

Import Growth and the Emergence of an Agricultural Productivity Gap*

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Abstract

This paper examines the impact of manufacturing import growth on agricultural productivity for a small open economy using a 2×2 sector endogenous growth model. We show that the increase of import variety share in manufacturing, when there is no trade induced labor reallocation, drives the emergence of a sectoral productivity growth gap: productivity growth in agriculture is lower than in manufacturing. This explains, from the viewpoint of international trade, the empirical evidence that cross-country productivity differences in agriculture are larger than in non-agriculture. Our argument is that the recent growth of manufacturing trade in poor countries benefits its own industry but brings costs to agriculture in terms of variety expansion. An effective policy in terms of increasing agricultural productivity in poor countries should be able to alleviate the negative impact of import growth in manufacturing. Cross-country evidence supports our results.

Keywords: Trade, Agriculture, Productivity

JEL: F12, O13, O31

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1 Introduction

Agriculture is a large and unproductive sector in poor countries; it is a small, but highly productive sector in rich countries. It is well established that low labor and total factor productivity in agriculture are central factors in explaining cross-sectional and inter-temporal differences in income level across nations (Caselli, 2005; Gollin, Lagakos and Waugh, 2014). Hence the agricultural productivity gap in poor countries presents both an important social problem and a compelling theoretical puzzle.

When and how does the productivity gap between manufacturing and agricultural sectors emerge? Interestingly, in richer economies, agriculture labor and factor productivity is again growing at the same rate as the general economy (Martin and Mitra, 2001). As economies grow from a Malthusian subsistence trap economy, there must be a period in which this productivity gap emerges, though it disappears later. A classic explanation is Schultz (1953) “food problem”. Food is a necessity. Workers stay in agriculture to avoid starvation, even when productivity and wages become higher in industrial sectors.¹ However, the income elasticity of food is low: while it dominates the budget of the poor, it dwindles to 20% or less of the rich consumer’s budget. The agricultural sector falls to 5% or less by employment.

In this paper, we propose a different and complimentary mechanism for the emergence of the productivity gap using a 2×2 sector endogenous growth model based on Romer (1990) and Grossman and Helpman (1993). International trade is modeled in the spirit of Krugman (1980). We begin with a baseline state in which there is no difference in productivity growth and we analyze the impact of international trade change on this economy. We impose

¹Rural to urban migration issues are beyond the scope of the present paper, but we note that issues include barriers to mobility and the high unemployment which reduces expected returns from higher wages.

two key assumptions: increased openness to trade does not lead to labor reallocation, and import variety share in manufacturing increases faster than in agriculture. Given these two assumption, international competition in the manufacturing sector drives higher productivity and growth in manufacturing, while productivity grows slowly or is stagnant in agriculture.

There are two primary reasons for these results. Firstly, under an R&D based endogenous growth framework, existing varieties have a spillover effect on new intermediate variety creation. More imports from other countries in one industry will generate expansion in the domestic industry's own new variety creation, and hence generate an expansion in productivity. Secondly, more imports in one industry will leave more room for the relative price of the other industry to grow. The former captures the benefit of imports for its own industry, and the latter captures the cost for the other industry.

The mechanism presented in this paper provides an explanation for economies with the following features: (i) the economy has two major sectors, a rural-agriculture sector and an emerging urban industrial sector; (ii) there are initially identical levels of growth rates in the two sectors; (iii) and there is a restricted flow of labor between sectors when trade policies change.

Cross-country trade and agricultural productivity data provides empirical evidence on the above analytical results. By giving different variety weights for each product according to the export of each country, we compared agricultural productivity and weighted import variety of each country in 1985. We find that poor countries import more variety from other countries as well as have lower labor productivity in agriculture.

This paper is related to the growing literature analyzing which factors are responsible for the large cross-country productivity differences in agricultural sectors, but relatively small

productivity differences in the non-agricultural sector². In the paper by Lagakos and Waugh (2013), self-selection of heterogeneous workers determines sector productivity. In poor countries, subsistence requirements induce low productive workers into agriculture where they may be “stuck” (non-mobile) for institutional and economic reasons. Using a two-sector general equilibrium model, Restuccia, Yang and Zhu (2008) show that differences in economy-wide productivity, barriers to modern intermediate inputs in agriculture, and barriers in the labor market are the key elements generating productivity difference. Other factors investigated include: transportation (Adamopoulos, 2011), farm size (Adamopoulos and Restuccia, 2014), intermediate inputs risks (Donovan, 2014), and financial frictions (Liao and Wang, 2014).

This paper enriches this literature in two ways. First, we focus on the impact of international trade on sectoral productivity growth difference. While Uy, Yi and Zhang (2013) study an open multi-sector economy similar to ours; they only focus on the Korean case. Moreover, their results are mostly based on simulations. Fadinger and Fleiss (2011) estimate how trade affects sectoral productivity, but they only consider the manufacturing industries. Tombe (Forthcoming) analyzes the impact of international trade on changes in agriculture and manufacturing sectors - including different growth rates and a resulting productivity gap. Święcki (2014) shows that domestic intersectoral distortion affects gains from trade. This paper follows this trade-oriented literature, but it adds consideration of how intersectoral market imperfections, including labor market immobility, might affect sectoral growth.

Second, we model an emerging two-sector economy in which the subsistence level is already met in both agriculture and manufacturing and the final product is produced by

²See Caselli (2005), Chanda and Dalgaard (2008), and Vollrath (2009*b*).

differentiated intermediate varieties in each industry. Hence the theory describes an economy that may have escaped Malthusian and Schultzian traps, but still is relatively poor and only partially linked to world markets. This is different from a static approach with calibration or simulation, or either a neoclassical or a unified growth approach (Vollrath, 2009a). Furthermore, we add realism and richness by allowing for monopolistic competition in agriculture instead of the usual assumption of agriculture as a homogeneous and perfectly competitive sector (Grossmann, 2013). People eat a variety of foods, processed in a variety of ways; they don't eat raw grain, vegetables, and livestock.

The paper is organized as follows. Section 2 describes the basic setup of dual economy endogenous growth model with international trade. Section 3 shows analytical results on balanced growth path. Section 4 discusses the impact of trade on productivity growth. Section 5 shows empirical evidence. Section 6 discusses the model and concludes.

2 Model

We now introduce an endogenous growth framework in which there are two countries: home and foreign, $i \in \{H, F\}$. In each country, there are two industries, agriculture and manufacturing, $j \in \{a, m\}$. There is international trade in both industries.

2.1 Consumption and the Inter-Temporal Choice

The representative consumer in each country consumes final products from both agriculture and manufacturing. The consumer maximizes its inter-temporal utility from aggregate

consumption of agriculture (C_a^i) and manufacturing (C_m^i) commodities,

$$U^i(t) = \int_t^\infty e^{-\rho(\tau-t)} [\psi \log C_a^i(\tau) + (1 - \psi) \log C_m^i(\tau)] d\tau,$$

where C is the consumption of final product, ρ is the subjective discount rate, and ψ is the relative taste for agricultural versus manufacturing goods, and the inter-temporal elasticity of substitution is one. The budget constraint is

$$\int_t^\infty e^{-[R^i(\tau)-R^i(t)]} [P_a^i(\tau)C_a^i(\tau) + P_m^i(\tau)C_m^i(\tau)] \leq \int_t^\infty e^{-[R^i(\tau)-R^i(t)]} w^i(\tau)L^i d\tau + W^i(t),$$

where $R^i(\tau) \equiv \int_0^\tau r^i(s)ds$ represents the discount factor from time τ to time 0, P is the price of the final product, w is the countrywide wage rate, and W is the value of the household's asset holding. By maximizing the representative consumer's utility subject to budget constraint, we obtain the following Euler equation,

$$\frac{\dot{C}_j^i(t)}{C_j^i(t)} = r^i(t) - \rho - \frac{\dot{P}_j^i(t)}{P_j^i(t)}, \quad (1)$$

where r^i is the countrywide interest rate for both agriculture and manufacturing, and \dot{C} and \dot{P} represent the change of consumption and price, respectively.

2.2 Final Good Production and the Intermediate Goods Sets

At the aggregate level, in each industry of each country, the final good is produced from intermediate goods with a constant elasticity of substitution (CES) production function,

$$Y_j^i(t) = \left(\int_0^{N_j^i(t)} y_j^i(k, t)^{(\sigma_j-1)/\sigma_j} dk \right)^{\sigma_j/(\sigma_j-1)}, \quad (2)$$

where Y is the output of final product, y is the input of intermediate product, σ is the elasticity of substitution between varieties, N is the number of intermediate varieties. We use k to denote each intermediate variety. We will assume trade in intermediate products but no trade in final products (since the final products in both countries are identical). Hence, final domestic consumption will equal final domestic production. We assume that, in each country, elasticity of substitution for agriculture and manufacturing are different, and the elasticity of substitution in agriculture is larger³; also we assume that both countries have the same elasticity of substitution parameters. It is worth noting that the agricultural sector can be either homogeneous or heterogeneous, depending on the value of elasticity of substitution. Both cases capture important characteristics of agricultural sectors in the real world.

Since the final good is produced from a set of intermediate products, based on Dixit and Stiglitz (1977), the price index of the final good can be written as a function of prices of

³This assumption ensures that manufacturing products are more heterogeneous, and agricultural products are more homogeneous.

intermediate products as

$$P_j^i(t) = \left(\int_0^{N_j^i(t)} p_j^i(k, t)^{(1-\sigma_j)} dk \right)^{1/(1-\sigma_j)},$$

where p is the price of the intermediate variety.

Each country produces a different set of intermediate products, and the final product can be produced in both countries. Hence, the intermediate product set for producing the final good can be divided into domestic set and importing set as the following,

$$N_j^i(t) = N_j^{i,i}(t) + N_j^{i,-i}(t),$$

where $N_j^{i,i}$ is the number of intermediary varieties produced domestically, and $N_j^{i,-i}$ is the number of intermediate varieties imported from the other country.

2.3 Sectoral Productivity

As shown in Chapter 10 of Feenstra (2003), the above endogenous growth setup has a traditional (neoclassical) productivity implication. In the symmetric case, each intermediate variety will have the same property and the final good production function (2) can be rewritten as

$$Y_j^i(t) = N_j^i(t)^{\sigma_j/(\sigma_j-1)} y_j^i(t) = N_j^i(t)^{1/(\sigma_j-1)} N_j^i(t) y_j^i(t).$$

The above expression can be understood as $Y_j^i(t) \equiv A_j^i(t) \Phi_j^i(t)$, where $A_j^i(t) \equiv N_j^i(t)^{1/(\sigma_j-1)}$ is technology in the neoclassical growth framework, and $\Phi_j^i(t) \equiv N_j^i(t) y_j^i(t)$ is the input to final good production. Hence, this “endogenous growth” approach can be easily related

to the neoclassical growth literature and the development accounting literature in which productivity is the key to growth in the economy. Moreover, in this framework, productivity is entirely related to the number of intermediate varieties. The relationship between the productivity growth rate and the number of intermediate varieties growth rate is given in the following lemma.

Lemma 1. *The growth rate of productivity is $g = g_N/(\sigma - 1)$.*

Proof. From the definition of productivity. □

2.4 Intermediate Goods Production and Firms' Decisions

Labor is the only input for producing intermediate products. To simplify the analysis, we assume a relationship of one labor unit to one variety product type as

$$x_j^i(k, t) = l_j^i(k, t),$$

where l is the labor input, and x is the output of intermediate variety.

The above setup is similar to standard monopolistic competition models, so we have the standard monopolistic competition solution in final good production. The markup pricing rule is

$$p_j^i(k, t) = w^i(t)\sigma_j/(\sigma_j - 1),$$

and the profit for each variety is

$$\pi_j^i(k, t) = w^i(t)l_j^i(k, t)/(\sigma_j - 1). \tag{3}$$

In this basic setup, labor is perfectly mobile. This ensures a natural (baseline) state which is useful for comparing the subsequent state with international trade policy changes. In Section 4, when trade policy changes, we have the labor market shares in agriculture and manufacturing remain the same based on empirical evidence.

Following Grossman and Helpman (1993), we find the no-arbitrage condition for each variety as the following

$$\dot{v}_j^i(k, t) = r^i(t)v_j^i(k, t) - \pi_j^i(k, t), \quad (4)$$

where v is the stock market value of a particular intermediate variety.

2.5 Intermediate Variety Expansion and Free Entry

Firms with potential new varieties are always trying to enter the market in each industry. In order to enter the market, each variety (firm) needs to hire labor. The entrance of each new variety is affected by existing varieties and labor input. We assume variety growth functions as

$$\dot{N}_j^{i,i}(t) = \frac{1}{\eta_j^i} [N_j^{i,i}(t) + N_j^{i,-i}(t)]^{\gamma_j^i} [N_{-j}^{i,i}(t) + N_{-j}^{i,-i}(t)]^{1-\gamma_j^i} l_{j,n}^i(t), \quad (5)$$

where $l_{j,n}$ is the labor input, η is the productivity parameter, \dot{N} is the variety set of new varieties, $-i$ denotes the other country, $-j$ denotes the other industry, γ is an exogenous parameter for existing varieties' externality, and the Cobb-Douglas term captures the spillover effect from existing varieties. We consider three sources of the externality from existing varieties: domestic variety, foreign variety, and variety from the other sector⁴. Moreover,

⁴A good example of inter-industry spillover effect is biofuel. Biofuel is a combination of industrialized technology and traditional agriculture

as discussed above, based on the assumption of intermediate goods production (one unit of labor to one variety), the variety growth functions can capture two kinds of innovation: process and production innovation⁵. Hence, variety expansion can be seen as either the creation of a new product (product innovation) or the improvement of an existing product (process innovation).

As shown in Section 2.3, each variety has a value function v , so the free entry condition for new varieties can be written as

$$v_j^i(t) \dot{N}_j^{i,i}(t) = w^i(t) l_{j,n}^i(t). \quad (6)$$

2.6 Equilibrium

In the intermediate goods market, the output of an intermediate variety can be used for either domestic final production or exporting or both. So we have:

$$y_j^{i,i}(k, t) + y_j^{-i,i} = x_j^i(k, t), \quad (7)$$

where $y_j^{i,i}$ and $y_j^{-i,i}$ represent the intermediate products used for domestic final good production and exporting, respectively. The above setup implies that trade occurs in intermediate products only. Therefore final good equals consumption as $C_j^i(t) = Y_j^i(t)$. Hence, condition (1) holds for final goods output as well.

In the labor market, labor endowment L in each country is constant. Labor is used to

⁵See a discussion by Atkeson and Burstein (2010) and Dhingra (2013).

produce both existing varieties and new varieties. So the labor market clearing condition is

$$\sum_j \left(\int_0^{N_j^{i,i}(t)} l_j^i(k, t) dk + l_{j,n}^i(t) \right) = L^i. \quad (8)$$

3 Baseline State of the Home Country

Now we consider the case where the home country is only a tiny part of the globe. We add a labor endowment constraint $L^F \gg L^H$ to the setup of the last section. This is the case for most developing countries. Now the foreign country is just a much larger version of the home country, and we can take it as the rest of world.

In this case, we analyze the balanced growth path for the home country. Specifically, we consider a state in which the government of the home country imposes a trade policy to each industry such that, on the balanced growth path, import variety set is proportional to domestic variety set. This is assured by two characteristics of the home country: one is that it is a small open economy; the other is that agriculture and manufacturing are symmetric. Therefore, in symmetric equilibrium, for the home country, we have

$$N_j^{H,F}(t) = \alpha_j^H N_j^{H,H}(t), \quad (9)$$

where α_j^H denotes the proportion of the import intermediate variety set to the domestic intermediate variety set, and we call it the import variety share of sector j . Given the implied balanced trade condition, exports will also be proportional to domestic consumption

for each variety as the following

$$y_j^{F,H}(t) = \beta_j^H y_j^{H,H}(t), \quad (10)$$

where β_j^H denotes the percentage of export to domestic use for a given intermediate variety.

For the home country, we normalize the price index of the manufacturing final product to one. The remaining price index P is now simply the relative agricultural price for the home country. According to the above considerations and dropping the superscript of country index i for each variable, the conditions for solving the balanced growth path of home country are:

$$g_{Y_a} = r(t) - \rho - g_P, \quad (11)$$

$$g_{Y_m} = r(t) - \rho, \quad (12)$$

$$Y_j(t) = (1 + \alpha_j)^{\sigma_j/(\sigma_j-1)} N_j(t)^{\sigma_j/(\sigma_j-1)} (1 + \beta_j)^{-1} l_j(t), \quad (13)$$

$$\pi_j(t) = w(t)l_j(t)/(\sigma_j - 1), \quad (14)$$

$$r(t)v_j(t) - \pi_j(t) = 0, \quad (15)$$

$$\dot{N}_j(t) = \eta_j^{-1} (1 + \alpha_j)^{\gamma_j} (1 + \alpha_{-j})^{1-\gamma_j} N_j(t)^{\gamma_j} N_{-j}(t)^{1-\gamma_j} l_{j,n}(t), \quad (16)$$

$$v_j(t)\dot{N}_j(t) = w(t)l_{j,n}(t), \quad (17)$$

$$(1 + \beta_j)y_j(t) = x_j(t), \quad (18)$$

$$\sum_j (N_j(t)l_j(t) + l_{j,n}(t)) = L, \quad (19)$$

where g is the growth rate, and $\dot{v} = 0$.

Using the above equilibrium conditions, we can solve for the productivity growth rate for

each sector. The following proposition shows the result.

Proposition 1. *The productivity growth rate in each industry is affected by import variety and relative price as the following*

$$g_a = \frac{1}{2b/(1 + \alpha_a) + 2d/(1 + \alpha_m)}L - \frac{1}{2}\rho - \frac{b/(1 + \alpha_a) + 2d/(1 + \alpha_m)}{2b/(1 + \alpha_a) + 2d/(1 + \alpha_m)}g_P; \quad (20)$$

$$g_m = \frac{1}{2b/(1 + \alpha_a) + 2d/(1 + \alpha_m)}L - \frac{1}{2}\rho + \frac{b/(1 + \alpha_a)}{2b/(1 + \alpha_a) + 2d/(1 + \alpha_m)}g_P, \quad (21)$$

where $b = \eta_a(\sigma_a - 1)(\eta_a/\eta_m)^{(1-\gamma_a)/(\gamma_a-\gamma_m)} > 0$ and $d = \eta_m(\sigma_m - 1)(\eta_a/\eta_m)^{-\gamma_m/(\gamma_a-\gamma_m)} > 0$.

Proof. See Appendix A. □

In the above proposition, b and d are exogenous variables, as well as L and ρ . These variables represent the preference and technology for home economy. Three variables are critical to labor productivity growth rate: α_a , α_m , and g_P . Relative price has opposite effects on agriculture and manufacturing, and the values of α_a and α_m determines how much relative price affects labor productivity.

Since agriculture and manufacturing are symmetric, there is no relative price growth ($g_P = 0$) in our baseline state. Intuitively, if there is a change in the relative price in the initial state, labor will migrate until the growth of relative price is zero (since labor is perfectly mobile). So the growth rates for agriculture and manufacturing are equal. However, we still keep g_P in Proposition 1 as we want to compare this with the case when trade policy changes and labor market distortion exists.

We emphasize that this baseline state is a convenient starting point for analyzing the effect of international trade. In fact, it represents a case of a country in which there is a

fixed import variety share and no growth difference between agriculture and manufacturing. Now we can examine the impact of altering import variety share. This is our major task in next section.

4 The Impact of Import Growth on Agricultural Productivity

Based on the above results, we can now examine how sectoral productivity changes when the home country becomes more open to trade. We start by considering trade induced labor reallocation.

4.1 Labor Reallocation

There are two possible channels of trade induced labor reallocation: intra-industry reallocation, in which labor move from unproductive firms to productive firms; and inter-industry reallocation, in which labor move from comparatively disadvantaged industries to comparatively advantaged industries. Since we do not incorporate firm productivity heterogeneity (Melitz, 2003), inter-industry reallocation is the only channel available in our model, and it is the one we are concerned with here. First, we review some empirical results to help justify the labor market assumption in our model.

Papageorgiou et al. (1990) analyze 19 episodes of liberalization in developing countries, and find very little relationship between trade liberalization and employment shift. Similarly, using a larger set of 25 liberalization episodes, Wacziarg and Wallack (2004) show that trade

liberalization has weakly negative effects on intersectoral reallocation between agriculture and manufacturing. In addition Menezes-Filho and Muendler (2011) examine inter-industry labor reallocation for Brazil's trade liberalization in the 1990s. Individual workers' jobs show that lowering tariffs induces worker displacements, but the displaced labor is absorbed neither by exporters nor sectors with comparative advantage.

In summary, the literature shows that there is little or no trade-induced labor reallocation between aggregate industries (agriculture and manufacturing). We adopt this as a stylized fact and impose the following restriction:

Assumption 1. *Labor share for agriculture and manufacturing remains the same when trade share changes.*

The strategy in this paper is to let the model be consistent with this stylized labor reallocation restriction. A more complicated way to do this is to add labor market frictions in Section 2. However, explicit modeling of labor market friction would not change the results we need and would add to mathematical complexity. Hence we simply impose the labor market restriction in order to focus on our main topic.

4.2 Relative Price

As shown in Proposition 1, in our 2×2 sector model, the relative price is very important to labor productivity growth. We document the effect of trade on the relative price in the following proposition.

Proposition 2. *When manufacturing import variety share increases, relative agricultural price growth rate is positive; and the larger the import share of manufacturing, the higher*

the growth rate of relative agricultural price.

Proof. See Appendix B. □

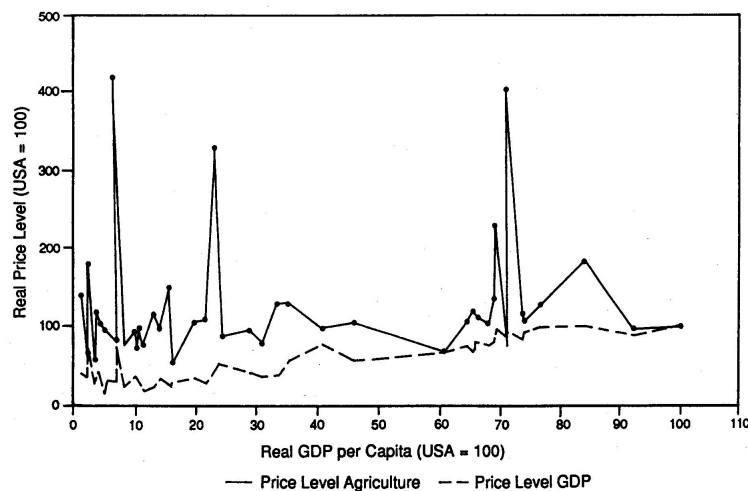


Figure 1: Price Levels of Agriculture and GDP (1985)

The importance of relative price is well supported by cross-country agricultural price data in Prasada Rao (1993). In the current literature, most empirical evidence about agricultural productivity is calculated from the data of year 1985⁶. Figure 1 is borrowed from Page 68 of Prasada Rao (1993). It shows that in 1985, the agricultural price level is generally higher than the overall price level across all countries; and poor countries have a higher price level difference between the general price level and the agricultural price level. That is food is relatively costly in poor countries.

Proposition 2 offers an explanation for Figure 1. Since poor countries generally produce low quality industrial products as in the work by Hausmann, Hwang and Rodrik (2007), and Mitchener and Yan (2014), they import more manufacturing varieties. In contrast, trade in

⁶See the work by Caselli (2005), Restuccia, Yang and Zhu (2008), and Lagakos and Waugh (2013).

agriculture is more restricted (Xu, Forthcoming). The result is that poor countries have a higher relative agricultural price than rich countries which is well documented by Figure 1.

4.3 The Emergence of Low Agricultural Productivity Growth

Based on the restriction of labor reallocation, and the impact of trade on relative price, growth rate difference between manufacturing and agriculture emerges. The following proposition states this result.

Proposition 3. *As the import variety share in manufacturing increases, the productivity growth rate of manufacturing is larger than agriculture; and the larger the import varieties share in manufacturing, the greater the difference of the productivity growth rate between agricultural and manufacturing.*

Proof. See Appendix C. □

Proposition 3 shows that, as import variety share in manufacturing increases, the difference in growth rates between agriculture and manufacturing also increases. The model we discussed above provides a mechanism to explain this story. When import variety share in manufacturing is larger, the relative agricultural price is more likely to increase. This will lead to more labor allocated to final good production and less labor to new products creation. Since the creation of new products is the pure engine of economic growth, agricultural productivity growth rate will be lower.

Figure 2 shows the transition from the baseline state to the diverging productivity growth state. In the baseline state, relative price is zero, so the productivity growth rate in manufacturing and agriculture are the same. In the new state, agricultural productivity growth

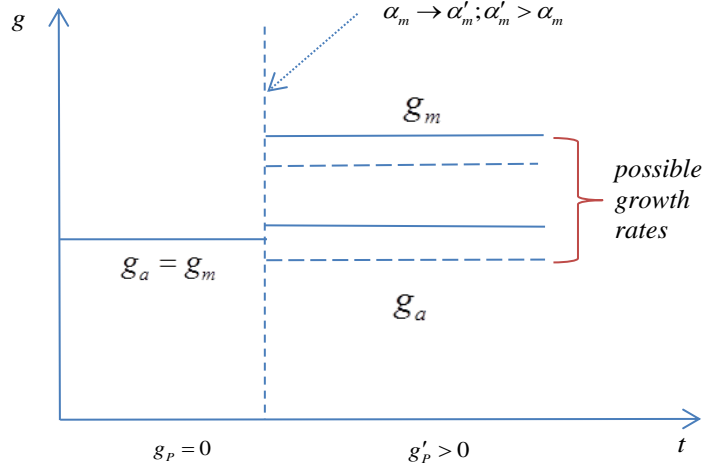


Figure 2: The Emergence of Productivity Growth Difference

could be lower (dotted line in Figure 2) or higher (solid line in Figure 2) than before (though more likely higher). However, what matters is its rate relative to manufacturing: where it is always the same in the baseline state, and is dependent on the change of import variety in manufacturing when trade policy changes. In the figure, the distance of productivity growth rates between solid lines and dotted lines are the same in the new state. In summary, the diagram illustrates that the productivity growth rate difference between agriculture and manufacturing emerges from changing import shares.

Proposition 3 has an intuitive cross-country implication. In the very beginning, countries are not at the same income level, both manufacturing and agriculture. All countries are looking for different methods to improve real income. Obviously, international trade is one of them. According to Proposition 3, introducing more trade in manufacturing will increase the productivity growth rate in manufacturing, but only slightly increase or even decrease the productivity growth rate in agriculture. When there is trade between a rich and a poor country, since they have different initial income levels, poor countries are more likely to have

more import variety share (the ratio of import and domestic production) in manufacturing than in agriculture. Hence, we should see that poor countries have larger import variety share in manufacturing, but lower agricultural productivity which is the result of lower productivity growth rate in agriculture. Therefore, we have greater cross-country productivity differences in agriculture than non-agriculture.

5 Quantitative Analysis

The main result derived from the model is that countries with large manufacturing import share have lower agricultural productivity. In this section, we use cross-country data to test if this result matches data. Specifically, we calculate the import share parameters for agriculture and manufacturing.

5.1 Import Variety Measurement

According to the production type of the model, the first thing we need to do is to give an appropriate variety weight for each product. And by adding the varieties of each import products, we obtain all the gross import varieties. We then need to delete the varieties that this country is producing domestically as well. We do not know what a country is truly producing, but we do know what they are exporting. So we use export varieties to represent the variety set that is producing domestically. This is consistent with the model, in which country exports all varieties one can produce domestically. The measurement procedure is the following steps:

- a) In this step, we calculate artificial productivity for each product. Let I_k be the export

indicator vector of country k , and x_k is the export value vector. Total export from country k can be written as

$$X_k = Ix'_k.$$

For each product, we sum the value percentage from all the exporters weighting by GDP per capita. In this way, we can solve the artificial productivity for product j as

$$\lambda_j = \frac{\sum_k \frac{x_{jk}}{X_k} Y_k}{\sum_k \frac{x_{jk}}{X_k}},$$

where λ_j is artificial productivity of product j , Y_k is GDP per capita for country, and x_{jk} is export value of product j .

- b) Given the artificial productivity for each product, we attribute a variety weight for each product. We choose the least productive product as unit variety, and give other product variety weight by

$$n_j = \frac{\lambda_j}{\lambda_{\min}}.$$

- c) Let IM_{ik} be import indicator for industry i , EK_{ik} be export indicator vector, and N_i be the variety weight vector for industry i consists of varieties calculated in the last step. Import variety share parameter can be calculated by

$$\alpha_i = \frac{IM_{ik}N'_i - EK_{ik}N'_i}{EK_{ik}N'_i}.$$

When import variety is less than export variety, we take α_i as zero.

5.2 Data

To fulfill the measurement of import variety, we use two datasets, Penn World Table7.1 and Feenstra et al. (2005). We delete countries without GDP per capita data and varieties that are not consistent with Standard International Trade Classification, Rev. 4. Finally, we have 130 countries and 870 varieties left for calibrating artificial productivity for each product.

Eventually, we want to know which countries are importing more varieties. So we focus our exercise on the year of 1985, in which agricultural productivity data is available from Prasada Rao (1993). We have 94 countries which are covered by all datasets and can be utilized in analysis.

5.3 Results

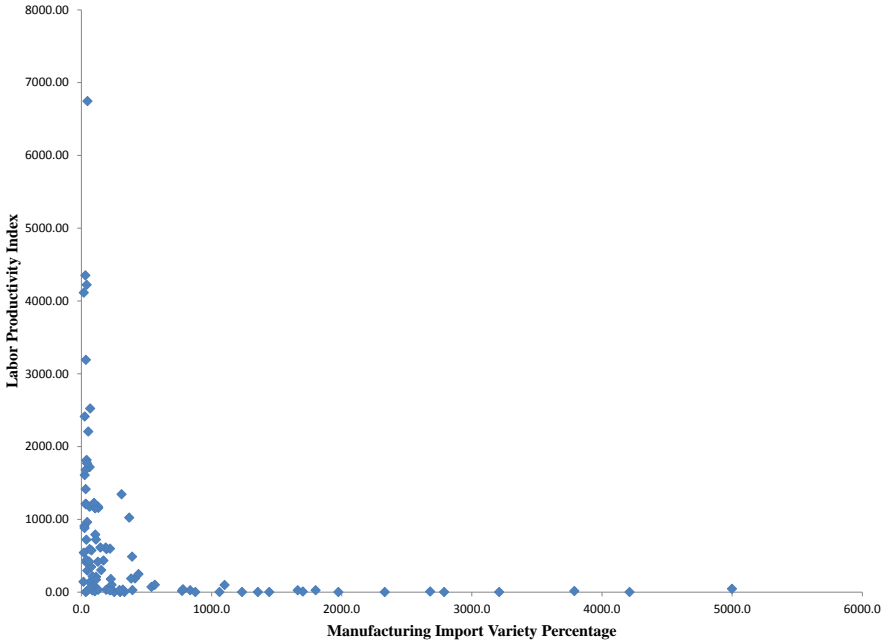


Figure 3: Import of Manufacturing and Agricultural Productivity

Figure 3 shows the relationship between manufacturing import variety percentage and

agriculture productivity. Countries with high manufacturing import variety share tend to have lower labor productivity in agriculture; however, countries with low manufacturing import variety share tend to have higher labor productivity in manufacturing. The result is consistent with our model. In this exercise, we also find that agriculture import variety share does not have significant relationship with agriculture productivity. One reasonable explanation is agricultural trade between countries are always under regulation due to social security consideration.

6 Discussion and Conclusion

This paper analyzes the role of international trade in explaining cross-country agriculture productivity differences and the productivity gap between agriculture and other sectors. It shows that, increased import variety share in manufacturing largely improves productivity growth in manufacturing, but only slightly increases, or even decreases, agricultural productivity growth.

Intuitively, the increase in competition from international trade drives greater innovation in the industrial sector, while the agricultural sector lags. When the poor economy is exposed to increased openness in international trade, it experiences entry of a large variety of foreign goods and services. Sectoral productivity growth is stimulated by competition from multiple competing varieties. The industrial-manufacturing sector is exposed to competition from a wider variety of foreign competitors than the rural-agricultural sector. An intuitive explanation is that industrial technology is relatively portable, whereas the technology in agriculture is relatively place-bound.

As productivity increases, real goods output increases in both sectors; but output grows faster in the manufacturing sector. Wages and prices must adjust to allow real income to rise enough to purchase the increase in real output. This relationship can be viewed as either a rise in wages or a fall in the price of final goods or some equivalent combination. For convenience, assume that the final price of manufacturing is fixed - it was set as the numeraire. In this case, as productivity increases, wages increase. In the baseline case wages increase equally in both sectors and prices of final goods remain the same. When import variety share in manufacturing increases, wages in agriculture grow more slowly than wages in manufacturing. The relative price of the final goods in agriculture also rise more quickly than the price of final goods in manufacturing. (Alternatively, manufacturing goods prices fall if agricultural prices are constant.)

The results of these price movements reinforce the initial productivity differences. Workers in both industries buy final products from both industries. However, since the price of agricultural goods is rising relative to manufacturing goods, consumers shift the shares in their market basket towards the industrial sector. Notice that, since wages are increasing, the agricultural sector may increase, decrease or stay the same in absolute size (physical output), but in value terms the industrial sector grows larger relative to the agricultural sector.

In summary, a logical consequence of the faster increase in productivity in the manufacturing sector is an agricultural sector that has: lower wages, slower growing productivity, and is relatively smaller than the manufacturing sector. These results reproduce the observed changes in the two sectors described in the introduction of the paper.

While our model superficially resembles traditional two sector economic growth models,

there is a critical difference. In employing modern endogenous growth theory, our model features heterogeneity in both agricultural and industrial sectors instead of assuming homogeneous sectors as traditional growth models do. Increasing productivity is associated with the increasing availability of innovation and variety in the intermediate goods markets, in agriculture as in manufacturing. We posit that as economies enter a transitional phase, the rural-agricultural economy becomes more diversified, though not as diversified as manufacturing.

The mechanism of this paper can be applied to other contexts as long as there are multiple sectors. Our result can be interpreted as poor countries are producing low quality products as signified by lower variety. More importantly, due to many reasons, poor countries are more likely to import manufactured products rather than agricultural products. Finally, industrial technology is generally transferable, while much agricultural technology is place specific. The result is that poor countries have a larger import variety share in manufacturing and a lower productivity growth rate in agriculture.

These results imply several policy options. For instance, agricultural and trade policies in terms of increasing agricultural productivity in poor countries could try to control the trade-induced relative agricultural price increase. Another policy approach would be to address labor mobility gaps between agriculture and other industries. Given that many poor countries have large urban unemployment problems, the actual problem may be one of “mobility” in labor quality rather than in physical location, but that is clearly a topic for another paper.

7 Appendices

7.1 Appendix A: Proof of Proposition 1

According to (14), since there is no labor market friction, the labor share between agriculture and manufacturing for each variety is,

$$l_a(t)/l_m(t) = (\sigma_a - 1)/(\sigma_m - 1). \quad (22)$$

Using (14)-(17), (19), and (22), we can solve the interest rate as

$$r(t) = (1 + \alpha_j)^{\gamma_j} (1 + \alpha_{-j})^{1-\gamma_j} (N_j(t))^{\gamma_j} (N_{-j}(t))^{1-\gamma_j} l_j(t) \eta_j^{-1} (\sigma_j - 1)^{-1}. \quad (23)$$

Since agriculture and manufacturing have the same interest rate, we have the following inter-industry variety set relationship

$$[(1 + \alpha_a)N_a(t)]/[(1 + \alpha_m)N_m(t)] = (\eta_a/\eta_m)^{1/(\gamma_a - \gamma_m)}. \quad (24)$$

We can obtain labor share of final good production for each industry from (23) and (24) as

$$N_j(t)l_j(t) = br(t)/(1 + \alpha_j). \quad (25)$$

Plugging (25) back into (16), we get labor share for creating new varieties as,

$$l_{j,n} = b(r(t) - \rho - g_P)/(1 + \alpha_a). \quad (26)$$

Interest rate on the balanced growth path is solved by using (19), (25), and (26) as

$$r = \frac{1}{2b/(1 + \alpha_a) + 2d/(1 + \alpha_m)}L + \frac{1}{2}\rho + \frac{b/(1 + \alpha_a)}{2b/(1 + \alpha_a) + 2d/(1 + \alpha_m)}g_P. \quad (27)$$

In each sector, final product is

$$Y_j = (1 + \alpha_j)^{\sigma_j/(\sigma_j-1)}N_j(t)^{1/(\sigma_j-1)}(1 + \beta_j)^{-1}N_j(t)l_j(t). \quad (28)$$

It implies that the relationship between final product and variety set is $g_j = g_{N_j}/(\sigma_j - 1)$.

Plug the interest rate back into (11) and (12), we can get sectoral growth rates.

7.2 Appendix B: Proof of Proposition 2

To examine the effect of trade, we change import parameters from initial level (α_j) to a new level (α'_j), and keep the labor share in manufacturing as constant, which is $L_m = L'_m$. this gives us the relationship between interest rates in two periods as,

$$2r/(1 + \alpha_m) - \rho/(1 + \alpha_m) = 2r'/(1 + \alpha'_m) - \rho/(1 + \alpha'_m). \quad (29)$$

The relationship between relative prices in two cases can be calculated as

$$g'_P = \frac{(1 + \alpha'_m)b + (1 + \alpha'_a)d}{(1 + \alpha_m)b + (1 + \alpha_a)d}g_P - \left[\frac{(1 + \alpha'_m)b + (1 + \alpha'_a)d}{b^2(1 + \alpha'_m)/(1 + \alpha'_a) + bd} - \frac{(1 + \alpha'_m)b + (1 + \alpha'_a)d}{b^2(1 + \alpha_m)/(1 + \alpha_a) + bd} \right] L.$$

Since $g_P = 0$ is the baseline state relative price growth rate, the new relative price growth rate is

$$g'_P = - \left[\frac{(1 + \alpha'_m)b + (1 + \alpha'_a)d}{b^2(1 + \alpha'_m)/(1 + \alpha'_a) + bd} - \frac{(1 + \alpha'_m)b + (1 + \alpha'_a)d}{b^2(1 + \alpha_m)/(1 + \alpha_a) + bd} \right] L. \quad (30)$$

Since $\alpha'_j > \alpha_j$, the above expression is positive. Take the first order derivative with respect to α'_m we get $\partial g'_P / \partial \alpha'_m > 0$.

7.3 Appendix C: Proof of Proposition 3

In the new state after import share changes, we have the following new growth rates similar to Proposition 1,

$$g'_a = \frac{1}{2b/(1 + \alpha'_a) + 2d/(1 + \alpha'_m)} L - \frac{1}{2}\rho - \frac{b/(1 + \alpha'_a) + 2d/(1 + \alpha'_m)}{2b/(1 + \alpha'_a) + 2d/(1 + \alpha'_m)} g_P; \quad (31)$$

$$g'_m = \frac{1}{2b/(1 + \alpha'_a) + 2d/(1 + \alpha'_m)} L - \frac{1}{2}\rho + \frac{b/(1 + \alpha'_a)}{2b/(1 + \alpha'_a) + 2d/(1 + \alpha'_m)} g_P. \quad (32)$$

The difference of labor productivity growth rate between agriculture and manufacturing is no longer zero as in the baseline state because $g'_m - g'_a = g'_P \neq 0$. Based on Proposition 2, we have $g'_m - g'_a > g'_P$, and the first order derivative $\partial(g'_m - g'_a) / \partial \alpha'_m$ is positive.

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