RESEARCH INSTITUTE OF
INDUSTRIAL ECONOMICS

IFN Working Paper No. 1107, 2016

Productivity Shocks, International Trade and Import Prices: Evidence from Agriculture

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February 2016

Abstract

The purpose of this study is to measure the sensitivity of trade volumes and unit values to agricultural productivity shocks at home and abroad. We find that the unit values of trade flows vary systematically with production shocks using both aggregate data on a large sample of countries and detailed firm-level imports to Sweden. We find that import prices increase (and import volumes fall) when importer production increases. This result is likely driven by a change in the quality composition of imports or by economies of scale in international trade. This beneficial terms-of-trade effect that we find may thus be an important coping mechanism for food net-importing countries that experience negative production shocks. Our results also suggest that trade volumes are relatively insensitive to changes in production. The results suggest that trade frictions, product differentiation and storage limit the role of international trade as way of coping with production volatility.

JEL Classification Codes: F14, F18, Q11, Q17, Q18 .

Keywords: Climate shocks, pass-through, quality sorting, agricultural trade

*Shon Ferguson gratefully acknowledges financial support from the Jan Wallander and Tom Hedelius Foundation, the Marianne and Marcus Wallenberg Foundation and the Swedish Research Council. Johan Gars gratefully acknowledges research support from the Erling-Persson Family Foundation. Thanks to Fredrik Andersson for assistance with the data.

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The recent volatility in food prices has brought issues of food security to the forefront of the policy debate. Agricultural production is sensitive to weather conditions and it is negatively affected by extreme weather events. As climate change progresses, many types of extreme weather events such as heat waves and storms are expected to become more frequent (IPCC, 2013) which may contribute to food price volatility in the years to come.

International trade in food is one potential mechanism to mitigate the effects of production volatility. Countries that experience a negative shock to agricultural productivity can reduce volatility in consumption by importing the products that they need. With this in mind we will here consider how the effects of agricultural productivity shocks are propagated between countries through trade via their impact on quantities traded and the prices at which they trade.

Using data on bilateral trade of agricultural commodities, our goal is to estimate the sensitivity of trade volumes and trade unit values to production. In our baseline approach we follow Roberts and Schlenker (2013) in exploiting year-to-year changes in yield as an instrument for production, but we do not attempt to identify supply and demand elasticities. Roberts and Schlenker (2013) find that yield shocks appear to stem mainly from random weather shocks, with little risk that short-run yield fluctuations are endogenously determined by prices. We exploit the variation in production between crops in the same country, which allows us to disentangle the effect of production on trade from other factors that vary by country and year, such as macroeconomic shocks.

We find that the unit values of imports vary systematically with production shocks using data on bilateral trade between countries for a wide variety of agricultural commodities. We find that import unit values of bilateral trade flows decline (and trade volumes increase) in years when the exporting countries' production is relatively high. This result is intuitive and simply reflects the impact of greater supply on world prices.

Since we are interested in how imports respond to domestic production, we concentrate our analysis on trade flows where the importing country also produces the same good.[1] The law of supply would thus imply that import volumes and their associated unit values should decline when importers' production increases. Although we find the expected negative relationship between importers' production and import volumes, we find no evidence of a negative relationship between importers'

[1]Countries may both produce and import agricultural commodities if they are a net importer, or if product differentiation by country-of-origin leads to intra-industry trade in agricultural products.

production and import unit values and in some cases a positive relationship. This finding is contrary to standard models of international trade but can be explained by a shift in the quality composition of imports for a particular good, whereby only high-quality varieties are imported when domestic production is high. The result may also be driven by economies of scale in international trade whereby the cost per unit increases when import volumes decrease due to high production in the importing country.

We explore the relationship between production and import unit values more deeply using a highly-detailed firm-level data set covering all food imports to Sweden by product and country of origin. In the firm-level data we find a robust positive relationship between import unit values and Swedish production. In other words, a rise in Swedish production for a particular agricultural commodity leads Swedish firms to import that commodity at a higher unit value, which supports the quality composition and/or trade economies of scale hypotheses. The results suggest that the pattern of higher import unit values when Swedish production rises is a phenomenon that occurs within firms over time and is not due to differences across firms that import goods with different unit values.

The result that import unit values increase when importer production rises is new to the literature on trade in agricultural commodities. Several studies show that the quality composition of traded goods is an important feature for understanding the unit values of international trade flows, but our use of production volatility is new to the literature. Hummels and Skiba (2004) empirically test the Alchian-Allan conjecture and find that the average quality of exports is higher for destination that are more costly to reach, holding supply constant. Studies using firm-level export data shows the presence of "quality sorting" whereby only firms producing high-quality goods and charging higher prices reach the furthest-away destinations (Manova and Zhang, 2012) and wine (Crozet et al., 2012). In contrast to these studies, we hold trade costs constant and explore the impact of supply shocks on trade unit values.

An alternative interpretation of this result is that importers pay lower prices for imports in years where production in the importing country is poor, due to decreases in import quality and/or via economies of scale in trade when import quantities rise. The beneficial terms-of-trade effects that we find may thus be an important coping mechanism for food net-importing countries that experience negative production shocks.

We also find that trade volumes respond inelastically to production shocks.

Given that international trade is small compared to total production one would expect that small percentage increases in production could potentially lead to large percentage changes in trade. This result suggests that trade costs, product differentiation or storage severely impede the role of international trade as a method of coping with production variation. Our results suggest that the relationship between trade volumes and importer production shocks would be even more inelastic if the mechanisms of changing quality composition and/or trade economies of scale were not at play, since a country experiencing a negative production shock could afford to import even higher quantities at lower unit values.

Our study is related to a growing literature on food price volatility, particularly those studies that focus on transmission of productivity shocks via international trade. While many studies have measured the pass-though of world prices to domestic prices (Mundlak and Larson, 1992; Baffes and Gardner, 2003; Dawe, 2008; Ferrucci et al., 2012; Imai et al., 2008; Yang et al., 2015), few have considered the implications of trade costs on the magnitude of price pass-through.

Reimer and Li (2010) estimate and simulate a Ricardian-based model of the world crop market. They find that trade in crops is significantly lower than what it would be in a frictionless world. They also find that distance limits the extent by which changes in one country are transmitted to others. This is in line with our finding that trade responds little to short term fluctuations in produced quantities.

The connection between climate change and food production is a well researched topic within crop science. For example, Schlenker and Roberts (2009) find that temperatures above a certain threshold are very harmful to corn, soybean and cotton yields. IPCC (2014) provide an overview of the main results and a more detailed synthesis can be found in the full IPCC report. The importance of the connection from an economics perspective has also been long recognized. There are a number of papers investigating the role of trade as a means of adaption (see, e.g., Reilly and Hohmann, 1993; Rosenzweig and Parry, 1994; Tsigas et al., 1997; Randhir and Hertel, 2000).

The paper most related to our work is Reimer et al. (2009), who adapt the Eaton and Kortum (2002) model of Ricardian trade to estimate the effect of higher yield volatility on trade and welfare. They find that increased yield volatility would lead to increased trade, and the welfare losses from increased volatility are amplified by trade costs. Their study uses one year of cross-section data on trade and production to calibrate the model and then explores various counterfactual scenarios to make inferences on the pattern of trade and production. In contrast, our study uses historical time-series data on production to explore the effectiveness of trade to adapt to short term (year-to-year) production variations.

Our work is also related to Costinot et al. (2014), who analyze climate change impacts on agricultural productivity by calibrating a Ricardian model of international trade. They use climate change scenarios and agricultural models to derive the changes in agricultural productivity on a highly resolved geographical grid. They then consider how adaptation through both changed production patterns and changed trade patterns can mitigate the negative welfare effects. They find that the aggregate global effects are a loss of 0.26% of world GDP (constituting about one sixth of the total value of the agricultural sector) if the average climate changes from today's climate to the climate predicted in their baseline scenario for the years 2071-2100. They find, however, significant heterogeneity over space and some countries will suffer significant welfare losses. Their model also allows them to disentangle the importance of adaptation through changes in growing patterns (growing the appropriate crops in each location) and through changes in trade patterns. They find that adapting through changes in growing patterns is more important than changing the trade patterns. Our study is different from theirs in that we focus on the year-to-year fluctuations to which adaptation through changes in production patterns is much less feasible and adaptation must primarily occur through trade or on consumption adaptation. Our results, however, lend support their prediction that international trade in agricultural products plays a relatively small role in adapting to future climate shocks.

Our work is also related to Jones and Olken (2010) who use trade data to investigate the effects of weather on exports. They find that in poor countries, higher temperature is associated with lower export. They estimate that a 1 degree higher temperature is associated with 2-5.7% lower growth of exports. The effects come mainly from agriculture and light manufacturing while the effects on heavy manufacturing and raw materials are small. Compared to their analysis we instrument for production and consider how changes in production translate into changes in prices and traded quantities. Furthermore, we consider both imports and exports. This gives us a more complete picture of how trade patterns are affected.

Conceptual Framework

The standard approach to modeling trade in agricultural products is a partial equilibrium model of demand and supply for a particular product. We discuss this model in more detail in appendix A. Such a model can explain the impact of production on trade volumes that we observe as well as the impact of exporter production on trade unit values. It cannot, however, explain how an increase in domestic production leads to an increase in the price of imported goods. The same critique also applies to a basic Ricardian model.

Horizontal product differentiation by country of origin can explain why changes in exporter production affect trade unit values, but product differentiation alone cannot explain a positive relationship between import unit values and importers' production. Vertical product differentiation is a more realistic explanation, whereby trade between country pairs is composed of multiple qualities of the same commodity. A positive relationship between import prices and domestic production could then be explained either from the demand or supply side. If the high-quality variety has a lower demand elasticity then its imports will be less sensitive to a supply shock.[2] A symmetric increase in the importer's production of the high- and low-quality good will thus shift the composition of imports in favor of the high-quality variety. If this quality composition effect is large enough to outweigh the negative effect of a supply increase on the world price then we would observe an increase in the import value of trade when importer production increases.[3] International trade in agricultural commodities is commonly composed of several quality levels within the same product code, with high-quality and low-quality varieties of the same good traded between the same countries. For example, a country may import high-quality wheat for making bread and at the same time import low-quality wheat for use as as animal feed from the same country of origin.[4]

A large body of recent work has empirically investigated the pattern of unit values in international trade data and found evidence to support the idea that countries produce goods of varying quality but exports typically consist of high-quality goods (Hummels and Skiba, 2004). The quality of traded products has been shown to related to export countries' technology (Schott, 2004) and import countries' per-capita income levels (Hallak, 2006) and income distributions (Choi et al., 2009). The quality sorting literature (Manova and Zhang, 2012; Crozet et al., 2012) emphasizes that

[2] In the context of exchange rate pass-through, Chen and Juvenal (2014) provide both theory and evidence to support the claim that the elasticity of demand perceived by exporters is lower for high-quality goods.

[3] A systematic correlation between yield and quality for agronomic reasons may also explain a connection between the quality composition of trade and crop yields. However, our results suggest that a connection between quality and yield are not driving our results.

[4] For a discussion of the influence of product heterogeneity and product differentiation on unit values of agricultural trade, see Lavoie and Liu (2007).

countries export goods that vary by quality, even within narrowly defined product categories. These studies typically use unit values as a proxy for quality. Recent work uses trade unit values to measure how real exchange rate shocks (Verhoogen, 2008) and increased import competition (Amiti and Khandelwal, 2013) drive firms to upgrade the quality of their exports. Chen and Juvenal (2015) investigate the pattern of Argentinean wine exports during the global financial crisis and show that exports of higher-quality goods are more sensitive to negative income shocks. To the best of our knowledge, no one has explored the impact of agricultural productivity shocks on unit values and their relation to the quality composition of trade.

In order to guide our empirical analysis we employ the gravity model of trade, which is well-suited to understanding bilateral trade flows and motivates the connection between productivity and trade. The gravity equation takes the following form:

$$q_{ijkt} = \alpha_k GDP_{it} GDP_{jt} \frac{p_{ijkt}^{-\sigma_k}}{P_{jkt}^{1-\sigma_k}}, \tag{1}$$

where

$$P_{jkt} = \left[\sum_{i \in \bar{I}} p_{ijkt}^{1-\sigma_k} \right]^{\frac{1}{1-\sigma_k}} \tag{2}$$

is the importer's price index for good k and σ_k is the elasticity of substitution between different varieties (distinguished by country of origin) of good k. q_{ijkt} is the quantity of good k traded from exporting country i to importing country j in year t. GDP_{it} and GDP_{jt} represent the aggregate expenditure and income for the exporter and importer each year respectively. p_{ijkt} is the price of the traded good, which is a function of bilateral trade costs τ_{ijk} and the exporter's domestic price p_{ikt}, which is in turn determined by productivity φ_{ikt} and wages w_{it}:

$$p_{ijkt} = \tau_{ijk} p_{ikt} = \frac{\tau_{ijk} w_{it}}{\varphi_{ikt}}. \tag{3}$$

Substituting (3) into (1) and taking logs yields the following expression upon which we base our empirical analysis:

$$\begin{aligned} \ln(q_{ijkt}) \quad = \quad & \alpha_k + \ln(GDP_{it}) + \ln(GDP_{jt}) - \sigma_k \ln(\tau_{ijk}) - \sigma_k \ln(w_{it}) \\ & + \sigma_k \ln(\varphi_{ikt}) + (1 - \sigma_j) \ln(P_{jkt}). \end{aligned} \tag{4}$$

Equation (4) illustrates that the quantity traded increases with exporter productivity and decreases with trade costs. We can also take logs of equation (3) in order to arrive at predictions for productivity and the pattern of unit values:

$$\ln\left(p_{ijkt}\right) = \ln\left(\tau_{ijk}\right) + \ln\left(w_{it}\right) - \ln\left(\varphi_{ikt}\right). \qquad (5)$$

Equation (5) illustrates that unit values increase with trade costs and decrease with productivity. We employ equations (4) and (5) in the empirical analyses at both the country-level and firm-level.

Data and Descriptive Statistics

For our empirical analysis we combine country-level data on food production, yields and prices with data on bilateral trade flows. The country-level data on food production and yields is taken from the FAOSTAT database. Production data is reported in tonnes, while yield data is reported in hectograms per hectare. Figure 1 illustrates that the data exhibits significant variation in yield over time.

The aggregate bilateral trade unit-value data is taken from CEPII's Trade Unit Values (TUV) Database, which is available for the years 2000-2013 at the 6-digit HS product level. The database reports unit value data in term of Free On Board (FOB) and Cost Insurance Freight (CIF). FOB unit values reflect the price when the good leaves the exporting country, while CIF unit values reflect the price when it arrives at its destination. We use traded quantity data directly from the COMTRADE website for the same years, products and country pairs as the CEPII data. We match trade flows with exporter and importer production and yield data using FAOSTAT's concordance between its own commodity classification and 6-digit HS2007.

Since we are interested in how weather affects trade flows we focus on agricultural commodities that are sensitive to weather, such as grains, vegetables, fruits and nuts. We do not use processed food production data in this analysis since the amount of processed food production is arguably independent from agricultural productivity shocks is endogenous to trade in primary agricultural commodities. We also disregard animal-based commodities since it is difficult to interpret year-to-year variations in animal yields in the same way as crop yields. A complete list of products included in the analysis is provided in the Appendix. In addition, we remove trade flows where the exporting country does not produce the commodity according to FAOSTAT. There are many instances where country-pairs do not trade certain goods, which we do not include in the analysis. After all of these restrictions we are left with a maximum of 151,226 observations for the country-level analysis covering 78 FAO products, 175 exporting countries and 157 importing countries for the years 2000 to 2013. Descriptive statistics are given in Table 1.

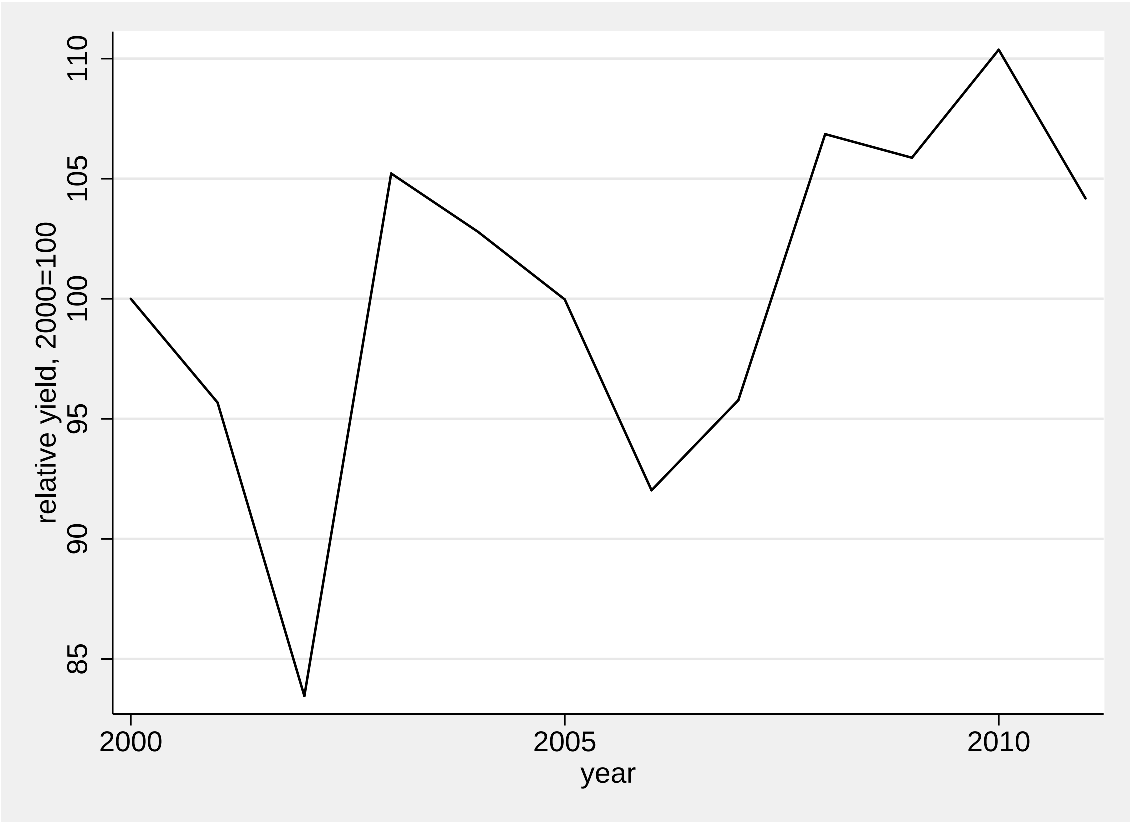

Figure 1: U.S. wheat yields, 2000-2011. Source: FAOSTAT

The firm-level data were obtained from the Swedish Survey of Manufacturers conducted by Statistics Sweden, the Swedish government's statistical agency. We use data for 2000-2011, which includes all Swedish firms that import agricultural products. The survey contains information on each firms NACE industry code plus annual data on output, value-added and employment. We merge the data on firms' characteristics with customs data on annual firm-level imports by product and country of origin. The customs data allows us to observe the quantity and value of firm imports by eight-digit Common Nomenclature (CN) product. We merge the firm-level data with the FAO national data on production and yield for Sweden and its trading partners and are left with a maximum of 9519 observations covering 362 importing firms, 26 FAO products and 47 exporting countries. The vast majority of importing firms are categorized as firms primarily engaged in wholesale or retail. Importers vary considerably in size, with the top 30 importers accounting for 91 percent of total import value and 57 percent of observations over the entire sample.

Table 1: Descriptive statistics, country-level analysis

Variable	obs.	mean	std. dev.	min	max
CIF unit values, USD: $p_{ijkt,CIF}$	151226	1961	3295	13	218975
FOB unit values, USD: $p_{ijkt,FOB}$	104266	1689	2839	15	139707
Quantity traded, '000 tonnes: q_{ijkt}	137812	13	197	.000001	23600
Exporter production, '000 tonnes: Y_{ikt}	151226	4253	23800	.001	768000
Lagged exporter prod., '000 tonnes: $Y_{ik,t-1}$	151226	4149	23000	.001	734000
Importer production, '000 tonnes: Y_{jkt}	151226	1715	15100	.001	768000
Lagged importer prod., '000 tonnes: $Y_{jk,t-1}$	151226	1667	14400	.001	734000

[1] Based on observations from column (4) of Tables 2, 3 and 4.

Empirical Specification

We first-difference equation (4), which takes the following form:

$$\begin{aligned}\Delta \ln (T_{ijkt}) &= \beta_0 + \beta_1 \Delta \ln (Y_{ikt}) + \beta_2 \Delta \ln (Y_{ik,t-1}) + \beta_3 \Delta \ln (Y_{jkt}) \\ &\quad + \beta_4 \Delta \ln (Y_{jk,t-1}) + \alpha_{it} + \alpha_{jt} + \epsilon_{ijkt},\end{aligned} \tag{6}$$

where T_{ijkt} is the quantity traded or its unit value from exporter country i to importer country j in product k in year t. We use production in the exporter country as a proxy for the productivity term φ_{ikt}. Production (or productivity) in the importing country does not show up in equation (4). It does, however, show up in the price index P_{jkt} and the implied effect of importer production is negative.[5] $\Delta \ln(Y_{ikt})$ and $\Delta \ln(Y_{ik,t-1})$ is the quantity produced in exporter country i of product k in year t and $t-1$ respectively, while $\Delta \ln(Y_{jkt})$ and $\Delta \ln(Y_{jk,t-1})$ is the quantity produced in importer country j of product k in year t and $t-1$ respectively. Variation in production should mainly be caused by short term fluctuations in growing conditions and there should be a close relationship between production and productivity. Exporter-year and importer-year fixed effects subsume the GDP and wage terms, and are denoted by α_{it} and α_{jt}. We include lagged production terms since many commodities are storable and experience long time lags due to transportation, implying that produc-

[5] The negative effect of importer production holds under the assumption $\sigma_k > 1$. There is also an effect of exporter production on the price index P_{jkt} that counteracts the direct effect of φ_{ikt}. The effect through φ_{ikt} will, however, always dominate the effect through P_{jkt} and the predicted net effect of exporter production is positive.

tion the previous year can affect current trade patterns. This is especially important in the Northern Hemisphere where many crops are harvested in the fall and then exported the next calendar year. The combination of first-differencing and using lags requires that a country-pair must produce and trade a particular good for at least three years in a row in order to be included in the regression. We thus explore the product-country intensive margin of trade in this study.

We first-difference all specifications since our production variables are not trend stationary.[6] First-differencing the data subsumes the panel (importer-exporter-product) fixed effects and thus controls for all time-constant variation along the country-pair-product dimension, including bilateral distance. Country-year fixed effects are necessary in order to control for any unobserved country-year variation that can explain trade flows or prices, including inflation. The combination of exporter-year and importer-year fixed effects also controls for the effect of exchange rates on trade and prices, and also subsumes the national wage and GDP terms from equation (4).

Country-Level Analysis

We begin with the regression results for traded quantities and trade unit values using bilateral trade data at the country level. Our variables of interest are current and lagged year-product-country-specific production. Since we are interested in knowing how productivity shocks in the importing country affect imports we restrict the sample to include only those trade flows where both countries produce the good.[7] We instrument with yield and lagged yield using Two Stage Least Squares and cluster standard errors at the exporter country level in all specifications.

Productivity Shocks and Traded Quantities

We first investigate the effect of production shocks on traded quantities in order to establish some stylized facts about trade volumes. The (unreported) results of the first-stage regressions reveal that yield instrument is strong.[8]

[6] The Hadri LM test statistics for exporter production ($\Delta \ln(Y_{ikt})$) and importer production (Y_{jkt}) are 26.89 and 35.22 respectively, which rejects the null hypothesis that all panels are stationary. We perform the test on 2021 time series for which there are no missing year observations.

[7] Regression results using a sample where importers do not necessarily produce the good are available upon request.

[8] We do not report the first-stage regressions in order to save space. The results of the first-stage regressions are available upon request.

The results for traded quantities are presented in Table 2, where we use only those observations for which we have import (CIF) trade value data to allow for comparison. In column (1) of Table 2 we present the results using first-differenced data but without any additional fixed effects. In each successive column we add more fixed effects until we arrive at our preferred specification. Year fixed effects are added in column (2), which controls for changes any unobserved covariates that affect all countries and products, such as the global business cycle. In column (3) we add importer and exporter fixed effects, which controls for differential trends between counties caused by domestic factors such as the institutional environment that may impact traded quantities or unit values. In column (4) we include exporter-year and importer-year fixed effects, which control for any country-specific variation over time that affects traded quantities or unit values of all commodities. Country-level macroeconomic shocks would be captured by the exporter-year and importer-year fixed effects, as would any weather event that affected exports of all crops. The fixed effects used in column (4) thus allow us to exploit the variation in production between crops in the same country. The combination of first-differencing and country-year fixed effects follows the work of Baier and Bergstrand (2007) in a gravity equation context.

The coefficients suggest that an increase in production in the exporter country leads to an increase in trade, while an increase in production in the importer country leads to a decrease in trade. These coefficient signs agree with the predictions of a simple partial equilibrium supply and demand framework or a gravity model of trade where trade depends on productivity.[9] The coefficients in column (4) of Table 2 suggest that a one percent increase in exporter production leads to a 0.41 percent increase in trade the same year and a 0.21 percent increase in trade the following year. A one percent increase in importer production leads to a 0.18 percent decrease in trade the same year and a 0.13 percent decrease in trade the following year.

As a robustness check, we estimate the effect of production shocks on traded quantities by product group and country characteristics. In Table B.2 we present the subsample results separately for grains, vegetables and fruits and find that the results are strongest for trade in grains and fruits. Comparing the results for grains and fruits we can see that if the effects over two years are summed they are of similar size but the time profiles are quite different. For grains, the effects are spread relatively evenly across the two years while for fruits almost the entire effect occurs within

[9] The negative effect of importer production follows from equations (1) and (2) as long as different varieties of good k (distinguished by country of origin) are fairly good substitutes ($\sigma_k > 1$).

Table 2: Productivity shocks and import quantities, country-level

	(1)	(2)	(3)	(4)
Exporter prod.: $\Delta \ln(Y_{ikt})$	0.390***	0.392***	0.390***	0.414***
	(0.0512)	(0.0529)	(0.0537)	(0.0562)
Lagged exporter prod.:	0.224***	0.234***	0.231***	0.205***
$\Delta \ln(Y_{ik,t-1})$	(0.0535)	(0.0528)	(0.0529)	(0.0444)
Importer prod.: $\Delta \ln(Y_{jkt})$	-0.201***	-0.198***	-0.207***	-0.177***
	(0.0256)	(0.0231)	(0.0241)	(0.0267)
Lagged importer prod.:	-0.171***	-0.162***	-0.170***	-0.133***
$\Delta \ln(Y_{jk,t-1})$	(0.0339)	(0.0324)	(0.0309)	(0.0330)
Fixed effects:		year	year exporter importer	exp.*year imp.*year
Observations	96,023	96,023	96,023	96,023
R-squared	0.002	0.003	0.008	0.053

Notes: Dependent variable is first-differenced log quantities, using importer-reported values.
Robust standard errors in parenthesis, clustered by exporter country.
A constant term is included, but not reported, in all specifications
All variables are first-differenced *** p<0.01, ** p<0.05, * p<0.1

the same year. This difference is consistent with grains being significantly more storable than fruits. In Table B.3 we present the subsample results distinguishing between OECD and non-OECD member countries. Our main result holds regardless of whether the importing and/or exporting country is an OECD member.

Overall, we find that the relationship between to production is relatively inelastic. Furthermore, the data suggests that total exports and imports are small relative to domestic production, which would imply a trade elasticity in excess of unity. We illustrate the fact that trade is relatively small relative to production in figure 2. Panel A of figure 2 ranks importer-product-year observations by import intensity, which we define as the ratio of total imports to domestic production for each product and year. Panel B of figure 2 ranks exporter-product-year observations by export intensity, which we define as the ratio of total exports to domestic production for each product and year. This illustrates that imports and exports are small relative to domestic production in the majority of cases in the data. Given that exports and imports tend to be small relative to domestic production we would expect much higher trade elasticities in a frictionless world as small percentage changes

Table 3: Productivity shocks and (CIF) unit values, country-level

	(1)	(2)	(3)	(4)
Exporter prod.: $\Delta \ln(Y_{ikt})$	-0.0434***	-0.0450***	-0.0471***	-0.0383***
	(0.0121)	(0.0100)	(0.00980)	(0.0114)
Lagged exporter prod.:	-0.0812***	-0.0572***	-0.0589***	-0.0318***
$\Delta \ln(Y_{ik,t-1})$	(0.0142)	(0.0121)	(0.0125)	(0.0130)
Importer prod.: $\Delta \ln(Y_{jkt})$	0.00512	0.00716	0.00380	0.0132**
	(0.00698)	(0.00655)	(0.00660)	(0.00619)
Lagged importer prod.:	-0.0208***	-0.00163	-0.00454	0.000781
$\Delta \ln(Y_{jk,t-1})$	(0.00749)	(0.00722)	(0.00720)	(0.00633)
Fixed effects:			year	exp.*year
		year	exporter	imp.*year
			importer	
Observations	151,226	151,226	151,226	151,226
R-squared	0.001	0.022	0.025	0.075

Notes: Dependent variable is first-differenced log unit value, using CIF prices.
Robust standard errors in parenthesis, clustered by exporter country.
A constant term is included, but not reported, in all specifications
All variables are first-differenced. *** p<0.01, ** p<0.05, * p<0.1

in production would lead to large percentage changes in imports or exports. In sum, these results suggest that the forces of trade costs, product differentiation or storage severely restrict the rose of international trade to smooth out the year-to-year volatility in production caused by weather and other factors.

Productivity Shocks and Trade Unit Values

The results describing the impact of productivity shocks on CIF unit values are given in Table 3. We employ the same sample of years, products and country-pairs as the traded quantity regressions, and also use the same fixed effects. The dependent variable is the change in logged price (in U.S. dollars) between year $t-1$ and t.

The results indicate that changes in production among exporters influence unit values, with point estimates that are statistically significant at the 1 percent level for the contemporaneous and one-year lag. Higher exporter production leads to lower unit values in all columns of Table 3. The point estimates in column (4) of Table 3 suggest that a one percent increase in production in the exporting country decreases unit values by 0.038 percent in the same year and decreases unit values

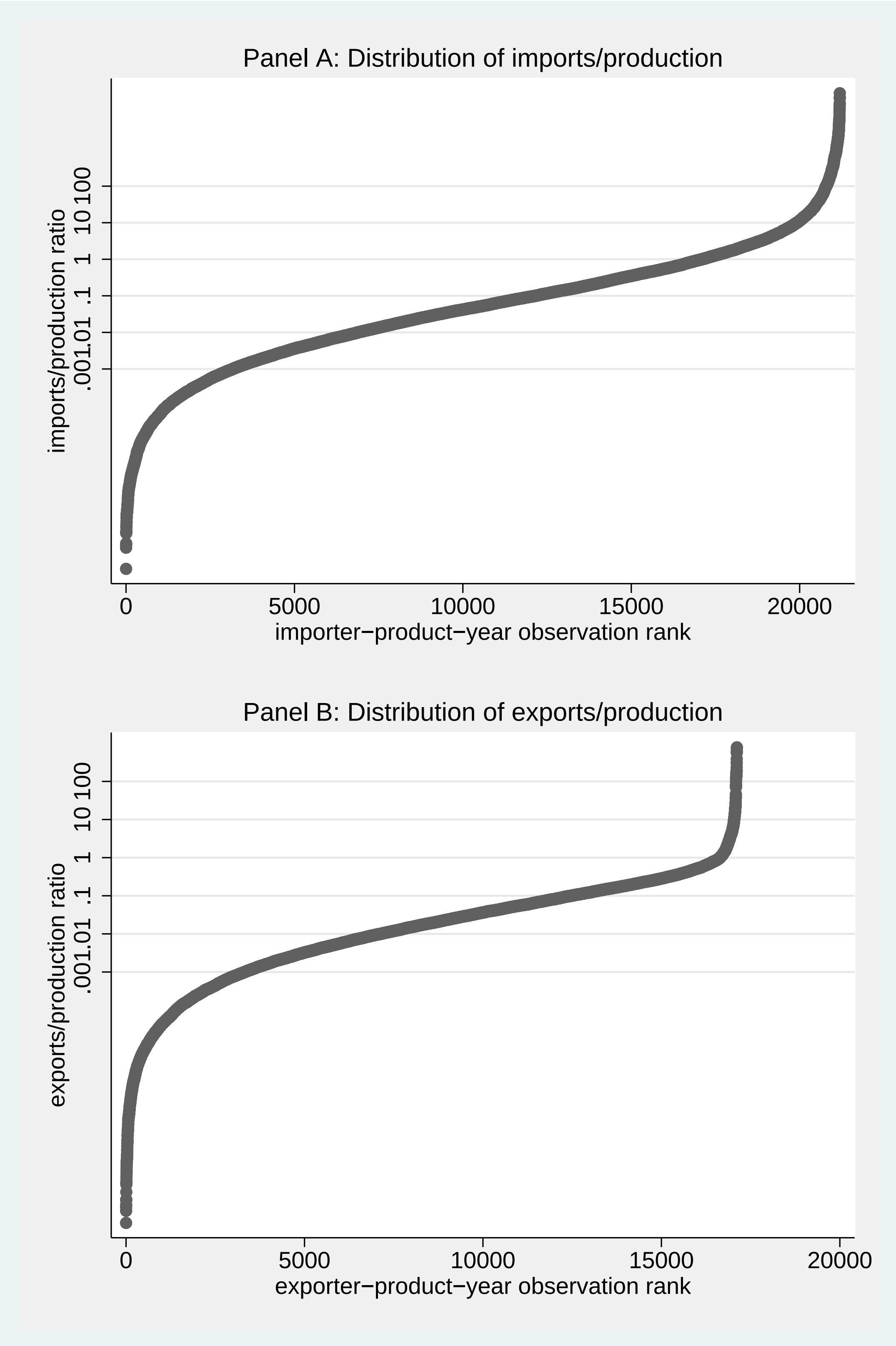

Figure 2: Import and export intensity. Notes: Based on observations from column (4) of Tables 3. Source: FAOSTAT

by 0.032 percent one year later. The negative coefficients for exporter production and lagged exporter production reflect the fact that increased supply leads to lower world prices.

The coefficients for importer production suggest a negative relationship in column (1) of Table 3, but the this negative relationship disappears when fixed effects are subsequently added across columns (2), (3) and (4). In column (4) of Table 3 the coefficient on importer production ($\Delta \ln(Y_{jkt})$) is positive and statistically significant at the 5 percent level, with a one percent increase in production in the importing country increasing unit values by 0.013 percent in the same year. This positive relationship between importer production means that import prices rise when importers' production rises. The effect of importer production is smaller in magnitude compared to that of exporter production, which is expected since the negative impact of production on world prices works against finding a positive relationship due to changing quality composition or trade scale economies.

We also present the results using FOB unit-value data. The results, presented in Table 4, yield a negative effect of exporter production on FOB unit values as well. FOB unit values respond more to exporter production than CIF unit values. This seems to speak against economies of scale in transportation as an explanation for the positive effect of importer production. Such economies of scale would imply lower trade costs when trade flows are large. Consider an increase in exporter production, which would increase trade volumes and decrease trade costs per unit. This decrease in trade costs should amplify the decrease in the FOB unit value, making the effect on the CIF unit value stronger.[10]

Considering instead the effects of importer production on FOB unit values, the positive effect that we find for CIF unit values cannot be detected in the FOB unit-value data. This lack of an effect may be interpreted as evidence against quality sorting as the explanation for the unexpected unit-value effect of importer production. It could, however, also be the result of higher reporting errors in the exporter-reported data and/or a lower number of available observations.

In an effort to more deeply explore the differences in our results between CIF and FOB unit values we report the impact of productivity shocks on the CIF/FOB unit value ratio in appendix Table B.6. The difference between CIF and FOB unit values can be used as a proxy for trade costs, and any systematic relationship

[10]This is unambiguous for iceberg trade costs. For per-unit trade costs this need not be the case. The net result would then depend on the size of the trade cost relative to the FOB unit value and on the size of the relative changes in FOB unit value and trade cost.

Table 4: Productivity shocks and FOB unit values, country-level

	(1)	(2)	(3)	(4)
Exporter prod.: $\Delta \ln(Y_{ikt})$	-0.0672***	-0.0696***	-0.0730***	-0.0643***
	(0.0223)	(0.0175)	(0.0178)	(0.0176)
Lagged exporter prod.:	-0.113***	-0.0775***	-0.0813***	-0.0510***
$\Delta \ln(Y_{ik,t-1})$	(0.0204)	(0.0179)	(0.0182)	(0.0172)
Importer prod.: $\Delta \ln(Y_{jkt})$	0.00854	0.00952	0.00861	0.00826
	(0.00751)	(0.00726)	(0.00733)	(0.00884)
Lagged importer prod.:	-0.0329***	-0.0125	-0.0140	-0.00845
$\Delta \ln(Y_{jk,t-1})$	(0.00970)	(0.00915)	(0.00909)	(0.00807)
Fixed effects:		year	year exporter importer	exp.*year imp.*year
Observations	90,721	90,721	90,721	90,721
R-squared	0.002	0.029	0.033	0.097

Notes: Dependent variable is first-differenced log unit value, using FOB prices.
Robust standard errors in parenthesis, clustered by exporter country.
A constant term is included, but not reported, in all specifications
All variables are first-differenced. *** p<0.01, ** p<0.05, * p<0.1

between productivity shocks and the CIF/FOB ratio may capture the role of scale economies in international shipping.[11] We find no statistically significant impact of productivity shocks on the CIF/FOB ratio.

As a robustness check, we estimate the effect of production shocks on CIF unit values by product group and country characteristics. The results are presented in the Appendix. In Table B.4 we present the subsample results for grains, vegetables and fruits. Exporter production negatively affects the unit values of grains and fruits, but not vegetables, while the positive effect of importer production on unit values appears to be driven mainly by observations for grain products. On the one hand, grains are highly tradable and influenced highly by weather, which may explain why it yields the strongest results. On the other hand, the relative ease of storing grain would reduce the sensitivity of trade to productivity shocks. As a further robustness check we present the subsample results distinguishing between OECD and non-OECD member countries in Table B.5. The coefficient on importer

[11] Hummels and Lugovskyy (2006) emphasize that interpreting CIF/FOB ratios as trade costs is not reliable when comparing across products. However, in our case we examine changes in the CIF/FOB ratio for the same product over time, which they deem as more reliable.

production is positive in the case where the exporter is an OECD member and the importer is not a member.

Overall, we find that positive production shocks in the exporting country leads to an increase in the quantity exported and a decrease in trade unit values, but the effect of production shocks in the importing country on import unit values is either lacking entirely or in some cases positive, which suggests that changing quality composition may be at play. However, there are also other possible explanations for the pattern of prices, which we now discuss.

A systematic negative correlation between yield and quality for agronomic reasons may also explain a connection between the quality composition of trade and crop yields. For example, a high-yielding, low-quality crop in the exporting country would likely decrease the average quality level of its exports and reduce trade unit values. In the importing country, a high-yielding, low-quality crop would likely lead to a greater share of high-quality imports and increase trade unit values. There appears, however, to be no consensus in the agronomy literature on the connection between crop yields and crop quality. For example, Kettlewell et al. (2003) find that higher summer rainfall tends to reduce wheat quality in the UK. The relationship between rainfall and yield in wheat is non-linear, whereby some rainfall at the right times increases yield but too much rainfall can lead to lower yields. Schlenker and Roberts (2009) find that precipitation has a statistically significant inverted-U shape relationship with corn and soybean yields in the United States. Overall, the relationship between yield and quality is crop- and country-specific. The non-linear relationship between weather, yield and quality suggests that an agronomic connection between quality and yield are not driving our results.

Another potential concern with our results is they may be driven by the fact that exporters are larger than importers and hence it is easier to detect exporter's effect on prices. We find that exporters produce an average of 4.3 mmt (million metric tons) in our sample, while importers produce 1.7 mmt. However, average total production for each food product in our sample is 100 mmt, so individual exporters are not large compared to the size of the total market.

Further investigation suggests that international transfer pricing, which is the setting of the price for goods sold between related legal entities within the same enterprise, cannot explain this pattern of unit values. Although we do not have access to unit value data for trade between related parties, the U.S. Census Bureau's related party trade data suggests that between 2002 and 2014 only 10% of U.S. imports and 5% of U.S. exports for agricultural commodities occurred between related parties.

Firm-Level Analysis

In an effort to more deeply explore how import unit values are affected by importer and exporter production shocks and in order to confirm our results using an independent data set we now present of the results of a firm-level analysis of imports using Swedish data. We employ a first-differenced specification similar to regression equation (6), which takes the following form:

$$\begin{aligned}\Delta \ln(T_{ijkt}) &= \beta_0 + \beta_1 \Delta \ln(Y_{ikt}) + \beta_2 \Delta \ln(Y_{ik,t-1}) + \beta_3 \Delta \ln(Y_{Sweden,kt}) \\ &\quad + \beta_4 \Delta \ln(Y_{Sweden,k,t-1}) + \alpha_{it} + \alpha_{jt} + \epsilon_{ijkt},\end{aligned} \tag{7}$$

where T_{ijkt} is the quantity exported or its unit value from country i by importing firm j in product k in year t. $\Delta\ln(Y_{ikt})$ and $\Delta\ln(Y_{ik,t-1})$ is the quantity of product k produced by the exporting country i in year t and $t-1$ respectively, while $\Delta\ln(Y_{Sweden,kt})$ and $\Delta\ln(Y_{Sweden,k,t-1})$ is the quantity of product k produced by Sweden in year t and $t-1$ respectively. Firm*year and exporter*year fixed effects are captured by α_{jt} and α_{it}respectively. As in the previous analysis of aggregate trade flows, we include lagged production terms since many commodities are storable and experience long time lags due to transportation, implying that production in previous years can affect current trade patterns.

First-differencing the data subsumes the panel (firm*country-of-origin*product) fixed effects and thus controls for all time-constant variation along the country-pair-product dimension, including bilateral distance. Exporter*year fixed effects are necessary in order to control for any unobserved country-year variation that can explain trade flows or prices, including inflation. Firm*year fixed effects control of any changes in firms' average import prices from all countries of origin.

The results describing the impact of productivity shocks on within-firm CIF unit values are given in Table 5. The dependent variable is the change in logged price (in Swedish kronor) between year $t-1$ and t. In column (1) of Table 5 we present the results using first-differenced data but without any additional fixed effects. We add year fixed effects in column (2), then exporter and firm fixed effects in column (3). Finally, we employ exporter*year and firm*year fixed effects in column (4). The fixed effects used in column (4) thus allow us to exploit the variation in production between crops imported from the same country of origin by the same firm in Sweden.

The results in Table 5 indicate that changes in production among exporters and within Sweden influence unit values of firm-level imports, with point estimates that are statistically significant for the contemporaneous and one-year lag respectively. Higher exporter production leads to lower unit values in all columns of Table 5. The point estimates in for exporter production ($\Delta \ln(Y_{ikt})$) and lagged production ($\Delta \ln(Y_{ik,t-1})$) in column (4) of Table 5 suggest that a one percent increase in production in the exporting country decreases unit values by 0.124 percent in the same year and decreases unit values by 0.172 percent one year later.

The coefficients for Swedish production are positive and statistically significant across all columns of Table 5. In column (4) of Table 5 the coefficient on Swedish production ($\Delta \ln(Y_{Sweden,kt})$) and lagged production ($\Delta \ln(Y_{Sweden,k,t-1})$) suggest that a one percent increase Swedish production increases import unit values by 0.116 percent in the same year and 0.050 one year later. The same Swedish firm importing the same product over time will thus pay a higher import unit value in years when domestic production rises. Overall, the point estimates are larger in magnitude compared to the country-level results presented in Table 3.

We also estimate the effect of production shocks on firm-level CIF unit values by product group. The results are presented in the Appendix. In Table B.7 we present the results separately for grains, vegetables and fruits. Exporter production negatively affects the unit values of fruits, while the positive effect of Swedish production on firm-level unit values occurs for vegetables. We find no impact of production on the unit values of grain imports, which is understandable due to the lack of observations on grain imports.

Finally, as an additional robustness check we investigate whether the firm-level results are robust to restricting the sample in various respects and explore the impact of firm size. The results are provided in Table B.8. In some cases a FAO product in the data is derived from multiple firm-level CN8 product codes, which is the finest level of product disaggregation in the firm-level data. A potential risk is that within-firm changes to unit values may simply reflect a shift in imports from high-value to low-value CN8 products or vice versa included in the same FAO product aggregation. In order to check whether compositional changes at the CN8 level are driving our results for unit values at the FAO product level we omit any observations that are include more than one CN8 product code. The results, reported in column (1) of Table B.8, illustrate that our results are robust to excluding such products. In columns (2) and (3) of Table B.8 we report the results for wholesale or retail firms versus other types of firms, and our results hold for both categories. In columns (4)

Table 5: Productivity shocks and within-firm changes to CIF unit values

	(1)	(2)	(3)	(4)
Exporter prod.: $\Delta \ln(Y_{ikt})$	-0.108***	-0.106***	-0.130***	-0.124**
	(0.0371)	(0.0375)	(0.0389)	(0.0553)
Lagged exporter prod.:	-0.168***	-0.165***	-0.177***	-0.172***
$\Delta \ln(Y_{ik,t-1})$	(0.0393)	(0.0398)	(0.0397)	(0.0602)
Sweden prod.:	0.103***	0.103***	0.0981***	0.116***
$\Delta \ln(Y_{Sweden,kt})$	(0.0344)	(0.0340)	(0.0345)	(0.0379)
Lagged Sweden prod.:	0.0544**	0.0530**	0.0430*	0.0500*
$\Delta \ln(Y_{Sweden,k,t-1})$	(0.0250)	(0.0251)	(0.0253)	(0.0303)
Fixed effects:		year	year, firm exporter	firm*year exp.*year
Observations	9,519	9,519	9,519	9,519
R-squared	0.019	0.021	0.081	0.283

Notes: Dependent variable is first-differenced log unit value, using CIF prices.

Robust standard errors in parenthesis, clustered by firm.

A constant term is included, but not reported, in all specifications

All variables are first-differenced. *** p<0.01, ** p<0.05, * p<0.1

and (5) of Table B.8 we investigate how firms with above- and below-median sales respond to production shocks. We find that both large and small firms respond in a similar way to production shocks in Sweden and abroad. This result suggest that firm size does not play a decisive role in understanding how firms' import unit values respond to production shocks at home and abroad.

Overall, the firm-level results focusing on Swedish imports lend support to our country-level results based on a large set of countries. The firm-level results also emphasize that the impact of production shocks on import unit values is a phenomenon that occurs within firms over time. Our results thus suggest that changes in unit values are not driven by differences across firms that import at different unit values. This characteristic makes our results distinct from the previous firm-level studies on quality sorting for manufacturing goods (Manova and Zhang, 2012) and wine (Crozet et al., 2012), where differences in the trade unit values were due to cross-firm differences in "quality". Changing quality composition is still one possible explanation for these firm-level patterns of unit values if high- and low-quality goods are included in the same product code. Economies of scale in international shipping remains a plausible alternative explanation for these findings.

Conclusion

The purpose of this study is to measure how agricultural trade responds to agricultural productivity shocks at home and abroad. We find that the unit values of trade flows vary systematically with production shocks using both aggregate data on a large sample of countries and detailed firm-level imports to Sweden. The results suggest that production changes induce changes in transportation costs or the quality composition of the goods traded. The fact that import prices increase (and import quantity falls) when importer production increases suggests that the composition of trade shifts toward high-quality products or economies of scale in international trade. The fact that import prices decline in years when importers have a poor domestic production may act as a coping mechanism for countries that suffer from adverse food production conditions.

Our results also suggest that trade is relatively insensitive to changes in production. This insensitivity could be caused by storage, trade costs or product differentiation based on country of origin that introduces frictions to the shock transmission process. Our reduced-form results based on historical data support previous studies based on structural models predicting that international trade in agricultural products plays a relatively small role in adapting to future climate shocks. Moreover, the results suggest that the relationship between trade and production shocks would be even more elastic if the mechanisms of quality sorting and or economies of scale were not at play. It is hoped that the stylized facts presented in this paper promote the importance of quality in understanding the sensitivity of trade flows in agricultural products to production shocks.

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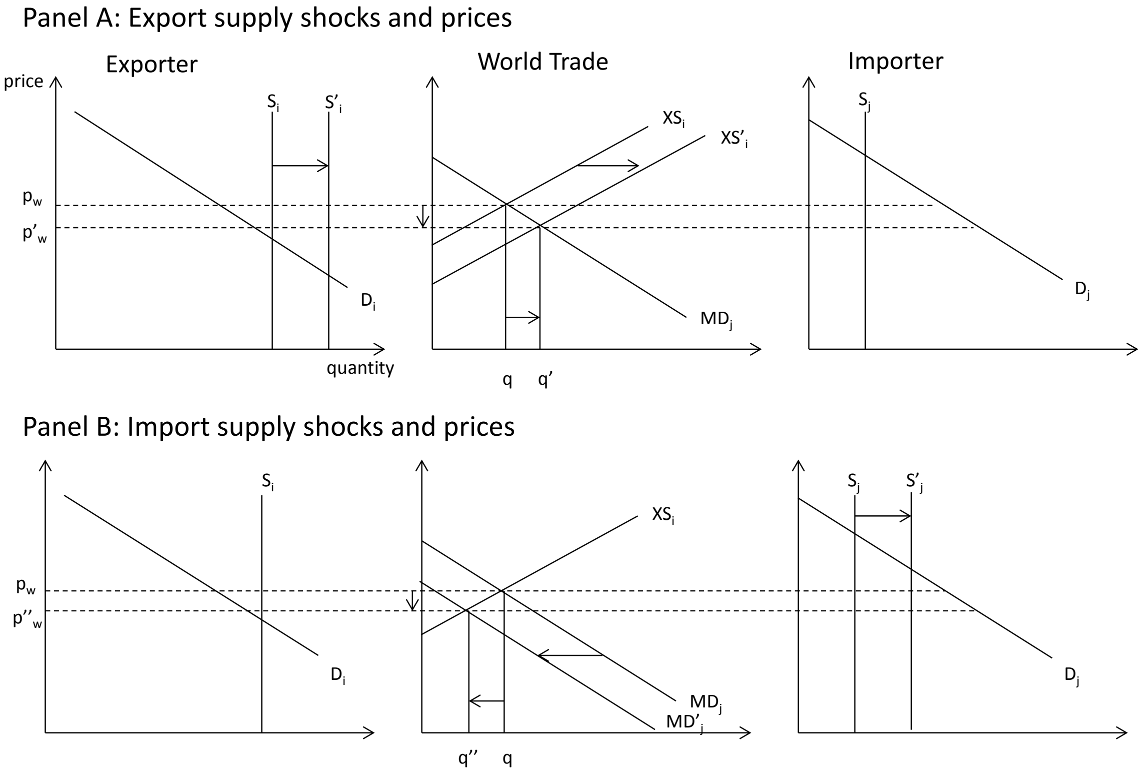

Figure A.1: Illustration of partial equilibrium modeling of trade

A Basic partial equilibrium trade model

The basic partial equilibrium trade model is illustrated in figure A.1. In this framework the equilibrium price under free trade occurs where export supply equals import demand. Export supply in both countries is perfectly inelastic in the short run. Free trade within this framework also implies that the price of the traded good and the domestic price in both countries equate. Panel A of figure A.1 illustrates that an increase in exporter supply from S_i to S_i' shifts the export demand curve outward from XS_i to XS_i'. An increase in exporter production decreases the world price from p_w to p_w' and increases in the quantity traded from q to q'. Panel B of figure A.1 illustrates that an increase in importer supply from S_j to S_j' shifts the import demand curve inward from MD_j to MD_j'. An increase in importer production decreases the world price from p_w to p_w'' but decreases the quantity traded from q to q''.

Any deviation of prices for traded goods from domestic prices (where prices include trade costs) cannot be explained with the simple partial equilibrium supply and demand framework.

B Additional tables

Table B.1: List of FAOSTAT Commodities

Almonds	Eggplants	Peas, dry
Apples	Garlic	Peas, green
Apricots	Grapefruit and pomelo	Pineapples
Asparagus	Grapes	Pistachios
Avocados	Groundnuts, in shell	Plums
Bananas	Hazelnuts (Filberts)	Poppy seed
Barley	Hops	Potatoes
Beans, dry	Kiwi fruit	Rapeseed or colza seed
Broad Beans, Green	Leeks and other alliaceous vegetables	Raspberries
Broad beans, dry	Lemons and limes	Rice, paddy
Buckwheat	Lentils, dry	Rye
Cabbages	Lettuce and chicory	Sesame seed
Canary seed	Linseed	Sorghum
Carrot	Maize	Soybeans
Cashew nuts	Mangoes	Spinach
Cassava	Mate	Strawberries
Cauliflowers and broccoli	Melons, Cantaloupes	Sugar beet
Cherries	Millet	Sugar cane
Chestnuts	Mushrooms	Sunflower seed
Chick-peas, dry	Mustard seed	Tangerines, mandarins etc.
Chillies and peppers (green)	Oats	Tea
Cocoa beans	Onions, shallots (green)	Tomatoes, fresh
Coconuts	Oranges	Triticale
Coffee green	Papayas	Walnuts
Cucumbers and gherkins	Peaches and nectarines	Watermelons
Dates	Pears	Wheat

[1] Based on observations from column (4) of Table 3.

Table B.2: Productivity shocks and import quantities by product group, country-level

	(1) Grains	(2) Vegetables	(3) Fruits
Exporter prod.: $\Delta\ln(Y_{ikt})$	0.288***	0.377***	0.561***
	(0.0822)	(0.127)	(0.105)
Lagged exporter prod.:	0.364***	0.318**	0.0208
$\Delta\ln(Y_{ik,t-1})$	(0.0671)	(0.145)	(0.0676)
Importer prod.: $\Delta\ln(Y_{jkt})$	-0.224***	-0.0251	-0.182***
	(0.0548)	(0.0808)	(0.0378)
Lagged importer prod.:	-0.236***	0.0205	-0.0717*
$\Delta\ln(Y_{jk,t-1})$	(0.0583)	(0.0689)	(0.0430)
Observations	30,320	23,397	33,889
R-squared	0.095	0.130	0.127

Notes: Dependent variable is first-differenced log import quantity.

Robust standard errors in parenthesis, clustered by exporter country.

Exporter*year and importer*year fixed effects included in all specifications.

A constant term is included, but not reported, in all specifications

All variables are first-differenced *** p<0.01, ** p<0.05, * p<0.1

Table B.3: Productivity shocks and import quantities by country, country-level

	(1) Both OECD	(2) Neither OECD	(3) Exporter OECD	(4) Importer OECD
Exporter prod.: $\Delta\ln(Y_{ikt})$	0.416***	0.325***	0.427***	0.563***
	(0.0805)	(0.0980)	(0.113)	(0.0865)
Lagged exp. prod.:	0.284***	0.101	0.251***	0.243***
$\Delta\ln(Y_{ik,t-1})$	(0.0780)	(0.0736)	(0.0690)	(0.0766)
Importer prod.: $\Delta\ln(Y_{jkt})$	-0.231***	-0.116**	-0.184***	-0.256***
	(0.0488)	(0.0582)	(0.0334)	(0.0886)
Lagged imp. prod.:	-0.120**	-0.119**	-0.161**	-0.127*
$\Delta\ln(Y_{jk,t-1})$	(0.0561)	(0.0530)	(0.0638)	(0.0718)
Observations	25,772	27,960	22,612	19,679
R-squared	0.034	0.109	0.086	0.085

Notes: Dependent variable is first-differenced log import quantity.

Robust standard errors in parenthesis, clustered by exporter country.

Exporter*year and importer*year fixed effects included in all specifications.

A constant term is included, but not reported, in all specifications

All variables are first-differenced *** p<0.01, ** p<0.05, * p<0.1

Table B.4: Productivity shocks and CIF unit values by product group, country-level

	(1) Grains	(2) Vegetables	(3) Fruits
Exporter prod.: $\Delta \ln(Y_{ikt})$	0.00971	-0.0144	-0.0835***
	(0.0180)	(0.0298)	(0.0209)
Lagged exporter prod.:	-0.0939***	0.0233	0.0111
$\Delta \ln(Y_{ik,t-1})$	(0.0253)	(0.0421)	(0.0158)
Importer prod.: $\Delta \ln(Y_{jkt})$	0.0285*	-0.00792	-0.0108
	(0.0161)	(0.0142)	(0.00882)
Lagged importer prod.:	-0.0161	0.0217	-0.0106
$\Delta \ln(Y_{jk,t-1})$	(0.0144)	(0.0203)	(0.00101)
Observations	46,615	36,557	54,072
R-squared	0.122	0.134	0.147

Notes: Dependent variable is first-differenced log unit value, using CIF prices.
Robust standard errors in parenthesis, clustered by exporter country.
Exporter*year and importer*year fixed effects included in all specifications.
A constant term is included, but not reported, in all specifications
All variables are first-differenced *** p<0.01, ** p<0.05, * p<0.1

Table B.5: Productivity shocks and CIF unit values by country, country-level

	(1) Both OECD	(2) Neither OECD	(3) Exporter OECD	(4) Importer OECD
Exporter prod.: $\Delta \ln(Y_{ikt})$	-0.0744***	-0.00234	-0.0682***	-0.0289
	(0.0143)	(0.0166)	(0.0205)	(0.0207)
Lagged exp. prod.:	-0.0495**	-0.0225	-0.0504*	-0.0251
$\Delta \ln(Y_{ik,t-1})$	(0.0195)	(0.0241)	(0.0258)	(0.0178)
Importer prod.: $\Delta \ln(Y_{jkt})$	0.0154	0.00320	0.0299**	-0.00353
	(0.0144)	(0.0105)	(0.0122)	(0.0187)
Lagged imp. prod.:	0.00849	-0.00469	-0.00191	-0.0147
$\Delta \ln(Y_{jk,t-1})$	(0.0183)	(0.00947)	(0.00972)	(0.0238)
Observations	37,760	45,909	35,877	31,680
R-squared	0.051	0.126	0.103	0.097

Notes: Dependent variable is first-differenced log unit value, using CIF prices.
Robust standard errors in parenthesis, clustered by exporter country.
Exporter*year and importer*year fixed effects included in all specifications.
A constant term is included, but not reported, in all specifications
All variables are first-differenced *** p<0.01, ** p<0.05, * p<0.1

Table B.6: Productivity shocks and the CIF/FOB ratio, country-level

	(1)	(2)	(3)	(4)
Exporter prod.: $\Delta \ln(Y_{ikt})$	-780.3	-789.1	-810.0	-1,200
	(763.3)	(788.8)	(806.4)	(1,213)
Lagged exporter prod.:	-891.1	-958.3	-988.2	-884.9
$\Delta \ln(Y_{ik,t-1})$	(995.3)	(1,076)	(1,104)	(992.3)
Importer prod.:	58.00	58.84	38.76	19.87
$\Delta \ln(Y_{jkt})$	(107.0)	(97.65)	(84.77)	(80.94)
Lagged importer prod.:	-23.75	-72.26	-118.4	-129.2
$\Delta \ln(Y_{jk,t-1})$	(210.4)	(177.8)	(170.0)	(201.2)
Fixed effects:		year	year exporter importer	exp.*year imp.*year
Observations	71,314	71,314	71,314	71,314
R-squared	0.000	0.000	0.000	0.108

Notes: Dependent variable is first-differenced ratio of CIF to FOB unit values.

Robust standard errors in parenthesis, clustered by exporter country.

A constant term is included, but not reported, in all specifications

All variables are first-differenced. *** p<0.01, ** p<0.05, * p<0.1

Table B.7: Firm-level results by product group

	(1) Grains	(2) Vegetables	(3) Fruits
Exporter prod.: $\Delta \ln(Y_{ikt})$	-0.227	-0.217	-0.0994
	(1.159)	(0.188)	(0.0678)
Lagged exporter prod.:	-0.697	-0.315	-0.165***
$\Delta \ln(Y_{ik,t-1})$	(0.878)	(0.195)	(0.0640)
Sweden prod.:	0.711	0.220**	-0.0597
$\Delta \ln(Y_{Sweden,kt})$	(0.902)	(0.1000)	(0.0449)
Lagged Sweden prod.:	0.930	-0.0306	0.0200
$\Delta \ln(Y_{Sweden,k,t-1})$	(1.038)	(0.110)	(0.0431)
Fixed effects:	firm*year	firm*year	firm*year
	exp.*year	exp.*year	exp.*year
Observations	745	4,277	4,333
R-squared	0.666	0.307	0.376

Notes: Dependent variable is first-differenced log unit value, using CIF prices.

Robust standard errors in parenthesis, clustered by exporter country.

Exporter*year and importer*year fixed effects included in all specifications.

A constant term is included, but not reported, in all specifications

All variables are first-differenced *** p<0.01, ** p<0.05, * p<0.1

Table B.8: Firm-level results, selected subsamples

	(1) 1 CN8 per FAO prod	(2) wholesale & retail	(3) non-whole. non-retail	(4) above-median Y	(5) below-median Y
Exporter prod.:	-0.118**	-0.123**	-0.206	-0.0721	-0.187**
$\Delta \ln(Y_{ikt})$	(0.0583)	(0.0580)	(0.316)	(0.0778)	(0.0843)
Lagged exporter prod.:	-0.170**	-0.206***	0.0918	-0.0763	-0.230***
$\Delta \ln(Y_{ik,t-1})$	(0.0740)	(0.0540)	(0.363)	(0.124)	(0.0760)
Sweden prod.:	0.134***	0.109***	0.276**	0.122*	0.118**
$\Delta \ln(Y_{Sweden,kt})$	(0.0399)	(0.0385)	(0.127)	(0.0725)	(0.0508)
Lagged Sweden prod.:	0.0338	0.0418	0.480*	0.0847**	0.0221
$\Delta \ln(Y_{Sweden,k,t-1})$	(0.0357)	(0.0306)	(0.259)	(0.0373)	(0.0481)
Fixed effects:	firm*year exp.*year	firm*year exp.*year	firm*year exp.*year	firm*year exp.*year	firm*year exp.*year
Observations	8,542	8,621	846	4,132	4,350
R-squared	0.297	0.247	0.587	0.311	0.300

Notes: Dependent variable is first-differenced log unit value, using CIF prices.

Robust standard errors in parenthesis, clustered by firm.

A constant term is included, but not reported, in all specifications

All variables are first-differenced. *** p<0.01, ** p<0.05, * p<0.1