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Bilateral Trade and Food Security

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ABSTRACT

We analyze the relationship between food security and trade, focusing on food importers' exposure to sudden market failures from relying on a narrow range of international suppliers. We compute a bilateral import penetration index (BIPI), which gauges the degree to which a country depends on another for food imports. Food trade maps are drawn by the application of a force-directed algorithm that sorts through computed BIPIs and maps the nodes corresponding to the strength of bilateral ties between country pairs, thereby showing importers' vulnerabilities to disruptions in bilateral channels. Results suggest that measures aimed at diversifying supply sources reduce vulnerability.

Keywords: food security, trade, bilateral trade, agriculture, agriculture trade

JEL classification**:** F13, Q17, Q18

I. INTRODUCTION

Trade has the potential to complement domestic food supplies, through both imports and the extra purchasing power generated from exports. Discussions about the relationship between food security and trade inevitably turn to the debate between food self-sufficiency and self-reliance. From the perspective of food self-sufficiency, trade can contribute to food security only if it increases agricultural productivity. On the other hand, a self-reliant emphasis on availability sees trade as a potential tool for making food cheaper and more widely accessible. As Anderson and Strutt (2012) note, self-sufficiency emphasizes production, while availability serves consumption. Governments in Asia, at least in rhetoric, tenaciously hold on to the self-sufficiency mantra while economists tend toward self-reliance.

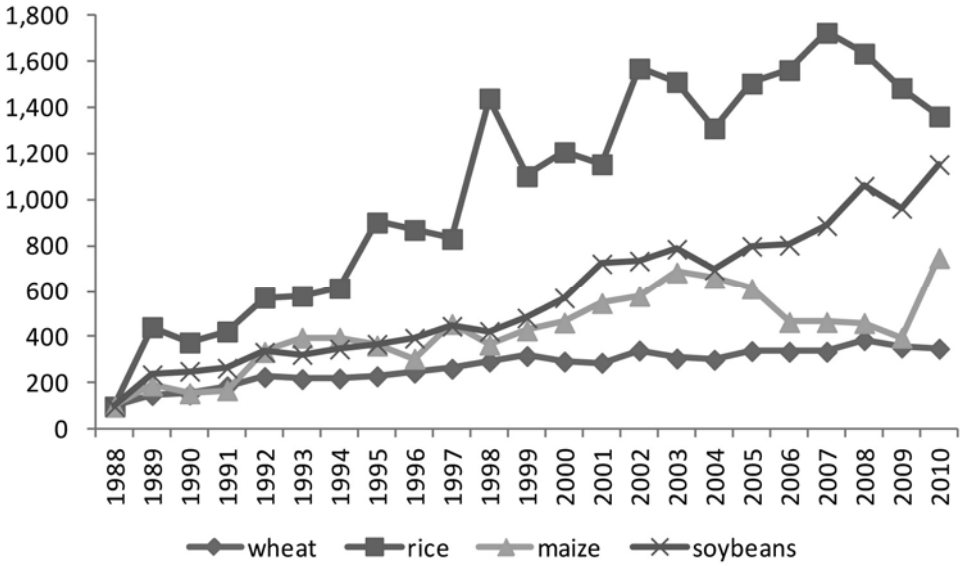
This paper strengthens the argument that the most important aspect of food security is self-reliance. Self-reliance is also more consistent with the formal definition of food security given by the Food and Agriculture Organization of the United Nations (FAO) (2003), which considers "physical, social, and economic access to sufficient, safe, and nutritious food… for an active and healthy lifestyle." Self-sufficiency commonly takes a national perspective without considering spatial aspects of access and distribution, and national self-sufficiency does not necessarily ensure sufficient sustenance for all households. Neither aggregate physical sufficiency nor abundance offers true food security if substantial proportions of the population do not have access to basic food items.

Food security can more easily be achieved when it is not limited to self-sufficiency. This applies to both households and countries. Just as division of labor and trade based on comparative advantage help households to raise income and living standards while simultaneously saving for investment or emergencies, they can also increase a country's options and policy space. The greater flexibility and resilience resulting from trade, particularly trade in food or agricultural commodities, can literally make the difference between life and death.

The increase in the volume of staples traded in the world since 1988, as shown in Figure 1, reflects countries' appreciation of the net benefits of trade. Still, the flexibility afforded by trade has too often been viewed from the perspective of global markets without sufficient attention to bilateral trade links that underlie the overall picture. From a national perspective, particularly in developing countries with less developed infrastructure and trade facilitation, bilateral trade relationships give better information on the possible implications of trade shocks on food security. The food price crisis experience in 2008 is instructive in this regard. India and Viet Nam imposed export bans on rice, and countries that were heavily dependent on them for rice imports felt the effects more severely than others.

The next section explains the various ways in which trade can influence food security. Section III describes the approach taken here to analyze the vulnerability of food-importing countries to supply disruptions in other countries, with focus on bilateral trading relationships. Section IV gives policy recommendations that can reduce vulnerabilities arising from bilateral trade relationships, and Section V concludes.

Figure 1: Wheat, Rice, Maize, and Soybeans Trade, Index of Volume (1988 = 100)



Note: The index was constructed based on the average of imports and exports from the UN Comtrade.

Source: Authors' calculations.

II. THE ROLE OF TRADE IN FOOD SECURITY

Trade can influence food security in a number of ways. First, it expands markets. For consumers, it opens access to additional sources that can supplement domestic production to meet demand. Imports may help lower food prices for the hungry or undernourished, and can be critical in times of domestic droughts, floods, disease, or other disruptions to domestic production. Access to greater markets can also benefit farmers, supporting their income through export sales of surplus and providing access to a greater variety of, or lower-priced, inputs such as seed, fertilizer, pesticides, and machinery. In addition, trade expands the range of options for exchanging nonfood products for food, and commodities with different nutritional characteristics for each other.

Second, trade can enhance food security through its impact on prices and the responses to the signals they transmit. A price differential between markets that is greater than the trade and transaction costs signals traders to move products from the lower price market to the higher price market. The extent to which trade can influence food security in this process is closely related to how integrated markets are. The integration of markets, in turn, is reflected in how fast and how fully price changes in one market induce a flow of goods between the markets. This flow of products from a region of surplus at current prices to a region of shortage results in an equilibrating change in prices between the markets, while simultaneously improving food security in the region of shortage.

Poorer households are more vulnerable to price spikes, and especially to frequent spikes. Trade in food or agricultural commodities can reduce price volatility, increasing predictability for planning by both producers and consumers. Prices tend to be less volatile when markets are more integrated. Supply and demand shocks in one geographical market can

be dampened naturally by the shifting of supplies to and from other markets, making prices more stable. Price differentials may be due to long-run but policy-responsive factors, such as a lack of transportation infrastructure across rugged terrain, or shorter-term disruptions, such as natural disasters.

Third, the integration of markets has implications not only for responses to short-term shortages, but also for long-term growth in production. Positive productivity effects can follow from trade, raising agricultural output and food security levels. Closed markets may discourage firms from adopting productivity-enhancing technology because doing so without an outlet for excess production would only depress the prices of their products in the local market (Barret 2005). This in effect discourages specialization according to comparative advantage, and may delay technology adoption. Closed markets may also deter the importation of technology, whether they are direct imports or associated with foreign direct investment that responds to market opportunities. Price signals reflecting full economic costs and benefits can also encourage diversification. Farm price support activities, by making the production of staples artificially more profitable relative to other crops, have prevented farmers from diversifying into higher valued products, which in the longer run sustain higher incomes.

Fourth, trade can influence food security through the expansion of competition. Opening markets to international trade promotes competition because markets become contestable across a larger spatial area. The depth and extent of market interlinkage can dictate whether the welfare effects resulting from market reforms will be transient or permanent in nature, which in turn informs policy makers whether certain types of government interventions are warranted or not (Meyer and von Cramon-Taubadel 2004). As farmers integrate into higher value-added agricultural processing chains, competition can help to avert monopsonistic procurement practices by those higher up the chain, preserving higher value for poor farmers.

In general, greater competition from expanded markets reduces rent-seeking opportunities and monopolistic practices, reinforcing the aims of competition policy (Brooks and Evenett 2005). The efficiency of more competitive markets also translates into more efficient risk management in cases of demand or supply shocks. Where markets are poorly integrated, prices are more volatile and poor households vulnerable to more frequent or prolonged price spikes.

Fifth, trade can indirectly influence food security through its impact on the effectiveness of macroeconomic tools. How well prices equilibrate in an economy, which is influenced by the trade policies adopted, affects how efficiently fiscal and monetary tools change the incentives faced by micro-level agents. In developing countries, food items typically account for a significant share of the consumer price index so food imports can lower inflationary expectations, leaving more space for monetary policy. Trade also contributes to government revenue through tariff collections. And when free trade agreements are signed, the depth of integration between markets within the agreements positively influences the extent to which the agreements are trade creating.

Sixth, how well markets function, aided by trade, also has a bearing on the design of relief operations in cases of emergency, or on investment decisions for stockpiling in areas of chronic food shortages due to insufficient production (Fackler and Goodwin 2001). For example, the United Nations World Food Programme (WFP), whose primary mission is delivering food aid, usually opts for cash-based interventions in cases where markets are well-integrated to avoid depressing commodity prices received by farmers in those localities. It may also procure food locally without negative effects on prices if food is readily imported, or procure from surplus areas not integrated with the deficit markets. The amount of food aid required for disaster relief

will also depend on how easily food aid can be supplemented by the activities of private traders (Taylor 2002).

State intervention, especially in the form of price stabilization, can impose a huge fiscal burden. Resources freed up from removing such interference in the market can be used for interventions such as infrastructure, research and development, market intelligence, or access to credit—or for other more targeted interventions such as cash transfers that address the root causes of food insecurity. In Pakistan, wheat subsidies to Punjab, the largest province in the country, exceeded all other agricultural expenditures including irrigation, infrastructure, and research and development (World Bank 2005). In the Philippines, the accumulated debt of the National Food Authority is estimated to be 12% of agricultural gross domestic product (GDP) in 2011.

Finally, to the extent that food imports reduce production in environmentally fragile areas, trade may reduce irreversible environmental degradation in times of short-term stress and thereby promote longer-term sustainable production.

While trade can have such beneficial impacts on food security, its effects are not always unambiguously positive. When poorly managed, food and agricultural imports can depress prices in domestic markets, lowering incomes and hence food security for marginal producers who depend on income earned through market sales to diversify their diet. If farmers exit production due to competition from imports, new or reentry may be difficult and not rapid enough to offset a sudden drop in those imports. And, as witnessed during the 2008 commodity price spikes, some major exporters may decide to withhold exports if they fear domestic consumption may suffer, particularly for thinly traded commodities such as rice. At the same time, where a commodity is thinly traded, a small change in one country's net export position can have a large impact on the international price of that commodity.

III. MAPPING FOOD TRADE

The relationship between trade and food security has generally been analyzed using equilibrium analyses, gravity, and price transmission models. By and large, these studies find that trade liberalization facilitates food security by increasing income, reducing poverty, reducing price volatility, making food cheaper, or simply making food physically available. Using computable general equilibrium analysis, Anderson and Strutt (2012) predict that the liberalization of global agricultural trade will increase world GDP, with most of the gains accruing to Association of Southeast Asian Nations (ASEAN) and Pacific island countries. They also found that liberalization leads to increases in agriculture sector total factor productivity, confirming the results of an earlier study by Martin and Mitra (2001), which used a production function framework to show that productivity increases in the agriculture sector are supportive of growth. Moreover, a literature survey from Winters, McCulloch, and McKay (2004) points to the poverty-alleviating effects of agricultural liberalization when farmers benefit, due to strong demand multiplier effects raising expenditures on locally produced non-tradeables.

However, the impact of market liberalization for food staples varies across countries. Some countries, such as Bangladesh, the People's Republic of China (PRC), and Viet Nam liberalized successfully, while Indonesia and the Philippines did not manage to improve food security substantially (Rashid, Gulati, and Cummings 2007; Timmer and Dawe 2007; World Bank 2005). Much of the literature aims at identifying the domestic and international factors accounting for observed differences in outcome across countries. Food imports are typically a

mixed blessing. On the one hand, they substitute or complement domestic production; on the other, they also make a country more vulnerable to international trade disruptions and coordination failure.

For example, the 2007–2008 food crisis saw the international price of rice tripling between October 2007 and April 2008, as temporary export restrictions enacted by Asia's key rice-producing countries exacerbated what at the onset had been a relatively moderate global supply–demand imbalance in the region (Abbott 2011; Martin and Anderson 2012; Timmer 2010). While there certainly was a multitude of factors at play in creating this crisis episode, it highlighted food importers' exposure to sudden market failures and heightened vulnerability from relying on a relatively narrow range of international suppliers.

Filling a gap in the literature, this section analyzes the main aspects of vulnerability in a country's bilateral and multilateral dependence on international food imports. Specifically, we compute a bilateral import penetration index (BIPI) that gauges the degree to which any one country depends on another for its food imports. Underlying the analysis is a matrix of world trade in rice, wheat, maize, and soybeans—the four major staples central to food security. The data on quantities in kilograms (kg) traded are derived from the United Nations Commodity Trade Statistics Database (Comtrade).[1] The trade data are combined with FAO country food balance sheets (FBS) for the same commodities.

In relation to any particular food item *f* and period *t,* say rice during 2009–2010, BIPI is the share of rice imports of country *i* from country *j* out of the total supply of rice in country *i* (net of stock adjustments)*.* The stronger country *i*'s reliance on imports from country *j* to meet its domestic demand for rice—which is assumed equal to final domestic supply—the higher the BIPI. Specifically, BIPI is defined as:

$$BIPI_{ij} = \frac{M_{ij}}{\sum_{j=1}^{n}\left(X_{ij} - M_{ij}\right) + P_i} = \frac{M_{ij}}{\sum_{j=1}^{n} M_{ij}} \frac{\sum_{j=1}^{n} M_{ij}}{\sum_{j=1}^{n}\left(X_{ij} - M_{ij}\right) + P_i} \tag{1}$$

where M_{ij} refers to imports of country *i* from country *j*. X_{ij} refers to exports of country *i* to country *j*, and P_i refers to domestic production in country *i* (all variables are quantities).

The expression after the second equal sign indicates that bilateral import penetration may be thought of as the product of the share of country *j* in country *i*'s total imports and its overall reliance on imports to satisfy domestic demand. The latter may be termed the total import penetration index (TIPI):

[1] Following standard practice, trade data were "mirrored" to favor importers' records when they are available. Value data also tended to be more readily available than volume data. In cases where volume data were missing, imputations were derived using the average unit price of commodities from the countries for which both sets of data were available.

$$TIPI_{ij} = \frac{\sum_{j=1}^{n} M_{ij}}{\sum_{j=1}^{n} \left(X_{ij} - M_{ij}\right) + P_i} \quad (2)$$

To smooth year-to-year fluctuations, we calculate the BIPI by summing up the trade and production data for 2006 and 2007. Data until 2009 are available but were not used here to avoid distortions in trade patterns induced by the food crisis. Table 1 lists the top 20 country pairs ranked by BIPI for rice, as well as imports and domestic supply data. Congo has the highest BIPI in relation to Viet Nam, which accounts for over 50% of its rice imports. Comparing imports with domestic consumption (estimated to be the sum of production and net imports) reveals that the amount imported exceeds the amount of domestic consumption in Congo. This is because Congo re-exports some of what it imports, and also engages in substantial stockpiling activities. The stock movements observed in the data may also reflect the activities of aid agencies such as the US Agency for International Development and the WFP. There may also be unrecorded exports of rice to other countries, especially those that share borders with Congo. On the other hand, Mongolia is almost exclusively dependent on imports from the PRC for its rice consumption since it produces minimal amounts of rice. It is also worth noting that Thailand and India feature prominently as primary sources of rice for the 20 countries with the highest import dependence on single import sources.

Based on the set of computed BIPI values across country pairs and years, food trade maps are drawn by applying a force-directed algorithm that sorts through the entire set of BIPI data and maps the nodes corresponding to the strength of relationships across all the countries included.[2] The maps highlight the strength of bilateral trade ties and the food security vulnerability of individual importing countries to disruptions in those bilateral trade flows.

Table 1: Top 20 BIPIs for Rice

Importer		Exporter				'000 Tons		
Code	Country	Code	Country	BIPI	TIPI	Bilateral Imports	Total Imports	Domestic Supply (P+M-X)
COG	Congo	VIE	Viet Nam	1.000	0.326	128	249	60
COG	Congo	THA	Thailand	0.580	0.326	74	249	60
AGO	Angola	VIE	Viet Nam	0.576	0.167	297	514	242
MON	Mongolia	PRC	People's Republic of China	0.476	0.080	47	47	46
BEN	Benin	THA	Thailand	0.474	0.176	487	1081	482
SVN	Slovenia	ITA	Italy	0.449	0.119	14	23	15
SYC	Seychelles	IND	India	0.448	0.079	11	12	12
VAN	Vanuatu	AUS	Australia	0.422	0.076	21	22	23
LUX	Luxembourg	BEL	Belgium	0.417	0.110	2	3	2

continued on next page

[2] Interested readers are referred to http://med.bioinf.mpi-inf.mpg.de/netanalyzer/help/2.7/index.html for concepts in network analysis.

Table 1: *continued*

Importer		Exporter				'000 Tons		
Code	Country	Code	Country	BIPI	TIPI	Bilateral Imports	Total Imports	Domestic Supply (P+M-X)
CZE	Czech Republic	ITA	Italy	0.415	0.091	96	125	108
BRU	Brunei Darussalam	THA	Thailand	0.409	0.083	65	78	74
KWT	Kuwait	IND	India	0.406	0.089	348	454	402
SWZ	Swaziland	ZAF	South Africa	0.405	0.073	38	41	44
LBY	Libya	EGY	Egypt	0.397	0.083	252	316	298
NAM	Namibia	ZAF	South Africa	0.385	0.073	11	12	13
ATG	Antigua	VCT	Saint Vincent and the Grenadines	0.377	0.111	2	3	2
SYR	Syria	EGY	Egypt	0.366	0.065	388	411	497
DJI	Djibouti	IND	India	0.359	0.073	73	89	96
MDV	Maldives	IND	India	0.359	0.077	31	40	41

BIPI = bilateral import penetration index, M = import, P = production, TIPI = total import penetration index, X = export.

Note: BIPI and TIPI values computed based on equations (1) and (2) were normalized to take values from 0 to 1.

Source: Authors' estimates.

Figures 2 to 5 show the ensuing maps of bilateral and global food dependencies for each of the four commodities, with reference to total trade during 2006 and 2007. For better readability, the maps show only country pairs with the strongest bilateral trade dependency—the top decile by BIPI for wheat, maize, and soya, and the top 5% for rice.[3]

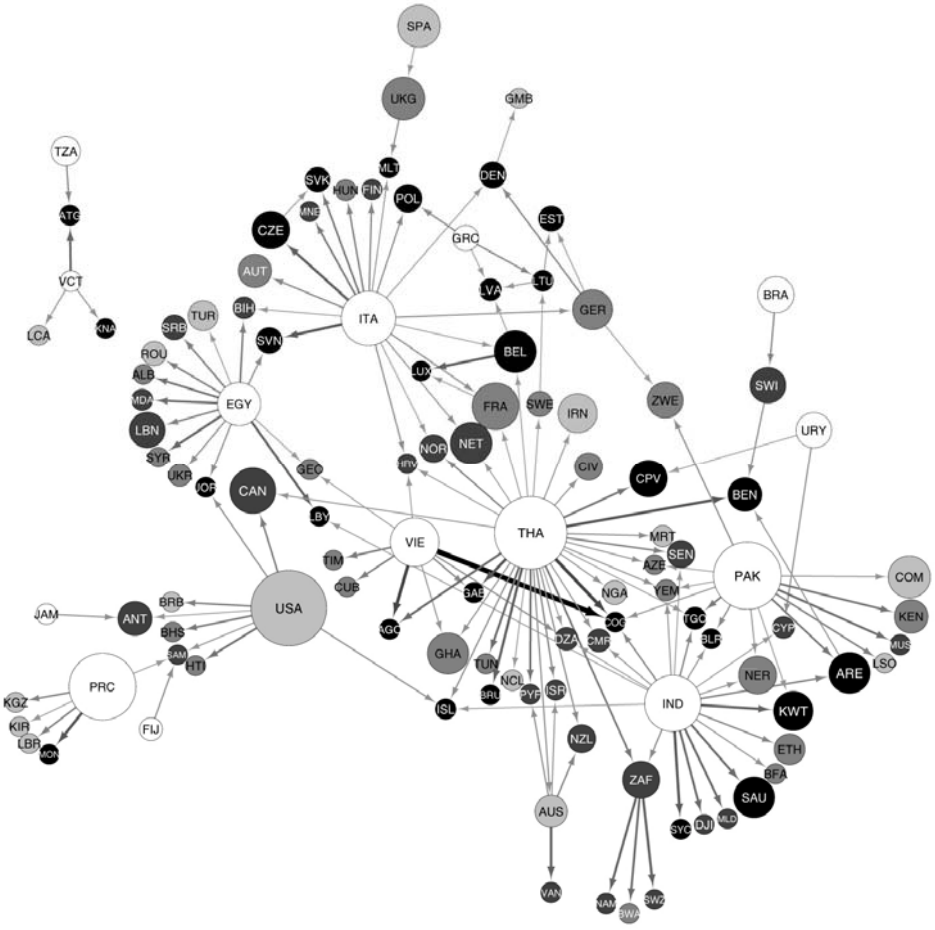
A. Rice

Figure 2 refers to global trade in rice among the top 5% of countries in terms of BIPI. The circles or nodes, represent the countries trading in rice. The shade of the circles reflects the countries' total dependence on food imports, gauged by TIPI (equation 2): the higher the TIPI, the darker the shade. Countries in white, such as India, Pakistan, Thailand, and Viet Nam, are leading rice exporters and, as such, are largely independent of other countries' rice exports.[4] Albeit to a lower degree, countries in light and dark gray are relatively independent of rice imports to cover domestic demand, too. Such is the case of the United States (US) and France. As the color spectrum moves to darker gray and further to black, strong import dependence is detected, and with it, a country's heightened degree of vulnerability to potential disruptions to global supply. For example, Mongolia, Saudi Arabia, and Belgium are all represented with black nodes.

[3] An exception is made for the rice map (Figure 2) for purposes of readability. A decile map of rice trade is still too dense for easy visual appreciation.

[4] It should be kept in mind that maps show only the top 10% (5% for rice) of country pairs ranked according to decreasing BIPI. Therefore, even countries colored in white depend on imports to a higher degree than do 9/10 (19/20 for rice) of all the other countries in the sample. Put differently, white and light gray indicate a relatively lower degree of import penetration among the subsample of countries with the highest BIPI.

Figure 2: Rice Trade Map



Note: See Appendix Table 4 for the complete list of country codes.

Source: Authors' estimates.

The location of nodes on the map reflects countries' connectedness within the global network of trade in rice. Unsurprisingly, the world's top rice producers and exporters are shown to be hubs in the rice map. This is clearly observable for Egypt, India, Italy, Pakistan, Thailand, and the US.

The size of any node relates to its so-called "betweenness centrality," or the number of shortest paths going through it.[5] A pronounced centrality is shown as a large node size on the map, indicating a country's capacity to impact trade within the entire network or substantial parts of it. Such market clout could be exerted through a country acting as a main hub for an entire region, giving it a certain capacity to influence prices or the power to hoard commodities. Once again, the large rice exporters tend to show up as the larger nodes on the map.

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5 The betweenness centrality index (BCI) is computed as $BCI(\upsilon) = \sum_{S \neq \upsilon \neq W} \frac{\lambda_{sw}(\upsilon)}{\lambda_{sw}}$ where *sw* represents paths running from *s* to *w*, and λ_{sw} is the total number of shortest paths from *s* to *w* passing through node υ. BCI thus relates to a country's influence on the entire network of food trade relationships.

It is also interesting to observe how different sets of countries cluster around the major rice exporters. Egypt is a hub for Eastern Europe and Arab countries, while Italy is depicted to play this role in Europe. An important point to note here is that most of the countries that rely heavily on Italy for exports, such as the Czech Republic and Slovenia, do not consume rice as a staple. This means that while they may be vulnerable to disruptions in Italy's rice supply or production, it would be far-fetched to claim that they are food insecure in terms of the formal definition of food security cited in the Introduction.

Globally, the US is also a very important supplier of rice as is easily apparent from its node size. While farther away from the dense network surrounding the Thailand–Viet Nam–India–Pakistan cluster, the US is central to a network that spans a greater geographic scope and a greater number of countries for a single supplier (recall that only nodes in the top 5% BIPI are shown in the rice map).

Whereas the shade and size of the nodes relate to the characteristics of rice exporters that are relevant to the global market as a whole, the shade and width of lines connecting any pair of nodes describe the degree of dependence on each other. For example, a narrow and light line, or arc, in relation to Pakistan's rice exports to Azerbaijan denotes a relatively low BIPI (albeit the fact that it is visible on the map implies that the intensity of this bilateral link figures among the top 5% across all country pairs). In contrast, Mongolia's dependence on rice imports from the PRC is more exclusive and puts the country at greater risk of suffering from potential disruptions affecting this particular supply channel. The same can be said of Congo's dependence on Viet Nam, though in this case, the disruption may affect not only domestic consumption but also exports to other countries such as Togo, and possibly aid operations. This highlights how vulnerabilities can also be passed through. The map's depiction of the network surrounding South Africa is instructive. South Africa's high dependence on Thailand and India for its rice imports is passed on as vulnerabilities to Botswana, Namibia, and Swaziland.

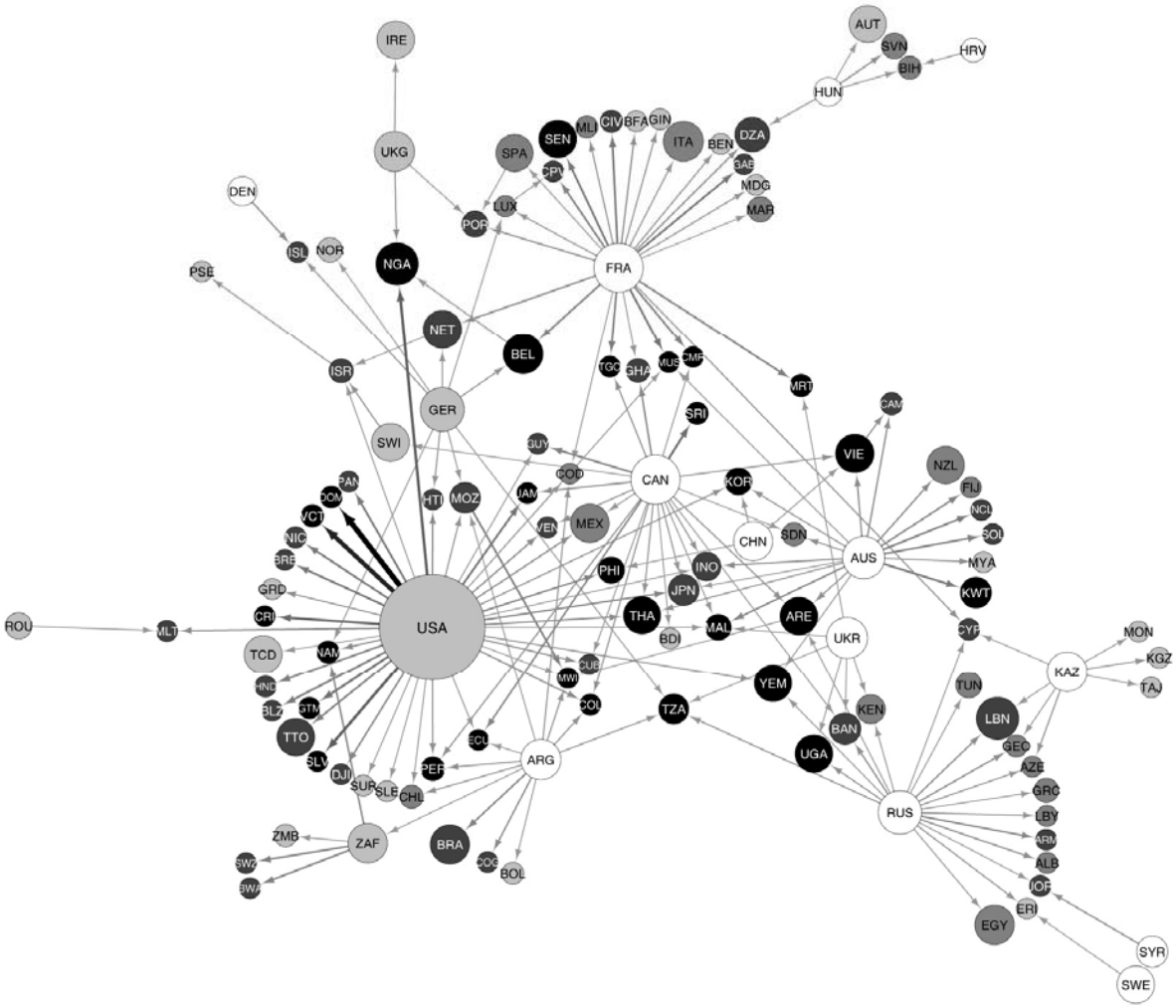
An interesting revelation from this map is that most Asian countries, with the exception of Mongolia and Brunei Darussalam, are shown to be only weakly reliant on imports for the bulk of their domestic consumption. Big rice importers in the region, such as Bangladesh, Indonesia, Malaysia, and the Philippines do not even show up on the map.[6] This is because they are also large rice producers and import only a small fraction of their total domestic consumption. As a result, their BIPI is low. In the case of the PRC, also a large rice importer, no incoming arrows are shown on the map, because its reliance on a large number of smaller suppliers associates it with a BIPI value below the top fifth percentile.

B. Wheat

Figure 3 shows that the global trade of wheat is centered on several key players—the US, Canada, Australia, the Russian Federation, Kazakhstan, and France. The first three countries are particularly important suppliers for a number of Asian countries, while the Russian Federation and Kazakhstan are key suppliers for Central Asia and other former Soviet republics. France is the main wheat hub for most of Europe and a number of African countries. Finally, the importance of the US to Central American and Caribbean countries shows clearly on the map, and is easily confirmed by an examination of Appendix Table 2, which shows the US as the most important trading partner for most of the country pairs with the top 20 BIPIs. This indicates the heightened vulnerability of some importers to supply disruptions in the US.

[6] These countries would, however, be on the map had we presented the top decile of the rice BIPIs. Nonetheless, their TIPIs would have lighter shades indicating weaker import dependence for domestic consumption.

Figure 3: Wheat Trade Map



Note: See Appendix Table 4 for the complete list of country codes.

Source: Authors' estimates.

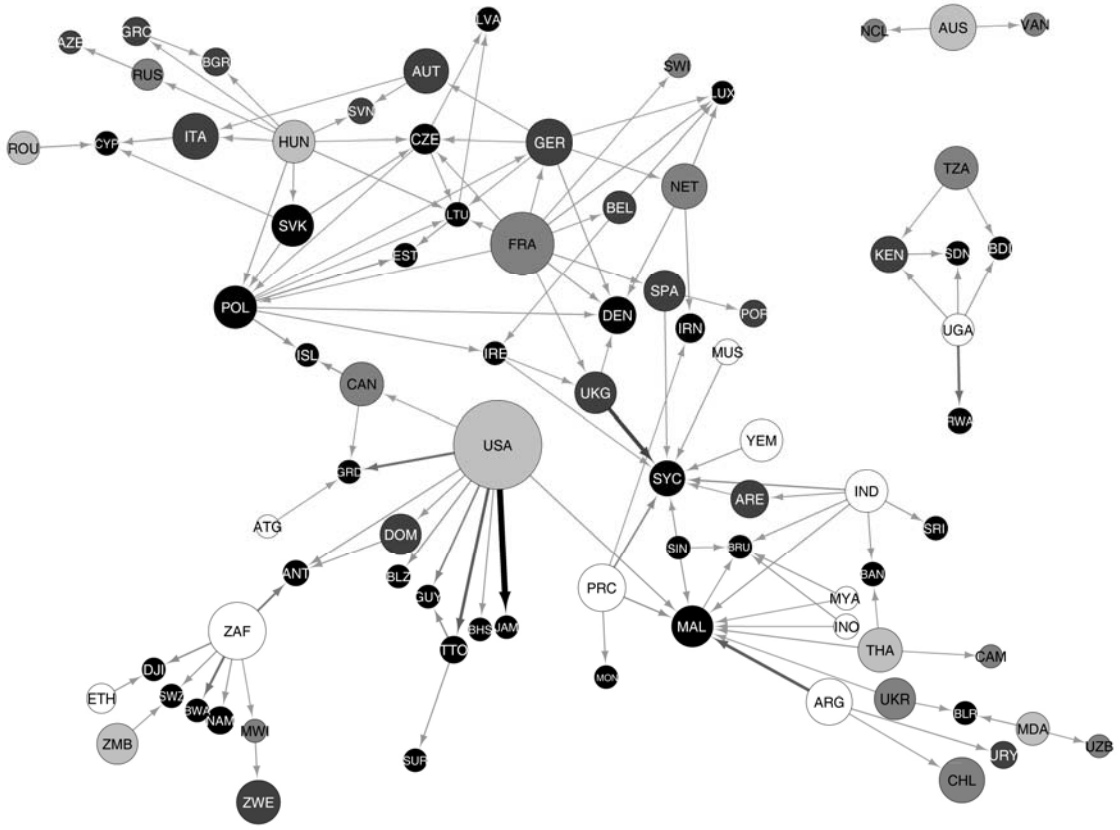
The wheat map also shows that many big Asian countries, such as Japan, the Republic of Korea, Indonesia, Malaysia, the Philippines, and Viet Nam, are highly dependent on imports for domestic consumption. However, the multitude of edges (lines) connecting these countries to major suppliers indicates reliance on a relatively broad import base, involving more suppliers compared to other importers on the map.

C. Maize

Figure 4 distinguishes several hubs of the maize network trade—the US, South Africa, France, and Hungary. The ASEAN countries, although not central to the global maize trade, form a close-knit network, supplying import-dependent countries such as Brunei Darussalam and Malaysia. Also noteworthy is some countries' reliance on a well-diversified pool of suppliers. For example, Malaysia and Seychelles import substantial volumes of maize from a plethora of suppliers scattered across the world. For Malaysia, the main supplier is Argentina, and for

Seychelles it is the United Kingdom. Seychelles and Malaysia have the second- and third-highest BIPIs in the global maize trade with respect to these two countries (see Appendix Table 2). While this makes the two countries somewhat vulnerable to possible disruptions involving their main suppliers, their vulnerability is reduced by the option to divert demand, thanks to adequate supporting infrastructure and income, to alternative suppliers, especially those with large capacities, such as India and the PRC.

Figure 4: Maize Trade Map



Note: See Appendix Table 4 for the complete list of country codes.

Source: Authors' estimates.

Singapore's position on the map demonstrates its importance as a port for food shipments to the region, such as for maize to Brunei Darussalam and Malaysia. More broadly, Singapore's excellent trade infrastructure and policy stability represent a significant supply channel to the broader region, particularly for countries wanting to diversify their sources of maize or other food commodities.

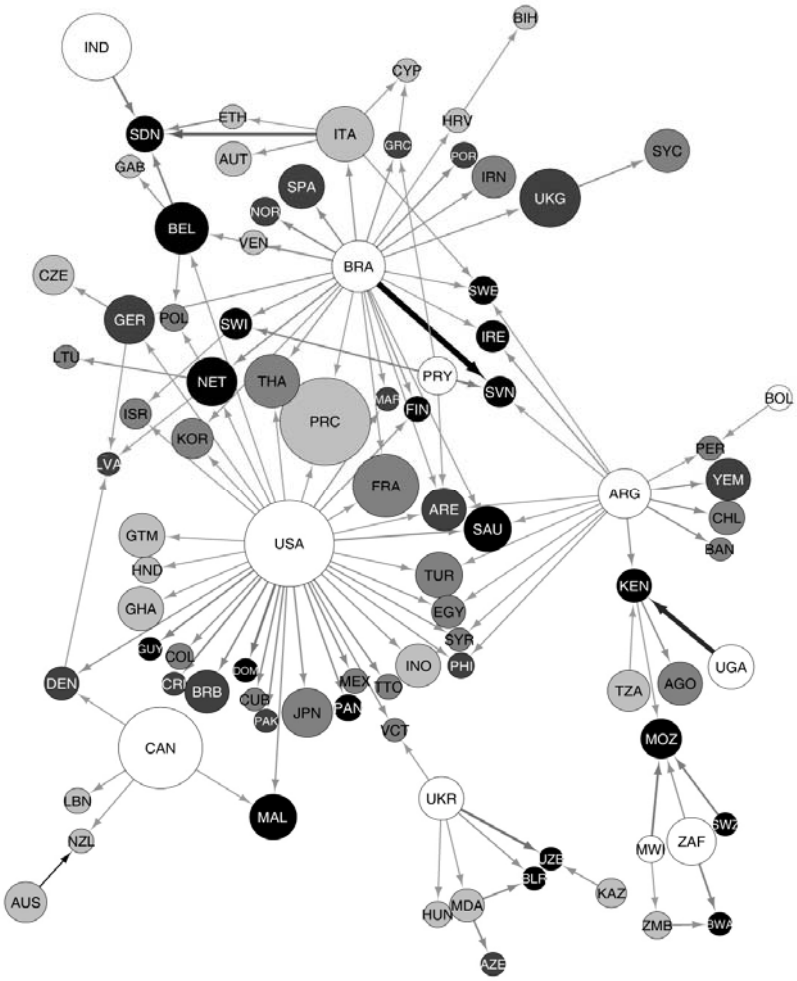
Another notable feature of the maize map is the smaller clusters of nodes that are not connected to the main network. Notice that Australia's network with Pacific island countries is rather isolated, while the East African countries form a tightly knit network of dependencies among themselves.

Finally, it should be remarked that three significant importing countries in Asia—the PRC, Japan, and the Republic of Korea—either do not appear on the map or do so as exporters. This is because their large supplier network does not make them particularly dependent on any specific maize exporter.

D. Soybeans

In East Asia, soybeans form an important part of the diet and a substantial portion of domestic consumption is supplied through imports. Unsurprisingly, Japan and the Republic of Korea figure prominently in Figure 5 as larger gray nodes. The PRC has a lower TIPI among East Asian countries, but takes a more central role in the soybeans network as an important supplier as well as importer in the global soybeans trade.[7] The US, Brazil, and Argentina are the top three suppliers of soybeans in the global markets.

Figure 5: Soybean Trade Map



Note: See Appendix Table 4 for the complete list of country codes.

Source: Authors' estimates.

[7] The PRC shows up only as an importer in the soybean BIPI map. An examination of the trade matrix, however, reveals that it is also a supplier of note to several countries.

An interesting thing to note about the BIPI computations for soybeans (see Appendix Table 3) is that most of the countries with the highest BIPIs have imports that exceed domestic consumption. This suggests wide re-exporting or stocking activities, which are especially relevant for countries that export processed soybean products such as soybean meal or oil.

E. Caloric Map

From the perspective of nutrition, and abstracting from strong food preferences, food security relates to the physical and economic availability of a caloric intake that fulfills the dietary needs of a household or population.[8] As such, trade in nutrition or calories is best represented by a map aggregating relevant food items after their conversion into caloric equivalents, rather than by a commodity-specific map. We first convert the four staples into their caloric equivalents using the FBS and then calculate BIPI based on the total calories, rather than quantities, countries trade and consume.

The results for the top 20 country pairs are presented in Table 2. Much in line with our findings in relation to the four individual commodities, the US comes out as a critical supplier of staples for a large number of countries scattered across the globe. The centrality of the US in staple food trade is confirmed in Figure 6 where a corresponding map presents the country pairs with BIPIs in the top 5%.

Table 2: Top 20 BIPIs in Aggregate Calories

Importer		Exporter				Trillion Calories		
Code	Country	Code	Country	BIPI	TIPI	Bilateral Imports	Total Imports	Domestic Supply (P+M-X)
JAM	Jamaica	USA	United States	1.000	0.573	5530	6380	3160
DOM	Dominican Republic	USA	United States	0.786	0.405	18000	18300	13300
BRU	Brunei Darussalam	THA	Thailand	0.757	0.455	477	576	367
HTI	Haiti	USA	United States	0.694	0.464	5620	7610	4747
TIM	Timor-Leste	VIE	Viet Nam	0.658	0.414	737	931	660
TTO	Trinidad and Tobago	USA	United States	0.634	0.372	1230	1430	1140
BWA	Botswana	ZAF	South Africa	0.627	0.328	962	986	907
BRB	Barbados	USA	United States	0.616	0.319	536	541	515
NGA	Nigeria	USA	United States	0.552	0.472	92200	163000	100100
ARM	Armenia	RUS	Russia	0.543	0.338	3560	4410	3931
COG	Congo	VIE	Viet Nam	0.511	0.726	944	2900	1116
BEL	Belgium	FRA	France	0.439	0.505	23000	56700	32243
CRI	Costa Rica	USA	United States	0.399	0.212	5050	5070	7902
DJI	Djibouti	IND	India	0.393	0.443	542	1310	863

continued on next page

[8] It is recognized, however, that in the long run, a balanced diet capable of delivering sufficient amounts of macro- and micronutrients is essential for a true sense of food security.

Table 2: *continued*

Importer		Exporter				Trillion Calories		
Code	Country	Code	Country	BIPI	TIPI	Bilateral Imports	Total Imports	Domestic Supply (P+M-X)
SEN	Senegal	THA	Thailand	0.389	0.471	6550	17200	10519
DJI	Djibouti	USA	United States	0.383	0.443	527	1310	863
ARE	United Arab Emirates	PAK	Pakistan	0.383	0.636	6920	25600	11379
GEO	Georgia	RUS	Russia	0.372	0.281	4170	6400	7092
BEN	Benin	THA	Thailand	0.360	0.380	3590	8130	6344
GAB	Gabon	THA	Thailand	0.357	0.475	561	1640	1000

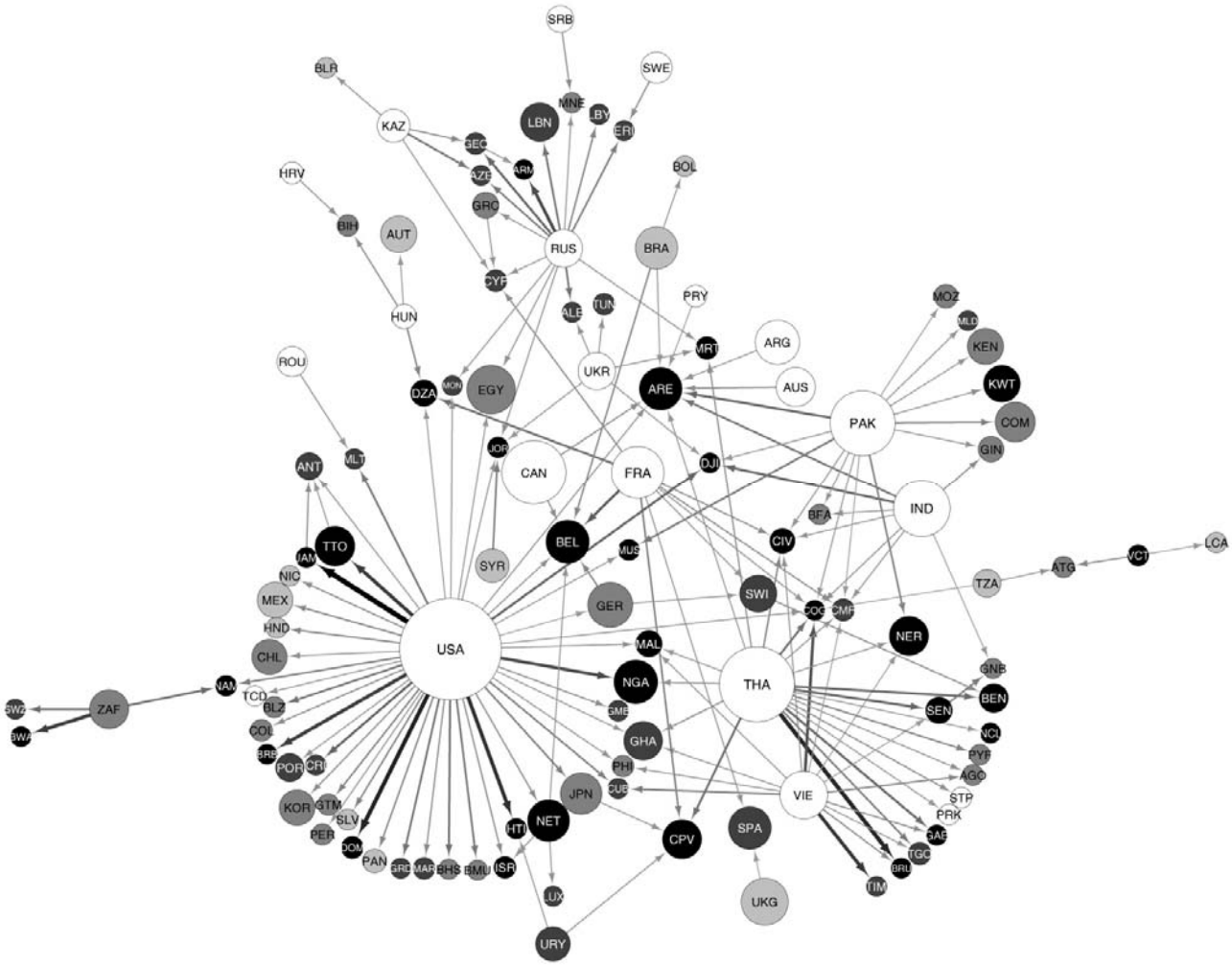
BIPI = bilateral import penetration index, M = import, P = production, TIPI = total import penetration index, X = export.

Note: BIPI and TIPI values computed based on equations (1) and (2) were normalized to take values from 0 to 1.

Source: Authors' estimates.

The sheer number of countries that are highly dependent on the US, as represented by the size of its node, testifies to its status as the prime player in world staple trade with a significant bearing on the entire network. The vulnerability of small countries in the Caribbean to supply disruptions in the US is particularly pronounced. Jamaica, the Dominican Republic, Haiti, Trinidad and Tobago, and Barbados—all within the 10 highest-ranking BIPIs in terms of calories—are all dependent on the US to a very high degree (see Table 2). In the case of Jamaica, and Trinidad and Tobago, Figure 6 shows that they also have significant exporting activities, especially to Antigua. With a diversified set of imports, Antigua should in principle be less vulnerable to supply disruptions. This "fallback" position, however, is severely compromised by the fact that its two other sources are also highly dependent on US supply conditions.

Figure 6: Caloric Trade Map



Note: See Appendix Table 4 for the complete list of country codes.

Source: Authors' estimates.

The caloric map also shows that, in general, countries in Asia that are dependent on imports for their staples are not exceptionally vulnerable to supply disruptions from single country sources. Instead, the region is home to important global suppliers of calories—India, Pakistan, Thailand, and Viet Nam. There are exceptions, however. One is Brunei Darussalam, which in the caloric map appears highly vulnerable due to the combined effects of its high dependence on imports and its high bilateral dependence on Thailand for its caloric consumption. Malaysia also stands out within Asia because it shows up as a black node dependent on three big supplying countries: Thailand, the US, and Viet Nam. The black node is explained by imports, which exceed domestic consumption, while the edges to the three countries represent the bilateral dependence of Malaysia on Thailand for rice and maize; the US for wheat, maize, and soybeans; and Viet Nam for rice. Imports from these three countries make up over 30% of domestic caloric intake for staples in Malaysia. This raises the question whether Malaysia, being dependent on three big suppliers of calories, is really vulnerable. The other two big suppliers can potentially step up should the supply lines in the third country be

disrupted. On the other hand, it is also easily conceivable that disruptions in big countries have global repercussions, and affect the supplying capacities of other countries as well.

The United Arab Emirates (UAE), which imports nearly all of its caloric consumption, also stands out in the map as bilaterally dependent to a considerable degree on eight different suppliers. As in the case of Malaysia's trading partners, these suppliers are all relatively large players in the world market and the diversity of sources itself may offer some degree of protection from single country disruptions.

F. Network Characteristics

Table 3 provides some summary network statistics for each commodity and their aggregated caloric equivalents for 2006–2007 and 2008–2009. These indicators assume values from 0 to 1.

Table 3: Summary of Network Statistics

Network Statistics	2006–2007	2008–2009
Rice		
Network density	0.153	0.158
Network centralization	0.636	0.633
Wheat		
Network density	0.099	0.105
Network centralization	0.548	0.519
Maize		
Network density	0.075	0.078
Network centralization	0.494	0.48
Soybeans		
Network density	0.112	0.112
Network centralization	0.449	0.492
Aggregate Caloric		
Network density	0.186	0.205
Network centralization	0.600	0.609

Source: Authors' estimates.

The network density gives the number of existing trade links as a proportion of all possible trade links. This can be taken as an indicator of how well-exploited alternative trade links are. While the appropriateness of this indicator for our purposes is imperfect given that it does not account for supply capabilities, a higher density can be interpreted as a general pattern toward diversity in supply sources. Keeping this in mind, rice trade exhibits the highest network density among the staples considered here, confirming the greater number of trade links in rice during 2006–2007. This implies that rice was more widely traded than the rest of the foodstuff considered in this study—an interesting revelation given that rice is known to be thinly traded. The coefficient is only higher for the calorie network, which is not surprising since there tend to be more clusters in a network involving the trade of four commodities compared to one.

Finally, network centralization measures the extent to which a few countries dominate the entire network. A value closer to 1 implies a higher degree of concentration. The centralization measure for rice is substantially higher than that for the other staples, indicating that only a few big players dominate the world rice trade. The corresponding value for the caloric network is slightly below that of rice, which reflects both the lower network centralization observed for wheat, maize, and soybeans, and the greater flexibility afforded by the possibility of switching between commodity sources of calories.

It is notable that for all four commodities, the number of countries linked by bilateral connections increased in 2008–2009, as indicated by higher values of network density. During the same period, the dominance of a few countries decreased, as implied by smaller values of network centralization. The results of the commodity-based analysis are likewise reflected in the caloric network. Overall, these suggest a general increase in the diversity of trading partners in the crisis period and its aftermath.

IV. POLICIES TOWARD REDUCING VULNERABILITY

The previous section highlighted the importance of bilateral trade in food security considerations. This section discusses how food security vulnerability to trade disruptions can be addressed, with particular focus on bilateral trade relations. The most straightforward strategy that arises from studying the BIPIs and the resulting maps is to diversify one's sources of imports. This is especially relevant for countries that import most of the food items they consume, and consume them as staples. Having said this, how can countries diversify their import sources?

Preferential trade agreements (PTAs) are one possible avenue. Stagnation or deadlock in the Doha Round of multilateral World Trade Organization (WTO) negotiations has led to a proliferation of bilateral or regional PTAs. Agriculture was a sticking point in the WTO negotiations, and the lack of progress there signals the loss of potential agricultural trade which could be critical for food security in Asia—the region with most of the world's farmers, consumers, and poverty.

Results from a gravity model by Korinek and Melatos (2009) suggest that the creation of the ASEAN Free Trade Area (AFTA) and other PTAs[9] has increased trade in agricultural products between participating countries. Since no robust indications of trade diversion with respect to imports from outside the region were found, such agreements appear to be net trade creating. In the absence of multilateral liberalization, this appears to be an enhancement of food security, at least from a self-reliance perspective. Regional PTAs can also be mechanisms through which supply guarantees can be sought. A good example of this is the ASEAN Plus Three Emergency Rice Reserve System, which became a permanent arrangement in October 2011. The mechanism has yet to prove its reliability, however, since its earlier version was not invoked during the food price crisis of 2008 because of overly cumbersome procedures.

Models of global trade liberalization often show increased demand for developing countries' exports. Countries with more diversified agricultural market structures and trading partners are likely to adjust quickly and take advantage of market signals, while countries that

[9] The other PTAs studied are Common Market for Eastern and Southern Africa (COMESA) in Southern Africa, which has eliminated tariffs on all goods exported within its borders, and Mercado Común del Sur (MERCOSUR) in South America, a customs union.

have a weak market infrastructure or rely on a small number of export commodities generally show smaller gains.

The market access policies of importing countries also affect their source diversification potential. Countries that manage or control the import of foodstuff—such as the Philippines or Indonesia—usually do so through parastatals, which in general are less creative in finding alternative sources than the private sector (as is the case in Bangladesh). Additional layers of administrative requirements such as tariff-rate quotas (TRQs), and the possible uncertainties arising from the imposition of additional duties through special safeguards can also deter private sector efforts to invest in the search for additional sources.

Export subsidies and food aid are a controversial topic for food security. On the one hand, they provide cheap sources of food, while on the other, they have been identified as detriments to the development of agricultural sectors in developing countries that cannot provide such subsidies. To the extent that we view things from a diversification point of view, export subsidies artificially favor source countries providing these subsidies.

Domestic subsidies, insofar as they are trade distorting, also prevent the diversification of sources through the same principle as export subsidies. But an additional argument against their use has been their preventing producers from other countries access to the host market and to markets to which the subsidized goods are exported.

On the import side, domestic prices in countries with high tariffs could decline under trade liberalization if the reduction in tariffs outweighs any rise in world prices. In that case, costs to consumers would decline—while their purchasing power, and so their food security, would grow—as would returns to producers, whose purchasing power would also grow. If initial tariffs were relatively low, however, world prices would be expected to pass through to the domestic economy, leading to higher prices that benefit producers (who include a large share of the poor in Asia) but do not necessarily benefit consumers. The effects on agricultural employment, an important factor for food security, will vary from country to country, requiring careful local analysis.

On the export side, trade liberalization leading to improved access to developed markets could lead to an increase in exports for developing countries. This effect would be dampened by the extent to which developing countries already receive preferential access to developed country markets. Unfortunately, low-income countries generally show a low production response to increases in producer prices.

Countries might find it useful to introduce programs that stabilize export revenues, such as hedging or crop insurance. On the import side, countries might consider options to make import costs more predictable. Proposals have included international import insurance or a financial rebate program for low-income countries (Trueblood and Shapouri 2001).

The previous rise of higher-income Asian economies provided an early wave of demand stimulus, accompanied by agrofood supply chain development and technology transfer around the region. This was followed by rising middle-class consumption in rapidly emerging Asian economies and finally, the dramatic emergence of demand from the PRC over the last 3 decades and India more recently. With rising incomes, diets are becoming more grain- and protein meal-intensive through the greater demand for lot-fed livestock. The PRC has already switched from being a net exporter to a major importer of maize and soybeans. And since it is

the world's largest food consumer, a small shift in the PRC's net export position could be enough to move global markets—with impacts on food security for other countries.

Jha, Roland-Holst, and Sriboonchitta (2010) note that as the PRC's middle class continues to emerge and expand, the resource intensity of the consumption of food such as meat and dairy is rising, leading to greater net imports and requiring the expansion of agricultural capacity elsewhere. This situation suggests a significant opportunity for lower-income Southeast Asia, which is still likely well below its agricultural potential, possibly yielding a food security improvement through agrofood export expansion.

Clear trends emerge when looking at high-income Asian agricultural trade, where the countries have all had significant increases in imports of meat as well as feed grains to fuel domestic production. Vast areas of farmland are needed to yield the grains necessary to raise cattle and other livestock, and as higher-income countries mostly have low arable land-to-population ratios and their self-sufficiency ratios have been declining for years, it is unlikely they can produce the quantities needed. The PRC accounts for roughly 20% of world population but just 7% (and declining) of the world's arable land. Declining freshwater availability is likely to impose an additional constraint. Therefore, in many cases, such countries will depend on imports of grain in addition to meat products.

As the PRC continues to increase its meat demand and many millions more Indians join the middle class (ADB 2010), vast quantities of grain will be needed, creating tremendous pressure on global agricultural markets. As the middle class grows in countries with food subsidies for urban consumers, such subsidies may no longer be considered necessary, allowing a rise in prices in rural areas as well, thus benefiting poor farmers.

Infrastructure is also an enabling tool for diversification. Since trade and transaction costs are usually not negligible, an important measure in the integration of markets is the balance between regional price differentials and transaction costs, including transportation. The greater the amount by which the price differential exceeds the expected transaction cost, the greater the incentive for traders to move supplies from the lower priced area to the higher priced one. In this context, transport and logistics costs remain important determinants of agricultural and other trade flows (Brooks and Hummels 2010). The manner in which these costs influence the ability to reorient to alternative suppliers and the relative costs involved has important implications for food security. General infrastructure such as roads and telecommunications are necessary to physically transport products into or out of a country. Infrastructure helps food get to deficit areas and prevents surplus from depressing local prices by access to the export valve. The low value-to-bulk ratio of most food products means that their delivered prices are highly sensitive to increasing logistics costs. Where the price differential remains higher than the associated transaction costs over an extended period, indicating segmented markets, there may be a clear role for policies and investments to address the gap.

Food also tends to be a special commodity, requiring specific types of infrastructure in addition to the general ones:

1. Food handling requires specialized infrastructure such as refrigerated vans, special packaging, humidity control, and others to retain ideal food quality. For example, the improper storage and handling of maize and nuts lead to the development of aflatoxins which may be carcinogenic.

2. Food products, especially fresh produce, tend to have limited shelf lives. This means poor transport conditions, extended duration of shipments, and other sources of delays can lead to spoilage and wastage.
3. Food items can be vectors of diseases as they carry microorganisms or pests and diseases. Special protocols are therefore required to minimize the probability of spreading disease or pests during transport. The introduction of pests or diseases to a country already experiencing a food deficit can cause additional economic devastation.

Trade costs from inadequate infrastructure and a cumbersome regulatory environment can be significantly higher than those from tariffs and nontariff barriers, and much higher in developing than developed economies (Anderson and van Wincoop 2004). The costs of transit delays are especially high for time-sensitive goods like perishable agricultural products. Improvements in infrastructure can reduce trade costs and time, and increase its reliability, thus increasing flows and benefiting sectors that use infrastructure services more intensively. In the process, such improvements can increase the potential for new bilateral trade patterns, reducing vulnerability to disruptions from any single source.

There are countries that have the means and comparative advantage to produce important food items but are unable to export them efficiently because of poor infrastructure. Myanmar and Cambodia, for example, have the clear potential to produce rice in excess of their domestic needs but are unable to export to more destinations because of infrastructure limitations. In contrast, Singapore, which does not produce primary food products, is able to transship maize to Brunei Darussalam and Seychelles.

V. CONCLUSIONS

Food trade plays an important role in nutritional security in many countries. Since historical trade patterns can be subject to abrupt changes or disruptions, food security assessment requires an examination of bilateral trade dependence for critical commodity imports to identify and address possible weaknesses in essential supply patterns. This is what the BIPI intends to do.

The BIPI captures food security vulnerability arising from having an undiversified import base. This is one aspect that needs to be considered when examining food security risks related to trade.[10] But there are obvious limitations to the BIPI. Vulnerabilities arising from other factors such as Balance of Payments-related issues would need a different method of assessment. As was pointed out earlier, in the case of Italy's role as a rice-supplying hub in Europe, the BIPI may—in cases where a food item does not form an important part of the diet—overstate a country's vulnerability. The examples of Malaysia and Seychelles having numerous suppliers for their domestic consumption also bring attention to the need to consider other factors, such as the use of food products for processing, feeds, and so on.

Nonetheless, the BIPIs and the food maps presented reveal some messages worth emphasizing. First, the maps are good tools for tracing direct and indirect paths of dependence in food trade. They can therefore be useful in identifying possible sources of supply shocks

[10] Other indices such as the Global Hunger Index developed by the International Food Policy Research Institute, or the Global Food Security Index by the Economist Intelligence Unit, cover other aspects of food security commonly discussed in the literature.

outside one's own country and can help governments strategize on potential alternative suppliers based on the trade network clusters, and between food trade and "gravitational forces" of demand.

Second, actual trade vulnerabilities can be easily assessed from the maps along several dimensions—the BIPI, the TIPI, centrality, and the clusters—and provide useful information that can complement traditional studies for assessing food security impacts of trade. Third, several countries feature very prominently as central players in all the food trade networks considered here. The maps and the indices underlying them can give warning indications of global food price hikes triggered by supply shocks in these key countries, and by which importing countries will be most immediately affected. In particular, the US appears with large nodes assigned to it for all of the commodities we have mapped. This information may be particularly relevant when the US experiences drought, as in 2012.

The main lesson we draw is that countries should diversify their import sources to make themselves less vulnerable to localized supply disruptions in source countries. Bilateral agreements with nontraditional suppliers, regional trade agreements, reserve systems, infrastructure, and institutional setups highly influence the ability of a country to diversify its supply base. Aid for trade, enhanced trade facilitation, and better trade financing and foreign exchange hedging systems could also be important contributions from the international community toward food security.

Further extension of this work could develop a diversification index which assesses how diversified a country's current staple food import sources are in relation to potential sources. This should give due consideration to quality by using export and import unit prices. Low-grade wheat is mostly used for feed, while higher grades are used for human consumption. It would also be interesting to look at how the trade maps evolve through time, which will also provide the opportunity to assess changing relationships. Further work with regressions and correlations can examine the effectiveness and robustness of the BIPI as an indicator of vulnerability.

By utilizing the fact that not all trade routes are equally employed or available for all countries, and that potential exists for expanding such opportunities, our understanding of food security becomes more nuanced, analysis can be more focused, and policy making more efficiently targeted.

APPENDIXES

Appendix Table 1: Top 20 BIPIs for Wheat

Importer		Exporter				'000 Tons		
Code	Country	Code	Country	BIPI	TIPI	Bilateral Imports	Total Imports	Domestic Supply (P+M-X)
DOM	Dominican Republic	USA	United States	1.000	1.000	3152	3192	866
VCT	Saint Vincent and the Grenadines	USA	United States	0.776	0.770	40	40	14
NGA	Nigeria	USA	United States	0.398	0.604	16100	24800	11149
SLV	El Salvador	USA	United States	0.396	0.391	455	455	316
CRI	Costa Rica	USA	United States	0.333	0.328	403	403	333
SRI	Sri Lanka	CAN	Canada	0.285	0.311	1838	2029	1771
GTM	Guatemala	USA	United States	0.280	0.295	851	909	837
MUS	Mauritius	FRA	France	0.253	0.321	232	298	252
JAM	Jamaica	USA	United States	0.250	0.360	314	458	346
GAB	Gabon	FRA	France	0.244	0.241	153	153	173
KWT	Kuwait	AUS	Australia	0.242	0.274	536	615	609
BRB	Barbados	USA	United States	0.242	0.239	44	44	50
SEN	Senegal	FRA	France	0.241	0.267	673	756	769
CIV	Cote d' Ivoire	FRA	France	0.228	0.239	531	563	641
PAN	Panama	USA	United States	0.224	0.242	219	241	270
NIC	Nicaragua	USA	United States	0.220	0.217	243	243	304
BLZ	Belize	USA	United States	0.219	0.229	26	27	32
NCL	New Caledonia	AUS	Australia	0.216	0.215	60	61	77
TGO	Togo	FRA	France	0.213	0.304	111	160	143
MWI	Malawi	MOZ	Mozambique	0.210	0.396	137	263	180

BIPI = bilateral import penetration index, M = import, P = production, TIPI = total import penetration index, X = export.

Note: BIPI and TIPI values computed based on equations (1) and (2) were normalized to take values from 0 to 1.

Source: Authors' estimates.

Appendix Table 2: Top 20 BIPIs for Maize

Importer		Exporter				'000 Tons		
Code	Country	Code	Country	BIPI	TIPI	Bilateral Imports	Total Imports	Domestic Supply (P+M-X)
JAM	Jamaica	USA	United States	1.000	1.000	637	637	565
SYC	Seychelles	UKG	United Kingdom	0.618	0.867	11	17	18
MAL	Malaysia	ARG	Argentina	0.479	0.628	2776	3960	6252
TTO	Trinidad and Tobago	USA	United States	0.473	0.480	54	54	123
RWA	Rwanda	UGA	Uganda	0.391	0.398	90	90	274
GRD	Grenada	USA	United States	0.389	0.401	1	1	2
BWA	Botswana	ZAF	South Africa	0.358	0.366	38	38	133
ANT	Antigua	ZAF	South Africa	0.302	0.346	0.2	0.3	1
GUY	Guyana	USA	United States	0.270	0.351	4	7	25
SYC	Seychelles	PRC	People's Republic of China	0.247	0.867	3	17	18
SYC	Seychelles	IND	India	0.215	0.867	2	17	18
DJI	Djibouti	ZAF	South Africa	0.214	0.239	0.2	0.2	2
GUY	Guyana	TTO	Trinidad and Tobago	0.211	0.351	2	7	25
EST	Estonia	POL	Poland	0.201	0.232	2	3	25
MAL	Malaysia	PRC	People's Republic of China	0.199	0.628	483	3960	6252
ISL	Israel	CAN	Canada	0.198	0.248	4	7	58
BLZ	Belize	USA	United States	0.193	0.204	5	5	71
ISL	Israel	POL	Poland	0.180	0.248	3	7	58
SDN	Sudan	UGA	Uganda	0.170	0.189	10	12	240
SYC	Seychelles	YEM	Yemen	0.168	0.867	1	17	18

BIPI = bilateral import penetration index, M = import, P = production, TIPI = total import penetration index, X = export.

Note: BIPI and TIPI values computed based on equations (1) and (2) were normalized to take values from 0 to 1.

Source: Authors' estimates.

Appendix Table 3: Top 20 BIPIs for Soybeans

Importer		Exporter				'000 Tons		
Code	Country	Code	Country	BIPI	TIPI	Bilateral Imports	Total Imports	Domestic Supply (P+M-X)
SVN	Slovenia	BRA	Brazil	1.000	1.000	15	19	2
KEN	Kenya	UGA	Uganda	0.758	0.711	44	53	8
SDN	Sudan	ITA	Italy	0.436	0.781	3	7	1
UZB	Uzbekistan	UKR	Ukraine	0.294	0.301	15	20	7
DOM	Dominican Republic	USA	United States	0.253	0.195	18	18	10
SDN	Sudan	IND	India	0.238	0.781	2	7	1
MOZ	Mozambique	MWI	Malawi	0.229	0.444	2	4	1
SVN	Slovenia	PRY	Paraguay	0.216	1.000	3	19	2
MOZ	Mozambique	SWZ	Swaziland	0.205	0.444	1	4	1
SDN	Sudan	BEL	Belgium	0.183	0.781	1	7	1
BWA	Botswana	ZAF	South Africa	0.178	0.204	1	2	1
GUY	Guyana	USA	United States	0.166	0.128	1	1	1
CHE	Switzerland	PRY	Paraguay	0.165	0.242	103	196	86
BLR	Belarus	MDA	Moldova	0.146	0.173	1	2	1
CRI	Costa Rica	USA	United States	0.139	0.108	548	548	542
SDN	Sudan	ETH	Ethiopia	0.138	0.781	1	7	1
NOR	Norway	BRA	Brazil	0.138	0.106	817	817	818
BRB	Barbados	USA	United States	0.137	0.105	50	50	50
AZE	Azerbaijan	MDA	Moldova	0.136	0.106	17	17	17
MEX	Mexico	USA	United States	0.135	0.104	7375	7377	7549

BIPI = bilateral import penetration index, M = import, P = production, TIPI = total import penetration index, X = export.

Note: BIPI and TIPI values computed based on equations (1) and (2) were normalized to take values from 0 to 1.

Source: Authors' estimates.

Appendix Table 4: Economy Codes

Code	Economy	Code	Economy
ABW	Aruba	CIV	Côte d'Ivoire
AFG	Afghanistan	CMR	Cameroon
AGO	Angola	COD	Democratic Republic of the Congo
AIA	Anguilla	COG	Congo
ALB	Alabania	COL	Columbia
AND	Andorra	COM	Comoros
ANT	Netherlands Antilles	COO	Cook Islands
ARE	United Arab Emirates	CPV	Cape Verde
ARG	Argentina	CRI	Costa Rica
ARM	Armenia	CUB	Cuba
ASM	American Samoa	CXR	Christmas Island
ATA	Antarctica	CYM	Cayman Islands
ATG	Antigua and Barbuda	CYP	Cyprus
AUS	Australia	CZE	Czech Republic
AUT	Austria	DEN	Denmark
AZE	Azerbaijan	DJI	Djibouti
BAN	Bangladesh	DMA	Dominica
BDI	Burundi	DOM	Dominican Republic
BEL	Belgium	DZA	Algeria
BEN	Benin	ECU	Ecuador
BFA	Burkina Faso	EGY	Egypt
BGR	Bulgaria	ERI	Eritrea
BHR	Bahrain	EST	Estonia
BHS	Bahamas	ETH	Ethiopia
BHU	Bhutan	FIJ	Fiji
BIH	Bosnia and Herzagovia	FIN	Finland
BLR	Belarus	FRA	France
BLZ	Belize	FSM	Federated States of Micronesia
BMU	Bermuda	GAB	Gabon
BOL	Bolivia	GEO	Georgia
BRA	Brazil	GER	Germany
BRB	Barbados	GHA	Ghana
BRU	Brunei Darussalam	GIB	Gibraltar
BWA	Botswana	GIN	Guinea
CAF	Central African Republic	GMB	Gambia
CAM	Cambodia	GNB	Guinea-Bissau
CAN	Canada	GNQ	Equatorial Guinea
CCK	Cocos Islands	GRC	Greece
CHL	Chile	GRD	Grenada

continued on next page

Appendix Table 4 *continued*

Code	Economy	Code	Economy
GRL	Greenland	MKD	Macedonia
GTM	Guatemala	MLD	Maldives
GUM	Guam	MLI	Mali
GUY	Guyana	MLT	Malta
HKG	Hong Kong, China	MNP	Northern Mariana Islands
HND	Honduras	MON	Mongolia
HRV	Croatia	MOZ	Mozambique
HTI	Haiti	MRT	Mauritania
HUN	Hungary	MSR	Montserrat
IND	India	MUS	Mauritius
INO	Indonesia	MWI	Malawi
IRE	Ireland	MYA	Myanmar
IRN	Iran	MYT	Mayotte
IRQ	Iraq	NAM	Namibia
ISL	Iceland	NAU	Nauru
ISR	Israel	NCL	New Caledonia
ITA	Italy	NEP	Nepal
KEN	Kenya	NER	Niger
KGZ	Kyrgyz Republic	NET	Netherlands, The
KIR	Kiribati	NFK	Norfolk Island
KNA	Saint Kitts and Nevis	NGA	Nigeria
KOR	Republic of Korea	NIC	Nicaragua
KWT	Kuwait	NIU	Niue
LAO	Lao People's Democratic Republic	NOR	Norway
LBN	Lebanon	NZL	New Zealand
LBR	Liberia	OMN	Oman
LBY	Libya	PAK	Pakistan
LCA	Saint Lucia	PAL	Palau
LSO	Lesotho	PAN	Panama
LTU	Lithuania	PER	Peru
LUX	Luxembourg	PHI	Philippines
LVA	Latvia	PNG	Papua New Guinea
MAC	Macau SAR, China	POL	Poland
MAL	Malaysia	POR	Portugal
MAR	Morocco	PRC	People's Republic of China
MDA	Moldova	PRK	Democratic People's Republic of Korea
MDG	Madagascar	PRY	Paraguay
MEX	Mexico	PSE	Palestine Occupied Territories

continued on next page

Appendix Table 4 *continued*

Code	Economy	Code	Economy
PYF	French Polynesia	SYC	Seychelles
QAT	Qatar	SYR	Syria
RMI	Republic of the Marshall Islands	TAJ	Tajikistan
ROU	Romania	TCD	Chad
RUS	Russian Federation	TGO	Togo
RWA	Rwanda	THA	Thailand
SAM	Independent State of Samoa	TIM	Timor-Leste
SAU	Saudi Arabia	TKM	Turkmenistan
SDN	Sudan	TTO	Trinidad and Tobago
SEN	Senegal	TUN	Tunisia
SHN	Saint Helena	TUR	Turkey
SIN	Singapore	TZA	Tanzania
SLE	Sierra Leone	UGA	Uganda
SLV	El Salvador	UKG	United Kingdom
SOL	Solomon Islands	UKR	Ukraine
SOM	Somalia	URY	Uruguay
SPA	Spain	USA	United States
SRB	Serbia	UZB	Uzbekistan
SRI	Sri Lanka	VAN	Vanuatu
STP	Sao Tome and Principe	VCT	Saint Vincent and the Grenadines
SUR	Surinam	VIE	Viet Nam
SVK	Slovakia	YEM	Yemen
SVN	Slovenia	ZAF	South Africa
SWE	Sweden	ZMB	Zambia
SWI	Switzerland	ZWE	Zimbabwe
SWZ	Swaziland		

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