The Missing Food Problem: How Low Agricultural Imports Contribute to International Income Differences

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Abstract

Poor countries have low labour productivity in agriculture relative to other sectors, yet predominantly consume domestically-produced food. The foregone gains from trade are simple and well understood: imports substitute for low productivity domestic producers and facilitate labour reallocation towards more appropriate tasks, agricultural or otherwise. In this paper, I embed an augmented Eaton and Kortum [2002] trade model within a dual-economy model of structural change to show low food imports by poor countries contribute to cross-country agricultural and aggregate productivity differences. I exploit this framework to infer sectoral labour productivity from observable trade data, avoiding data limitations that prevent more direct measures. I also quantify an important interaction between domestic distortions and trade barriers not found in the existing dual-economy literature, which largely abstracts from open-economy considerations. Through various counterfactual experiments, I find limited food imports and labour misallocation accounts for a quarter of the aggregate labour productivity gap between rich and poor countries and half the gap in agriculture.

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1 Introduction

The difference in agricultural labour productivity between rich and poor countries is large and accounts for most of the aggregate income and productivity gap.[1] Average labour productivity in agriculture, for example, differ nearly by a factor of 70 between the poorest- and richest-10% of countries, but by only 6 in nonagriculture.[2] Differences within agriculture drive differences in aggregate, since agriculture accounts for most employment and spending in poor countries (see Figures 1a and 1b), and Schultz [1953] calls this the Food Problem. Existing literature focuses on domestic distortions within closed-economy frameworks to understand large agricultural productivity gaps, pointing to low imports by poor countries as support (see Figure 2). I depart from this approach and show limited food imports inhibits structural change and lowers agricultural productivity in poor countries. There is also a quantitatively important interaction between domestic distortions and trade barriers. Overall, I find limited food imports and labour misallocation account for nearly half the agricultural labour productivity gap between rich and poor countries, and a quarter of aggregate income and productivity differences.

To demonstrate food imports have a first-order contribution to aggregate productivity gaps between rich and poor countries, I present a trade model consistent with stylized facts of development that builds upon Yi and Zhang [2010].[3] Specifically, I embed an augmented Ricardian trade model into a dual-economy (agriculture vs. nonagriculture) model of structural change. The model incorporates horizontally differentiated and tradable agricultural and manufactured goods, individually structured as in Eaton and Kortum [2002], and a nontraded service-sector. I exploit this framework to infer sectoral labour productivity from observable trade data, avoiding data limitations that prevent more direct measures.[4] I also perform counterfactual experiments within the fully calibrated model to highlight the importance of agricultural trade - or lack thereof - in accounting for cross country income and productivity differences.

[1] See, for example, Kuznets [1971], Kawagoe et al. [1985], Hayami and Ruttan [1985], Rao [1993], Gollin et al. [2004], Cordoba and Ripoll [2006], Gollin et al. [2007], Adamopoulos [2010], Vollrath [2009], Adamopoulos and Restuccia [2010], Duarte and Restuccia [2010], Lagakos and Waugh [2010].

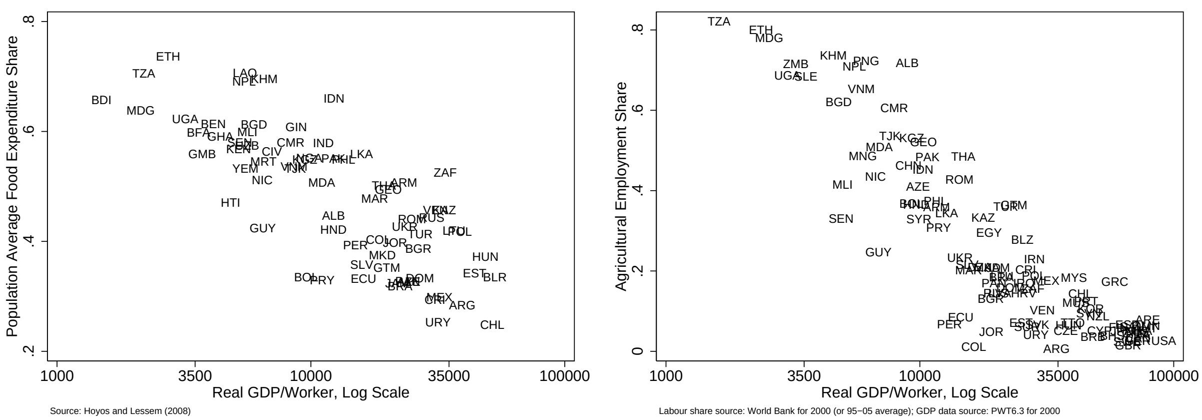
[2] These results are for 2000 and utilize PPP-adjusted agricultural value added data from the UN-FAO. The aggregate difference in this sample of 173 countries is 35. Restuccia et al. [2008] find similar results: for 86 countries in 1985, the poorest 10% have agricultural labour productivity 56 times lower than the richest 10%, but differ in nonagriculture by only 5. Caselli [2005] finds that equalizing agricultural productivity across countries nearly eliminates all international income differences. Specifically, he finds the 90/10 ratio of aggregate income falls from 19 to 1.9 in a sample of 80 countries.

[3] Yi and Zhang [2010] develop a multi-sector version of Eaton and Kortum [2002] and clearly link trade and structural transformation. My contribution builds on their stylized treatment by quantitatively applying the framework to cross country data and by incorporating various economic distortions.

[4] Data limitations lead most studies of cross-country sectoral productivity to focus on developed economies. Rao [1993], Restuccia et al. [2008] are important exceptions, using FAO farm output prices to measure real agricultural productivity across countries.

Figure 1: The Food Problem in Poor Countries

(a) Food Expenditure Shares, Selected Countries, 2005 (b) Agricultural Employment Shares, by Country

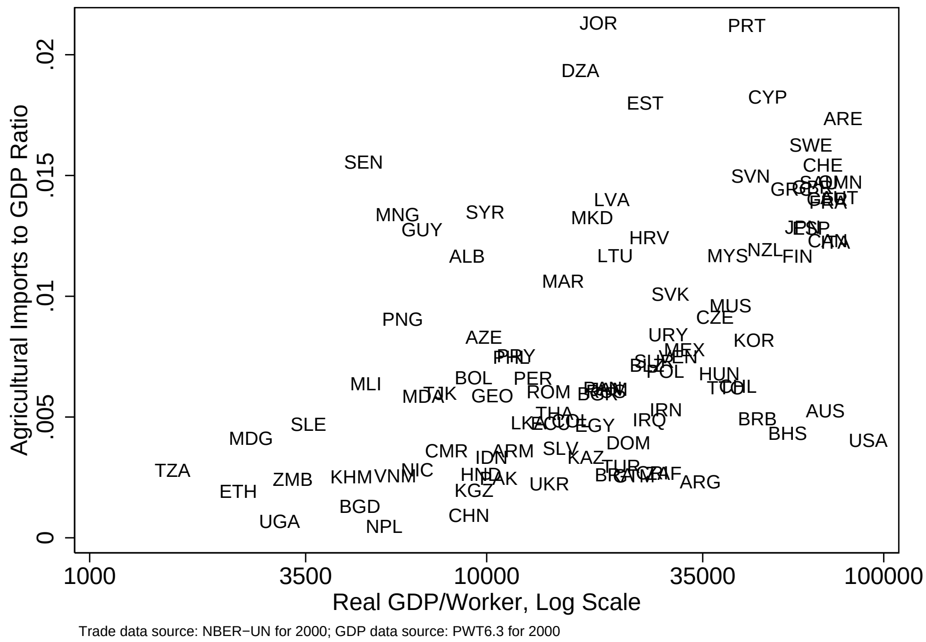


I focus on two distortions that limit food imports: high international trade barriers and costly labour mobility. Trade barriers, such as tariffs, quotas, regulations, or poor infrastructure, increase import prices and lead consumers to opt for lower productivity domestic producers. Costly labour mobility, such as regional migration restrictions or scarce rural education, makes switching to non-agricultural activities difficult for farm labour, thereby increasing farm employment and decreasing farm wages.[5] In fact, wages in agriculture relative to non-agriculture increase strongly with a country's level of development, and differ by a factor of four to five in many poor countries. Low farm wages imply low output prices and consumers - again - opt for lower productivity domestic producers over imports. Without these distortions, increased imports lead low productivity producers to shut down and labour to concentrate in fewer agricultural varieties or switch to nonagricultural activities. Admittedly, I incorporate both distortions in a simple way and do not address complex political-economy issues to explain *why* these distortions exist, such as balancing pressures between rural and urban residents.

While agnostic about the causes, I can quantify the costs of these distortions independently of implementation and transition issues governments would face. Specifically, I investigate: (1) lowering import barriers everywhere to the average level of the richest countries; (2) eliminating labour mobility costs; and (3) both together. The two distortions have important interaction effects, with trade liberalization and improved labour mobility together driving the largest reductions in cross-country differences. The aggregate

[5] Vollrath [2009] shows wage gaps do not reflect sectoral differences in physical or human capital endowments. See Caselli and Coleman [2001] for an exploration of the role learning costs play in structural change and, as a follow up, Tombe [2008] for how such costs may interact with transportation costs in a larger set of US states. Cordoba and Ripoll [2006] find schooling or migration costs do not account for the sectoral labour productivity differences, but low *quality* of human capital in rural areas.

Figure 2: Agricultural Import Share of GDP, by Country



productivity gap between the richest and poorest 10% of countries shrinks by 37% when both distortions are reduced, but only 20% and 8% when import barriers and labour mobility costs are eased individually. These results are particularly important given the literature's focus on domestic distortions alone.

A broad overview of the global food trade puts these results and the overall framework in context. The share of a typical poor country's food expenditure going to domestic producers is approximately 98%.[6] The corresponding figure for a typical rich country is 63%. Bilateral trade patterns reveal poor countries source 55% of imports from rich countries and only 6% from other poor countries, with the remainder from middle-income exporters.[7] Rich countries import nearly 75% of their total food imports from other rich countries but only 2% from poor. While I present precise productivity and import barrier estimates from thousands of importer-exporter flows in Section 3.1, the intuition is straightforward. The low share of imports from poor countries implies low productivity and the high share of poor country expenditures sourced domestically implies high import barriers.[8] I estimate poor country import barriers of approximately

[6] Poor and rich refer to the bottom and top quartile of countries. The precise data used and approach taken to estimate expenditure shares, both domestic and foreign (by source), is similar to Bernard et al. [2003]. I use the NBER-UN Trade Database for the year 2000. I provide details in Section 3.1.

[7] For more on the low South-South trade levels, see Linder [1961], Markusen [1986], Feenstra [1988], Hunter [1991], Echevarria [2000], Fieler [2010]

[8] An alternative mapping of bilateral import share patterns to productivity and trade costs presented by Waugh [2010] will be investigated in Section 6.4

320% in agriculture and 276% in non-agriculture, compared to 73% and 22% among rich countries.[9] Labour productivity estimates suggest rich countries are well over 90 times more productive in agriculture than poor countries, and over 70 times more in manufacturing.[10] Non-tradable services productivity is calibrated so the baseline model aggregate matches data, resulting in a factor of over 10.

Unlike direct estimates, labour productivity inferred from observed trade flows avoids using producer price and labour input data, which are problematic for most developing countries. For certain years, industry-level producer prices among OECD countries are available through the Groningen Growth and Development Centre [Inklaar and Timmer, 2008]. For developing countries, only expenditure prices, not producer prices, are available through the World Bank's International Comparisons Project (ICP). Productivity estimates from expenditure prices will be biased for two reasons: (1) distribution margins are systematically related to a country's level of development [Adamopoulos, 2008]; and (2) expenditure prices capture many manufactured and service components of consumption, such as packaging or preparation. With these limitations in mind, Duarte and Restuccia [2010] study structural change and productivity growth over time in OECD economies with model-implied sectoral productivity estimates; their approach, however, requires accurate employment data. For many developing countries, standard surveys overestimate farm labour since rural residents and farm workers are treated synonymously [Gollin et al., 2004].[11] For these reasons, productivity revealed through observed bilateral trade patterns is ideal.

I contribute to a large international macroeconomics literature on agriculture's role in development.[12] This literature focuses on causes of low agricultural productivity and explanations vary from inefficient farm sizes [Adamopoulos and Restuccia, 2010], poor domestic transportation infrastructure [Adamopoulos, 2010, Gollin and Rogerson, 2010], comparatively low quality farm workers [Lagakos and Waugh, 2010], barriers to labour or intermediate inputs [Restuccia et al., 2008], or just overcounting farm workers in the data [Gollin et al., 2004]. Trade, however, substitutes for the lowest productivity farms to meet subsistence food

[9] Anderson and van Wincoop [2004] report tariff-equivalent US trade costs of 170%. My corresponding estimate for rich countries, geographic costs plus country-specific import barriers, are nearly 120%. Geographic costs are 20-30% for agriculture and 40-50% in non-agriculture for most countries. Details will follow in Section 3.1.

[10] Agriculture's relative labour productivity is low in poor countries, consistent cross country productivity comparisons in the macro literature. This does not imply poor countries have comparative advantage in manufacturing, as in a pure Ricardian framework, since labour market distortions lower farm wages. Relative productivity to wages in agriculture is higher in poor countries than rich. This is consistent with a Hechser-Ohlin interpretation: poor countries are abundant in unskilled labour (or land) used intensively in farming.

[11] Brandt et al. [2008] and Brandt and Zhu [2010], for example, use household-level surveys to infer a 26% agricultural labour share in 2007 rather than the official figure of 41%, when considering hours spent on farm work.

[12] Timmer [1988, 2002] provide an effective summary. Matsuyama [1992] and, more recently, Lucas [2009] highlight dynamic gains from labour reallocation, with learning-by-doing in manufacturing. This paper focuses on static gains to structural change.

requirements, increasing average sectoral productivity as they shut-down. My study is not the first to link trade to structural change. Stokey [2001], for example, finds food imports account for the United Kingdom's reduction in agricultural output between 1780 and 1850, and for much of the increased manufacturing. More recently, Teignier [2010] demonstrates a similar pattern for South Korea since the 1960s, although agricultural subsidies and tariff protection limited reallocation and subsequent productivity growth. Rather than investigate time series growth patterns as in these papers, I quantify to what extent the lack of food imports can account for the current cross sectional level differences.

The model's trade components follow a large literature based on Eaton and Kortum [2001, 2002].[13] Of particular relevance to this paper, Costinot et al. [2010] and Levchenko and Zhang [2010] infer productivity and comparative advantage using a similar framework, but only for manufacturing. Waugh [2010] studies trade flows and the impact of trade on cross country income differentials, but - again - only for manufacturing.[14] My model is distinct in two important ways. First, to capture declining food expenditure shares, consumer preferences are non-homothetic. Fieler [2010] also employs nonhomoethetic preferences within an Eaton-Kortum framework to investigate the low level of trade between developing countries. My approach differs by linking low income elasticity to the good with a high degree of international productivity variation - namely, agriculture. Fieler [2010] considers the opposite case, which may be more relevant within the set of manufactured goods than between agriculture and non-agriculture.[15] The second distinct feature in my model, to capture sectoral wage differentials in poor countries, is costly labour mobility out of agriculture. The remaining aspects of the model are standard: markets are perfectly competitive, trade arises through sectoral and international differences in technology, and labour is the only productive input. My approach fits within a broad literature in international macroeconomics and development, and focuses attention on sectoral divisions that matter most for poor countries. I also relate the food problem, trade, and international income and productivity differences.

[13]For recent studies utilizing a similar framework, see Bernard et al. [2003], Alvarez and Lucas [2007], Caliendo and Parro [2009], Kerr [2009], Burstein and Vogel [2010], Chor [2010], Costinot et al. [2010], Donaldson [2010], Fieler [2010], Levchenko and Zhang [2010], Waugh [2010], Yi and Zhang [2010].

[14]My findings are robust to alternative specifications of the bilateral trade-cost function. I reproduce my results using an exporter (as opposed to importer) specific trade costs specification. See, for example, Waugh [2010] on the role of export costs within this class of models. I find evidence the type of trade cost asymmetry found by Waugh [2010] for manufactured goods trade is also a feature of the agricultural goods trade.

[15]Additionally, she uses modeling features to generate variable budget shares in a fundamentally different manner from the Stone-Geary preferences I use in this paper.

2 A Model Consistent with Stylized Facts

This section presents the general equilibrium trade model I use to capture the cross sectional patterns observed in the data. I use the calibrated model to investigate productivity and trade cost patterns revealed by international trade flows and perform counterfactual experiments to determine the importance of low food imports for international income and productivity variation. The model builds on Yi and Zhang [2010] and a large and growing literature based on Eaton and Kortum [2002] but is distinct in two important ways. First, to capture declining food expenditure shares, consumer preferences are non-homothetic. Second, to capture large sectoral wage differentials in poor countries, labour movements out of agriculture is costly. The remaining aspects of the model are standard: markets are perfectly competitive, trade arises through sectoral and international differences in technology, and labour is the only productive input.

2.1 Households

The environment is composed of N countries, indexed with i, each populated by L_i agents endowed with an inelastically supplied unit of labour. Within each country, households share consumption evenly with individual agents. Non-homothetic preferences are modeled as subsistence food requirements within a Stone-Geary type utility function. Households select consumption and labour allocation to maximize

$$\max_{\{C_{ik},L_{ik}\}_{k\in\{a,m,s\}}} U(C_{ia},C_{im},C_{is}) = \varepsilon_a ln(C_{ia}-\bar{a})+\varepsilon_m ln(C_{im})+\varepsilon_s ln(C_{is}) \quad (1)$$

$$\text{s.t.} \sum_{k\in\{a,m,s\}} P_k C_k = \sum_{k\in\{a,m,s\}} w_k L_k \quad (2)$$

I capture labour market distortions with a reduced-form wedge between sectoral wages.[16] Specifically, $w_{ia} = \xi_i w_i$ and $w_{im} = w_{is} = w_i$, where $\xi_i < 1$ captures labour's cost to move off the farm.

2.2 Production Technology

I model N-by-N bilateral trade flows with two differentiated tradable goods, agriculture and manufacturing, similar to Eaton and Kortum [2002]. Goods, denoted $k \in \{a,m\}$, are composed of a continuum of differentiated varieties. Firms produce individual product varieties, denoted z, with linear technology

$$y_{ik}(z) = A_{ik}(z)L_{ik}(z).$$

[16] I abstract from how these differentials are supported in equilibrium. See Lagakos and Waugh [2010] for an excellent treatment of the relationship between sectoral labour frictions and the food problem.

Markets are perfectly competitive, which implies the producer price will equal marginal costs, $\frac{w_{ik}}{A_{ik}(z)}$. Productive technologies for each firm/variety are independent random draws from Frechet distribution specific to each country-i and sector-k

$$F_{ik}(z) \quad = \quad e^{-(z/A_{ik})^{-\theta_k}},$$

where θ_k governs productivity dispersion and A_{ik} the overall level of productivity, with $A_{ik} \propto E\left[A_{ik}(z)\right]$.[17]

Varieties are aggregated by a firm in each country into composite goods through a CES technology with an elasticity of substitution of ρ,

$$Y_{ik} \quad = \quad \left[\int_0^1 y_k(z)^{1-1/\rho} dz\right]^{\rho/(\rho-1)}.$$

Finally, nontradable services are produced with a similar linear production technology, $Y_{is} = A_{is}L_{is}$.

2.3 International Prices and Trade Patterns

Firms producing the composite manufactured and agricultural good purchase individual varieties from the lowest cost source - at home or abroad. As in Samuelson [1954], trade costs are iceberg: τ_{ijk} sector-k goods are shipped per unit imported by country-i from country-j. To avoid shipments through third-party countries, the triangle inequality holds: $\tau_{ij} < \tau_{ih}\tau_{hj}$, for any country h. Consequently, the price of variety z in country-i for good-k is

$$p_{ik}(z) \quad = \quad \min_{j\in\{1,..,N\}} \left[\frac{\tau_{ijk}w_{jk}}{A_{jk}(z)}\right]. \tag{3}$$

Given the distribution of productivities across varieties, Eaton and Kortum [2002] demonstrate a country's price index for tradable good-k in country-i reduces simply to

$$P_{ik} \quad = \gamma \quad \left[\sum_{j=1}^{N} \left(\frac{\tau_{ijk}w_{jk}}{A_{jk}}\right)^{-\theta_k}\right]^{-1/\theta_k}, \tag{4}$$

where $\gamma = \Gamma\left(1 + \frac{1-\rho}{\theta_k}\right)^{\frac{1}{1-\rho}}$.[18] Notice, Equation 4 is the price paid by consumers in country-i for the aggregate

[17] The constant of proportionality is $\Gamma\left[1 - \frac{1}{\theta_k}\right]^{-1}$. This relates to the scale parameter of a Frechet distribution. $\lambda_{ik} = A_{ik}^{\theta_k}$.

[18] $1 + \theta_k > \rho$ must hold, I set ρ such that $\gamma = 1$, which does not violate this restriction.

good-k and no knowledge of individual variety sources is necessary.

Model trade patterns depend on the share of country-i expenditures sourced from country-j. This share, in turn, depends on the fraction of varieties produced in j that have the lowest price of all producers in any other country, from the perspective of country-i consumers. As in Eaton and Kortum [2002] the share of country-i spending sourced from country-j for good-k is

$$\pi_{ijk} = \frac{\psi_{ijk}}{\sum_{j=1}^{N} \psi_{ijk}}, \tag{5}$$

with $\psi_{ijk} = \tau_{ijk}^{-\theta_k} \left(A_{jk}/w_{jk}\right)^{\theta_k}$ as the product of trade costs and competitiveness of country-j from the perspective of country-i consumers. A_{jk}/w_{jk} is a country's competitiveness, which rises with technological productivity A_{jk} and falls with labour costs w_{jk}.

Trade shares combine with household demand to determine the total sales of domestic industries for each country. With labour as the only productive input, total sectoral revenue from all sources - foreign and domestic - equals labour income by sector

$$\xi_i w_i L_{ia} = P_{ia} Y_{ia} = \sum_{j=1}^{N} \left[L_j (P_{aj}\bar{a} + \varepsilon_a \tilde{M}_j) \pi_{jia} \right], \tag{6}$$

$$w_i L_{im} = P_{im} Y_{im} = \sum_{j=1}^{N} \left[L_j \varepsilon_m \tilde{M}_j) \pi_{jim} \right], \tag{7}$$

$$w_i L_{is} = \varepsilon_s \tilde{M}_i L_i, \tag{8}$$

for all $i = 1, ..., N$, where $\tilde{M}_i$ is per-capita income net of subsistence food spending, $\tilde{M}_i = \xi_i w_i \left(\frac{L_{ia}}{L_i}\right) + w_i \left(1 - \frac{L_{ia}}{L_i}\right) - P_a \bar{a}$. These equations determine wages and labour allocations since, given technology and trade costs, sectoral prices are a function only of wages across countries. In the above system, wage levels and labour shares are independent of service-sector labour productivity. If $\bar{a} = 0$, $\xi_i = 1$, and there is only one tradable sector, the above system would collapse to $w_i L_i = \frac{\varepsilon}{1-\varepsilon} \sum_{j=1}^{N} \left[L_j w_j \pi_{ji}\right]$, where ε is the tradable goods' budget share. In this framework, the elasticity of substitution across goods is one (from household preferences) and, therefore, budget shares are constant. Thus, this system of equations determines wages across countries, given technology and trade costs.[19] More general preferences, however, would imply $\{\varepsilon_a, \varepsilon_m, \varepsilon_s\}$ are functions of an overall price index and, by extension, productivity in every sector, including services.

[19] These wage equations are similar to Equation 21 in Eaton and Kortum [2002], which corresponds to their special case of immobile labour.

2.4 Market Clearing

Sectoral labour allocations must total to national employment,

$$\sum_{k \in \{a,m,s\}} L_k = L_i \quad \forall\, i = 1,..,N. \tag{9}$$

The sectoral revenue and labour earnings conditions of the previous section imply international trade balances for each country. Specifically, combine Equations 6 to 8 to yield

$$L_i(P_{ai}\bar{a} + (\varepsilon_a + \varepsilon_m)\tilde{M}_i) = \sum_{j=1}^{N} L_j[(P_{aj}\bar{a} + \varepsilon_a \tilde{M}_j)\pi_{jia} + \varepsilon_m \tilde{M}_j \pi_{jim}] \quad \forall\, i = 1,..,N. \tag{10}$$

Country-i appears on both the left and right side, so this equation is identical to imports equaling exports.

2.5 Equilibrium Definition and Solving the Model

A competitive equilibrium in this framework is a set of prices $\{P_{ia}, P_{im}, P_{is}\}_{i=1}^{N}$, wages $\{w_i\}_{i=1}^{N}$, consumption allocations $\{C_{ia}, C_{im}, C_{is}\}_{i=1}^{N}$ and labour allocations $\{L_{ia}, L_{im}, L_{is}\}_{i=1}^{N}$ such that (1) given prices and wages, households solve Equation 1; (2) given wages, price aggregates from the firm aggregators is consistent with Equation 4; (3) given wages, prices, and labour allocations, international trade balances through Equation 10; and (4) labour markets clear through Equation 9.

To guide intuition through the calibration, I first describe the order to solve the model. First, estimate competitiveness $\frac{A_{ik}}{w_{ik}}$ and trade costs τ_{ijk} from bilateral trade flows (details in Section 3.1). These estimates together imply prices from Equation 4 and trade shares from Equation 5. Given prices and trade shares, determine international disposable income levels $\tilde{M}_i$ to balance international trade from Equation 10. Given income and prices, consumer demands from the household problem imply wages and labour allocations consistent with international demands and income levels through Equations 6 and 8. The product of competitiveness $\frac{A_{ik}}{w_{ik}}$ and wages now implies sectoral technology parameters A_{ik}. Finally, given the three-sector structure of the model, PPP-adjusted GDP/Worker is total nominal consumer expenditures deflated by a country-specific Geary-Khamis price index. This procedure follows the World Bank's International Comparisons Program and represents how Penn-World Table measures of GDP/Worker comparable across countries would be constructed in a world with only three goods [Heston et al., 2009]. To begin, international prices of each good-k are

$$IP_k = \frac{\sum_{i=1}^{N} \frac{P_{ik}C_{ik}}{PPP_i}}{\sum_{i=1}^{N} C_{ik}},$$

where PPP_i is the purchasing power parity exchange rate for country-i, expressed as

$$PPP_i = \frac{\sum_{k\in\{a,m,s\}} P_{ik}C_{ik}}{\sum_{k\in\{a,m,s\}} IP_k C_{ik}}.$$

Solve the above system, the model's PPP-adjusted GDP/Worker is then $\frac{Y_i}{L_i} = PPP_i^{-1} \sum_{k\in\{a,m,s\}} P_{ik}C_{ik}$.

3 Calibrating the Model

For the quantitative exercises, I use a set of 114 countries, listed in Table 10. A number of parameters can be easily set to generally accepted values in the literature. Preference parameters and the variance parameter from the productivity parameter. In order: $\varepsilon_a = 0.01$, $\varepsilon_m = 0.24$, and $\varepsilon_s = 0.75$; and, $\theta_a = \theta_m = 7$.[20] Total employment is inferred from PWT6.3. The model parameters I calibrate, their values, and targets are listed in Table 1. The following sub-sections describe parameterizing productivity, trade costs, subsistence level of food consumption, and, finally, labour market distortions. Given these, all other variables are endogenously determined. I proceed in two stages: (1) estimate competitiveness and trade costs to fit bilateral trade, independently of the structure of the household sector supporting such flows in equilibrium; and (2) select subsistence parameter to match US data.

3.1 Productivity and Trade Costs

The empirical strategy relates variation in bilateral import and export flows, relative to each country's domestic purchases, to infer import barriers, export competitiveness, and bilateral trade costs. The share of

[20] The estimates from a plain vanilla gravity model of bilateral trade flows on importer and exporter fixed effects and a measure of Δ_{ij} from the CEPII trade database yields $\theta = 5.5$ in agriculture and $\theta = 7$ in manufacturing. For colonial India, Donaldson [2010] finds $\theta = 3.8$ with the 17 agriculture varieties for which he has data, but $\theta = 5.2$ with the entire sample of 85 commodities. Lower theta in agriculture enhances my results by increasing the scope for comparative advantage within agriculture. To be conservative, I set $\theta_a = \theta_m$. For other estimates, Alvarez and Lucas [2007] set $\theta = 6.67$, Eaton and Kortum [2002] set $\theta = 8.3$, and Anderson and van Wincoop [2004] reviews the literature and finds anything between 5 and 10 reasonable. Finally, Waugh [2010] finds $\theta = 7.9$ for OECD countries and $\theta = 5.5$ for non-OECD countries, which is identical to my estimate for agricultural trade. All development accounting and trade flow counter-factual exercises are robust to alternative values.

Table 1: Calibration of Model Parameters

Parameters	Target	Value
$\{\theta_a, \theta_m\}$	Cost-Elasticity of Trade Flows	$\{7,7\}$
$\{\varepsilon_s, \varepsilon_m, \varepsilon_a\}$	Long-Run US Employment Shares	$\{0.75, 0.24, 0.01\}$
A_{is}	Services Value-Added/Worker Data	*Country-Specific*
ξ_i	Relative Wage Data	*Country-Specific*
L_i	Total Employment Data	*Country-Specific*
$\{A_{ia}, A_{im}, \tau_{ija}, \tau_{ijm}\}$	Bilateral Trade Data	*Country-Specific*
$\bar{a}$	US Sectoral Employment Data	0.0057

This table provides a list of model parameters that must be calibrated. All other variables in the model are endogenously determined. The parameters in the bottom two rows are dealt with in detail as Stage 1 and Stage 2, all other parameters either map to observable data or are generally accepted values. Long-run employment shares reflect the values to which US employment data appear to be converging.

country-i expenditure imported from country-j, from Equation 5 can be expressed as

$$\pi_{ijk} \quad = \quad P_{ik}^{\theta}\left(\frac{A_{jk}}{\tau_{ijk}w_{jk}}\right)^{\theta} = P_{ik}^{\theta}\left(\frac{T_{jk}}{\tau_{ijk}}\right)^{\theta},$$

where $T_{jk} = A_{jk}/w_{jk}$ is a country's competitiveness, which rises with technological productivity A_{jk} and falls with labour costs w_{jk}. Domestic spending shares are similar: $\pi_{iik} = P_{ik}^{\theta}\left(A_{ik}/w_{ik}\right)^{\theta} = P_{ik}^{\theta}T_{ik}^{\theta}$. The ratio of π_{ijk} to π_{iik} is a normalized import share that depends only on competitiveness measures (productivity per unit-input cost) and trade costs:

$$ln\left(\frac{\pi_{ijk}}{\pi_{iik}}\right) \quad = \quad \underbrace{\theta ln\left(T_{jk}\right) - \theta ln\left(T_{ik}\right)}_{\text{Competitiveness}} \quad - \quad \underbrace{\theta ln\left(\tau_{ijk}\right)}_{\text{Trade Costs}}$$

To estimate this expression, proxy trade costs with various bilateral characteristics and an importer-specific trade barrier, B_i. The bilateral costs include distance between capitals and indicators for shared border, common (ethnographic) language, and trade agreement status.[21][22] Importer-specific trade barriers is a reduced-form approach to capture all import costs such as tariffs, non-tariff barriers, health regulations, low quality local infrastructure, information asymmetries, among many others, in a single number. Importantly, trade costs in this setup are asymmetric between countries. It may be more expensive to import goods from the United States into Botswana than goods from Botswana into the United States. Alternative frameworks,

[21] Data on pairwise characteristics and Capital coordinates are from CEPII. http://www.cepii.fr/anglaisgraph/bdd/distances.htm. Distance between importer-i and exporter-e: $6378.7\arccos\left(\sin(lat_e)\sin(lat_i)+\cos(lat_e)\cos(lat_i)\cos(long_i - long_e)\right)$

[22] I find the trade agreement variable particularly important for European bilateral pairs. Without this control, productivity inferences for these countries, given their high levels of trade, are extremely large. Data is from Fieler [2010].

Table 2: Main Estimation Results

	Agriculture	Manufacturing
	(1)	(2)
Ln(Distance)	-.186	-.339
	(0.029)***	(0.024)***
Shared Border	1.858	2.335
	(0.108)***	(0.109)***
Shared Language	1.136	1.237
	(0.066)***	(0.06)***
Trade Agreement	1.524	1.350
	(0.131)***	(0.139)***
Observations	6207	9014
R^2	0.965	0.96

The OLS esimates of Equation 11. The dependent variable is the normalized import share, for importer-exporter pairs from the NBER-UN trade database, for each traded sector. Data on distance, borders, and language from CEPII; trade agreement indicator from Fieler (2010).

such as in Anderson and van Wincoop [2003], employ symmetric trade costs between pairs.[23] The precise empirical specification I use, separately for each sector, is:

$$ln\left(\frac{\pi_{ij}}{\pi_{ii}}\right) = \beta_1 Language_{ij} + \beta_2 Border_{ij} + \beta_3 ln\left(Distance_{ij}\right) + \beta_4 Agreement_{ij} + \eta_j + \delta_i + \varepsilon_{ij} \quad (11)$$

The model parameter estimates are derived from coefficient estimates as: $\hat{T}_{ik} = e^{\hat{\eta}_{ik}/\theta}$, $\hat{B}_{ik} = e^{-(\hat{\delta}_{ik}+\hat{\eta}_{ik})/\theta}$, and $\hat{P}_{ik} = \gamma\left[\sum_{j=1}^{N}\left(\hat{\tau}_{ijk}^{-1}\hat{T}_{jk}\right)^{\theta}\right]^{-1/\theta}$ from Equation 4.

To fit trade shares π_{ij} to data, I construct trade share measures similar to Eaton and Kortum [2001], Bernard et al. [2003]. Specifically, I take the ratio of country-i imports from country-j, reported in the NBER-UN trade database, relative to country-i's output less net exports

$$\hat{\pi}_{ij} = \frac{Import_{ij}}{SectoralOutput_i - Exports_i + Imports_i}$$

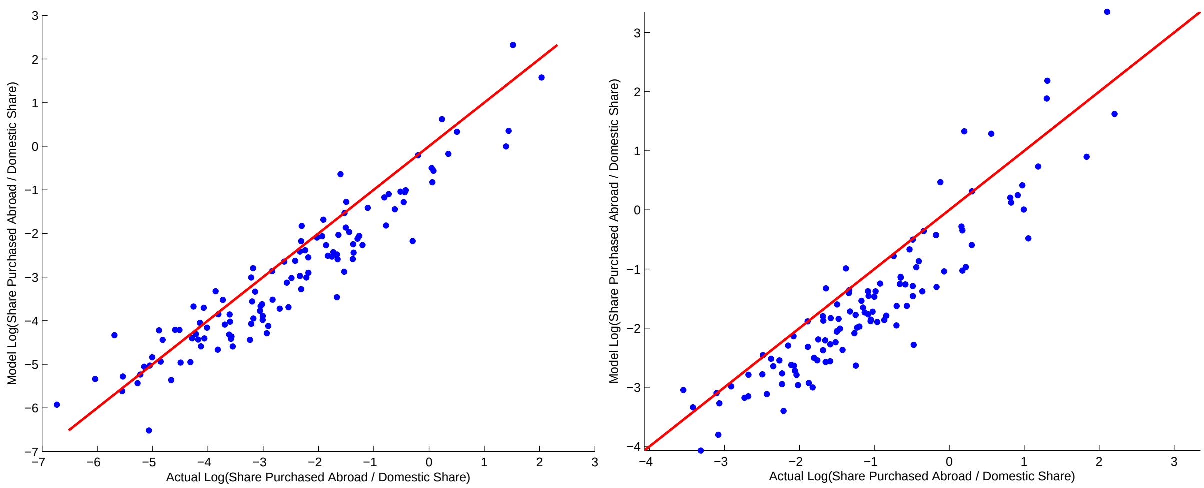
I infer sectoral output from World Bank GDP shares.[24] Bilateral trade data for 2000 is from the NBER-UN

[23]Asymmetric costs are not excluded from their framework, but it only identifies the *average* of any country-specific costs between members of a pair. Separately identifying import barriers is not feasible.

[24]Gross output measures are ideal but I lack internationally comparable measures. The FAO reports gross and net production values (PPP-adjusted, while trade flows are exchange-rate adjusted) and I find a gross-to-net ratio of approximately 5% among developing countries, compared to 15% for the rich. Net output inferred from GDP shares underestimates home-bias in poor countries, so this approach is conservative. Consistent with my treatment in the manufacturing sector, I use the inferred net output measure for agriculture as well.

Figure 3: Fit of the Stage-1 Calibrated Model

(a) Agricultural Trade (b) Manufacturing Trade



Displays the fit of the Stage-1 calibrated trade flows in the model to the data for each traded goods sector. The normalized trade flow measure is the share of consumer expenditures imported from abroad relative to the share sourced domestically. The vertical axis is the model normalized import rate and the horizontal axis is calculated from the NBER-UN trade database.

Trade Database, which disaggregates by 4-digit SITC code.[25] Agricultural trade flows are all bilateral flows classified with an SITC 1-digit code of 0, such as 0573 (Bananas, Fresh or Dried). Finally, countries do not trade with every other country, leaving zeros in the data for those pairs. For my baseline estimates, I estimate the above specification only on the pairs with positive trade with OLS.[26]

The basic gravity-specification implied by the theory captures the trade data well. The parameter estimates are listed in Table 2 and all have the expected sign. The magnitude of the coefficients are also in line with literature.[27] There are 6,207 observed trade pairs in agriculture and 9,014 in manufacturing. Agriculture is more sensitive to these bilateral trade costs. To visualize the goodness of fit, I sum $\frac{\pi_{ij}}{\pi_{ii}}$ within countries, which represents the relative importance of goods sourced from abroad relative to domestic purchases. The actual and fitted values (summed in similar fashion) are found in Figure 3 and match extremely well. When the model is solved, Frechet productivity parameters are $A_{ik} = \hat{T}_{ik} w_{ik}$.

[25] See Feenstra et al. [2005] for details regarding the construction of this data.

[26] As a robustness check, to handle this left-censoring of the data, I estimate a Tobit model with the minimum observed π_{ij} for each country-i serving as the lower limit, below which statistical agencies do not observe the trade. This procedure is similar, but not identical to, [Eaton and Kortum, 2001]. See Anderson and van Wincoop [2003] for more on estimating gravity models. The censoring threshold for π_{ij} is selected as the maximum likelihood estimate $\bar{\pi}_i = \min_{j \in [1,..,N]} \pi_{ij}$, such that if the true $\pi_{ij} < \bar{\pi}_i$ then I will not observe a trade flow in the data for that i, j pair. The geographic component of trade becomes much more important within the Tobit structure. I explore this alternative specification in the appendix.

[27] Anderson and van Wincoop [2004] review the literature, and I take the preferred estimates of the distance elasticity, for example, to be between 0.2 and 0.4.

Table 3: Selected Values from Stage-1 Calibration

Mean for	Competitiveness, $\widehat{(A_{jk}/w_{jk})}$		Import Barriers, $\hat{B}_{ik}$	
Countries in:	Agriculture	Manufacturing	Agriculture	Manufacturing
Top-10%	0.73	1.29	73%	22%
Bottom-10%	0.44	0.53	320%	276%

Competitiveness and trade costs implied by the bilateral pattern of sectoral trade.

3.2 Subsistence, Service Sector Productivity, and Labour Market Distortions

An important driver of agriculture's high employment and spending share in lower income countries is the need to fulfill minimum food intake requirements. To capture this channel, without selecting subsistence to target potentially suspect employment data in poor countries, I set $\bar{a}$ to match US data. Specifically, I increase subsistence requirements until the model implied share of US employment in agriculture is near 2%, without causing any poor countries to exceed the observed maximum share of 0.9. Finally, service sector labour productivity, A_{is}, is calibrated to values that lead the model implied PPP-adjusted aggregate labour productivity to match data. Finally, each country's labour market distortion, ξ_i, can be matched to sectoral wage data from the International Labour Organization.[28] Wage data is unavailable for many countries. I use the observed relationship between relative agricultural wages and GDP/Worker to fit ξ_i for each of the 114 countries. Details on this procedure are in the Data Appendix.

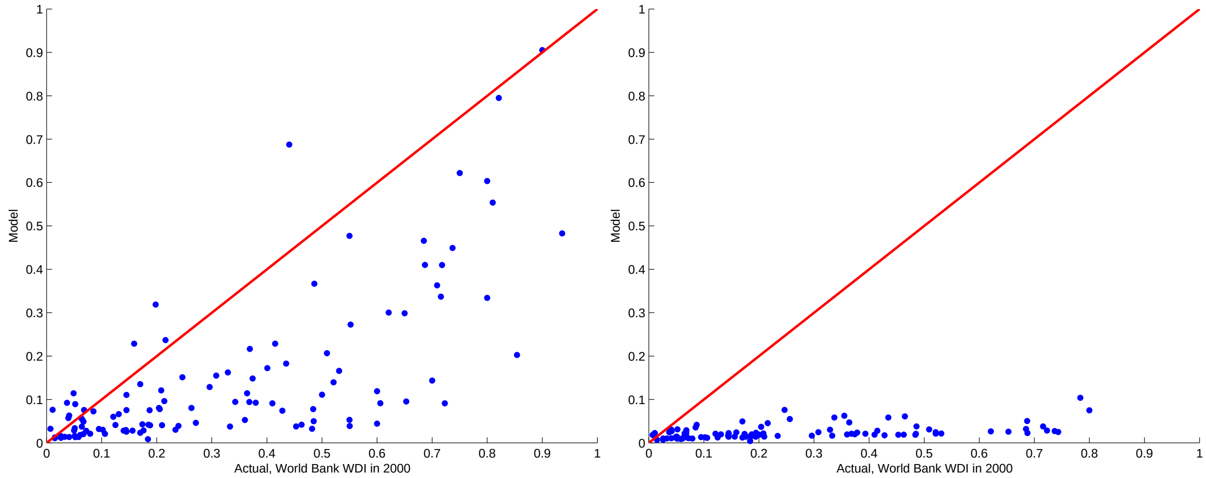
4 Results from the Baseline Calibration

I display the model-implied agricultural employment share in Figure 4a. If cross-country employment data are accurate, targeting US data accounts for approximately half of the international variation in agriculture's employment share. The fit is even stronger given overestimated farm worker statistics. I present other implications of the baseline model in Table 4. The model corresponds well to sectoral data, despite explicitly targeting only aggregate productivity differences. The model's food expenditures shares are lower since data captures many non-food (service or manufactured) components, such as packaging or restaurant services.

[28] http://laborsta.ilo.org/

Figure 4: The Role of Subsistence Food Requirements

(a) With Subsistence Food Requirement Set to Match US Data (b) With Subsistence Food Requirements Set to Zero



Displays the model implied share of employment in agriculture along the vertical axis relative to the share reported for 2000 in the World Bank's WDI database. The left panel is the model with subsistence set to match US data. The right panel is the model with subsistence set to zero. Targeting US data allows the model to capture much of the cross country variation.

Table 4: Important Dimensions of the Model Match Data Well

	Mean of Bottom-10%		Mean of Top-10%	
	Data	Model	Data	Model
GDP/Worker, Relative to Top *	0.04	0.04	1	1
Agricultural Employment Share	0.67	0.46	0.04	0.02
Services Employment Share	0.25	0.41	0.67	0.74
Agricultural Consumption Share	0.60	0.27	0.08	0.01

$*$ denotes target. This table compares the model implications to data for various relevant statistics. Poor-country agricultural consumption share reflects the average share reported for Sub-Saharan Africa in Hoyos and Lessem (2008). Rich-country consumption share reflects share implied by US Historical Statistics, series CD153-CD155, for the year 1999 as the ratio of Food Purchased for Off-Premise Consumption relative to total consumption expenditures.

4.1 Trade Cost Estimates

Stage 1 generates trade cost estimates to match trade flows. I decompose the costs into bilateral factors, which include geographic components, language, and trade agreement indicators, and importer-specific import costs. To determine the overall extent of geographic trade barriers facing a given importer, I average across all source countries weighted by trade volume. Importers are then further grouped into quintiles of aggregate GDP per worker, with the trade costs averaged across importers within a given quintile weighted by trade volume. The importer-specific costs may be caused by any number of possible barriers: tariffs, quotas, health regulations, poor local road networks, or even cultural factors that mean imported food is viewed differently than local. The extent of trade barriers can be converted into its impact on price; a trade cost of τ will increase prices by $100(e^{\tau/\theta}-1)$ percent. Figure 11 displays the decomposition. The values found are quite reasonable, with barriers averaging around 320% for the poorest countries. While much larger than tariffs, the other components of import costs - such as domestic infrastructure quality - could account for the rest.[29] I go into a full discussion later in the paper. Manufacturing trade cost estimates are displayed in Figure 12.

4.2 Sectoral Labour Productivity

As noted by Costinot et al. [2010], Waugh [2010], Yi and Zhang [2010], A_{jk} is the labour productivity in autarky. With trade, labour productivity in sector-k is given by the conditional mean of operating producer productivity, $y_{ik}=\frac{w_{ik}}{P_{ik}}=E\left[A_{ik}(z)\mid z\in\{y_{ik}(z)>0\}\right]$, can be expressed as

$$y_{ik} = \underbrace{\pi_{iik}^{-1/\theta_k}}_{\text{Trade}} \cdot \underbrace{A_{ik}}_{\text{Technology}} . \tag{12}$$

In autarky, all producers operate and labour productivity is A_{ik}. Imports, which lower π_{iik}, leads average productivity to grow as inefficient producers shut-down.[30] I plot relative productivity between agriculture and manufacturing in Figure 9; relative agricultural labour productivity increases strongly with a country's level of development. In the figure, I separately show the pure technology ratio $\frac{A_{ai}}{A_{mi}}$ and the full observed productivity ratio, given trade selection.

Unfortunately, the model is unable to analytically produce PPP-adjusted estimates of sectoral labour

[29] See Anderson and van Wincoop [2004] for a full discussion of how large trade costs can truly be, with a headline figure of 170% for the United States.

[30] See Costinot et al. [2010] for a detailed discussion of the extent to which selection impacts observed productivity.

Table 5: Baseline Model: Cross Country Productivity Differentials

	Top-10% / Bottom-10%		Variance of Logs	
Sector	Data	Model	Data	Model
Aggregate	23	23	1.00	1.00
Agriculture	98	94	2.00	1.73
Manufacturing	-	74	-	1.83
Services	-	11	-	0.71
Nonagriculture	6	15	0.47	0.74

Presents the baseline estimates of sectoral productivity implied by bilateral trade flows and model wages. Services sector productivity is calibrated so the model aggregate productivity matches the dispersion of GDP/Worker in the PWT6.3. Agricultural labour productivity in the data is PPP-adjusted value-added per worker using net farm output data from FAO, valued at international prices, for 1999-2001. The precise procedure follows Restuccia, Yang, and Zhu (2008) and Caselli (2005).

productivity since individual variety producer-prices and production quantities are unknown. To provide proper comparisons with data, I simulate the model on a set of 50,000 products for each sector and country. Within the simulation, I track individual producer prices and quantities to construct PPP adjustment-factors following the World Bank procedures. I provide details in the Appendix. Overall, productivity estimates from Equation 12 match appropriate PPP-adjusted estimates very well. Table 5 displays the aggregate and sectoral productivity dispersion implied by the baseline model, which match the data well for agriculture. I plot a complete comparison for all countries in Figure 10. Nonagricultural productivity variation, however, is larger than data suggests, reconciled by the model's lower agricultural employment share. Similar comparisons within the manufacturing and service sectors across a broad range of countries are difficult for lack of producer price data. Broadly speaking, however, lower service-sector productivity variation than in tradable goods sectors is consistent with Herrendorf and Valentinyi [2010].[31]

While direct international comparison is problematic, I examine a subset of countries for which real labour productivity (per hour) exists in the GGDC Productivity Level Database [Inklaar and Timmer, 2008]. I find the variance of log manufacturing productivity is 1.67 in the model for these countries and 0.14 in services, while GGDC figures are 0.56 and 0.17.[32] Moreover, the ratio of the 75th to 25th percentile is 7 in the model and 3 in the GGDC data. An alternative trade cost specification in Section 6.4 provides less variation in productivity estimates. The counterfactual results in the following section are robust - indeed,

[31] For an interesting illustration of the difficulty of making direct cross-country productivity comparisons, especially within the service-sector, see Baily and Solow [2001]

[32] I use the GGDC figures corresponding to manufacturing less electrical equipment and services less postal and telecommunications. Electrical equipment, postal, and telecommunications are aggregated into a single, separate category.

strengthened - by this alternative specification, so I continue with the baseline model.

5 Counterfactual Experiments: Trade, Productivity, and Income

To account for the sources of productivity gaps between rich and poor countries, I perform a set of counterfactual experiments within the model. Specifically, I investigate: (1) lowering import barriers everywhere, B_i, to the average level of the richest-10% of countries; (2) allowing full labour mobility by setting $\xi_i = 1$ for all i; and (3), to capture interactions between the domestic and foreign distortions, both (1) and (2) together. Following each of these experiments, poor countries increases their level of food imports dramatically (see Figures 5, 6, and 7). Imports allow the lowest productivity domestic producers to shut down and tradeable-sector productivity increases, especially in poor countries. I interpret the portion of the rich-poor gap that these counterfactual experiments eliminates as the contribution of the two distortions. I present details in the following sections.

5.1 International Food Trade Flows

I present the bilateral trade patterns for the trade liberalization experiment in Table 6. Until subsistence food requirements are met, poor country consumers allocate significant resources to agriculture since trade barriers inhibit their ability, and internal labour markets reduce their incentive, to import food. Following liberalization, the fraction of varieties produced domestically falls below that of rich countries. The fraction of food imports sourced from other poor countries more than triples and the fraction from rich countries falls in half. Middle-income countries (not displayed explicitly in the table) also become an important source for poor-country food imports. I find some developing countries *increase* their resource commitment to agriculture while others move labour into non-agricultural activities. In essence, poor countries more efficiently allocate their food production among themselves. The counterfactual volume of South-South trade grows by an order of magnitude to account for nearly one-quarter of global agricultural trade (see Figures 13 and 14). These counterfactual trade patterns drive important changes in productivity and income differences between rich and poor countries, to which I now turn.

Table 6: Trade Between Rich and Poor *(1st and 4th Quartiles)*

(a) Baseline Model (Data)

	Import Share from: Poor	Import Share from: Rich	Domestic Share
Poor	6%	55%	98%
Rich	2%	75%	63%

(b) Following Trade Liberalization Experiment

	Import Share from: Poor	Import Share from: Rich	Domestic Share
Poor	18%	28%	36%
Rich	9%	48%	45%

Displays the fraction of total imports by source-country income levels. Poor are the bottom quantile of countries in terms of GDP/Capita and rich are the top. Large shares imported from Rich countries does not imply that rich countries export more food to poor countries than vice-versa (in fact, the reverse is true). Prior to liberalization, poor countries bought very little from each other. Following liberalization of import and labour markets, food trade between poor countries rises dramatically. The fraction of varieties domestically produced also falls. This Ricardian-selection is the source of the increased sectoral productivity.

5.2 Cross-Country Productivity Gaps

Table 7 displays model-implied gaps in sectoral and aggregate productivity across countries, under various measures and experiments. Reducing import barriers and allowing costless labour mobility results in dramatic reductions in productivity gaps. The richest 10% of countries initially had aggregate productivity nearly 23 times the poorest but those same countries were only 17 times as productive after both distortions were relaxed. The agricultural productivity gap for these countries is nearly cut in half, from over 98 to 55. Variation in log aggregate productivity is three-quarters of its original magnitude. Finally, though not displayed, relative labour productivity in agriculture increases significantly in poor countries, increasing from 0.64 to 0.80. By comparison, the relative productivity for the rich countries falls slightly from 0.91 to 0.86. Similar gains result from lowering only agricultural import barriers, in conjunction with costless labour reallocation, though not reported. Overall, nearly all the aggregate gains found in the broader liberalization experiments remain when *only* agricultural import barriers are reduced. This is intuitive, given the importance of the agricultural sector for poor country consumers resulting from subsistence food requirements.

Together, these results suggest that over one-quarter (6/23) of the gap between rich and poor countries can be accounted for by the lack of food imports. There are also important interaction effects between domestic and foreign (trade) distortions. Initlally, the difference between the richest and poorest 10% of countries if 22.8. Lowering import barriers lowers the gap to 20.1, labour mobility barrier reductions lower the gap to 21.2, combined the gap falls to 16.6. This implies 12% of the observed gap is from high import barriers alone, 7% from costly labour mobility alone, but 27% from both distortions together. The reduction in cross-country income variation reveals a similar pattern. The variance in log GDP/Worker across all countries

Table 7: Reduction in Rich-Poor Productivity Differences

	Liberalization Experiments			
	Baseline	Liberalized Trade	Mobile Labour	Both
Top-10%/Bottom-10%				
Aggregate	23	20	21	17
Agriculture	98	84	93	55
Manufacturing	74	45	75	52
Variance of Logs				
Aggregate	1.00	0.90	0.94	0.79
Agriculture	2.00	1.89	1.97	1.58
Manufacturing	1.83	1.44	1.85	1.54

Various measures of cross-country dispersion demonstrates the biggest reduction in cross country productivity differences results from liberalizing trade in the presence of costless labour mobility. Liberalized-trade involves lowering both agricultural and manufacturing import barriers. Import barriers are lowered to the average for the richest ten-percent of countries, by sector. Mobile labour involves eliminating between-sector wage differences.

in the sample falls by 10% following trade liberalization, 6% following labour mobility improvements, and 21% following an improvement in both distortions. The contribution of both distortions is greater than the sum of their individual contributions. This result is particularly important given the literatures focus on domestic distortions within closed-economy frameworks.

5.3 Decomposition: Cross Country Aggregate Productivity and Income Variation

Given technology levels, I decompose aggregate productivity changes into two broad channels: (1) trade selection and (2) structural change. Selection occurs because of low productivity domestic producers shutting down with increased import levels. Recall Equation 12, $y_{ik} = \pi_{iik}^{-1/\theta_k} A_{ik}$, defines sectoral labour productivity, which changes inversely with the domestic expenditure share. Aggregate real output per worker is an employment-weighted average of sectoral productivity,

$$\frac{Y}{L} = y_a\left(\frac{L_a}{L}\right) + y_m\left(\frac{L_m}{L}\right) + A_s\left(\frac{L_s}{L}\right) \tag{13}$$

I find trade-selection's contribution to reductions in productivity variation by holding employment shares constant and setting sectoral productivity to counterfactual levels. The reverse, with fixed sectoral produc-

Table 8: Reduction in Cross Country Variance in Log(GDP/Worker)

Liberalization Experiment	Overall	Decomposing Productivity Increases into Specific Channels: Structural Change Only	Trade Selection Only
Eliminate Import Barriers	10%	8%	3%
Costless Labour Mobility	3.5%	3.4%	0.4%
Both	20%	17%	6%

Reduction in Var(Y/L) from Equation 13. The first column is the overall reduction; the second column holds sectoral productivities constant, changing only the labour shares; and the third column holds labour shares constant, changing only sectoral labour productivities. Results from the 2nd and 3rd columns do not sum to the 1st since reallocation is away from the sector with rising productivity - namely, agriculture.

tivity and counterfactual employment shares, estimates the contribution from structural change. I display the results in Table 8. Results from the 2nd and 3rd columns do not sum to the 1st since reallocation is away from the sector with rising productivity - namely, agriculture. Trade selection contributes 6% to the reduction in aggregate productivity variation.

That productivity differences *within sectors* shrinks following liberalized trade and labour markets is an important point to emphasize. Trade models with horizontally differentiated goods and heterogeneous productivities across firms can account for Ricardian selection, which contributes to approximately one-third of the overall reduction in productivity variation, while homogeneous goods frameworks cannot. It also suggests that many of the inefficient production technologies employed in low-income countries - such as small farm sizes - may be abandoned if access to imports improves. To reiterate, however, I am not advancing a specific policy recommending. Accounting for within-sector changes is important to quantify the contribution of low imports and labour misallocation to observed income and productivity differences across countries.

6 Discussion and Robustness of Results

6.1 Alternative Counterfactual Experiment

I investigate more limited experiments involving reducing import-barrers in *only* the poorest-10% of countries by one-hundred percentage points, instead of to rich-country levels, and improve labour markets only until $\xi_i = 0.8$. The wage wedge implied by this value of ξ corresponds to an urban/nonagricultural unem-

Table 9: Results of Limited and Unilateral Liberalization in Poorest-10% of Countries

	Liberalization Experiments			
	Baseline	Liberalized Trade	Mobile Labour	Both
Top-10%/Bottom-10%				
Aggregate	23	23	21	20
Agriculture	98	97	93	84
Manufacturing	74	70	75	73

Comparing richest to poorest countries following a limited counterfactual experiment. Liberalized-trade involves lowering both agricultural and manufacturing import barriers in the poorest-10% by one-hundred percentage points. Mobile labour involves setting $\xi = 0.8$. Excludes Niger from the poorest group since this country gains significantly in the experiments and is not representative of other poor country gains.

ployment rate of 20% and no rural/agricultural unemployment in the Harris and Todaro [1970] framework.[33] I display the results of this experiment in Table 9. The reduction in the gap between rich and poor is, as expected, much less than prevous experiments. The magnitudes, though, are still impressive given the limited liberalization among only the poorest-10%. The gap between the richest and poorest falls by more than 10% (from 23 to 20) in aggregate and by approximately 14% within agriculture (from 98 to 84).

6.2 Actual Development Experiences

Between 1780 and 1850, the United Kingdom experienced massive reallocation of labour off the farm at the same time as food imports rose. Technological change in the manufacturing sector and the declining cost of important inputs, such as power and transportation, increased manufacturing productivity. Were higher trade volumes the result of higher manufacturing productivity or vice-versa? Stokey [2001] argues increased food imports, independent of technical change, accounts fully for the reduction in domestic food production and approximately half of real wage growth.

South Korea since the mid-1960s provides another experience where increased food imports may have facilitated structural change and increased aggregate productivity and income. The FAO Food Balance sheets for South Korea show products accounting for over 75% of calorie consumption - cereals and starchy-roots (potatoes, etc.) - were nearly all domestically produced in the early 1960s. By 2000, imports were twenty-seven times their 1961 quantity (nearly 9% growth per year) and more than double domestic production.

[33] To see this, the agricultural wage w_a will equal the *expected* nonagricultural wage w_n. The unemployment rate reflects the probability of not securing employment at a given wage. So, $w_a = u_n 0 + (1-u_n)w_n \Rightarrow \frac{w_a}{w_n} = 1 - u_n$, which equals 0.8 if $u_n = 0.2$.

Tariffs for some of the most important imported goods, such as Wheat, are as low as 3% (applied, and 9% bound). Consequently, South Korea's employment share in agriculture fell from over 50% to less than 10%. The remaining domestic production has become increasingly concentrated in fewer varieties, with rice alone accounting for more than 50% of cultivated land.[34] Teignier [2010] concludes food imports facilitated reallocation and productivity increases, though to a smaller extent than possible given large support programs - among the highest in the world - for domestic farmers.

6.3 Plausibility of Trade Cost Estimates

The country-specific import costs are plausible, given the voluminous contributions to trade costs beyond tariffs and transport costs that often cannot be directly measured (see Anderson and van Wincoop [2004] for an exhaustive review). Traditional measure of trade costs can account for much of the estimate. First, observed WTO average tariff rates are larger in poorer countries, on the order of 50% for agricultural imports. Tariff costs go beyond average values, since variation across substitutable products matters nearly as much. Kee et al. [2008], accounting for tariff variation across products and the different product elasticities imply trade restrictiveness[35] is 64% larger than average tariff rates imply. Large distortions from product-line tariff variation is also found for the United States by Irwin [2010], with a uniform tariff-equivalent estimate of 75%. Next, many studies find non-tariff barriers of roughly equal importance (and often more important) for a country's level of restrictiveness Kee et al. [2009].

A host of other trading difficulties exist for poor countries that increase trade costs. Contracting costs and insecurity, poor local distribution infrastructure, information gathering costs, currency controls, local content regulations, or health regulations in the case of food. Distribution costs are no doubt a significant driver of trade costs for poor countries, with such costs already on the order of 50% for rich countries. For comparison, the headline trade cost value advanced by Anderson and van Wincoop [2004] for the United States is 170% when all costs are tabulated, and 120% excluding transportation costs.

6.4 Implications for Price Differentials

Agricultural and manufacturing prices in the model decline with income. The *relative* price of agriculture to non-agricultural goods is rising with income. ICP data for 2005 suggest price levels in these traded goods

[34] Source: South Korea Agricultural Policy Review, Vol. 5 No. 1. Agriculture and Agri-Food Canada.

[35] Trade restrictiveness is the uniform tariff rate that generate identical dead-weight loss as a particular tariff/NTB structure

sectors are increasing with income, more strongly so for agricultural prices. FAO farm-gate prices, on the other hand, which I display in Figure 15, suggests far higher levels in poor countries than ICP. Moreover, model-prices capture the full price involved in purchasing goods, including transport to the point of consumption. Given low infrastructure quality in poor countries, these concerns may be significant. In any case, an alternative specification of trade costs allows the model to more closely match ICP-implied price levels.

6.4.1 Exporter-Specific Trade Costs

I redo the analysis under the alternative form of trade cost asymmetry suggested by Waugh [2010]; specifically, country-specific export costs rather than import costs.[36] The World Bank's *Doing Business Index* surveys the cost of exporting an identical shipment of goods from a variety of countries and displays a clear decline in such costs with income. Poor country export costs are perhaps twice that of rich. My baseline results are robust to including export costs instead of import barriers in the gravity specification. If exporter-costs are included only with the manufacturing sector, the baseline dispersion of productivity across countries shrinks. Counterfactual experiments in this environment yield even greater reductions in aggregate productivity since poor country manufacturing sectors - to which farm labour will reallocate - have higher productivity. I conclude that my results are robust to my choice of trade cost asymmetry and provide more detailed results, with specific Tables and Figures, in the appendix.

6.5 OECD Agricultural Producer Support

Support programs for the agricultural sector in higher-income countries are large. The OECD estimates producer support estimates as high as 60% of production in Korea and Japan, 31% in the European Union, 22% in Canada, and 11% in the United States.[37] My main productivity estimates, A_{ia}, capture producer supports. Previous counter-factual exercises apply if PSE levels remain unchanged. Removal of support results in lower poor-country imports and higher rich-country imports. I present details of this experiment in the appendix and I find all main results robust.

[36] I use the agricultural trade data and 2005 ICP prices to show asymmetric trade costs identified by Waugh [2010] for manufactured goods is also a feature of the agricultural goods trade. For example, it is generally most costly for the United States to import food from developed economies than for developing countries to import food from the US. Perhaps export subsidy programs may play a role here.

[37] Source: Agricultural Policies in OECD Countries 2009: Monitoring and Evaluation.

7 Concluding Thoughts

In this paper, I measure large cross-country variation in sectoral productivity and show low food imports accounts for approximately one-quarter of this variation. By employing the structure of a standard trade model within a dual-economy macro model of structural change, I estimate PPP-adjusted productivity without producer price or employment data. This is particularly important since reported agricultural employment shares likely overstates the true share of labour hours [Brandt and Zhu, 2010, Brandt et al., 2008, Gollin et al., 2004] and manufacturing producer price estimates in developing countries is unavailable. Counterfactual experiments within the calibrated model show increased imports shut-down low productivity domestic producers and facilitates labour reallocation out of unproductive agricultural varieties. Overall, low food imports and labour misallocation accounts for half the agricultural productivity differences between rich and poor countries and a quarter of the aggregate productivity and income differences.

References

Tasso Adamopoulos. Do richer countries have higher distribution margins. 2008.

Tasso Adamopoulos. Transportation costs, agricultural productivity and cross-country income differences. *International Economic Review*, Forthcoming 2010.

Tasso Adamopoulos and Diego Restuccia. The size distribution of farms and international productivity differences. April 2010.

Fernando Alvarez and Robert Jr. Lucas. General equilibrium analysis of the eaton-kortum model of international trade. *Journal of Monetary Economics*, 54(6):1726–1768, September 2007.

James E. Anderson and Eric van Wincoop. Gravity with gravitas: A solution to the border puzzle. *American Economic Review*, 93(1):170–192, March 2003.

James E. Anderson and Eric van Wincoop. Trade costs. *Journal of Economic Literature*, 42(3):691–751, September 2004.

Martin Neil Baily and Robert M. Solow. International Productivity Comparisons Built from the Firm Level. *Journal of Economic Perspectives*, 15(3):151–172, Summer 2001.

Andrew B. Bernard, Jonathan Eaton, J. Bradford Jensen, and Samuel Kortum. Plants and productivity in international trade. *American Economic Review*, 93(4):1268–1290, September 2003.

Loren Brandt and Xiaodong Zhu. Accounting for china's growth and structural transformation. *Working Paper*, 2010.

Loren Brandt, Chang-Tai Hsieh, and Xiaodong Zhu. Growth and structural transformation in china. In *China's Great Economic Transformation*, pages 569–632. Cambridge University Press, 2008.

Ariel Burstein and Jonathan Vogel. Globalization, technology, and the skill premium: A quantitative analysis. Working Paper 16459, National Bureau of Economic Research, October 2010.

L. Caliendo and F. Parro. Estimates of the Trade and Welfare Effects of NAFTA. 2009.

Francesco Caselli. Accounting for cross-country income differences. In Philippe Aghion and Steven Durlauf, editors, *Handbook of Economic Growth*, volume 1 of *Handbook of Economic Growth*, chapter 9, pages 679–741. Elsevier, 2005.

Francesco Caselli and Wilbur Coleman. "The u.s. structural transformation and regional convergence: A reinterpretation". *The Journal of Political Economy*, 109(3):584–616, 2001.

Davin Chor. Unpacking sources of comparative advantage: A quantitative approach. *Journal of International Economics*, Forthcoming 2010.

Juan Carlos Cordoba and Marla Ripoll. Agriculture, aggregation, and cross-country income differences. *Working Paper, Rice University and University of Pittsburg*, 2006.

Arnaud Costinot, Dave Donaldson, and Ivana Komunjer. What goods do countries trade? a quantitative exploration of ricardo's ideas. Working Paper 16262, National Bureau of Economic Research, August 2010.

Dave Donaldson. Railroads of the raj: Estimating the impact of transportation infrastructure. 2010.

Margarida Duarte and Diego Restuccia. The role of the structural transformation in aggregate productivity. *The Quarterly Journal of Economics*, 125(1):129–173, February 2010.

Jonathan Eaton and Samuel Kortum. Trade in capital goods. *European Economic Review*, 45(7):1195–1235, 2001.

Jonathan Eaton and Samuel Kortum. Technology, geography, and trade. *Econometrica*, 70(5):1741–1779, September 2002.

Cristina Echevarria. Non-homothetic preferences and growth. *Journal of International Trade and Economic Development*, 9(2):151–171, June 2000.

Robert Feenstra, editor. *Per-capita income as a determinant of trade*. MIT Press, Cambridge, 1988.

Robert C. Feenstra, Robert E. Lipsey, Haiyan Deng, Alyson C. Ma, and Hengyong Mo. World trade flows: 1962-2000. Working Paper 11040, National Bureau of Economic Research, January 2005.

Anna Cecilia Fieler. Non-homotheticity and bilateral trade: Evidence and a quantitative explanation. *Working Paper*, 2010.

Douglas Gollin and Richard Rogerson. Agriculture, roads, and economic development in uganda. 2010.

Douglas Gollin, Stephen L. Parente, and Richard Rogerson. Farm work, home work, and international productivity differences. *Review of Economic Dynamics*, 7(4):827–850, October 2004.

Douglas Gollin, Stephen L. Parente, and Richard Rogerson. The food problem and the evolution of international income levels. *Journal of Monetary Economics*, 54(4):1230–1255, May 2007.

John R Harris and Michael P Todaro. Migration, unemployment & development: A two-sector analysis. *American Economic Review*, 60(1):126–42, March 1970.

Yujiro Hayami and Vernon Ruttan. *Agricultural Development: An International Perspective*. John Hopkins University Press, Baltimore, MD, 1985.

Berthold Herrendorf and Akos Valentinyi. Which sectors make the poor countries so unproductive? *Journal of the European Economic Association*, Forthcoming 2010.

Alan Heston, Robert Summers, and Bettina Aten. Penn World Table Version 6.3. *Center for International Comparisons of Production, Income and Prices at the University of Pennsylvania*, August 2009.

Linda Hunter. The contribution of nonhomothetic preferences to trade. *Journal of International Economics*, 30(3-4):345–358, May 1991.

Robert Inklaar and Marcel P. Timmer. GGDC productivity level database: International comparisons of output, inputs and productivity at the industry level. Technical report, 2008.

Douglas Irwin. Trade restrictiveness and deadweight losses from us tariffs. *American Economic Journal: Economic Policy*, 2, 2010.

Toshihiko Kawagoe, Yujiro Hayami, and Vernon W. Ruttan. The intercountry agricultural production function and productivity differences among countries. *Journal of Development Economics*, 19(1-2):113 – 132, 1985.

Hiau Looi Kee, Alessandro Nicita, and Marcelo Olarreaga. Import demand elasticities and trade distortions. *The Review of Economics and Statistics*, 90(4):666–682, 07 2008.

Hiau Looi Kee, Alessandro Nicita, and Marcelo Olarreaga. Estimating trade restrictiveness indices. *The Economic Journal*, 119:172–199, January 2009.

William Kerr. Heterogeneous technology diffusion and ricardian trade patterns. 2009.

Simon Kuznets. *Economic Growth of Nations*. Harvard University Press, Cambridge, MA, 1971.

David Lagakos and Michael E. Waugh. Specialization, agriculture, and cross-country productivity differences. April 2010.

Andrei Levchenko and Jing Zhang. The evolution of comparative advantage: Measurement and welfare implications. *RSIE Discussion Paper*, (610), 2010.

Staffan Linder. *An essay on trade and transformation*. Almqvist & Wiksell Boktr, Uppsala, 1961.

Robert E. Lucas. Trade and the diffusion of the industrial revolution. *American Economic Journal: Macroeconomics*, 1(1):1–25, January 2009.

James R Markusen. Explaining the volume of trade: An eclectic approach. *American Economic Review*, 76 (5):1002–11, December 1986.

Kiminori Matsuyama. Agricultural productivity, comparative advantage, and economic growth. *Journal of Economic Theory*, 58(2):317–334, December 1992.

Presada Rao. Intercountry comparisons of agricultural output and productivity. *FAO Economic and Social Development Papers*, 112, 1993.

Diego Restuccia, Dennis Tao Yang, and Xiaodong Zhu. Agriculture and aggregate productivity: A quantitative cross-country analysis. *Journal of Monetary Economics*, 55(2):234–250, March 2008.

Paul Samuelson. The transfer problem and transport costs, ii: Analysis of effects of trade impediments. *The Economic Journal*, 64(254):264–289, 1954.

T.W. Schultz. *The Economic Organization of Agriculture*. McGraw-Hill, New York, 1953.

Nancy L. Stokey. A quantitative model of the british industrial revolution, 1780-1850. *Carnegie-Rochester Conference Series on Public Policy*, 55(1):55–109, December 2001.

Marc Teignier. The role of trade in structural transformation. *Working Paper, University of Chicago*, 2010.

C. Peter Timmer. Agriculture and economic development. In B. L. Gardner and G. C. Rausser, editors, *Handbook of Agricultural Economics*, volume 2 of *Handbook of Agricultural Economics*, chapter 29, pages 1487–1546. Elsevier, 2002.

Peter Timmer. The agricultural transformation. In Hollis Chenery and T.N. Srinivasan, editors, *Handbook of Development Economics*, volume 1 of *Handbook of Development Economics*, chapter 8, pages 275–331. Elsevier, December 1988.

Trevor Tombe. Structural change and regional growth dynamics. Working paper, University of Toronto, 2008.

Dietrich Vollrath. The dual economy in long-run development. *Journal of Economic Growth*, 14(4):287–312, December 2009.

Michael E. Waugh. International trade and income differences. *American Economic Review*, forthcoming 2010.

Kei-Mu Yi and Jing Zhang. Structural change in an open economy. Working Papers 595, Research Seminar in International Economics, University of Michigan, April 2010.

A Tables and Figures

Table 10: Relative Productivity and Trade Estimates

Country	Real GDP/Worker (PWT 6.3)	Relative Ag. Productivity	Home Bias in Ag	Home Bias in Nonag	Ag Import Barrier	Nonag Import Barrier
ALB	7590.271	.38042712	.96141678	.69874883	365.11984	234.92281
ARE	66576.617	.46265137	.61258745	.42578775	121.98535	62.753689
ARG	28930.211	.60547918	.92331129	.81713331	132.7283	110.05305
ARM	9728.3887	.49268472	.98607594	.93895686	275.16705	309.87057
AUS	60072.863	.59961802	.68545008	.54253531	83.856606	75.367683
AUT	65356.531	.44534779	.4135825	.21421564	100.17406	33.014053
AZE	8344.5225	.39236882	.95296329	.93601954	309.55713	251.94221
BDI	1484.5964	.39339659	.9966318	.9570998	302.76471	475.19064
BGD	4014.1082	.32378858	.99489081	.91947263	291.47635	182.66039
BGR	15948.272	.42035177	.95872879	.60820246	197.91151	100.75153
BHR	43883.574	.48561257	.37662947	.62962717	116.24689	95.346169
BHS	48276.43	.59481698	.44156331	.27013373	121.93488	164.25244
BIH	11547.183	.39850476	.87371927	.73112261	218.32986	168.53099
BLR	25513.055	.46037084	.98642498	.9683097	309.51358	232.01411
BLZ	21620.295	.7693252	.83211309	.79179543	153.66617	322.78494
BOL	7833.9316	.44115886	.95463169	.86706454	301.74362	272.9371
BRA	17660.801	.48709458	.94823343	.85341001	142.1813	77.622162
BRB	40506.512	.69069791	.88369179	.81707412	259.8237	313.12546
CAN	60726.898	.54990381	.17978513	.10846359	46.105331	31.219803
CHL	36284.004	.59222162	.83947229	.77406633	135.30011	115.62183
CHN	7559.1113	.28743553	.99373788	.90127778	235.23108	57.308014
CMR	6600.2842	.40703908	.98312026	.90316433	300.51825	255.02336
COL	13745.382	.52046055	.94951999	.85174996	203.64774	147.67537
CRI	22434.385	.65270722	.91839951	.74750924	148.70195	165.02821
CUB	16589.055	.71548831	.90199858	.95611066	166.18927	332.85263
CYP	43011.164	.55954248	.60781217	.30474305	130.95293	108.0336
CZE	31778.24	.41612566	.78479379	.45648283	138.14896	62.546646
DOM	18871.377	.59479207	.94462961	.83033311	224.29726	259.035
DZA	14551.485	.2704362	.8226999	.88474596	315.43991	136.74631
ECU	12178.112	.61667931	.80907476	.83972847	112.49481	188.60368
EGY	15739.912	.43426722	.97270417	.89575201	278.4032	160.17967
ESP	55540.348	.48365963	.69178373	.52950901	88.76844	28.351147
ETH	2001.5085	.34939107	.99612582	.9237144	312.65768	271.47815
FRA	61215.82	.4338707	.47984272	.2127251	50.137318	-9.7841005
GAB	19198.613	.41030857	.85290688	.7041955	258.73282	177.06104
GBR	55386.16	.47943464	.19167638	.30696738	40.181488	6.7211208
GEO	8629.6055	.41612819	.97356004	.92317873	291.80615	233.89807
GER	60376.449	.45358336	.1989603	.23394805	26.228508	-15.270523
GHA	3109.5029	.37348878	.98229206	.75973243	257.47629	217.70943

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... table 10 continued

Country	Real GDP/Worker (PWT 6.3)	Relative Ag. Productivity	Home Bias in Ag	Home Bias in Nonag	Ag Import Barrier	Nonag Import Barrier
GMB	2867.2598	.28164554	.90920943	.61966658	288.53735	223.94823
GRC	48963.172	.53791076	.79882061	.54401541	137.73734	69.112343
GTM	19613.189	.80110925	.98411417	.84365767	235.74345	267.80444
GUY	5755.3135	.48788428	.9320249	.79902595	229.84222	250.01816
HND	8106.8535	.56270468	.97656822	.79237938	225.68578	236.72397
HRV	21563.98	.50152922	.86566246	.589167	154.49463	135.06985
HUN	32281.992	.47059742	.84972095	.25820506	107.72468	62.038235
IDN	8827.8955	.32878563	.97858161	.91279435	210.05771	93.335899
IRN	24279.256	.47720981	.96224785	.90294707	197.26602	119.40436
ITA	65438.621	.43697089	.62625158	.45005322	73.483177	-1.5275453
JAM	17163.977	.46312204	.90370435	.65703332	225.9882	176.13173
JOR	16173.863	.41627511	.48802936	.6774441	195.94138	163.81837
JPN	53166.207	.33266848	.57334828	.61662436	120.46312	20.969246
KAZ	15065.728	.42482772	.959952	.8687017	212.6806	130.79657
KGZ	7831.019	.43614542	.9946304	.93580574	416.27655	317.09811
KHM	3811.2412	.27592996	.99335039	.7234664	482.02994	221.26999
KOR	39495.418	.31146702	.84103942	.45653099	196.54831	23.532513
LAO	3883.1799	.3701742	.99248093	.78021073	394.80615	305.2012
LBY	42501.613	.4990547	.77914327	.88688254	189.68947	173.46838
LKA	10848.017	.5034067	.97575247	.83043873	187.13243	175.18735
LTU	17925.152	.4389137	.81858528	.51731342	156.43968	125.57661
LVA	17569.195	.38837361	.75201631	.28633946	154.38063	87.902184
MAR	13006.281	.4630959	.927104	.74079555	178.80681	128.8623
MDA	5778.0376	.37613425	.97938186	.74590325	235.35236	173.59058
MDG	2116.3748	.31069821	.98440021	.7474438	263.2634	216.48782
MEX	26379.596	.40546009	.81716233	.36352396	173.28296	70.980843
MKD	15400.013	.43832865	.89876306	.66855162	213.21107	166.46748
MLI	4272.3198	.31979957	.98487151	.85884619	347.08875	226.9532
MNG	4949.4604	.35388187	.96017265	.60031152	262.80008	210.95775
MOZ	2643.6362	.37327668	.97207379	.86094666	301.15167	313.47946
MRT	5089.9858	.44915861	.91180551	.77724105	144.66618	190.43141
MUS	34345.426	.65127838	.83736217	.79004896	202.50432	246.00499
MYS	33878.715	.41827574	.1155616	.09930795	49.872589	16.587152
NER	2440.2144	.26712999	.98998141	.86838865	472.01123	328.84671
NGA	4234.168	.23022604	.9738096	.82959747	309.84344	101.45034
NIC	5743.2651	.53571326	.9832809	.81121922	236.91698	277.83984
NPL	4679.5435	.3855767	.99880934	.9483645	440.79218	325.31952
OMN	64533.863	.58274662	.48471743	.45963252	111.7597	94.940422
PAK	9059.4248	.37297758	.99065626	.88874733	288.18207	135.30775
PAN	16515.746	.40337172	.87120342	.13788819	149.37828	82.988716
PER	11026.101	.48794758	.91168296	.81760824	169.49678	153.8764
PHL	9777.0186	.370318	.95292133	.61925316	240.35066	130.02588
PNG	5147.5142	.39967966	.97337526	.77683401	284.24753	268.60101
POL	23813.854	.46558669	.8617813	.65672165	124.79034	91.019814

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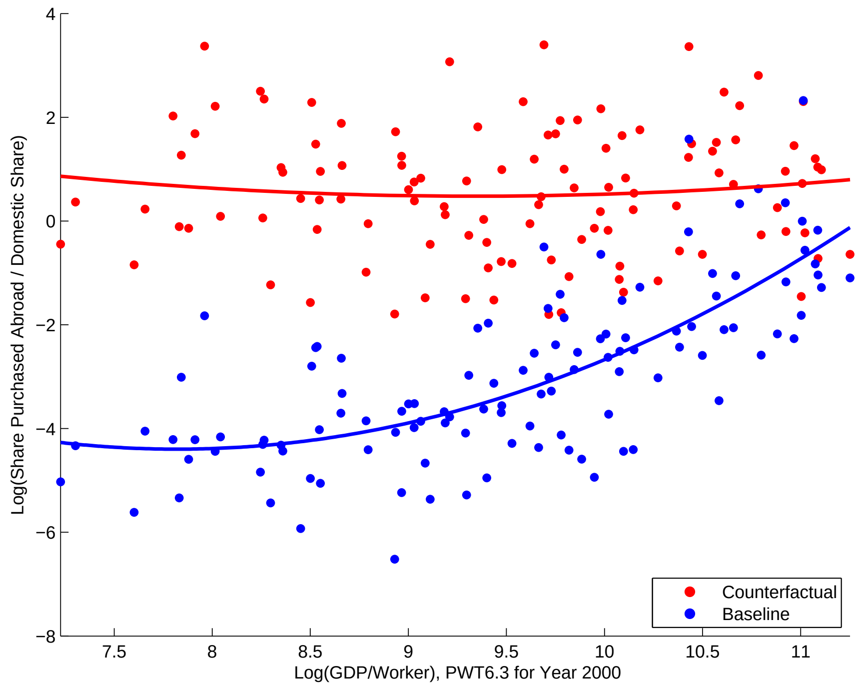
... table 10 continued

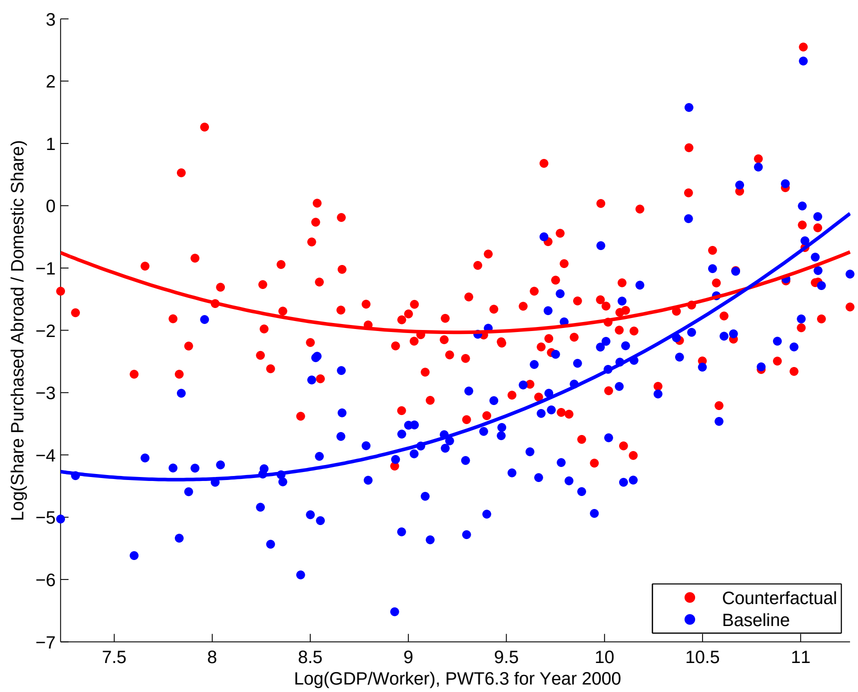
Country	Real GDP/Worker (PWT 6.3)	Relative Ag. Productivity	Home Bias in Ag	Home Bias in Nonag	Ag Import Barrier	Nonag Import Barrier
PRT	38223.16	.43993396	.60384381	.42459369	136.21736	61.98381
PRY	10000.54	.47434917	.9551084	.74019635	378.7265	264.70389
ROM	11892.55	.36474103	.95351768	.73561662	204.33945	93.37352
RUS	16792.43	.35200277	.90989524	.90612638	149.40471	71.339127
SAU	57897.566	.35633767	.76930201	.80598259	210.08069	84.054382
SDN	5175.5542	.37290612	.9942534	.91511351	347.74188	220.34032
SLE	3026.7737	.29400906	.99199003	.89181894	497.48825	357.60162
SLV	13053.375	.58772802	.96081477	.83843374	256.44479	239.69035
SUR	22195.484	.58568096	.90996349	.72771931	189.56143	198.68599
SVK	24524.709	.42100933	.79760838	.44502318	167.22633	94.953697
SVN	38960.258	.42130527	.64999944	.27385515	149.94113	68.182449
SYR	8355.4863	.39122808	.94422925	.76356459	220.64247	137.84477
TGO	2544.9956	.27688482	.96148098	.61944824	239.72197	173.74998
THA	12530.275	.40103576	.92903525	.64243913	108.65699	52.790394
TJK	6530.2212	.49014178	.97833043	.97203553	201.34097	273.02731
TKM	20911.957	.47436574	.99226308	.96496046	364.16068	285.03629
TTO	33820.656	.58545673	.54945815	.75556767	126.86472	189.51054
TUN	22505.564	.42077544	.9370814	.63800621	229.3997	117.20605
TUR	18381.109	.42249295	.97293139	.65911072	167.74257	55.790054
TZA	1376.3237	.26183638	.99364263	.81406415	296.6911	205.53207
UGA	2519.8564	.4369508	.99762428	.95553136	354.08636	422.1355
UKR	12087.757	.32890159	.98681301	.88269752	268.87842	109.78645
URY	24083.666	.65677541	.82175672	.71544683	159.97552	179.79887
USA	77003.289	.51533431	.67464781	.58444643	50.482288	7.1214838
UZB	3857.9875	.29173091	.98547316	.84358966	265.55154	150.70049
VEN	25604.17	.43488136	.84088588	.82016724	183.0269	117.20059
VNM	4914.9805	.37170246	.98893237	.83897406	210.6758	147.06209
YEM	5050.4082	.32699406	.79635417	.84302258	227.48785	183.61348
ZAF	23749.947	.45100114	.89864075	.76840812	133.7572	83.719009
ZMB	2729.6191	.27803972	.9891625	.66928852	353.89853	227.19014
ZWE	10903.287	.47055852	.99608648	.88828504	390.78046	273.50214

Figure 5: Normalized Import Shares: No Import Barriers



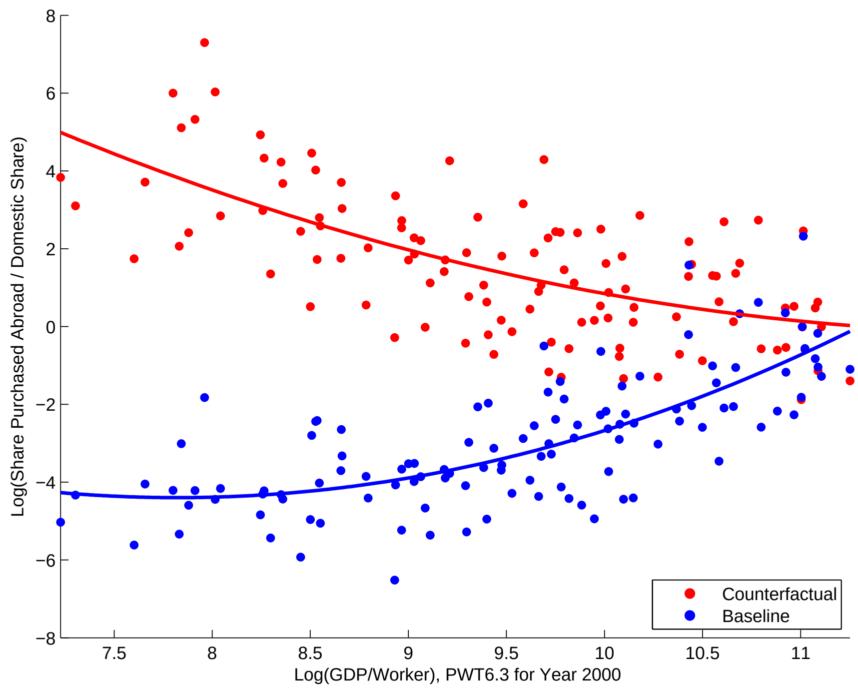
Display result of setting import barriers to the average level in rich-countries. Poor country normalized import shares increase slightly more than rich. The resulting normalized import share is unrelated to income. Dots represent countries with a quadradic best-fit line also illustrated.

Figure 6: Normalized Import Shares: No Labour Mobility Costs



Display result of removing labour mobility costs, $\xi_i = 1$, in all countries. Poor country normalized import shares increase as a result. Dots represent countries with a quadradic best-fit line also illustrated.

Figure 7: Normalized Import Shares: No Import Barriers or Labour Mobility Costs



Display result of removing both labour mobility costs, $\xi_i = 1$, and setting import barriers to the average of rich-country levels. Normalized import shares increase more in poor countries than rich. Dots represent countries with a quadradic best-fit line also illustrated.

Figure 8

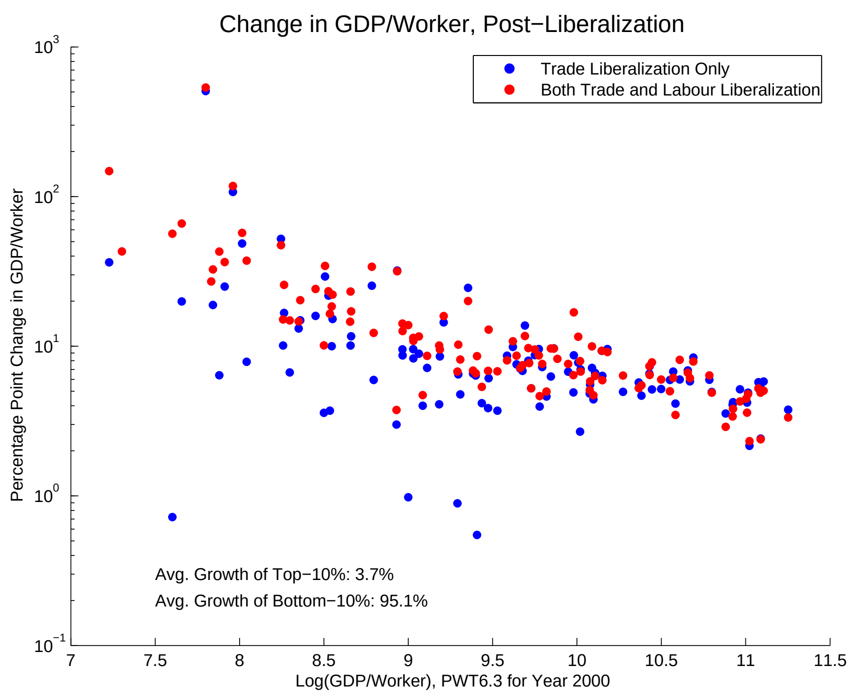


Figure 9: Real Output-per-Worker in Agriculture Relative to Manufacturing

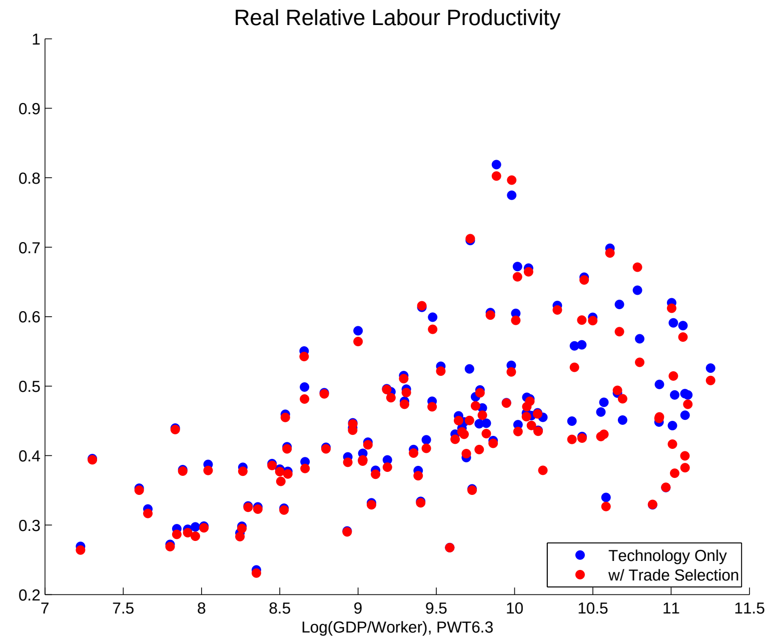


Figure 10: Trade-Model Estimates of Relative Agricultural Productivity, Compared to Data

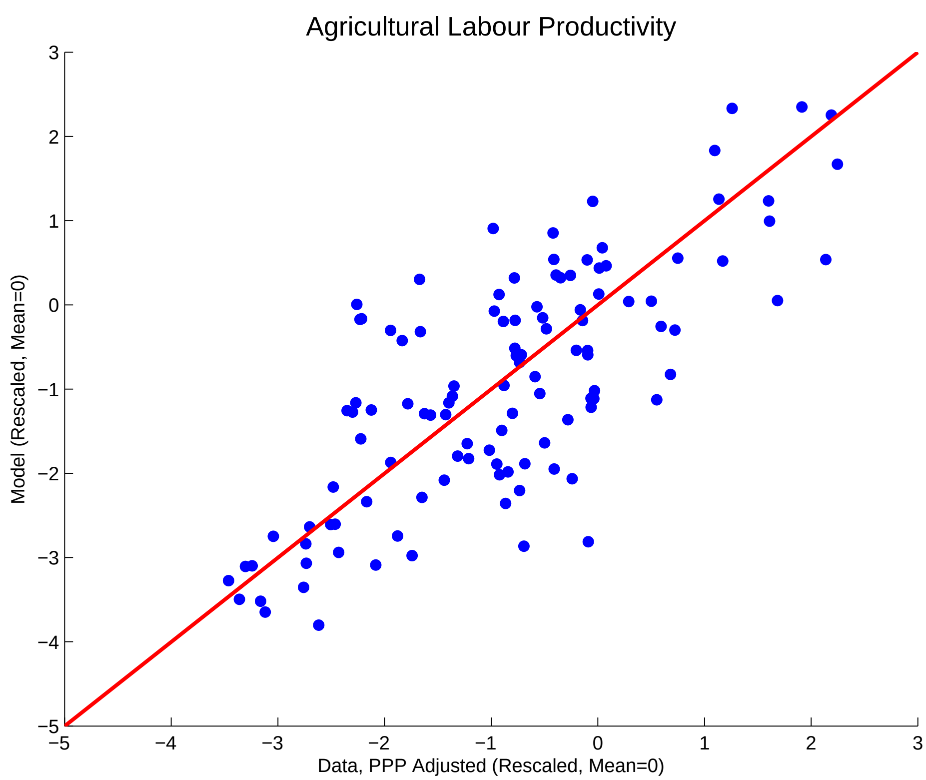


Figure 11: Trade Cost Estimates for Agricultural Goods

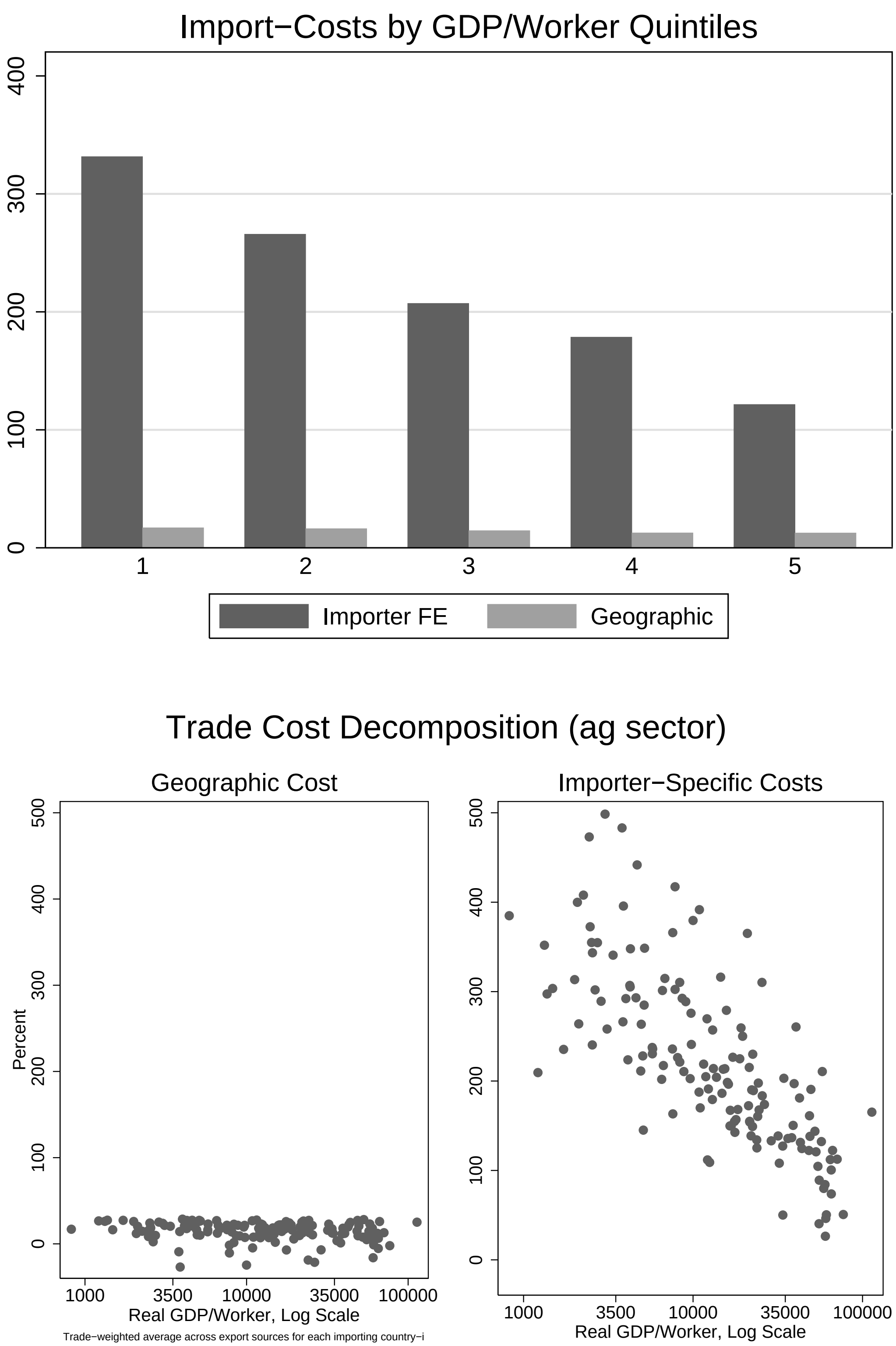


Figure 12: Trade Cost Estimates for Manufactured Goods

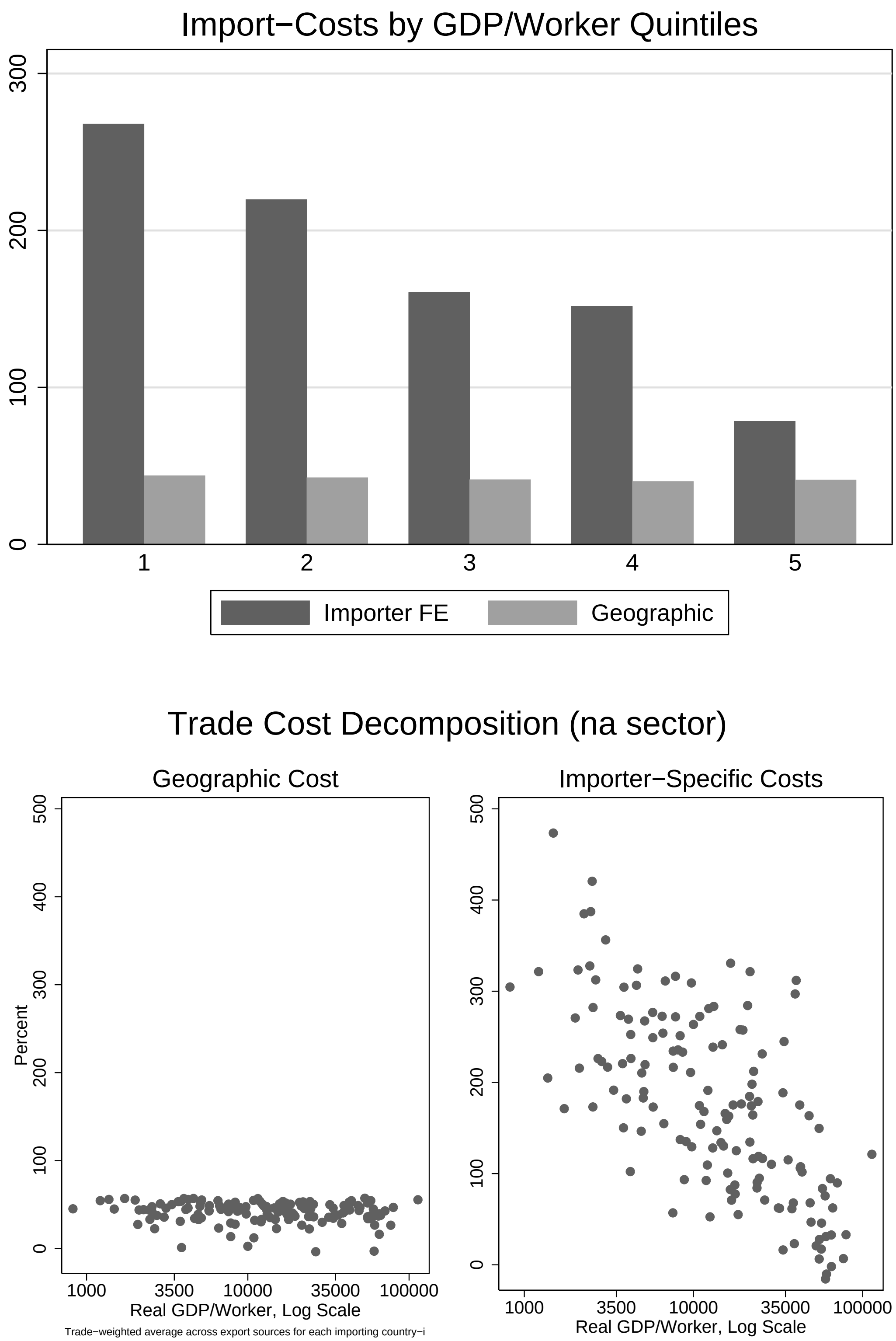


Figure 13: Increasing S-S Trade, Following Full Removal of Import Barriers

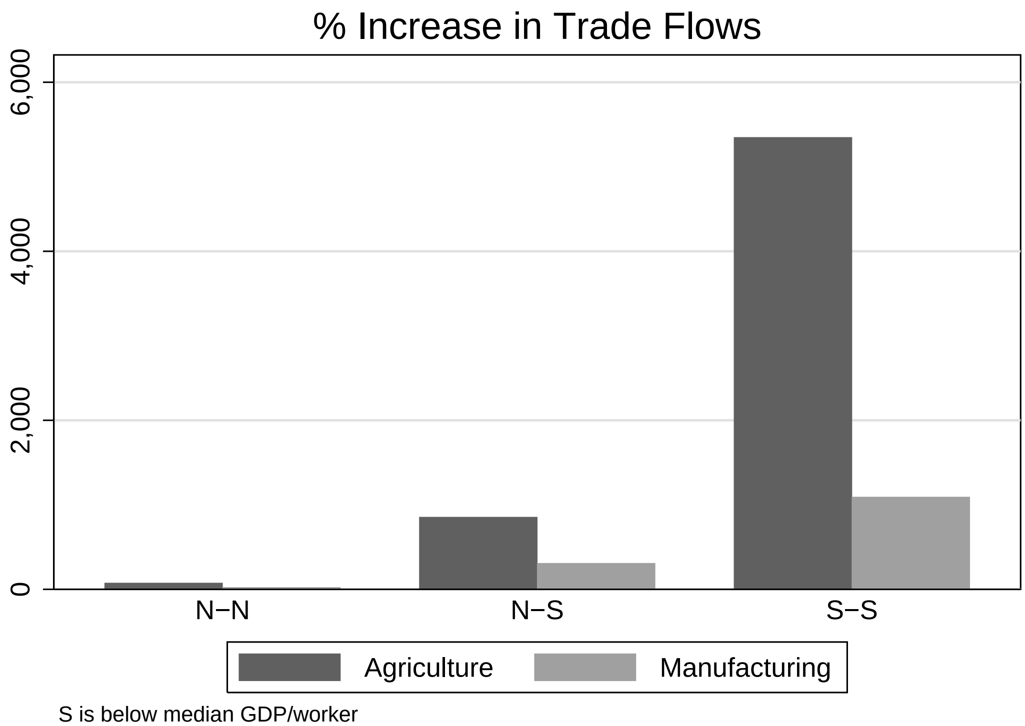


Figure 14: Increasing S-S Trade, Following Full Removal of Import Barriers

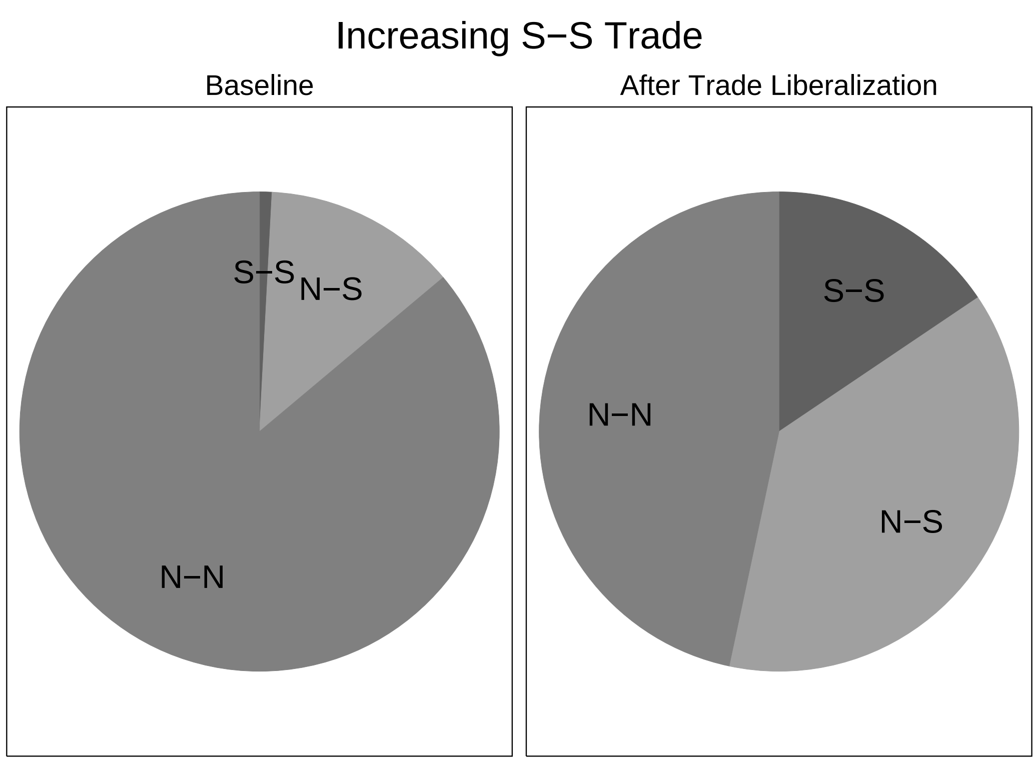
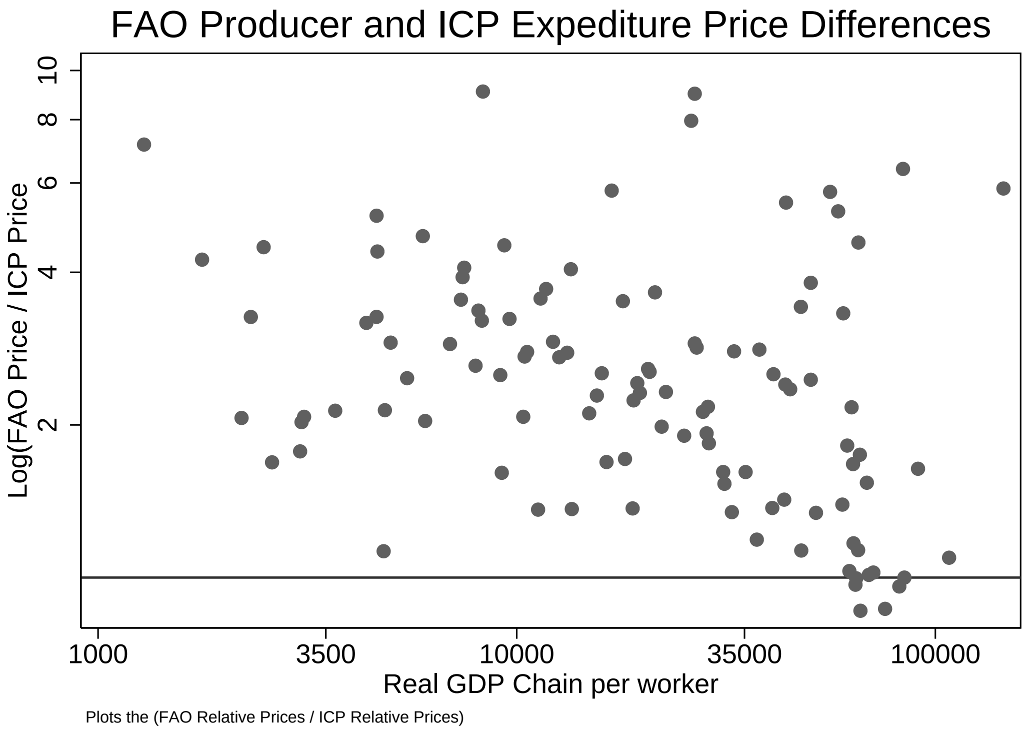


Figure 15


FAO Producer and ICP Expediture Price Differences
Log(FAO Price / ICP Price
10
8
6
4
2
1000
3500
10000
35000
100000
Real GDP Chain per worker
Plots the (FAO Relative Prices / ICP Relative Prices)