20 to 30 percent. In other words, agricultural productivity improvements can partially mitigate exposure to trade risk and reduce the need for protective policies such as subsidies or tariffs.

To more systematically examine the effects of agricultural productivity improvements, we run another counterfactual where we introduce trade risk in a world where agricultural productivity in every country increases to its potential level from GAEZ. The average results of this experiment are reported in Table 5, column one for importers of food, and column three for exporters. Columns two and four repeat the effects of trade risk without agricultural productivity improvements. Improving agricultural productivity for all countries would result in an improvement in food security and welfare for all countries, especially current food importers. While risk still induces countries to retreat from trade this is smaller than without the productivity improvements. Current net importers of food would engage more in domestic agricultural production than at current agricultural productivity levels.

8 Concluding remarks

Food security has become a key policy objective for governments and international organizations. While the importance of food security for welfare is ubiquitous, the implications for international trade flows, sectoral production patterns, and potential policy responses are less understood. Our starting point is the observation that trade in agricultural goods is large and that many countries rely on food imports to meet domestic demand. While trade

can raise welfare and productivity in the long-run, and help hedge idiosyncratic production risks in the short run, we show that the trade disruption risks we study here may significantly limit these gains.

Trade risk matters for real outcomes. We study the role of trade risk for food security, sectoral patterns of production and trade, and the potential for policy interventions to mitigate these risks. We document cross-country stylized facts and provide micro-level evidence on the impact of international trade on food security. We develop a general equilibrium model of international trade risk and structural change to interpret this evidence and to examine the aggregate implications of trade risk. In our model, importing decisions are subject to trade cost risk, leading to a tradeoff between international purchases that can be cheaper but risky vs. domestic purchases that are more expensive but safer. We find that trade risk has a substantial quantitative impact on welfare, trade, and production patterns across countries. The potential policy responses to secure a stable food supply for the domestic population include subsidies to domestic farmers and protective tariffs on food imports. Such policies are widespread across the world. We show that while these protective policies can achieve food security and alter trade and production patterns, agricultural productivity improvements can endogenously generate these outcomes.

While our analysis has focused on food security, we note that trade risk can play an important role in understanding the international sourcing of other critical final goods in consumption (e.g, water, electricity, vaccines) or intermediate goods in production (e.g., fertilizers, semi-conductors). Our framework can be used to think about both the positive and normative aspects of these issues.

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Appendix

A Cross-Country Evidence on Food Security and Trade

In Section 2 we showed the relationship between the Food and Agricultural Organization's (FAO) experiential measure of food security and import dependence on cereals. Here we examine two alternative measures of food insecurity. The first is the prevalence of undernourishment in the population, which is a measure of calorie consumption relative to a threshold needed for survival. While the experiential measure is available for all countries, the undernourishment measure is available from the FAO only for lower income countries. The second measure is food price volatility relative to general price volatility, which can be computed from FAO data for a wide range of countries.[9]

Figure 14 plots the undernourishment measure and the relative food price volatility measure for all countries against the import dependency ration in cereals. Panel A plots relative food price volatility for each country as the ratio of standard deviation in the logarithm of monthly domestic food prices within each country over 2014-2023, relative to the standard deviation of monthly logarithm of the CPI in each country over the same period. Panel B plots the prevalence of undernourishment in the population, where we have replaced all countries with an undernourishment rate of under 2.5, to exactly 2.5 for the purposes of illustration. Both measures are plot against the cereal import dependency ratio as in Figure 2.2, Panel A.

The message conveyed is similar to that with the experiential measure of food insecurity. On average, net importers face higher food insecurity than exporters. The relative consumer food price volatility is 1.39 for importers, whereas only 1.22 for exporters. The prevalence of undernourishment jumps from 4.69 for exporters to 11.31 for importers. In addition, the higher dispersion in either metric of food insecurity is higher for importers than exporters, just as in Figure in Figure 2.2, Panel A.

Next we ask whether the patterns of food insecurity with respect to import dependency are driven by income differences across countries. In Table A we regress each measure of food insecurity against the import dependency ratio alone (first column under each measure), as well as controlling for the logarithm of real GDP per capita (second column for each measure). In each case we find that the measure of food insecurity is significantly associated with importing cereals, and remains highly statistically significant even after controlling for real GDP per capita. In other words, the effect of import exposure on food insecurity is not driven by income variation.

B Estimation of Probability of Trade Disruption

As described in Section 2.1, to identify food trade disruptions empirically, we use annual data from FAOSTAT on the volume of food imports by country over 1961-2023 for the entire world. A food trade disruption is defined as an annual drop in food imports of 20% or more. Using all country-year observations we find the annual trade disruption probability is 9.53%.

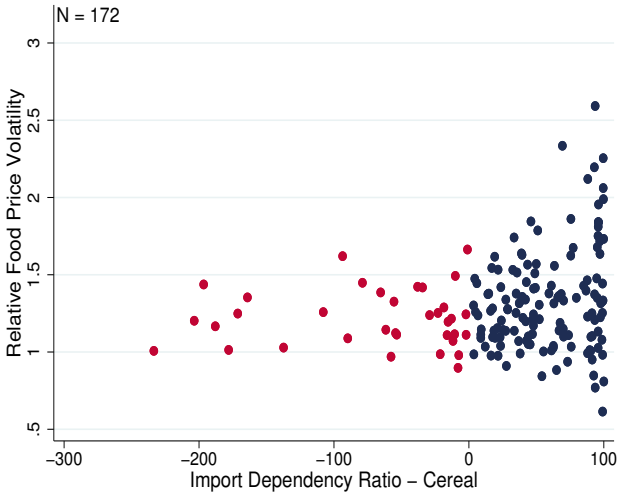
Here, we estimate the effect of geopolitical risk and trade policy uncertainty on the probability of import disruptions in food trade. This approach is analogous to that in Caldara and Iacoviello (2022) who estimate the effect of geopolitical risk on the probability of an economic disaster.

We create a dummy variable D_{it} for country i and year t that takes the value of 1 if there is a trade disruption, i.e., a year-to-year decline in the import quantity index of 20% or more as defined above. Then

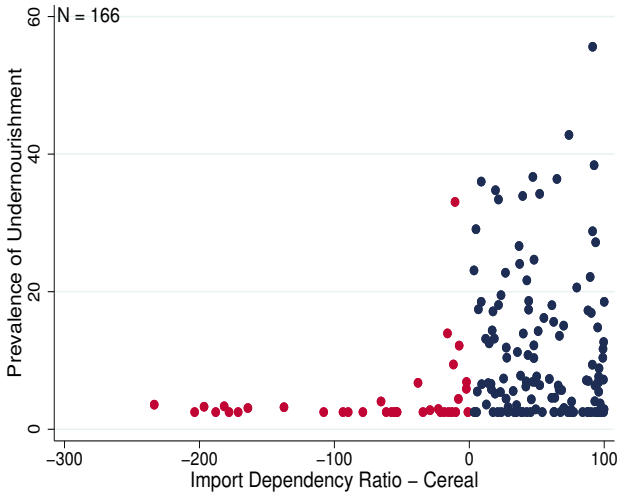
[9] All the data are from the FAO database, FAOSTAT. Data on the prevalence of undernourishment are obtained from FAOSTAT suite, "Food Security and Nutrition/Suite of Food Security Indicators," (downloaded December 7, 2024). The monthly data "Food Indices (2015=100)" and "Consumer Prices, General Indices" are obtained from the "Consumer Price Indices" suite of the FAO (downloaded April 21, 2025). Figures are based on averages of these variables over 2014-2023. All data are available from https://www.fao.org/faostat.

Figure 14: Metrics of Food Insecurity and Import Dependency

Panel A: Relative Food Price Volatility



Panel B: Prevalence of Undernourishment



Notes: Each point in the scatter plots represents a country. The y-axis in Panel A measures relative food price volatility, as the ratio of the standard deviation in the logarithm of monthly domestic food prices within each country over 2014-2023, relative to the same moment for the general CPI. The y-axis in Panel B measures prevalence of undernourishment in the population. The x-axis measures the import dependency ratio for cereals in both panels. Source: FAOSTAT.

we estimate linear probability models of the following form,

$$D_{it} = \beta_{GPR} GPR_t + \beta_{TPU} TPU_t + \delta \Delta IM_{it-1} + \epsilon_{it}$$

where GPR is the annualized average global geopolitical risk index from Caldara and Iacoviello (2022), and TPU is the annualized average trade policy uncertainty index from Caldara et al. (2020), as described in Section 2.1. Variable ΔIM_{it-1} is the one-period lagged import growth for country i, which controls for food trade vulnerability, since a previous year drop in food imports may signal trade distress or supply chain fragility.

Both the GPR and TPU indices are textual analysis based-metrics of the frequency of occurrences of geopolitical tensions (GPR) and trade policy and uncertainty (TPU) from newspaper articles in major newspapers. Both indices are reported on a monthly basis and cover a long periods of time. In Section 2.1 we show the evolution of geopolitical risk and trade policy uncertainty indices over recent years.

Table 7 displays the effect of geopolitical risk and trade policy uncertainty on the probability of a food import disruption. The estimates of the linear probability model are reported in three columns. The first and second columns, in turn, show the effect of the GPR and TPU alone, while the third column shows the effect when both indices are included. Lagged import growth is controlled for in all estimations. The data availability and year coverage of the different variables dictate the period, provided in the last row, over which we estimate the trade disruption probabilities.

From columns one and two, both coefficients β_{GPR} and β_{GPR} are positive and individually statistically significant at the 1% level, suggesting that elevated geopolitical risk and hightened trade policy uncertainty separately predict food trade disruptions. A one-unit increase in the global GPR index raises the probability of a trade disruption by 0.07 percentage points. The effect of trade policy uncertainty is higher, with a one-point increase in the TPU index raising the probability of a trade disruption by 0.14 percentage points.

Table 6: Food Insecurity and Import Dependency, Controlling for Income

	Experiential Measure		Food Price Volatility		Undernourishment Measure	
IDR	0.079***	0.031**	0.001***	0.001***	0.033***	0.016**
	(0.003)	(0.047)	(0.008)	(0.002)	(0.004)	(0.05)
constant	28.47***	183.7***	1.28***	0.68***	8.86***	69.49***
	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)
log GDP per capita		−16.25***		0.062***		−6.35***
		(0.000)		(0.002)		(0.000)
Obs.	146	144	172	168	166	159
R^2	0.058	0.685	0.041	0.095	0.049	0.554

Note: All columns contain estimates from OLS regressions of measures of food security (experiential measure, food price volatility, and undernourishment) on the import dependency ratio (first column for each measure) as well as log-real GDP per capita (second column for each measure). p-values are in the parentheses, ***, **, and * represent significance at the 1% ($p < 0.01$), 5% ($p < 0.05$), and 10% ($p < 0.10$) level respectively.

When both TPU and GPR are included in the regression (third column), GPR remains highly significant, while TPU becomes statistically insignificant. This suggests that, while GPR and TPU individually have strong predictive power, GPR has stronger explanatory power for trade disruptions when controlling for both geopolitical and trade policy uncertainty. We note however, that the sample period for TPU alone is much longer, starting in the early 1960s.

We next use these estimates to calculate the predicted chance of a food trade disruption since 2022. Using the estimated coefficient $\beta_{GPR} = 0.0007$ from the linear probability model and the average GPR of 138.06 since January 2022, the predicted probability of a trade disruption is $0.00073 \times 138.06 = 10.06\%$. When we use the estimated coefficient from the individual TPU regression and the average TPU since January 2022, the predicted probability of a trade disruption is $0.0014 \times 136.90 = 19.15\%$. The predicted probability of a trade disruption from the jointly estimated linear probability model is $.0007067 \times 138.06 + .0000566 \times 136.90 = 10.53\%$. These estimates reflect the elevated geopolitical, and especially trade policy risk since 2022. Reconciling the historical frequency of trade disruptions of 9.5% calculated above with the regression-based conditional probabilities given recent elevated geopolitical and trade policy risk levels, we follow a conservative approach and set the probability of a trade disruption in our main experiment to 10%.

C Impact of Cyclical Trade Risk

So far, we have focused on tail trade risk—low-probability, high-impact events that can lead to abrupt trade disruptions. However, trade is also exposed to more frequent, moderate fluctuations that can significantly affect food access. These recurrent disruptions—driven by various sources such as price volatility in global agricultural markets, supply chain bottlenecks, and fluctuations in transportation costs—can be thought of as cyclical or regular trade risk. Food crises and price spikes are not uncommon, with three major episodes in the past two decades. For example, the 2007–08 crisis triggered widespread food riots in many countries.

Cyclical trade risk manifests in both international and domestic food price volatility. One key contrib-

Table 7: Probability of Food Trade Disruption

	(1) Geopolitical Risk	(2) Trade Policy Uncertainty	(3) Both
GPR Index	0.00073***		0.00071***
	(23.36)		(13.90)
TPU Index		0.0014***	0.000056
		(23.59)	(0.58)
Import Growth Lag	0.0762***	0.1044***	0.0762***
	(11.87)	(17.73)	(11.87)
Observations	7,251	10,839	7,251
R^2	0.098	0.085	0.098
$F-statistic$	393.59	502.88	262.48
Estimation Period	1985–2023	1963–2023	1985–2023

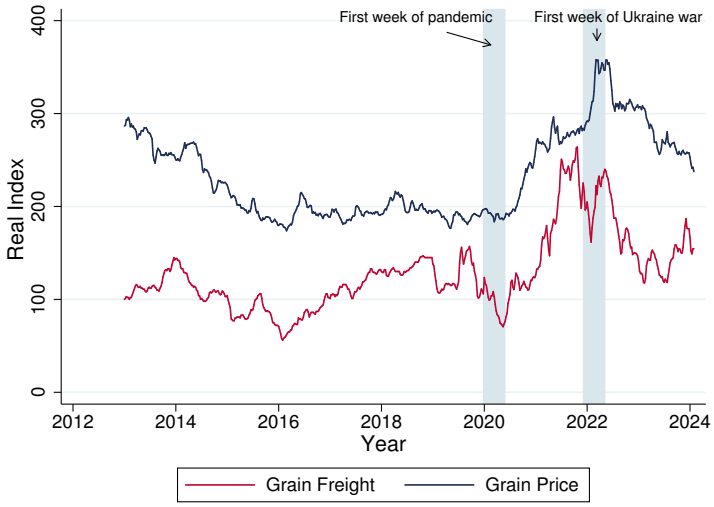
Notes: Linear probability model estimates. Dependent variable is dummy D_{it}, that takes the value of 1 if drop in imports is 20% or more. Standard errors in parentheses. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

utor to these fluctuations is maritime shipping costs, which influence the delivered price of imported goods. Figure 15 displays indices for exporting prices and freight rates for grains from all major producing and exporting countries to primary destination markets. The Grains and Oilseeds Freight Index covers shipments from regions such as Argentina, Australia, Brazil, the Black Sea, Canada, Europe, and the United States. The Grains and Oilseeds Price Index reports export prices for key staple crops including wheat, maize, soybeans, rice, and barley. Both series—reported at weekly frequency—exhibit substantial volatility: the standard deviation of the log of the freight index is 0.30, and that of the price index is 0.19. The shaded bars in Figure 15 indicate the periods surrounding the onset of the COVID-19 pandemic and the Ukraine–Russia war, both of which coincided with sharp spikes in freight rates and export prices. The correlation between the logs of the two indices is 0.65.

To quantify the effects of cyclical trade risk, we use the observed volatility in real freight rates from Figure 15 to calibrate symmetric fluctuations in trade costs. We consider an environment with two equally likely states of the world: one in which bilateral trade costs are lower than the baseline estimates, and another in which they are higher. The 50 percent probability is consistent with the empirical observation that freight rates were above trend in 7 out of the 15 years in our sample. The dispersion in trade costs across states is calibrated so that the standard deviation matches the observed volatility in freight rates, which has a log standard deviation of 0.30. This setup captures the magnitude of cyclical fluctuations in trade costs implied by historical variation in shipping conditions.

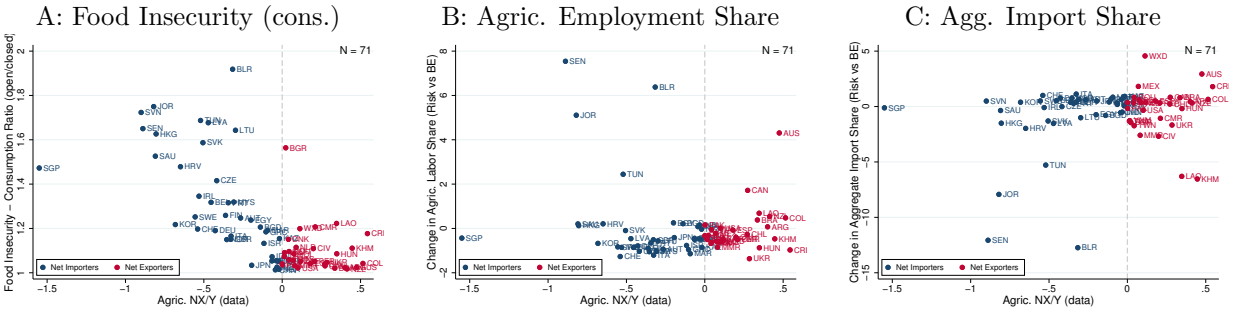
The results of the cyclical trade risk experiment are presented in Figure 16. Panels A, B, and C plot, respectively, food insecurity under the consumption metric, the change in the agricultural employment share, and the change in the aggregate import share—each against countries' agricultural trade imbalances. The effects of cyclical risk move in the same direction as those of tail risk, but are less pronounced. In equilibrium, cyclical risk also leads to higher levels and greater dispersion of food insecurity among net importers relative to exporters. Countries most exposed to trade respond more strongly by reducing their participation in international trade, and among net food importers, the shift toward domestic agricultural production is most pronounced in more vulnerable economies. These patterns resemble the tail risk results because, while the trade cost shocks under cyclical risk are less severe, the probability of experiencing elevated trade costs is higher.

Figure 15: Grain Shipping Costs and Exporting Prices Volatility



Notes:"Grain Freight" is the Grains and Oilseeds Freight Index, weekly data (1 January 2013 = 100). "Grain Price" is the Grains and Oilseeds Price Index, daily data (January 2000 = 100), in weekly frequency. Source: International Grains Council.

Figure 16: Impact of Regular Risk



Notes: "Change in Agric. Labor Share (Risk vs BE)" refers to the country-by-country difference between the equilibrium agricultural employment share in the economy with risk and that of the riskless open benchmark economy. "Food Insecurity (consumption)" refers to the ratio of consumption if the good (open economy) state occurs relative to if the bad state (autarky) occurs. "Change in Aggregate Import Share (Risk vs BE)" refers to the country-by-country difference between the equilibrium import share in the economy with risk and that of the riskless open benchmark economy. "Agric. NX/Y (data)" is the agricultural net exports to output ratio in the data (benchmark economy).