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Bilateral Trade and Food Security in Asia

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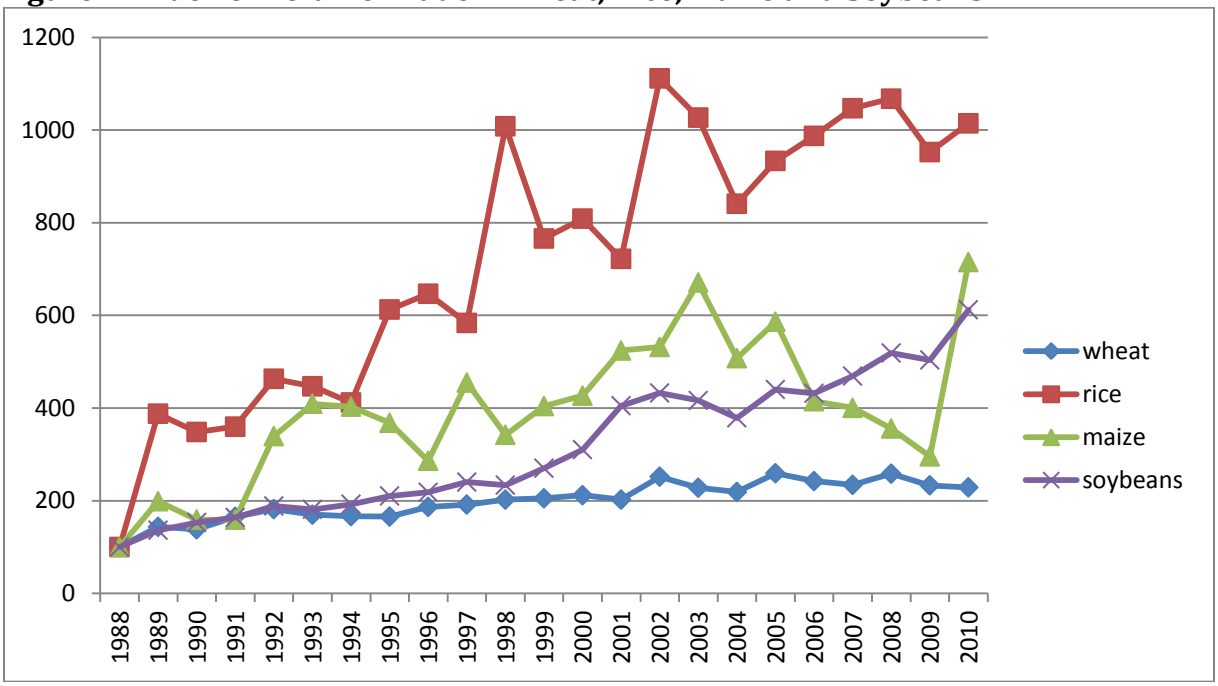
I. Introduction:

Trade (both through imports and via the extra purchasing power generated from exports) has the potential to complement domestic food supplies. The increase in the volume of staples traded in the world since 1988 as shown in Figure 1 is an indication of this.

Figure 1: Index of Volume Trade – Wheat, Rice, Maize and Soybeans



Notes: Index constructed based on the average of imports and exports from COMTRADE.
Source: Authors' calculations

Nonetheless, discussions about the relationship between food security and trade inevitably turn to the debate between food self-sufficiency and self-reliance. From the point of view of food self-sufficiency, trade can only contribute to food security if it increases agricultural productivity. On the other hand, an emphasis on availability sees trade as a potential tool for making food cheaper and more widely accessible. As Anderson and Strutt (2012) described, self-sufficiency emphasizes production, while availability places the emphasis on consumption. Governments in the Asia and Pacific region, at least in rhetoric, tenaciously hold on to the self-sufficiency mantra while economists tend to self-reliance.

This paper adds to the arguments that the most important aspect of food security is self-reliance. Neither aggregate physical sufficiency nor abundance makes sense if substantial proportions of the population do not have access to basic food items. 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. Self-reliance is also more consistent with the FAO formal definition of

food security which considers "physical, social and economic access to sufficient, safe, and nutritious food…for an active and healthy lifestyle".

Food security can more easily be achieved when it is not limited to self-sufficiency. This applies at both household and national levels. Just as division of labor and trade on the basis of comparative advantage helps households to raise income and living standards while simultaneously saving for investment or emergencies, it 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.

Still, trade has too often been viewed from a global point of view without sufficient attention to bilateral trade links that underlie the overall picture. From a country perspective, bilateral trade relationships give better information on possible implications of trade shocks on food security for individual countries. The experience during the food price crisis in 2008 is instructive in this regard. India and Viet Nam imposed export bans on rice, and countries that have been heavily dependent on them for rice supplies felt the effects more severely than others.

A. 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. Trade also expands the range of options for exchanging non-food 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 deliver. 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 changes in prices 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 their markets are more integrated. This is because 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. Note that 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 responding 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 imports of technology, whether directly imported 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 production of staples artificially more profitable relative to other crops have prevented farmers from diversifying into higher valued products, which in the longer run yield sustained higher incomes.

Fourth, trade can influence food security through the expansion of competition. Opening markets to international competition promotes competition among firms 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. 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 are vulnerable to more frequent or prolonged price spikes.

Fifth, trade can indirectly influence food security through its impacts 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 (Facker and Goodwin, 2001). For example, the United Nations' World Food Program (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, supporting incomes in these areas. 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. Freed up resources from removing such interference in the market can be used for interventions such as infrastructure, research and development, market intelligence, 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 for the province (World Bank 2005). In the Philippines, the accumulated debt of the National Food Authority (NFA) is about to be 12% of agricultural GDP in 2011.

Finally, to the extent that food imports reduce production in environmentally fragile areas, trade may reduce 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 re-entry 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, potentially endangering food security in other traders.

III. Mapping Food Trade

Traditional approaches to studying the links between trade and food security generally find that trade facilitates food security by increasing income, reducing poverty, improving market efficiency, making food stuff cheaper or simply making food physically available.

Evidence from country level studies is more nuanced. Liberalization of the staple markets in Bangladesh has been a widely acclaimed success. The same can be said of the liberalization efforts in the PRC and Viet Nam, the liberalizations in Indonesia and the Philippines were judged to not have made grounds in improving food security (Rashid et al. 2008). A host of factors can account for these differences. Nonetheless, examining bilateral relationships in food trade can make traditional analyses sharper.

The analysis in this section highlights the international trade dimension of food security, as it depends on particular trading partners and vulnerability to disruption in those bilateral trade links. We compute a bilateral import penetration index (BIPI) to gauge the degree to which any one country depends on another for its food imports. Underlying the analysis is a trade matrix of world trade in rice, wheat, maize and soybeans, the four major staples deemed central to food security. The data on quantities (kg) traded are derived from the UN COMTRADE database.[1] The trade data are combined with country food balance sheets (FBS) from the Food and Agriculture Organization (FAO) for rice, wheat, maize and soybeans.

In relation to any particular food item *f* and period of observation *t,* say rice during the years 2009 and 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 domestic supply—the higher will be the BIPI. Specifically, BIPI is defined as:

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

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 country *i*'s overall reliance on imports to satisfy domestic demand. The latter may be termed the total import penetration index (TIPI):

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

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

We calculated the BIPIs by summing up the trade and production data for 2006 and 2007, the latest years for which the FAO FBS data were available, and normalizing the resulting values. Table 1 lists the country-pairs with the top fifteen BIPIs for rice, together with some of the underlying data for the calculations. Angola is shown to have the highest BIPI in relation to Viet Nam which accounts for close to 60% of its rice imports. Comparing with domestic consumption (estimated to be the sum of production and imports, less exports) reveals that the amount imported from Viet Nam even exceeds the amount of consumed in Angola. The same story is observed between Mongolia and the PRC. More strikingly, Mongolia is almost exclusively dependent on the PRC for all its rice imports. It is also worth noting that Viet Nam, Thailand, Italy, India and Egypt feature prominently as primary sources of rice for the top fifteen countries with the highest import dependence on a single import source. [2]

Based on the set of computed BIPI values across country-pairs and years, food trade maps are drawn by application of 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. Figures 2 to 5 show the ensuing maps of bilateral and global food dependencies, for each of the four commodities and with reference to total trade during 2006 and 2007. For better readability, the maps only show country pairs with the strongest bilateral trade dependency (the top quintile by BIPI).

[2] Please refer to Tables 1 to 4 in the Appendix for the fifteen countries wit the highest BIPIs for rice, maize, wheat and soybeans.

Tabl e 1: Top Fifteen BIPIs for Rice

Importer		Partner		BIPI	Volume '000 Tonnes		
Code	Country	Code	Country		Bilateral Imports	Total Imports	Domestic Supply (Production + Imports - Exports)
AGO	Angola	VNM	Viet Nam	1.000	297	514	249
MNG	Mongolia	CHN	People's Rep. of China	0.851	47	47	46
GAB	Gabon	THA	Thailand	0.850	76	105	75
BEN	Benin	THA	Thailand	0.842	487	1081	485
SVN	Slovenia	ITA	Italy	0.802	14	23	15
COG	Republic of Congo	VNM	Viet Nam	0.800	128	249	134
SYC	Seychelles	IND	India	0.800	11	12	12
VUT	Vanuatu	AUS	Australia	0.754	21	22	23
CZE	Czech Republic	ITA	Italy	0.742	96	125	108
DJI	Djibouti	IND	India	0.733	73	89	84
KWT	Kuwait	IND	India	0.728	348	454	401
SWZ	Swaziland	ZAF	South Africa	0.724	38	41	44
LBY	Libya	EGY	Egypt	0.709	252	316	298
ATG	Antigua	VCT	St. Vincent & the Grenadines	0.674	2	3	2
SYR	Syria	EGY	Egypt	0.655	388	411	497

Rice

Figure 2 refers to global trade in rice among the top 20 percent of countries in terms of BIPI. The circles, or nodes, represent the countries trading in rice. The color of the circles reflects countries' total dependence on food imports, gauged by TIPI (eq.2). Countries in green, such as Thailand or India, are leading rice exporters and, as such, are less dependent on other countries' rice exports.[3] Albeit to a lower degree, countries in yellow are relatively independent on rice imports to cover domestic demand as well. Such is the case of the United States, Australia, etc. As the color spectrum moves to orange and further to red, a strong import dependence is detected and with it a country's heightened degree of vulnerability to potential disruptions in global supply. For example, South Africa, Saudi Arabia and the UAE are all represented with red nodes.

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 located nearer the center of the map. This is the case for Thailand, Viet Nam, India and Pakistan.
The size of any node relates to its so-called 'betweenness centrality', or the number of shortest paths (geodesics) going through it.[4] 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. For example, 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. The USA, Thailand, and Pakistan are visibly prominent in this regard.

It is also interesting to observe how different sets of countries cluster around the major rice exporters. China is a hub for a number of Central Asian countries, while Italy is depicted to play this role in Europe. An important point to note here is that except for Iran, most of the countries that rely heavily on Italy for exports such as Czech Republic and Poland do not consume rice as a staple. They are in this sense not really food insecure.

Globally, the United States 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 Thai-Viet-Ind-Pak cluster, the US is central to a network that spans a greater geographic scope and a

[3] It should be kept in mind that maps show only the top 20% of country pairs ranked according to decreasing BIPI. Therefore, even countries colored in green with arrows pointing inwards depend on imports to a degree higher than do 4/5 of all the other countries in the sample. Put differently, color green and yellow indicate a relatively lower degree of import penetration among the subsample of countries with the highest BIPI.

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

greater number of countries for a single supplier (recall that only nodes in the top quintile are shown in the maps).

Whereas the color and size of nodes relate to the characteristics of rice exporters that are of relevance to the global market as a whole, the color and width of lines connecting any pair of nodes describe the degree of their dependence on each other. For example, a narrow and green line, or arc, in relation to PRC's rice exports to Kazakhstan 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 20% across all country pairs). By contrast, Mongolia's dependence on rice imports from PRC is more exclusive and puts the country at a greater risk of suffering from potential supply disruptions affecting this particular supply channel.

An interesting revelation from this map is that most Asian countries, with the exception of Mongolia, 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, the PRC, Indonesia, Malaysia, and the Philippines only show up as green and yellow nodes with green and orange edges. This is because countries like these are also large rice producers and import only a small fraction of their total domestic consumption. The PRC, also a large importer does not even show up in the map as an importer, indicating the diversity of its sources of imports.

We also take the opportunity to point out that vulnerabilities of one country can also be passed through to other countries. The map's depiction of the network surrounding South African is instructive. South Africa's high dependence on Thailand and India for its rice imports is passed on as vulnerabilities to Swaziland and Botswana.

Wheat

The resulting wheat map in Figure 3 shows that global trade of wheat is centered on several key players– USA, Canada, Australia, Russia, Kazakhstan, and France. The first three countries are particularly important suppliers for a number of Asian countries while Russia together with Kazakhstan are important suppliers for Central Asia and other former Soviet republics.

The wheat map shows that many big Asian countries such as Viet Nam, Indonesia, Japan, Korea, Malaysia, and the Philippines are highly dependent on imports for domestic wheat consumption. But the edges connecting these countries to major suppliers (with the exception of the edge connecting Australia and Malaysia), indicate that they have relatively diverse import bases.

One striking feature of this map is that the UAE appears very prominent as an importer. Almost all the edges linked to the UAE are red despite having a large number of suppliers. The red node indicates its high import dependence and its larger node size also signal its centrality as a big importer. Demand shocks in the UAE and possible supply shocks

transmitted by changes in import behavior of the UAE will have palpable repercussions for supplying countries.

Maize

The maize map in Figure 4 distinctly shows several hubs of the maize network trade – the US, South Africa, France, the PRC, and India. It is easily apparent that the US is a major hub which supplies maize across regions to Asia, Africa, the rest of the Americas and Europe. The other suppliers tend to be more confined to their regional vicinity. The ASEAN countries, although not central to the global maize trade, form a closely knit network, especially in respect of supplying Brunei, which is highly dependent on imports for its domestic consumption. The case of Singapore being a supplier of note to Brunei is particularly interesting as it demonstrates how countries with good trade infrastructure, despite absence or insufficiency of actual production, can be used as possible centers for supply diversification.

It is also notable that of all the largest importing countries in Asia – Japan, Korea, and the PRC – the first two do not appear in the map, while the PRC is depicted as an exporter, indicating that these countries have sufficiently diverse supply sources.

Soybeans

East Asian countries where soybeans form an important part of the diet come out in the map (Figure 5) as larger nodes with Korea and Japan having a substantial fraction of their domestic consumption supplied through imports. It is worth noting that while the PRC has a lower TIPI than the other two; it has a more central role in the soybean network as a supplier to other countries as well as an importer. Thailand is also shown to be a central player in the soybean trade.

The most important bilateral suppliers of soybeans in the world are the USA, Brazil and Canada, but the soybean map also indicates that the nodes dependent on USA and Brazil tend to have less diversified sources.

Some Limitations

The BIPI captures food security vulnerability arising from having an undiversified import base. Vulnerabilities arising from other factors such as BOP related issues would need a different method of assessment. It was also pointed out earlier in the case of Italy's role as a rice supplying hub in Europe how the BIPI ,may in cases where a food item does not form an important part of the diet, can overstate a country's vulnerability.

IV. Policies towards Reducing Vulnerability

The previous section highlight 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 the BIPIs and the resulting maps is to diversify one's sources of imports. This is especially relevant for countries that import most of any food item they consume and consume it as staple. Having said this, how can countries diversity their import sources?

Preferential Trade Agreements (PTAs) are possible avenues. Stagnation (or deadlock) in the Doha Round of multilateral WTO negotiations has led to a proliferation of bilateral or regional preferential trading arrangements (PTAs). Agriculture was a sticking point in the WTO negotiations and the lack of progress there signals a loss of potential agricultural trade which could be critical for food security in Asia, the region with most of the world's consumers and most of the world's poor.

Results from a gravity model by Korinek and Melatos (2009) suggest that creation of AFTA and other PTAs[5] 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 the ASEAN Plus Three Rice Reserve System which became a permanent arrangement in October 2011. The mechanism has yet however to prove its reliability. The earlier version of the mechanism 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 would be likely to adjust quickly and take advantage of market signals, while countries with weak market infrastructure or that rely on a small number of export commodities would show smaller gains.

Market access policies of importing countries also affect their source diversification potential. Countries that manage or control the import of food stuffs usually do so through parastatals – Philippines, Indonesia – who in general are less creative in finding alternative sources than the private sector (case of Bangladesh). The administration of additional layers of administrative requirements such as TRQs, and the possible uncertainties by the imposition of additional duties through special safeguards can also deter private sector efforts to invest in the search for additional sources.

[5] The others studied are COMESA in Southern Africa, which has eliminated tariffs on all goods exported within its borders, and MERCOSUR in South America, a customs union.

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 culprits for preventing 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 subisdies artificially favor countries providing these subsidies as sources.

Domestic subsidies in as far as they are trade distorting also prevent diversification of sources through the same principle as export subsidies. But an additional argument against their use has been its ability to prevent produces from other countries access to one's own market and to markets to where the subsidized goods are exported to.

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. Recent proposals have included international import insurance or a financial rebate program for low income countries (ERS).

Jha et al (2010) note that as PRC's middle class continues to emerge and expand, the resource intensity of food consumption (eg, meat and dairy) is rising, leading to greater net imports and requiring 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, potentially yielding a food security improvement through agrofood export expansion.

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 three decades and India more recently. With rising incomes, diets are becoming more grain and protein meal intensive through the income-livestock–feed effect.

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 PRC's net export position can be enough to move global markets – with impacts on food security for other countries.

Clear trends emerge when looking at high income Asian agricultural trade, where the countries have all had significant increases in meat imports 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 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 (KI 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 influence the ability to divert 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 whether they be into a country 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. Their low value to bulk ratio – that most food products have low values compared to their bulk - 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. Specific types of infrastructure are needed in addition to the general ones: (1) Special handling and storage - specialized infrastructure for food handling such as refrigerated vans, special packaging, humidity control etc. to retain ideal quality of food. For example, improper storage and handling of maize and nuts lead to development of aflatoxins considered to be carcinogenic. (2) Sensitive shelf life – food products tend to have limited shelf lives, especially for fresh produce. This means transport conditions, length and delays can lead to spoilage and wastage. (3) Vectors and carriers of pests or disease causing organisms – food 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. Introduction of pests or diseases to a country already having food deficit status can cause more economic devastation.

Trade costs from inadequate infrastructure and a cumbersome regulatory environment can be significantly higher than those from tariffs and non tariff 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 would lower the cost and time of trade, and increase its reliability, thus increasing flows and benefiting sectors that use infrastructure services more intensively. In the process, they would 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 of producing important food items but are unable to export them efficiently because of poor infrastructure. Myanmar and Cambodia, for example have 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 and Seychelles.

V. Conclusions

The food maps presented above reveal some messages that are 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 outside one's own country and can help governments strategize on potential alternative suppliers based on the network clusters, and based on what we know from the gravity models that estimate links between food trade and "gravitational forces."

Second, actual trade vulnerabilities can be easily assessed from the maps along several dimensions – the BIPI, the TIPI, centrality and the clusters, and provide very useful information that can complement traditional studies for assessing food security impacts of trade.

Finally, several countries feature very prominently as central players in all the food trade maps shown 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 which countries will be most immediately affected. The US appears with large nodes assigned to it for all of the commodities we have mapped. This information is particularly relevant given the drought the US is experiencing.

The main lesson that 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 non-traditional suppliers, RTAs, reserve systems, infrastructure and institutional set ups 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.

Our work with the BIPI is a work in progress. We plan to make use of the data we have to make the analysis richer. To this end we are planning to: (1) develop a diversification index which assesses how diversified are the current staple food import sources of a country vis a vis the 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 maps evolve through time, which will also provide the opportunity to assess changing relationships. (2) We will extend the analysis to more recent years – 2008 to 2009, as the food balance sheets for those years have just become available. (3) Further work can examine the effectiveness of BIPI as an indicator of vulnerability – through regressions and correlations.

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

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Appendix Table 1: Top Fifteen BIPIs for Wheat

Importer		Partner		BIPI	TIPI
Code	Country	Code	Country		
ARE	United Arab Emirates	AUS	Australia	1.0000	1.0000
ARE	United Arab Emirates	CAN	Canada	0.8557	1.0000
ARE	United Arab Emirates	RUS	Russia	0.3796	1.0000
ARE	United Arab Emirates	ARG	Argentina	0.2497	1.0000
DOM	Dominican Republic	USA	United States	0.2030	0.0530
ARE	United Arab Emirates	USA	United States	0.1958	1.0000
ARE	United Arab Emirates	KAZ	Kazakhstan	0.1884	1.0000
ARE	United Arab Emirates	PAK	Pakistan	0.1769	1.0000
ARE	United Arab Emirates	DEU	Germany	0.1524	1.0000
NGA	Nigeria	USA	United States	0.1422	0.0564
ARE	United Arab Emirates	POL	Poland	0.1260	1.0000
ARE	United Arab Emirates	URY	Uruguay	0.1217	1.0000
VCT	St Vincent & the Grenadines	USA	United States	0.0925	0.0240
SLV	El Salvador	USA	United States	0.0809	0.0209
ARE	United Arab Emirates	TUR	Turkey	0.0763	1.0000

Appendix Table 2:Top Fifteen BIPIs for Maize

Importer		Partner		BIPI	TIPI
Code	Country	Code	Country		
JAM	Jamaica	USA	United States	1.0000	1.0000
SYC	Seychelles	GBR	United Kingdom	0.6181	0.8670
TTO	Trinidad and Tobago	USA	United States	0.4735	0.4802
RWA	Rwanda	UGA	Uganda	0.4020	0.4095
BWA	Botswana	ZAF	South Africa	0.3382	0.3467
DJI	Djibouti	ZAF	South Africa	0.2874	0.3278
SYC	Seychelles	CHN	People's Rep. of China	0.2475	0.8670
SYC	Seychelles	IND	India	0.2149	0.8670
EST	Estonia	POL	Poland	0.2011	0.2323
BLZ	Belize	USA	United States	0.1930	0.2037
GRD	Grenada	USA	United States	0.1896	0.2006
DJI	Djibouti	ETH	Ethiopia	0.1718	0.3278
SDN	Sudan	UGA	Uganda	0.1703	0.1891
SYC	Seychelles	YEM	Yemen	0.1678	0.8670
BDI	Burundi	UGA	Uganda	0.1663	0.1791

Appendix Table 3: Top Fifteen BIPIs for Soybeans

Importer Code	Importer Country	Partner Code	Partner Country	BIPI	TIPI
URY	Uruguay	PRY	Paraguay	1.0000	1.0000
KEN	Kenya	UGA	Uganda	0.7199	0.8657
UZB	Uzbekistan	UKR	Ukraine	0.2808	0.3720
BWA	Botswana	ZAF	Africa	0.1716	0.2543
CHE	Switzerland	PRY	Paraguay	0.1593	0.3003
CRI	Costa Rica	USA	United States of America	0.1350	0.1386
NOR	Norway	BRA	Brazil	0.1334	0.1370
MEX	Mexico	USA	United States of America	0.1305	0.1342
PAK	Pakistan	USA	United States of America	0.1262	0.1414
CUB	Cuba	USA	United States of America	0.1257	0.1295
TTO	Trinidad and Tobago	USA	United States of America	0.1253	0.1294
NLD	Netherlands	BRA	Brazil	0.1224	0.2015
CHL	Chile	ARG	Argentina	0.1207	0.1293
ESP	Spain	BRA	Brazil	0.1109	0.1381
PRT	Portugal	BRA	Brazil	0.1036	0.1428