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ABSTRACT

This paper provides evidence on monopolistic competition models with endogenous technology by studying the effects of sectoral export variety on country productivity. The effects are estimated in a translog GDP function system based on data for 34 countries from 1982 to 1997. Country productivity is constructed and export variety is shown to be significant. Instruments such as tariffs, transport costs, and distance are shown to affect country productivity through export variety, and only through this channel. Overall, while export variety accounts for only 2% of cross-country productivity differences, it explains 13% of within-country productivity growth. A 10% increase in the export variety of all industries leads to a 1.3% increase in country productivity, while a 10 percentage point increase in tariffs facing an exporting country leads to a 2% fall in country productivity.

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1. Introduction

Recent models of monopolistic competition and trade have emphasized that productivity levels are endogenous. For example, Eaton and Kortum (2002) allow for stochastic differences in technologies across countries, with the lowest cost country becoming the exporter of a product variety to each location. In that case, the technologies utilized in a country will depend on its distance and trade barriers with other countries. Melitz (2003) allows for stochastic draws of technology for each firm, and only those firms with productivities above a certain cutoff level will operate. A subset of these firms – the most productive – also become exporters. Melitz shows how the average productivity in a country is determined by the cutoff productivity level, which in turn depends on trade barriers faced by the exporters and other features of the world market. In Melitz's model and that of Eaton and Kortum, trade volume and variety are endogenous and are jointly determined with average productivity.

Empirical testing of this class of models can proceed by utilizing firm-level data and inferring the productivity levels of firms. That approach is taken by Bernard *et al* (2003) for U.S. firms; Eaton, Kortum and Kramarz (2003, 2004) for French firms; and Helpman, Melitz and Yeaple (2004) for U.S. multinationals operating abroad. When firm level data are available, it is highly desirable to make use of them like these authors do. But for many countries such data are not available, and in those cases, we are still interested in estimating the joint relationship between the productivity of countries and their trade volume and variety. The objective of this paper is to examine the effects of export variety on productivity at the country level, using a broad cross-section of advanced and developing nations and disaggregating across sectors.

Rather than modeling heterogeneity across firms, as in above-cited papers, we rely instead on product differentiation across firms to generate productivity gains. This idea is familiar from the earlier, endogenous growth models (e.g. Romer 1990, Grossman and Helpman, 1991) where greater variety of inputs leads to higher productivity. Similarly, we argue that a greater variety of outputs also leads to higher productivity, provided the outputs are differentiated from each other in production (i.e. use different factor intensities). Like many monopolistic competition models we will rely on a constant elasticity of substitution (CES) framework, but applied to the outputs of a country rather than its inputs. Empirically, we measure output variety by the *export variety* of each country. Our goal is to see how export variety (which is endogenous) affects aggregate productivity across countries.

Our work is complementary to other research estimating the gains from new varieties in a CES framework. Feenstra (1994) showed how the gains from new product varieties could be measured, and applied it to a handful of U.S. import goods. Broda and Weinstein (2003) have recently extended this to all U.S. imports, and find that increased import variety contributes to a 1.2% per year fall in the "true" import price index. On the output side, a direct link between export variety and productivity has been found by Feenstra *et al* (1999) for South Korea and Taiwan, and by Funke and Ruhwedel (2001a,b, 2002) for the OECD and East Asian countries.[1] Finally, Hummels and Klenow (2002) investigate the extent to which increased trade between countries consists a larger set of goods, or higher quantity of existing goods – what they call the "extensive" versus "intensive" margin.

We begin by constructing export variety indexes at the sectoral level in sections 2 and 3, as in Feenstra and Kee (2004). The variety indexes are incorporated into a translog GDP function for the economy in section 4. The effects of export variety on country productivity are shown to depend on the elasticities of substitution in production of different varieties in each

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[1] Funke and Ruhwedel (2003) use export variety measures to calculate the welfare gains from trade liberalization in Central and Eastern Europe.

sector. Analogous to Harrigan (1997), the differences in export variety across countries play the role of "price differences" in the GDP function, and therefore influence the shares of value added devoted to each sector. An empirical specification based on the translog GDP function is developed in section 5. The export variety indexes are regressors in the share equations, which are estimated along with a productivity equation for each country. The estimates are then used to construct country productivity based on data for 34 countries from 1982 to 1997.

In section 6, we report estimates of the system of the share equations and the productivity equation. Export variety is treated as an endogenous variable, and the instrumental variables used to determine export variety are those suggested by the work of Eaton and Kortum (2002) and Melitz (2003): tariffs, transport costs and distance. There is also an important *exclusion restriction* suggested by these models: tariffs and transport costs should not have an impact on aggregate productivity *except through* export (and import) variety. This exclusion restriction amounts to a test for overidentification in our system, as we describe. We formally test this overidentifying restriction in section 7, as well as hypothesis tests based on other restrictions imposed on the system of equations. Most importantly, the over-identifying restriction test is not rejected and confirms the importance of export variety as the *mechanism* (Hallak and Levinsohn, 2004) by which trade affects productivity.

We discuss the empirical importance of tariffs, transport costs, and distance on export variety in section 8. The results also show that a 10 percentage point increase in U.S. tariffs would lead to a 2% fall in exporting countries' productivity, which indicates that tariffs are statistically and economically important in affecting productivity via export variety. Increases in distance and transport costs are also significant in reducing export variety of the industries. In section 9, we decompose productivity differences across countries into that part explained by export variety and the remaining explained by other determinants, such as fixed effects and regression errors. We find that while export variety only accounts for 2% of the variation in country productivity differences in level (though if country fixed effects are not included in productivity differences, then export variety accounts for 60% of the variation), it can explain more than 13% of within-country productivity growth. Overall, at the sample mean, a 10% increase in export varieties of all industries leads to a 1.3% increase in country productivity. Additional conclusions are given in section 10.

2. Effect of New Varieties

Consider a world economy with many c=1,…,C countries, each of which produce many types of goods. For simplicity in this section we aggregate these goods into a single sector, but the extension to multiple sectors will be immediate. For each period t, let the set of goods produced in country c be denoted by $I_t^c \subset \{1,2,3,....\}$. Then the quantity vector of each type of good produced in country c in period t is denoted by $q_t^c > 0$. The aggregate output of each country c, Q_t^c, is characterized by a CES function of the output of each good in the country, q_{it}^c:

$$Q_t^c = f(q_t^c, I_t^c) = \left(\sum_{i \in I_t^c} a_i \left(q_{it}^c\right)^{(\sigma-1)/\sigma} \right)^{\sigma/(\sigma-1)}, a_i > 0,\ c = 1,...,C, \tag{1}$$

where the elasticity of substitution between goods is σ. We assume that total output obtained from the economy is constrained by the transformation curve:

$$F[f(q_t^c, I_t^c), V_t^c] = 0, \tag{2}$$

where $V_t^c = \left(v_{1t}^c, v_{2t}^c, ..., v_{Mt}^c\right) > 0$ is the endowment vector for country c in year t.

For *outputs,* we suppose that $\sigma < 0$ in (1), which means that the set of feasible varieties q_{it}^{c} in any country will lie along a strictly concave transformation curve defined by (2). This is shown in Figure 1, where we draw the transformation frontier between two product varieties q_{1t} and q_{2t}, within a country. For a given transformation curve, and given prices, an increase in the number of output varieties will raise revenue. For example, if only output variety 1 is available, then the economy would be producing at the corner A, with output revenue shown by the line AB. Then if variety 2 becomes available, the new equilibrium will be at point C, with an *increase* in revenue. This illustrates the benefits of output variety.

For *inputs,* we would instead use that $\sigma > 1$ in (1), which is then the formula for a CES production function. Given output $Q_t^c = \overline{Q}_t^c$, the inputs would lie along an iso-quant like that illustrated in Figure 2. If only input 1 is available, then the costs of producing $\overline{Q}_t^c$ would be minimized at point A, with the budget line AB. But if input 2 is also available, then the costs are instead minimized at point C, with a *fall* in costs. This illustrates the benefits of input variety. We will use the *output* case to illustrate the effects of export variety, whereas the *input* case would apply to import variety (as in Feenstra, 1994, and Broda and Weinstein, 2003).

3. Measuring Output Variety

Considering maximizing the value of output obtained in each industry, as in Figure 1. Under the assumption of perfect competition, and given equation (1), the value of output obtained in each country will be $P_t^c Q_t^c$, where P_t^c is a CES function of the prices of all output varieties produced in the country:

$$P_t^c \equiv c(p_t^c, I_t^c) = \left(\sum_{i \in I_t^c} b_i \left(p_{it}^c\right)^{1-\sigma} \right)^{1/(1-\sigma)}, b_i = a_i^\sigma > 0, \ c = 1,...,C, \tag{3}$$

and $p_t^c > 0$ is the domestic price vector for each country.

The right-hand side of expression (3) is a CES cost function, with potentially differing sets of product varieties across countries and over time. These cannot be evaluated with knowledge of the parameters b_i. But a standard result from index number theory is that the *ratio* of cost function can be evaluated, using data on price and quantities in the two periods or two countries. Feenstra (1994) shows how this result applies even when the number of goods is changing. In particular, the ratio of the CES cost functions over two countries a and b, equals to the product of the Sato-Vartia price index of goods that are common, $I \equiv \left(I_t^a \cap I_t^b\right) \neq \emptyset$, multiplied by terms reflecting the revenue share of "unique" goods:

$$\frac{P_t^a}{P_t^b} = \prod_{i \in I} \left(\frac{p_{it}^a}{p_{it}^b} \right)^{w_i(I)} \left(\frac{\lambda_t^a(I)}{\lambda_t^b(I)} \right)^{1/(\sigma-1)}, \quad a, b = 1,...,C, \tag{4}$$

where the weights $w_i(I)$ are constructed from the revenue shares in the two countries:

$$w_i(I) \equiv \left(\frac{s_{it}^a(I) - s_{it}^b(I)}{\ln s_{it}^a(I) - \ln s_{it}^b(I)} \right) \Big/ \sum_{i \in I} \left(\frac{s_{it}^a(I) - s_{it}^b(I)}{\ln s_{it}^a(I) - \ln s_{it}^b(I)} \right), \tag{5}$$

$$s_{it}^c(I) \equiv p_{it}^c q_{it}^c \Big/ \sum_{i \in I} p_{it}^c q_{it}^c, \text{ for } c = a,b, \tag{6}$$

$$\lambda_t^c(I) = \frac{\sum_{i \in I} p_{it}^c q_{it}^c}{\sum_{i \in I_t^c} p_{it}^c q_{it}^c} = 1 - \frac{\sum_{i \in I_t^c, i \notin I} p_{it}^c q_{it}^c}{\sum_{i \in I_t^c} p_{it}^c q_{it}^c}, \text{ for } c = a,b. \tag{7}$$

Notice that the output shares in (6), for each country, are measured relative to the *common* set of goods I. Then the weights in (5) are the *logarithmic mean* of the shares $s_{it}^{a}(I)$ and $s_{it}^{b}(I)$, and sum to unity over the set of goods $i \in I$.[2]

To interpret (7), notice that $\lambda_t^c(I) \leq 1$ due to the differing summations in the numerator and denominator. This term will be strictly less than one if there are goods in the set I_t^c that are *not found* in the common set I. In other words, if country a is selling some goods in period t that are *not sold* by country b, this will make $\lambda_t^a(I) < 1$.

We can re-express equation (4) in logs as:

$$\ln \frac{P_t^a}{P_t^b} = \sum_{i \in I} w_i(I) \ln\left(\frac{p_{it}^a}{p_{it}^b}\right) + \left(\frac{1}{\sigma - 1}\right) \ln\left(\frac{\lambda_t^a(I)}{\lambda_t^b(I)}\right), \qquad a, b, = 1, \ldots, C. \tag{8}$$

The first term on the right of (8) is the Sato (1976)-Vartia (1976) price index, which is simply a weighted average of the price ratios, using the values $w_i(I)$ as weights. What is new about equation (8) is the second term on the right, which reflect changes in product variety. If country a in period t has new, unique outputs (not in the common set I), we will have $\lambda_t^a < 1$. From (8), when $\sigma < 0$ this will *raise* the price index of outputs, P_t^a / P_t^b. In other words, the introduction of new output varieties will act in the same way as an increase in prices in a sector: it will draw resources towards that sector.[3]

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[2] More precisely, the numerator of (5) is the logarithmic mean of the output shares of the two countries, and lies in-between these shares. The denominator of (5) is introduced so that the weights $w_i(I)$ sum to unity,

[3] If instead we consider the case of input variety, then $\sigma > 1$ in (8). Then the introduction of new inputs will *lower* their price index. Thus, new input varieties would have the same positive efficiency effect as would a drop in input prices.

In practice, we will measure the ratio $\lambda_t^a / \lambda_t^b$ using exports of countries to the United States. While it would be preferable to use their worldwide exports, our data for the U.S. are more disaggregate, and allows for a finer measurement of "unique" products sold by one country and not another. Specifically, for 1972 – 1988 we will use the 7-digit Tariff Schedule of the U.S. Annotated (TSUSA) classification of U.S. imports, and for 1989 – 1997 we shall use the 10-digit Harmonized System (HS) classification of imports.

To measure the ratio $\lambda_t^a / \lambda_t^b$, we need to decide on a consistent "comparison country." For this purpose, we shall use the *worldwide exports* from all countries to the U.S. as the comparison. Denote this comparison country by *, so that the set $I_t^* = \bigcup_{c=1}^{C} I_t^c$ is the complete set of varieties imported by the United States in year t, and $p_{it}^* q_{it}^*$ is the total value of imports for good i. Then comparing country c to country * in year t, it is immediate that the common set of goods exported is $I_t^c \cap I_t^* = I_t^c$, or simply the set of goods exported by country c. Therefore, from (7) we have that $\lambda_t^c(I_t^c) = 1$, and:

$$\lambda_t^{c*} \equiv \lambda_t^*(I_t^c) = \frac{\sum_{i \in I_t^c} p_{it}^* q_{it}^*}{\sum_{i \in I_t^*} p_{it}^* q_{it}^*} = 1 - \frac{\sum_{i \in I_t^*, i \notin I_t^c} p_{it}^* q_{it}^*}{\sum_{i \in I_t^*} p_{it}^* q_{it}^*}. \tag{9}$$

Noting from (8) that product variety in country c relative to the comparison is measured as $\lambda_t^c(I_t^c) / \lambda_t^*(I_t^c)$, but this has a negative coefficient when $\sigma < 0$, let us instead invert it and measure product variety of country c relative to the world by $\lambda_t^*(I_t^c) / \lambda_t^c(I_t^c) = \lambda_t^*(I_t^c)$, which enters (8) with a positive coefficient $1/(1-\sigma)$. For brevity we denote this by λ_t^{c*} in (9). It is interpreted as the *share of total U.S. imports from products that are exported by country c.*

Equivalently, it is *one minus the share of total U.S. imports from products that are* not *exported by country c*. Note that this measure depends on the *set of exports* by country c, I_t^c, but not on its value of exports, except insofar as they affect the value of worldwide exports.

4. GDP Function with Export Variety

To study the effects of export variety on productivity, we need to model the allocation of factors among the production of goods in all industries. The effects of export varieties on productivity depend on the elasticities of substitution in production between different variety within the industries – for a two good case, the elasticity of substitution in production captures the curvature of the PPF of an economy given fixed endowments, as in Figure 1. In this section, we develop a general equilibrium based GDP function approach which links export variety to country productivity. Such a model will allow us to develop an empirical model for the estimation of the elasticities of substitution in production of various industries, and will also allow us to infer the contribution of export variety in explaining country productivity.

Suppose there are M kinds of factor endowments in the economy, denoted by the endowment vector $V_t^c = (v_{1t}^c,\ldots,v_{Mt}^c) > 0$. There are N differentiated traded good sectors in the economy, with output denoted by $(Q_{1t}^c,\ldots,Q_{Nt}^c)$, each of which is a CES aggregate as in (1) with $\sigma_n < 0$.[4] In addition to the N traded goods, each country has one homogeneous nontraded good sector produces output Q_{N+1t}^c. The aggregate output vector of the economy is denoted by $Q_t^c = \left(Q_{1t}^c,\ldots,Q_{Nt}^c,Q_{N+1t}^c\right) > 0$. Likewise, the aggregate price vector is $P_t^c = (P_{1t}^c,\ldots,P_{Nt}^c,P_{N+1t}^c) > 0$, which consists of N traded good prices as defined by the CES unit-costs in (3) , and one

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[4] In the case that some of these sectors are imported rather than exported, we would denote $Q_{nt}^c < 0$ as the negative of the CES aggregate (1), with $\sigma_n > 1$.

nontraded good price, P^c_{N+1t}. Given the assumption of perfect competition, total revenue or GDP of the economy in period t is:

$$G^c_t\left(P^c_t, V^c_t\right) \equiv \max\left\{ P^c_t \cdot Q^c_t : F^c_t\left(Q^c_t, V^c_t\right) = 0 \right\}, \tag{10}$$

where $F^c_t(Q^c_t, V^c_t) = 0$ is the transformation curve in period t that generalizes (2) when there are many sectors. $G^c_t\left(P^c_t, V^c_t\right)$ is homogeneous of degree one with respect to prices and, with the assumption that F is homogeneous of degree one, then $G^c_t\left(P^c_t, V^c_t\right)$ is also homogeneous of degree one with respect to endowments. As usual, the derivative of the GDP function with respect to P^c_t equals the sectoral outputs Q^c_t, and the derivative with respect to endowments V^c_t can be interpreted as the factor prices w^c_t.

To implement the above GDP function empirically, we will assume that it follows a translog functional form:

$$\begin{aligned} \ln G^c_t\left(P^c_t, V^c_t\right) = \alpha^c_0 + \beta^c_0 t + \sum_{n=1}^{N+1} \alpha_n \ln P^c_{nt} + \sum_{k=1}^{M} \beta_k \ln v^c_{kt} + \tfrac{1}{2} \sum_{m=1}^{N+1} \sum_{n=1}^{N+1} \gamma_{mn} \ln P^c_{mt} \ln P^c_{nt} \\ + \tfrac{1}{2} \sum_{k=1}^{M} \sum_{\ell=1}^{M} \delta_{k\ell} \ln v^c_{kt} \ln v^c_{\ell t} + \sum_{n=1}^{N+1} \sum_{k=1}^{M} \phi_{nk} \ln P^c_{nt} \ln v^c_{kt}. \end{aligned} \tag{11}$$

Notice that we allow this function to differ across countries based on the constant α^c_0 and also the exogenous time trend $\beta^c_0 t$. To satisfy the properties of homogeneity in prices and endowments as well as symmetry, we impose the following restrictions:

$$\begin{aligned} \gamma_{mn} = \gamma_{nm}, \sum_{n=1}^{N+1} \alpha_n = 1, \sum_{n=1}^{N+1} \gamma_{mn} = \sum_{n=1}^{N+1} \phi_{nk} = 0, \\ \delta_{k\ell} = \delta_{\ell k}, \sum_{k=1}^{M} \beta_k = 1, \sum_{k=1}^{M} \delta_{k\ell} = \sum_{k=1}^{M} \phi_{nk} = 0. \end{aligned} \tag{12}$$

The share of factor k in the GDP of the economy in period t equals to the derivative of $\ln G^c_t\left(P^c_t, V^c_t\right)$ with respect to $\ln v^c_{kt}$:

$$s_{kt} = \beta_k + \sum_{\ell=1}^{M} \delta_{k\ell} \ln v^c_{\ell t} + \sum_{n=1}^{N+1} \phi_{kn} \ln P^c_{nt}, \quad k = 1,\ldots,M. \tag{13}$$

Similarly, the share of sector n in GDP of period t equals to the derivative of $\ln G^c_t\left(P^c_t, V^c_t\right)$ with respect to $\ln P^c_{nt}$:

$$s_{nt} = \alpha_n + \sum_{m=1}^{N+1} \gamma_{mn} \ln P^c_{mt} + \sum_{k=1}^{M} \phi_{nk} \ln v^c_{kt}, \quad n = 1,\ldots,N+1. \tag{14}$$

To introduce export variety into the GDP function, we assume that the prices of goods sold by each country are the same across countries, but that they differ in the *variety* of products sold by each. Denote the set of varieties produced by industry n as I^c_{nt}, so the aggregate price P^k_{nt} is a CES function of the prices of these varieties:

$$P^c_{nt} \equiv c(p^c_t, I^c_t) = \left(\sum_{i \in I^c_{nt}} b_i \left(p^c_{it}\right)^{1-\sigma} \right)^{1/(1-\sigma)}, b_i = a_i^{\sigma} > 0, \quad c = 1,\ldots,C, \; n = 1,\ldots,N.$$

Using the union of all exporting countries as the comparison country, then from (8) and (9),

$$\ln \frac{P^c_{nt}}{P^*_{nt}} = \sum_{i \in I_{nt}} w_i(I) \ln\left(\frac{p^c_{it}}{p^*_{it}}\right) + \left(\frac{1}{\sigma_n - 1}\right) \ln\left(\frac{\lambda^c_{nt}}{\lambda^{c*}_{nt}}\right) \Rightarrow \ln \frac{P^c_t}{P^*_t} = \left(\frac{1}{1-\sigma_n}\right) \ln \lambda^{c*}_{nt}, \tag{15}$$

where the latter equality comes from assuming that $p^c_{it} = p^*_{it}$ for every tradable good. Thus, the ratio of CES price indexes depends only on the relative export variety of country c. A similar approach was used by Harrigan (1997) to model the effective price differences across countries as reflecting total factor productivity in the exporting sectors, whereas we are modeling the price differences as reflecting product variety of exports.

If we difference (14) with respect to the share equation of the comparison country, we obtain an expression that relates the industry share in country c in period t to λ_{nt}^{c*}:

$$s_{nt}^{c} = s_{nt}^{*} + \sum_{k=1}^{M} \phi_{kn}\left(\ln v_{kt}^{c} - \ln v_{kt}^{*}\right) + \sum_{m=1}^{N} \frac{\gamma_{mn}}{(1-\sigma_m)} \ln \lambda_{mt}^{c*} + \gamma_{N+1,n}\left(\ln P_{N+1,t}^{c} - \ln P_{N+1t}^{*}\right), \qquad (16)$$

where the last term captures the effect of a nontraded good on the industry shares. We measure the endowments of the hypothetical country by the *sum of endowments* of all sample countries, $v_{kt}^{*} = \sum_{c=1}^{C} v_{kt}^{c}$, while the nontraded goods price for the comparison country is a weighted average of the country nontraded good price indexes.[5]

Equation (16) allows us to estimate $1/(1-\sigma_m)$, which depends on σ_m, the elasticity of substitution between output varieties in industry m. However, given that $1/(1-\sigma_m)$ and γ_{mn} enter multiplicatively, it is not possible to separately identify the parameters based on (16). Thus, in addition to the share equations (16), a country productivity equation is derived from the GDP function is added to the estimation system. This will also allow us to estimate how the expansion of product varieties contributes to GDP and therefore to country productivity.

To derive the country productivity equation, we assume that the hypothetical country also has the translog function shown in (11), where without loss of generality we can normalize $\alpha_0^{*} = \beta_0^{*} = 0$. Then using the share equations in (13)-(14), it can be confirmed that the difference between GDP of country c and the comparison country is:

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[5] The nontraded good price indexes of the sample countries are obtained by netting the prices of traded goods, both export and import, from the country GDP deflators.

$$\ln G(P_t^c, V_t^c) - \ln G(P_t^*, V_t^*)$$
$$= \alpha_0^c + \beta_0^c t + \sum_{n=1}^{N+1} \tfrac{1}{2}(s_{nt}^c + s_{nt}^*)(\ln P_{nt}^c - \ln P_{nt}^*) + \sum_{k=1}^{M} \tfrac{1}{2}(s_{kt}^c + s_{kt}^*)(\ln v_{kt}^c - \ln v_{kt}^*). \qquad (17)$$

The right-hand side of (17) equals a time trend, plus a Törnqvist index of relative prices, plus a Törnqvist index of relative endowments. These indexes provide a decomposition of relative GDP into its price and factor-endowment components.[6]

In our case, the price differences of the traded goods industries are due entirely to export variety, so using (15) we can re-express (17) initially as:

$$\ln G(P_t^c, V_t^c) - \ln G(P_t^*, V_t^*) - \sum_{k=1}^{M} \tfrac{1}{2}(s_{kt}^c + s_{kt}^*)(\ln v_{kt}^c - \ln v_{kt}^*)$$
$$- \tfrac{1}{2}(s_{N+1t}^c + s_{N+1t}^*)(\ln P_{N+1t}^c - \ln P_{N+1t}^*) = \alpha_0^c + \beta_0^c t + \sum_{n=1}^{N} \tfrac{1}{2}(s_{nt}^c + s_{nt}^*)\frac{\ln \lambda_{nt}^{c*}}{(1-\sigma_n)}, \qquad (17')$$

where the differences in factor endowments between country c and the hypothetical country are moved to the left-hand side. Also listed as the last term on the left is the difference in the nontraded good's price between the countries. Thus, the left-hand side of this equation is interpreted as the country productivity differences between country c and the hypothetical country – it is the GDP of country c relative to that of the hypothetical country, net of the differences in factor endowments and prices due to nontraded goods. The remaining difference between the two countries GDP is the productivity differences due to export variety, on the right.

Equation (17') is not immediately useful since the GDP level of the hypothetical country, and its factor shares, are not observable. For the unobserved factor shares, given that we use the sum of sampled countries endowments to proxy for the endowments of the hypothetical country,

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[6] The decomposition in (17) is a special case of results in Diewert and Morrison (1986), which are summarized by Feenstra (2004, Appendix A, Theorem 5).

it is reasonable to assume that its factor shares are the average of the sampled countries factor shares. As for the unobserved GDP level, given that it is common across all countries in any year, it is possible to be controlled by year fixed-effects in a panel regression setting, i.e. $\alpha_t^* = \ln G(P_t^*, V_t^*)$, and moving it to the right-hand side of the equation,

$$\ln G(P_t^c, V_t^c) - \sum_{k=1}^{M} \tfrac{1}{2}(s_{kt}^c + s_{kt}^*)(\ln v_{kt}^c - \ln v_{kt}^*) - \sum_{n=1}^{N} \tfrac{1}{2}(s_{nt}^c + s_{nt}^*)(\ln P_{N+1t}^c - \ln P_{N+1t}^*) = \alpha_t^* + \alpha_0^c + \sum_{n=1}^{N} \tfrac{1}{2}(s_{nt}^c + s_{nt}^*)\frac{\ln \lambda_{nt}^{c*}}{(1-\sigma_n)} + (\ln P_{N+1t}^c - \ln P_{N+1t}^*) + \varepsilon_t^c \tag{18}$$

where $\tfrac{1}{2}(s_{N+1t}^c + s_{N+1t}^*) = 1 - \sum_{n=1}^{N} \tfrac{1}{2}(s_{nt}^c + s_{nt}^*)$ is used in order to leave the differences in nontraded good's prices on the right-hand side, and therefore test for the violation of homogeneity constraint in prices (due to measurement error in the nontraded price, for example).

Notice that the year fixed-effects completely absorb the explanatory power of time trend appearing in (17'), which makes the latter redundant. In addition, a classical error term ε_t^c is introduced in (18) to capture the productivity difference between country c and the hypothetical country. Equation (18) shows that the difference in country c productivity relative the hypothetical country can be estimated by a year fixed effect, a country fixed effect, its relative export variety, and the relative nontraded good price index.

5. Data and Estimating Equations

With data on GDP, factor endowments, nontraded good prices, and industry shares, we can estimate (18) with the sample data set together with the system of share equations. Most importantly, such a system of equations enables us to estimate the elasticity of substitution between different output varieties within an industry, σ_n , which is not sufficiently identified by the share equations alone. The output shares of the hypothetical country, appearing as s^*_{nt}, are measured using sample averages in (18), but will be fully absorbed by year fixed effects, δ_{nt} in the share equations (16). Then the equality of σ_n can be imposed between (16) and (18) to identify these elasticities.

Our data set covers 34 countries from 1982 to 1997, a total of 342 observations. GDP is measured in constant 1995 U.S. dollars to make cross country and time series comparisons appropriate. We will use (9) to measure export variety from country c to the U.S. in every years 1972 – 1988 (using the TSUSA data), and 1989 – 1997 (using the HS data). This gives a consistent comparison of export variety in each country relative to the hypothetical country producing all varieties.

There are three kind of primary factor endowments: labor, capital and agriculture land. Labor is defined as the number of persons in the labor force of each country. Capital is constructed using perpetual inventory method using real investment of the countries. Real investment is obtained by deflating the gross domestic capital formation of the countries with the respective GDP deflator on domestic capital formation. In addition, we construct the base year capital stock using an infinite sum series of investment prior to the first year, assuming that the growth rate of investment of the first five years are good proxy for investment prior to the first year. All these data, together with price deflators of GDP, exports and imports are available in World Development Indicators (World Bank, 2003).

We aggregate up all export goods into N = 7 sectors: agriculture, textiles & garments, woods & papers, petroleum & plastics, mining & basic metals, machinery & transport equipment, and the electronics. The value added of these sectors are available in the UNIDO data set, which we compare to the GDP values to construct the value added share of each sector in GDP. We also need information on factor shares in national income for the estimation. A United Nations national account data set is obtained which has information on labor share in GDP.[7] One minus the labor share gives us the sum of capital share and land share, which we are not be able to separately identify. To overcome this shortcoming, we chose to estimate the land share in the productivity equation as follows. It can be shown from (18) that the log of GDP is the sum of the log of overall prices (denoted P_t for brevity), productivity (A_t), and the weighted log of endowments:

$$\ln(\mathrm{GDP}_t) = \ln A_t + \ln P_t + s_{Lt} \ln L_t + s_{Kt} \ln K_t + (1 - s_{Lt} - s_{Kt}) \ln T_t .$$

Then we can estimate the share of land (T_t) by moving those terms for which we have data to the left-hand side:

$$\begin{aligned} \ln(\mathrm{GDP}_t) - s_{Lt}(\ln L_t - \ln T_t) - (1 - s_{Lt})(\ln K_t - \ln T_t) - \ln T_t = \\ \ln A_t + \ln P_t - (1 - s_{Lt} - s_{Kt})(\ln K_t - \ln T_t). \end{aligned} \tag{19}$$

Thus, when we use the labor share and one minus the labor share to weight $\ln \ell_t \equiv \ln(L_t / T_t)$ and $\ln(K_t / T_t)$, respectively, we should also include capital per unit of land $\ln k_t \equiv \ln(K_t / T_t)$ on the right-hand side of the equation, as shown in (19). The estimated coefficient associated with capital per unit of land is interpreted as the negative value of the average share of land in GDP.

We proceed with a system of eight equations, consists of the seven sectoral share (16) equations and the country productivity equation. According to (18) and (19), let the dependent variable of the country productivity equation be TFP *adjusted* for capital-land ratio and prices of nontraded goods:

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[7] We thank Ann Harrison for providing this data.

$$\begin{aligned}\text{Adj. TFP}_t^c \equiv \ln G\left(P_t^c, V_t^c\right) - \tfrac{1}{2}\left(s_{Lt}^c + s_{Lt}^*\right)\left(\ln \ell_t^c - \ln \ell_t^*\right) - \left(1 - \tfrac{1}{2}\left(s_{Lt}^c + s_{Lt}^*\right)\right)\left(\ln k_t^c - \ln k_t^*\right) \\ -\left(\ln T_t^c - \ln T_t^*\right) - \sum_{n=1}^{7} \tfrac{1}{2}\left(s_{nt}^c + s_{nt}^*\right)\left(\ln P_{8t}^c - \ln P_{8t}^*\right). \end{aligned} \tag{20}$$

Making use of the homogeneity restriction $\sum_{m=1}^{8} \gamma_{mn} = 0$ in the share equations, and introducing land and capital per unit of land onto the right of the productivity equation, our estimating system becomes:

$$\begin{aligned} s_{nt}^c = \delta_{nt} + \phi_{Ln}\left(\ln \ell_t^c - \ln \ell_t^*\right) + \phi_{Kn}\left(\ln k_t^c - \ln k_t^*\right) \\ + \sum_{m=1}^{7} \gamma_{mn}\left(\frac{\ln \lambda_{mt}^{c*}}{(1-\sigma_m)} - \left(\ln P_{8t}^c - \ln P_{8t}^*\right)\right) + \varepsilon_{nt}^c, \quad n = 1,\ldots,7, \end{aligned} \tag{21a}$$

$$\begin{aligned} \text{Adj. TFP}_t^c = \alpha_t^* + \beta_K\left(\ln k_t^c - \ln k_t^*\right) + \beta_8\left(\ln P_{8t}^c - \ln P_{8t}^*\right) \\ + \alpha_0^c + \sum_{n=1}^{7} \tfrac{1}{2}\left(s_{nt}^c + s_{nt}^*\right)\frac{\ln \lambda_{nt}^{c*}}{(1-\sigma_n)} + \varepsilon_t^c \ . \end{aligned} \tag{21b}$$

If the homogeneity constraint in prices are not violated we expect β_8 to equal to one, whereas β_K represents the negative value of the share of land in GDP. The constraints will be tested in the regressions. With the estimated parameters, we will be able to construct country productivity differences according (22):

$$\begin{aligned} \text{Estimated TFP}_t^c \equiv \text{Adj. TFP}_t^c - \hat{\alpha}_t^* - \hat{\beta}_K\left(\ln k_t^c - \ln k_t^*\right) - \hat{\beta}_8\left(\ln P_{8t}^c - \ln P_{8t}^*\right) \\ = \hat{\alpha}_0^c + \sum_{n=1}^{7} \tfrac{1}{2}\left(s_{nt}^c + s_{nt}^*\right)\frac{\ln \lambda_{nt}^{c*}}{(1-\hat{\sigma}_n)} + \hat{\varepsilon}_t^c \ . \end{aligned} \tag{22}$$

Due to cross equation restrictions on $1/(1-\sigma_m)$ and γ_{mn}, and the multiplicative nature of these parameters, we need to use nonlinear system estimation to estimate equations (21a) and (21b). This involves minimizing the criterion function of the full system with a consistently estimated variance-covariance matrix. In addition, endogeneity and measurement errors of some right-hand side variables need to be addressed. First, export variety could be endogenous.

Countries that have higher productivity may be able to produce more export varieties, which leads to correlation between export variety and the regression errors. To correct for such endogeneity, appropriate instrumental variables that are correlated to export variety but not country productivity would be necessary. Eaton and Kortum (2002) and Melitz (2003) provide us with such variables. In their models, export variety depends on various trade costs variables such as tariffs, transport costs and distance. More importantly these trade costs variables only affect country productivity through export variety. Thus, by using these variables as instruments we can obtain estimates that are consistent. A subsequent over-identifying restrictions test will then allow us to test for the validity of these instruments.

Second, due to the lack of available data, prices of nontraded goods are constructed using the GDP deflator net of price of tradable goods. This may introduce serious measurement errors and cloud correlation between the variables. In this case we can also treat the price of nontraded goods as correlated with the error, and IV estimation would allow us to have more precise estimates.

In the next section, we proceed by first estimating the system of equations without correcting for endogeneity of export variety and measurement errors of nontraded good prices. A full nonlinear 3SLS estimation with trade cost variables as instruments will then be presented. Based on the nonlinear 3SLS estimation, a series of specification tests are performed: on the homogeneity constraints on prices and endowments, symmetry constraints on cross price effects, as well as the over-identifying restrictions of the instruments will be implemented. Finally, since the first-stage regression of the nonlinear 3SLS system involves regressing the derivatives of the criterion function with respect to all parameters on all instruments and exogenous variables, we present some descriptive linear estimation linking export variety to all the instruments.

6. Estimation Results

Table 1 presents the result of the nonlinear system of share equations (21a) with the country TFP equation (21b), estimated using iterative seemingly-unrelated regressions (ISUR). All the homogeneity constraints on prices and endowments, as well as the symmetric constraints are imposed in the share equations. Columns (1) to (7) of the table show the estimated coefficients of each of the industry share equations, and the last column shows the estimated coefficients of the country productivity equation.

In the top part of Table 1 in columns (1) to (7) we report γ_{mn}, which are the partial price effects due to export variety changes of the industry in the rows on the share of industries in the columns. All the own-price effects γ_{nn} are estimated to be positive and most are highly significant.[8] In other words, the underlying supply curves of these industries are positively sloped. The bottom part of Table 1 in columns (1) to (7) presents the Rybczynksi effects of endowments on the share of each industry. Positive point estimates indicate industry expansions due to the increases in certain endowments. For example, an increase in the labor endowment relative to that of land hurts agriculture, wood & paper, and the machinery & transport industry. On the other hand, an increase in the labor endowment relative to land benefits textiles & garments, petroleum & plastics, mining & metals, and the electronics industry. Similarly, while an increase in capital relative to land hurts textiles & garments, petroleum & plastics, and mining & metals, such an increase benefits woods & paper, machinery & transport, and the electronics industry. These finding are reasonable and broadly similar to those of Harrigan (1997).

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[8] Due to convergence problem, the γ_{nn} coefficient of the petroleum & plastics industry (industry 4), is estimated separately, by fixing all the rest of the parameters in the optimal values. We repeated the process a few rounds, and the estimation results are very stable, as presented in Table 1.

The top half of column (8) in Table 1 presents the ISUR estimates of $1/(1-\sigma_n)$ for each industry in the row. All the point estimates are positive, and most are smaller than one. This implies that the underlying elasticities of substitution are negative, as suggested by theory. The industry that is the most heterogeneous in production is electronics, for which an increase in export variety contributes the most to country productivity. Furthermore, from the coefficient of capital-land ratio in the lower part of column (8) in Table 1, we can infer that the average estimated land share in GDP is about 10 percent. Finally, the coefficient on the price of nontraded goods is significantly less than one, which violates the homogeneity constraint on prices when we do not use instruments.

Table 2 presents the estimated coefficients using nonlinear 3SLS with a set of instruments consisting of U.S. tariffs by industry, exporting country and year (seven industry effective tariffs), indicator variables for various trade agreements between the U.S. and the exporting countries (CANFTA, NAFTA, CBI, ANDEAN), distance between exporting countries and US (in kilometers), average transport costs interact with two distance dummies, and relative endowments. The nonlinear 3SLS estimates of the own-price effects reported in Table 2 are significantly larger than the ISUR estimates from Table 1. This is not surprising since apart from endogeneity problems, the export variety indexes and relative price of the nontraded sector may have measurement errors which bias the estimates toward zero. Point estimates of the own price effects range from 0.004 in machinery & transport to 0.133 in the wood & paper industry. The Rybczynski effects of endowments presented in the bottom of this table are very similar to that of the ISUR estimates, both in terms of magnitude and statistical significance.

The nonlinear 3SLS estimates of $1/(1-\sigma_n)$ presented in column (8) of Table 2 are larger than the ISUR estimates in general. They range from 0.324 in the agriculture industry to 0.977

in the electronics industry. Thus agriculture industry is revealed to be most homogeneous in production while the electronics is the least homogeneous: an increase in export variety in the electronics industry would contribute most to country productivity, while export variety in agriculture contributes the least. The ranking of industries according to their implied elasticities of substitution are: electronics (-0.024), machinery & transport (-0.575), mining & basic metals (-0.637), woods & paper (-0.669), textiles & garments (-0.698), the petroleum & plastics industry (-1.976), and agriculture (-2.086).

The lower part of Table 2 presents the control variables in the country TFP equation. As mentioned above, the estimated coefficient associated with the log capital-land ratio has the interpretation of the negative of the average share of land in GDP. However, while this land share is about 10 percent in the previous ISUR estimation, it is not precisely estimated in the current nonlinear 3SLS estimation. The estimated coefficient on the log-difference in the nontraded goods price is about 0.26. Similar to the previous ISUR finding, this estimate is significantly less than one which indicates that the price of nontraded goods is poorly measured. However, with the country and year fixed effects, and the inclusion of these two variables as controls, as long as the measurement error in nontraded goods is not systematically related to the country productivity or the export variety indexes, our estimation results should remain robust. Overall, the results presented in Table 2 show that export variety is significant in determining industry shares in GDP and aggregate country productivity.

7. Specification Tests

Given that the above nonlinear 3SLS estimation involves minimizing the criterion function, the minimized value provides a test statistic for hypothesis testing. The difference between the values of the criterion functions of the restricted and unrestricted models is asymptotically chi-squared distributed with degree of freedom equal to the number of restrictions. According to Davidson and MacKinnon (1993, p. 665), it is important that the same estimate of variance-covariance matrix be used for both the restricted and unrestricted estimations, in order to ensure that the test statistic is positive.

The nonlinear 3SLS estimation has the following restrictions. For each of the share equation, the homogeneity constraints on prices and endowments are imposed. The homogeneity constraint on endowments is imposed in the GDP function but not the homogeneity constraint on prices due to the possible measurement errors in nontraded good prices. The twenty-one symmetry constraints on the cross-price effects are also imposed on the whole system of equations, as well as the over-identifying restrictions due to the extra instruments. We first test for all the homogeneity constraints one at a time. In each case, we constrain the variance-covariance matrix to be that of the unrestricted model. We further test for the overall specification of the system by jointly testing the symmetry constraints (12) and over-identifying restrictions, conditional on all the accepted homogeneity constraints. This is done by comparing the value of criterion function of the restricted model to a just-identified model with no symmetry constraints and no extra instruments.

Table 3 presents the test statistics and the associated p-values of all the hypothesis tests. None of the homogeneity constraints for endowments are rejected, and all industry share equations satisfy the homogeneity constraints in prices. The only violation of homogeneity constraint in prices is for the TFP equation, which we did not impose in the previous estimation. Thus, the results supported our previous specification in terms of the imposed homogeneity constraints.

Conditional on all the satisfied homogeneity constraints, the total number of parameters estimated (excluding country fixed effects) is 178 and the total number of instruments is 264 (33 per each equation). This implies that the number of over-identifying restrictions is 86. This jointly tests the 21 symmetry constraints, as well as 65 over-identifying constraints if the system was just-identified. The minimized value of criterion function of the restricted system with the fixed variance-covariance matrix is 89.4, and given that the value of criterion function of a just-identified system is 0 (see Davidson and MacKinnon, 1993, p. 234), the overall specification of the model is not rejected. The p-value of the test statistics is 0.38. Thus the data support the joint hypotheses of symmetry constraints and over-identifying restrictions. Table 4 also provide separate test statistics for the 21 symmetry constraints and the 65 over-identifying restrictions. In both cases, the individual hypotheses are not rejected.

In summary, not only is the overall specification of the nonlinear 3SLS model not rejected by the data, all the instruments included are also shown to be not related with the regression errors (given that they jointly passed the over-identifying restriction test). Thus, the results presented in Table 2 provide evidence that trade cost variables such as tariffs, distance and transport costs affect country productivity only through export variety, so that variety is the *mechanism* (Hallak and Levinsohn, 2004) through which trade affects country productivity. In the next section, we will further present some direct evidence linking these trade costs variables to export varieties of the industries.

8. Effects of Tariffs and Transport Costs on Export Variety

Table 4 presents least squares (LS) estimation linking export variety to all instruments and exogenous variables of the nonlinear 3SLS system presented in Table 2. This is similar but not identical to the first-stage estimation of the nonlinear system, which involves regressing the derivatives of each equation with respect to the parameters of the system on all the instruments and exogenous variables. For example, differentiating (21b) with respect to $1/(1-\sigma_n)$ we obtain $\frac{1}{2}\left(s_{nt}^{c}+s_{nt}^{*}\right)\ln\lambda_{nt}^{c*}$, which is the export variety index for country c and sector n, times the average share of that industry. In comparison, the regressions we present in Table 4 just use the export variety index $\ln\lambda_{nt}^{c*}$ as a dependent variable, which allows us to see the partial relationships between export variety and the trade cost variables.

The top part of Table 4 shows the effects of a one percentage point increase in the U.S. tariff on the export variety of the industry in the columns. Tariffs are constructed from detailed U.S. custom data by taking the ratio of duties paid over imports. They vary by industries, countries and years. We expect industry export variety to decrease with the own tariff of the industry, while there may exist some positive effects due to reallocation of resources among industries when there is a tariff increase in *other* industries.

All industry export variety indexes are negatively correlated with own tariffs except for the textiles & garments and the electronics industry. For textiles & garments, MFA quotas are known to be more restrictive and binding than tariffs, which may explain the insignificant effect of tariffs on export variety. For the electronics industry, it could be the case that non-tariff barriers, transport costs and skilled labor endowments are more important in explaining expansion in export variety than tariffs. For the rest of the industries, the own tariff effects are all negative and statistically significant. A one percentage point increase in U.S. tariffs lowers export variety by 16.7 percent in the petroleum & plastics industry, at the highest, and 3.7 percent in the mining & basic metals industry, at the lowest. Finally, most industries benefit from tariffs imposed on other industries due to reallocation of productive resources. For example, the textiles & garments industry expands its export variety due to tariffs imposed on agriculture industry and basic metals industry. Tariffs imposed on the basic metals industry also benefits the machinery & transport industry, and the electronics industry. Using these tariff impact estimates, along with the estimates of $1/(1-\sigma_n)$ in Table 2 and the sample average industry shares, we calculate that a 10 percentage point increase in all U.S. tariffs would reduce the exporting country productivity by 2 percent due to the decreases in export variety of the industries. This implies that tariffs are both statistical and economically important in explaining export variety and country productivity.

The next section of Table 4 shows the marginal effects of four trade agreement dummies (CANFTA, NAFTA, CBI and ANDEAN) on export variety. Given that we already control for tariffs, these variables capture the effect of the reduction in non-tariff barriers due to the signing of such agreements on export variety. CANFTA is shown to have positive and significant impact on export variety in textiles & garments, wood & paper, machinery & transport and the electronics industry, while NAFTA is shown to have no significant additional effects on variety. On the other hand, the CBI increases the export variety in agriculture, textiles & garments, machinery & transport, and the electronics industry, while ANDEAN provides for variety expansion in textiles & garments and the petroleum & plastics industry.

The third section of Table 4 focuses on the effects of geography related trade costs variables such as distance (in log of kilometers) and transport costs.[9] In order to allow for transport costs to have different effects on countries that are in different location, we interact transport costs with nearby and far-away country dummies, defined as countries that are less or more than median distance (7,037km) to the U.S. An increase in distance between an export country and the U.S. diminishes the export variety in agriculture, petroleum & plastics and the

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[9] Distance from US is the geographical distance in kilometers between the capitol cities, as obtained from Nicita and Olarreaga (2004).

mining & basic metals industry, while distance does not seem to matter to the export variety in the electronics industry. On the other hand, increases in transport costs reduce export variety in all industries except agriculture. Transport costs are particularly important for the nearby countries exporting textiles & garments, and far-away countries exporting petroleum & plastics products. Transport costs are significant in reducing export variety in the machinery & transport and electronics industries for countries in all locations.

The last section of Table 4 presents the effects of endowment differences in explaining export variety in different industries. These variables are the exogenous variables from the system of share equations and the country productivity equations. All the endowment variables are positive and highly significant. The R^2 values of these regressions range from 0.62 in the agriculture industry to 0.83 in the mining & basic metals industry. Overall, the results presented in Table 4 suggest that all the trade costs variables are important in explaining export variety of the various industries, as well as the endowment variables. This provide empirical support to models such as Eaton and Kortum (2002) and Melitz (2003), where trade costs are shown to determine export variety.

9. Productivity Decomposition

To gain additional insight into the links between export variety and country productivity, we performed a post-regression decomposition of estimated productivity based on the results in Table 2. Using (22), we compute the variance of estimated country TFP as:

$$\begin{aligned}\text{var}(\text{Estimated TFP}_t^c) &= \text{var}(\hat{\alpha}_0^c) + \text{var}\left[\sum_{n=1}^{7} \tfrac{1}{2}\left(s_{nt}^c + s_{nt}^*\right)\frac{\ln \lambda_{nt}^{c*}}{(1-\hat{\sigma}_n)}\right] \\ &\quad + 2\,\text{cov}\left[\hat{\alpha}_0^c, \sum_{n=1}^{7} \tfrac{1}{2}\left(s_{nt}^c + s_{nt}^*\right)\frac{\ln \lambda_{nt}^{c*}}{(1-\hat{\sigma}_n)}\right] + \text{var}(\hat{\varepsilon}_c^t)\,. \qquad (23)\end{aligned}$$

The first term on the right is the variance of country fixed effects, the second is the contribution of export variety constructed as a weighted average across industries, the third is the covariance between these, and the fourth is the error variance. If we remove the country fixed effects and the regression error, then the "variety-induced" country TFP is defined as:

$$\text{Variety-induced TFP}_t^c \equiv \sum_{n=1}^{N} \tfrac{1}{2}\left(s_{nt}^c + s_{nt}^*\right)\frac{\ln \lambda_{nt}^{c*}}{(1-\hat{\sigma}_n)} \ , \tag{24}$$

Taking the first difference of (23) within a country across two years, we can derive the growth decomposition of country productivity into two terms, which is the growth of variety induced country TFP and the change in regression errors:

$$\text{Growth of TFP}_t^c \equiv \sum_{n=1}^{N}\left(\tfrac{1}{2}\left(s_{nt}^c + \hat{s}_{nt}^*\right)\frac{\ln \lambda_{nt}^{c*}}{(1-\hat{\sigma}_n)} - \tfrac{1}{2}\left(s_{nt-1}^c + \hat{s}_{nt-1}^*\right)\frac{\ln \lambda_{nt-1}^{c*}}{(1-\hat{\sigma}_n)}\right) + \left(\hat{\varepsilon}_t^c - \hat{\varepsilon}_{t-1}^c\right). \tag{26}$$

The variance in the growth rate of country TFP is therefore the sum of the variance of the growth rate of variety-induced country TFP, and the variance of the difference in error terms, along with the covariance between the two terms.

Table 5 shows the variance decomposition of country TFP in levels and growth rates. Not surprisingly, most of the cross-country differences in the TFP levels are explained by country fixed effects which is not unusual for this type of cross-country study. Controlling for country fixed effects, variety-induced country TFP can only account for about 2% of the country productivity levels. However, variety-induced TFP and country fixed effects are correlated, which jointly contribute nearly 14% of the cross-country variation in TFP levels. If we set aside country fixed effects, and only focus on variety-induced TFP and regression error terms, then variety-induced TFP can explain 60% of country productivity in levels.

The second column of Table 5 shows the growth decomposition of country productivity. About 13% of the within-country growth in TFP can be explained by the year-to-year growth in export variety, while the remaining part is explained by the change in regression errors and the correlation between the two terms.[10] This suggests that while the overall productivity differences across countries are mainly explained by country fixed effects, export variety nonetheless is important in explaining within country productivity differences in levels and growth rates.

To further illustrate the effects of export variety on country productivity, according to (24) a 1% increase in the export variety of each industry n would increase country productivity by $\frac{1}{2}\left(s_{nt}^{c} + s_{nt}^{*}\right)\frac{1}{(1-\hat{\sigma}_n)}$ percent. Thus, we can compute that at the sample mean, a 10% increase in export varieties of all industries could lead to 1.3% increase in country productivity. This effect is significant both statistically and economically.

Figures 3 and 4 plot the partial scatter graph of the country TFP against the export variety in level and in growth respectively (conditional on country fixed effects and regression errors). It is evident that holding all else constant, export variety has significant explanatory power for the variation of the country productivity differences, both in level across countries and in growth within countries.

Figure 5 presents a cross country scatter plot of the country TFP against export variety in 1991. Both variables are shown in deviation from their sample means. There is a clear positive relationship between the export variety of a country and its productivity, which is highlighted by the positive sloping regression line. Canada has the most export variety which is twice as much as the sample mean. In terms of the productivity differences, Canada is 42% higher than the sample mean. Japan has the highest productivity which is 77% higher than the sample mean. In

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[10] Similar results are obtained when we express the productivity growth decomposition using Tornqvist approximation, rather than first different as in (26). Contribution of variety growth to the growth country TFP is around 10%.

terms of export variety, an industry in Japan produces 83% more export products than the sample mean.

Other countries that have higher than productivity and export variety in Figure 5 include South Korea, Singapore, and some other OECD countries such as Britain, France, Italy and Australia. These countries appear on the first quadrant. Countries that perform poorly in terms of the country productivity and export variety are in the third quadrant. They include Uruguay, Kenya, Turkey, and the Philippines. For example, export industries in Uruguay produces 179% less variety than the sample mean, and its productivity is 84% lower. We can also compare country pairs from the figure. For instance, in 1991, Singapore produces 60% more export products than the Philippines, and the productivity of Singapore is about twice as high as that of the Philippines.

We further explore the movement of export variety and productivity within a country over time. Figure 6 compares Canada to the sample mean in terms of productivity, variety-induced productivity differences, and the weighted-average export variety, from 1985 to 1997. The two productivity series are presented in bars relative to the left-hand scale. The export variety index is shown as a line in the figure, measured relative to the vertical right-hand scale. In 1985, Canada's productivity is 14% higher than the sample mean, while it produces 93% more export products relative to the sample mean. In 1997, the productivity gap reduces to 7% while the export variety difference is about 62%. Thus over the years, we see a gradual decline of export variety in Canada relative to the rest of the world and this is reflected in the productivity series.

Figure 7 compares Japan to South Korea. Similar to the previous figure, the two productivity series are presented in bars relative to on left-hand scale. The export variety index is shown as a line in the figure, relative to the right-hand scale. The line series shows that, in 1982, industries in Japan produced 50% more export variety than South Korea. The Japanese advantage over Korea deteriorates over time such that in 1995, an industry in Japan produced only 20% more variety than Korea. On the other hand, the first bar series shows that, over the same period of time, the underlying TFP advantage of Japan declines from 20% to near zero. Thus, with Korea catching up in export variety, the underlying productivity gap between Korea and Japan is also narrowing.

A similar comparison can be done for Israel and Greece, as shown in Figure 8. In 1985, Israel produced 30% more export variety than in Greece, and by 1995, the advantage of Israel over Greece widens to nearly 90%. On the other hand, with a negative 4% TFP difference, in 1982 Israel was less productive than Greece, but by 1995, Israel had became about 10% more productive than Greece. Thus, there is a positive correlation between the observed export variety difference and the country productivity difference, as predicted by the variety-induced productivity difference, the second bar series in the figure.

10. Conclusions

Existing analyses of export variety and growth have been restricted to a limited range of countries (e.g. Feenstra et al, 1999), or a single aggregate measure of export variety correlated with GDP (Funke and Ruhwedel, 2001a,b, 2002). In this paper we have attempted to improve the estimation of product variety on country productivity by allowing for multiple sectors, and introducing export varieties into the GDP function. In exploiting the translog GDP function we are following Harrigan (1997), who hypothesized that export prices would differ across countries due to total factor productivity in exports. We have used the industry CES price indexes that differ across countries due to export variety, and enter as “price effects” into the GDP function and sectoral share equations. Estimating the share equations simultaneously with the GDP equation (transformed to become relative country productivity) allows us to identify and estimate the elasticity of substitution σ_n between export varieties in each sector, and then infer the contribution of export variety to country productivity.

The resulting elasticity estimates range from a low of -0.02 in the electronics industry, to a high of –2 in the agriculture industry and the petroleum & plastics industry. Because these are the elasticity of substitution between *outputs* (measuring the curvature of the concave production possibilities frontier), we have less intuition about the magnitude of the expected estimates than for inputs. But the ranking we have obtained seems reasonable, since there is the least substitution between export varieties in electronics, and the greatest substitution between varieties within agriculture and petroleum & plastics. In electronics, the estimate of -0.02 indicates that a 10% expansion of product varieties has the same effect as a 10/1.02 = 9.8% increase in prices, in terms of drawing resources into that sector. For agriculture and petroleum, however, a 10% increase in product variety has the same effect as a 10/3 = 3.3% rise in prices, since these products are more highly substitutable in terms of production.

We have treated export variety as an endogenous variable, and as instruments use those suggested by the work of Eaton and Kortum (2002) and Melitz (2003): tariffs, transport costs and distance. By using an over-identifying restriction test on the nonlinear system estimation, we have also been able to test the important exclusion restriction suggested by these models, that tariffs and transport costs should not have an impact on productivity except through export variety. This restriction cannot be rejected, and confirms the importance of export variety as the mechanism (Hallak and Levinsohn, 2004) by which trade affects productivity. Our results also show that a 10 percentage point increase in U.S. tariffs would lead to a 2% fall in exporting countries' productivity, which indicates that tariffs are statistically and economically important in affecting productivity via export variety.

Finally, we have also calculated the impact of export variety differences across countries on their respective productivities. Not surprisingly, country fixed effects in a panel regression still account for the vast majority of country productivity differences, so that export variety explains only 2% of the total variation in country productivity. But setting aside country fixed effects, export variety can explain 60% of the residual productivity differences, as well as 13% of the within-country productivity growth. Moreover, at the sample mean, a 10% increase in export varieties of all industries leads to a 1.3% increase in country productivity. By considering specific pairs of countries over time, we have also traced out quite plausible patterns between changes in export varieties and changes in country productivities. These patterns confirm the importance of export variety in explaining county productivity.

References

Bernard, Andrew, Jonathan Eaton, J. Bradford Jensen and Samuel Kortum (2003) “Plants and Productivity in International Trade,” *American Economic Review*, 93, September, 1268-1290.

Broda, Christian and David Weinstein (2003) “Globalization and the Gains from Variety,” Federal Reserve Bank, New York and Columbia University.

Diewert, W. Erwin and Catherine J. Morrison (1986) “Adjusting Outputs and Productivity Indexes for Changes in the Terms of Trade,” *Economic Journal,* 96, 659-679.

Davidson, Russell and James MacKinnon (1993) *Estimation and Inferences in Econometrics*, Oxford University Press.

Eaton, Jonathan and Samuel Kortum (2002) “Technology, Geography and Trade,” *Econometrica,* 70(5), September, 1741-1780.

Eaton, Jonathan, Samuel Kortum and Francis Kramarz (2003) “An Anatomy of International Trade: Evidence from French Firms,” unpublished, CREST, University of New York and University of Minnesota.

Eaton, Jonathan, Samuel Kortum and Francis Kramarz (2004) “Dissecting Trade: Firms, Industries, and Export Destinations,” *American Economic Review*, 94(2), 150-154.

Feenstra, Robert C. (1994) “New Product Varieties and the Measurement of International Prices,” *American Economic Review*, 84(1), 157-177.

Feenstra, Robert C. (2004) *Advanced International Trade: Theory and Evidence.* Princeton University Press.

Feenstra, Robert C. and Hiau Looi Kee (2004) “On the Measurement of Product Variety in Trade," *American Economic Review*, 94(2), 145-149.

Feenstra, Robert C., Dorsati Madani, Tzu-Han Yang, and Chi Yuan Liang (1999), “Testing Endogenous Growth in South Korea and Taiwan,” *Journal of Development Economics,* 60, 317-341.

Funke, Michael and Ralf Ruhwedel (2001a) “Product Variety and Economic Growth: Empirical Evidence from the OECD Countries,” *IMF Staff Papers,* 48(2), 225-242.

Funke, Michael and Ralf Ruhwedel (2001b) “Export Variety and Export Performance: Evidence from East Asia,” *Journal of Asian Economics,* 12, 493-505.

Funke, Michael and Ralf Ruhwedel (2002) “Export Variety and Export Performance: Empirical Evidence for the OECD Countries,” *Weltwirtschaftliche Archiv,*138(1), 97-114.

Funke, Michael and Ralf Ruhwedel (2003) “Trade, Product Variety and Welfare: A Quantitative Assessment for the Transition Economies in Central and Eastern Europe,” BOFIT Discussion Paper no. 17, Bank of Finland.

Grossman, Gene M. and Elhanan Helpman (1991) *Innovation and Growth in the Global Economy.* MIT Press: Cambridge, MA.

Hallak, Juan Carlos and James Levinsohn (2004) “Fooling Ourselves: Evaluating the Globalization and Growth Debate,” NBER working paper no. 10244.

Harrigan, James (1997) “Technology, Factor Supplies, and International Specialization: Estimating the Neoclassical Model,” *American Economic Review,* 87(3), 475-494.

Hausman, J. (1983) “Specification and Estimation of Simultaneous Equation Models,” in Z. Griliches and M. Intriligator, eds., *Handbook of Econometrics*, Amsterdam: North Holland.

Helpman, Elhanan, Marc Melitz and Stephen Yeaple (2004) “Exports vs. FDI with Heterogeneous Firms,” *American Economic Review*, March, 300-316.

Hummels, David and Peter Klenow (2002) “The Variety and Quality of a Nation’s Trade,” NBER working paper no. 8712.

Melitz, Marc J. (2003) “The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity,” *Econometrica,* 71(6),1695-1725.

Nicita, Alessandro and Marcelo Olarreaga (2004) “Exports and Information Spillovers,” the World bank.

Romer, Paul (1990) “Endogenous Technological Change,” *Journal of Political Economy* 98(5), pt. 2, October, S71-S102.

Sato, Kazuo (1976) “The Ideal Log-Change Index Number,” *Review of Economics and Statistics* 58, May, 223-228.

Vartia, Y.O. (1976) “Ideal Log-Change Index Numbers”, *Scandinavian Journal of Statistics* 3, 121-126.

Table 1: Dependent Variables - Industry Shares in Columns (1) to (7), and Adjusted TFP in Column (8)

Estimation method: Iterative Seemingly Unrelated Regressions
Total system observations: 2736
Observations per equation: 342

	Independent Variables:	(1) Agriculture	(2) Textiles & Garments	(3) Wood & Paper	(4) Petroleum & Plastics	(5) Mining & Basic Metals	(6) Machinery & Transports	(7) Electronics	(8) Adj. TFP
Log of Relative Export Variety in:	Agriculture	**0.038*****	-0.005	-0.017***	0.010**	-0.019***	-0.005*	-0.001	0.303***
		(0.010)	(0.004)	(0.006)	(0.004)	(0.005)	(0.003)	(0.001)	(0.076)
	Textiles & Garments	-0.005	**0.068*****	-0.039***	-0.018***	0.007***	-0.009***	-0.004**	0.282***
		(0.004)	(0.010)	(0.008)	(0.005)	(0.002)	(0.003)	(0.002)	(0.043)
	Wood & Paper	-0.017***	-0.039***	**0.102*****	-0.042***	-0.004*	0.005	-0.004*	0.233***
		(0.006)	(0.008)	(0.013)	(0.006)	(0.002)	(0.003)	(0.002)	(0.031)
	Petroleum & Plastics	0.010**	-0.018***	-0.042***	**0.051**	0.005***	0.002	-0.005**	0.091***
		(0.004)	(0.005)	(0.006)	-	(0.002)	(0.003)	(0.002)	(0.015)
	Mining & Basic Metals	-0.019***	0.007***	-0.004*	0.005***	**0.015*****	-0.006***	0.001	0.788***
		(0.005)	(0.002)	(0.002)	(0.002)	(0.004)	(0.002)	(0.001)	(0.217)
	Machinery & Transports	-0.005*	-0.009***	0.005	0.002	-0.006***	**0.005**	0.009***	0.516***
		(0.003)	(0.003)	(0.003)	(0.003)	(0.002)	(0.003)	(0.003)	(0.130)
	Electronics	-0.001	-0.004**	-0.004*	-0.005**	0.001	0.009***	**0.005*****	1.030***
		(0.001)	(0.002)	(0.002)	(0.002)	(0.001)	(0.003)	(0.002)	(0.359)
Log of Relative:	Labor-Land Ratio	-0.004***	0.004***	-0.004***	0.007***	0.006***	-0.003***	0.005***	
		(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	
	Capital-Land Ratio	0.002	-0.002**	0.004***	-0.004***	-0.005***	0.007***	0.002**	-0.107***
		(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.023)
	Non-Traded Goods Prices								0.214***
									(0.006)
	Year Fixed-Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Country Fixed-Effects								Yes
	R-squared	0.3396	0.3804	0.4614	0.1916	0.4217	0.5897	0.5976	0.9980

Note: For columns (1) to (7), each log of relative export variety coefficient is the partial price effect of the industry in that row on the share of the industry in the column. These are the point estimates of the gamma's. Own price effects are in bold.
For column (8), each log of relative export variety coefficient is the point estimate of 1/(1-sigma) of the industry in that row.
*, **, and *** indicate significance at 90%, 95%, and 99% confidence levels respectively, and White-robust standard errors are in parentheses.

Table 2: Dependent Variables - Industry Shares in Columns (1) to (7), and Adjusted TFP in Column (8)

Estimation method: Three Stage Least Squares Regressions

Total system observations: 2736

Observations per equation: 342

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Independent Variables:	Agriculture	Textiles & Garments	Wood & Paper	Petroleum & Plastics	Mining & Basic Metals	Machinery & Transports	Electronics	Adj. TFP
Log of Relative Export Variety in:	Agriculture	**0.062****	-0.015**	-0.008	-0.013*	-0.016*	-0.002	0.002	0.324**
		(0.026)	(0.008)	(0.013)	(0.007)	(0.009)	(0.006)	(0.005)	(0.143)
	Textiles & Garments	-0.015**	**0.051****	-0.054*	0.005	0.019*	-0.015*	0.012*	0.589**
		(0.008)	(0.023)	(0.029)	(0.005)	(0.011)	(0.009)	(0.007)	(0.264)
	Wood & Paper	-0.008	-0.054*	**0.133****	-0.018	-0.039**	0.038*	-0.048**	0.599**
		(0.013)	(0.029)	(0.065)	(0.013)	(0.019)	(0.022)	(0.024)	(0.267)
	Petroleum & Plastics	-0.013*	0.005	-0.018	**0.040****	0.002	-0.010	0.004	0.336**
		(0.007)	(0.005)	(0.013)	(0.017)	(0.004)	(0.007)	(0.005)	(0.145)
	Mining & Basic Metals	-0.016*	0.019*	-0.039**	0.002	**0.035****	-0.016*	0.012	0.611**
		(0.009)	(0.011)	(0.019)	(0.004)	(0.016)	(0.010)	(0.008)	(0.273)
	Machinery & Transports	-0.002	-0.015*	0.038*	-0.010	-0.016*	**0.004**	0.009	0.635**
		(0.006)	(0.009)	(0.022)	(0.007)	(0.010)	(0.010)	(0.008)	(0.249)
	Electronics	0.002	0.012*	-0.048**	0.004	0.012	0.009	**0.018***	0.977**
		(0.005)	(0.007)	(0.024)	(0.005)	(0.008)	(0.008)	(0.010)	(0.448)
Log of Relative:	Labor-Land Ratio	-0.002	0.004***	-0.004	0.005***	0.006***	-0.002	0.007***	
		(0.002)	(0.001)	(0.002)	(0.002)	(0.001)	(0.002)	(0.001)	
	Capital-Land Ratio	0.000	-0.003**	0.004**	-0.004**	-0.004***	0.005***	0.000	0.000
		(0.002)	(0.001)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.110)
	Non-Traded Goods Prices								0.262***
									(0.022)
	Year Fixed-Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Country Fixed-Effects								Yes
	R-squared	0.2760	0.2710	0.2397	0.1072	0.2221	0.4779	0.4999	0.9562

Note: For (1) to (7), each coefficient of the log of relative export variety in the row industry is the partial price effect of that industry on the share of the column industry. These are the point estimates of gamma's. Own price effects are in bold.

For (8), each coefficient of the log of relative export variety in the row industry is the point estimate of 1/(1-sigma) of that industry.

*, **, and *** indicate significance at 90%, 95%, and 99% confidence levels respectively, and White-robust standard errors are in parentheses.

Instruments: effective tariffs, trade agreement dummies (CANFTA, NAFTA, CBI, ANDEAN), distance, average transport cost interacts with distance dummies, relative land, labor and capital endowments.

Table 3: Hypothesis Testing

Null Hypothesis	Homogeneity in Endowments	Homogeneity in Prices	Symmetry in Cross Price Effects	Over-identifying Restrictions	Overall Specification
Degree of Freedom	1	1	21	65	86
Critical Value at 95%	3.841	3.841	32.671	84.821	108.648
Overall System			28.179 (0.135)	58.202 (0.712)	89.432 (0.379)
Agriculture	0.367 (0.544)	0.427 (0.514)			
Textiles & Garments	0.888 (0.346)	0.011 (0.916)			
Wood & Paper	0.548 (0.459)	0.552 (0.458)			
Petroleum & Plastics	0.571 (0.450)	0.612 (0.434)			
Mining & Basic Metals	0.435 (0.510)	0.440 (0.507)			
Machinery & Transports	0.519 (0.471)	0.516 (0.473)			
Electronics	0.391 (0.532)	0.422 (0.516)			
GDP Function	2.140 (0.144)	554.986*** (0.000)			

Notes: All test statistics are asymptotically Chi-squared distributed with degree of freedom equals number of restrictions. Numbers in parentheses denote p-value of the test statistics.

Table 4: Dependent Variables - Export Variety Index

Estimation method: Ordinary Least Squares

Observations per equation: 342

		Eq (1)	Eq(2)	Eq(3)	Eq(4)	Eq(5)	Eq(6)	Eq(7)
	Independent Variables:	Agriculture	Textiles & Garments	Wood & Paper	Petroleum & Plastics	Mining & Basic Metals	Machinery & Transports	Electronics
Log of 1+ Effective Tariff of :	Agriculture	**-7.901*****	4.362***	-3.790***	-7.426***	-2.153*	-0.747	-2.878*
		(1.269)	(1.007)	(1.309)	(2.319)	(1.292)	(1.795)	(1.675)
	Textiles & Garments	-0.899	**0.088**	-2.318***	-1.947	-0.750	-3.321***	-3.645***
		(0.662)	(0.525)	(0.683)	(1.210)	(0.674)	(0.937)	(0.874)
	Wood & Paper	1.336	0.534	**-5.053*****	3.198	-4.919***	-2.629	-1.334
		(1.709)	(1.356)	(1.763)	(3.123)	(1.740)	(2.417)	(2.255)
	Petroleum & Plastics	-7.938***	1.066	0.652	**-16.707*****	0.977	3.659*	0.836
		(1.551)	(1.231)	(1.600)	(2.835)	(1.579)	(2.195)	(2.047)
	Mining & Basic Metals	3.048**	4.248***	3.742**	-0.236	**-3.678****	7.713***	7.774***
		(1.494)	(1.186)	(1.541)	(2.730)	(1.521)	(2.114)	(1.972)
	Machinery & Transports	0.968	-1.885	-3.507*	-0.650	-6.680***	**-14.716*****	-9.127***
		(1.904)	(1.510)	(1.964)	(3.478)	(1.938)	(2.693)	(2.512)
	Electronics	1.085	-1.869	9.095***	4.396	9.690***	12.928***	**12.279*****
		(2.067)	(1.640)	(2.132)	(3.777)	(2.104)	(2.924)	(2.728)
Dummy Variable for:	Canada-US Trade Agreement	0.233	0.346**	0.445**	-0.423	0.228	0.542**	0.842***
		(0.174)	(0.138)	(0.179)	(0.318)	(0.177)	(0.246)	(0.230)
	North America Free Trade Agreement	0.131	0.073	-0.024	-0.132	-0.026	0.021	-0.104
		(0.194)	(0.154)	(0.200)	(0.355)	(0.198)	(0.275)	(0.256)
	Caribbean Basin Initiative	0.731***	0.613***	0.078	-0.356	-0.405***	0.366*	0.329*
		(0.136)	(0.108)	(0.140)	(0.248)	(0.138)	(0.192)	(0.179)
	ANDEAN	0.256	0.383***	-0.027	0.662**	-0.395**	-0.227	-0.209
		(0.181)	(0.144)	(0.187)	(0.331)	(0.185)	(0.256)	(0.239)
	Log of Distance	-0.219***	-0.031	-0.049	-0.348***	-0.101**	-0.072	0.140**
		(0.050)	(0.040)	(0.051)	(0.091)	(0.051)	(0.070)	(0.066)
	Transport Cost of Close-by Country	2.088**	-2.283***	-0.911	-2.462	-1.413	-6.591***	-5.455***
		(0.998)	(0.792)	(1.030)	(1.824)	(1.016)	(1.412)	(1.318)
	Transport Cost of Far-away Country	2.868**	-1.174	-1.573	-6.116***	-1.576	-5.560***	-6.592***
		(1.155)	(0.917)	(1.192)	(2.111)	(1.176)	(1.634)	(1.525)
Log of :	Labor-Land Ratio	0.191***	0.136***	0.216***	0.256***	0.049	0.163***	0.224***
		(0.036)	(0.028)	(0.037)	(0.065)	(0.036)	(0.050)	(0.047)
	Capital-Land Ratio	0.125***	0.064**	0.140***	0.302***	0.426***	0.306***	0.071*
		(0.032)	(0.026)	(0.033)	(0.059)	(0.033)	(0.045)	(0.042)
	Difference in Land	0.278***	0.179***	0.273***	0.489***	0.489***	0.397***	0.175***
		(0.022)	(0.018)	(0.023)	(0.041)	(0.023)	(0.031)	(0.029)
	Years	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	R-squared	0.6193	0.6195	0.6480	0.6502	0.8268	0.7628	0.6264

Note: All figures in bold are the own partial effects of effective tariffs. Standard errors are in parentheses.

Effective tariffs are the ratios of duties paid over industry exports.

Transport costs are the ratios of freight and insurance in custom values.

*, **, and *** indicate significance at 90%, 95%, and 99% confidence levels respectively.

Table 5: Productivity Decompositions

	Level Decomposition (in % of TFP)	Growth Decomposition (in % of TFP)
Variance of Estimated Country TFP	0.2592 (100)	0.0016 (100)
Variance of Country Fixed Effects	0.2157 (83.2)	-
Variance of Variety Induced TFP	0.0047 (1.8)	0.0002 (13.1)
2*Covariance between Country Fixed Effects and Variety Induced TFP	0.0356 (13.8)	

Source: Authors calculation based on regression results of Tables 2.

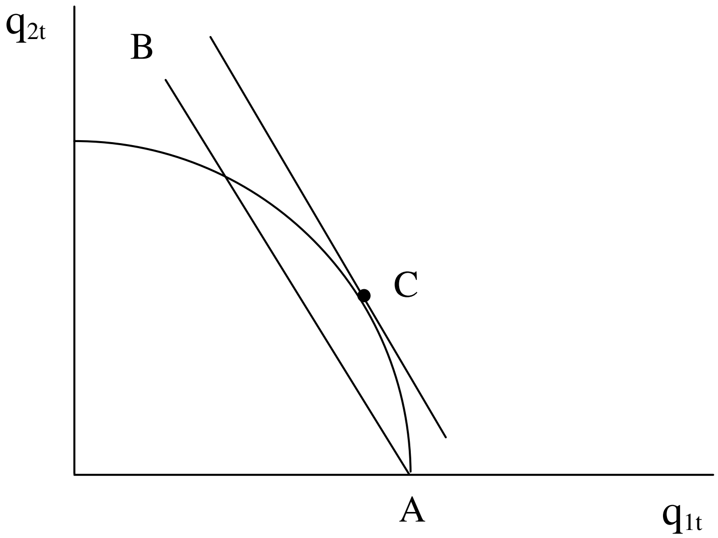

Figure 1: Output Varieties

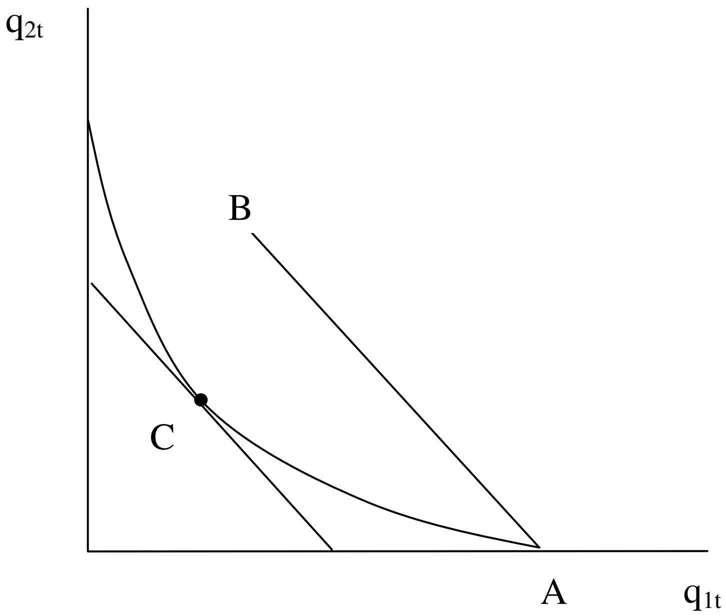

Figure 2: Input Varieties

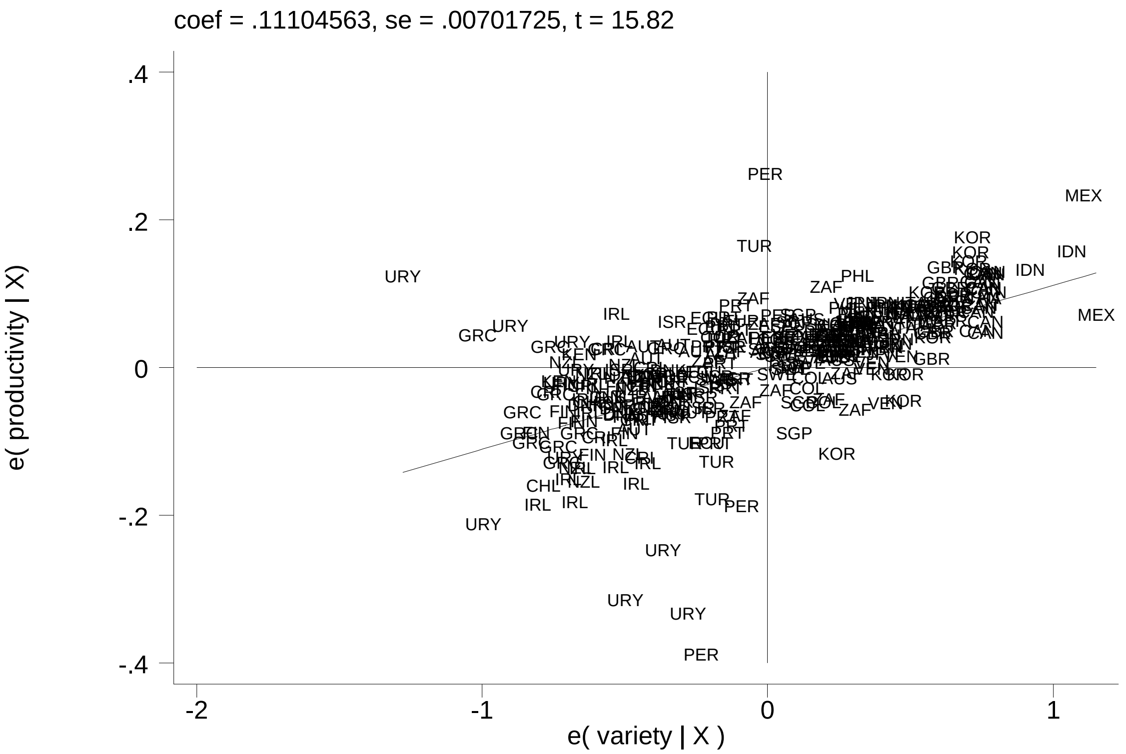

Figure 3: Country Productivity versus Average Variety

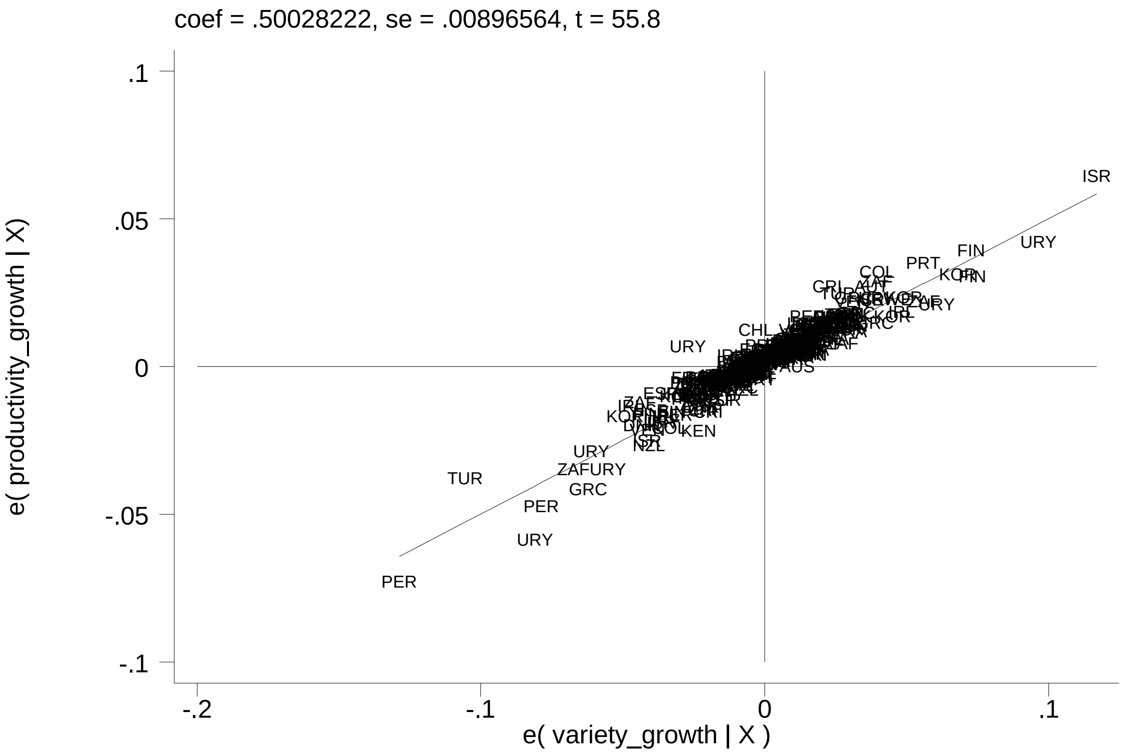

Figure 4: Productivity Growth versus Variety Growth

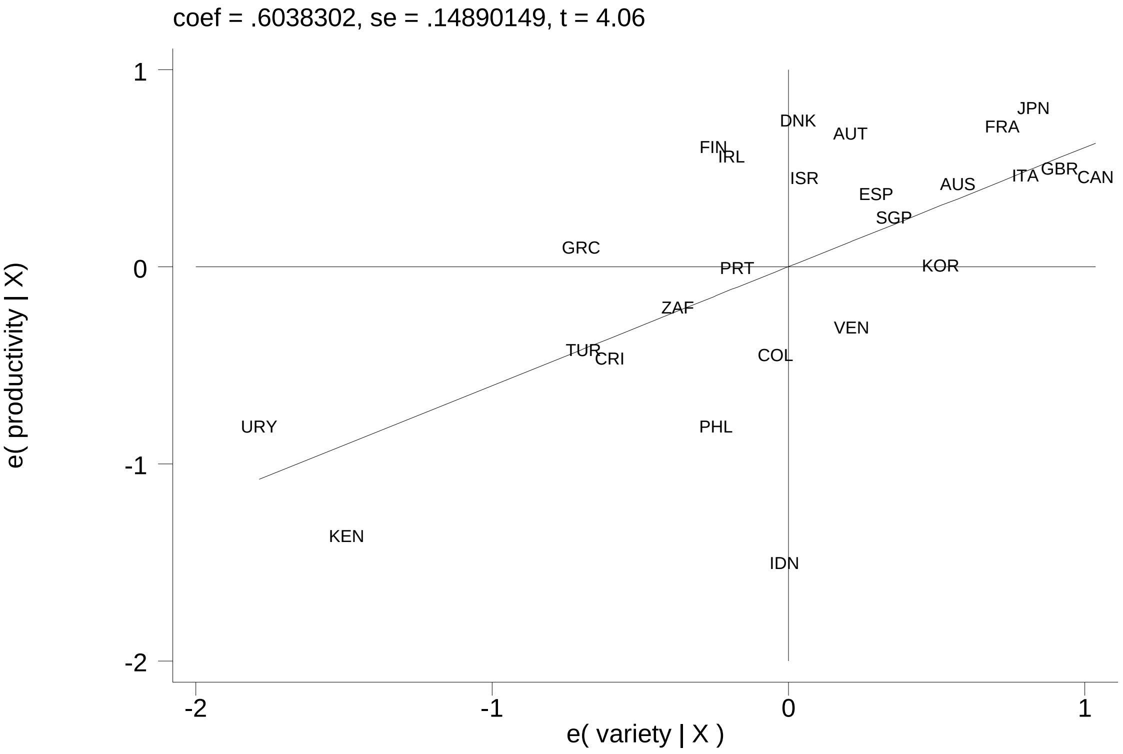

Figure 5: Productivity Differences versus Product Variety Differences, 1991

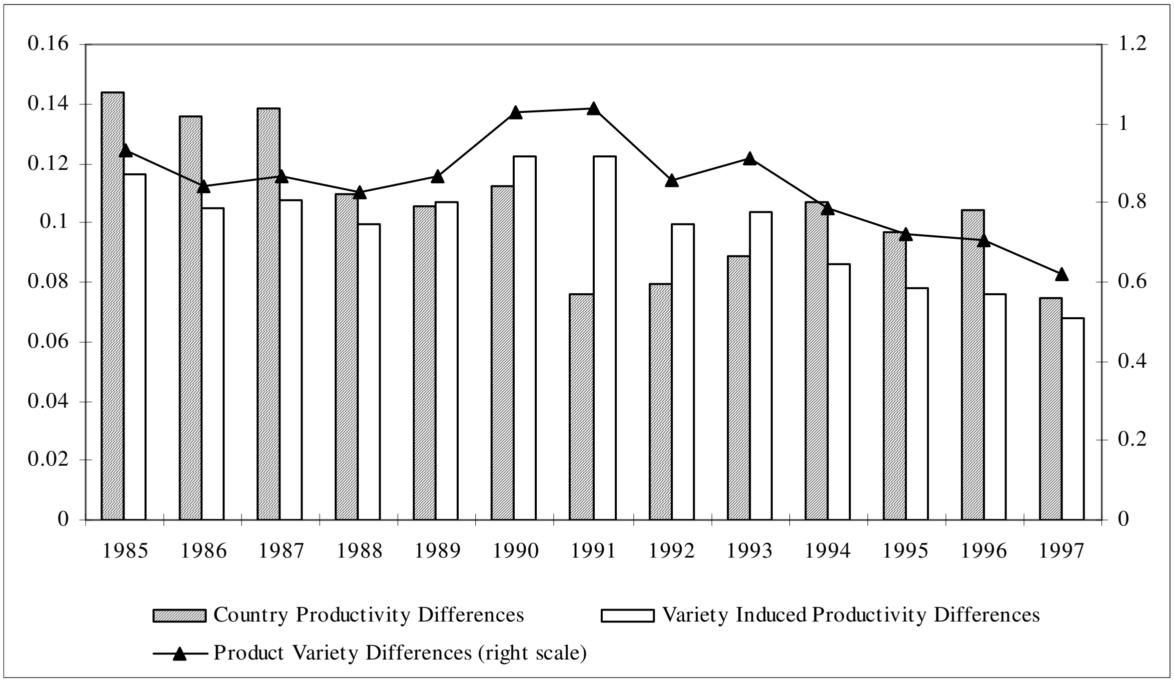

Figure 6: Canada compared to Sample Mean

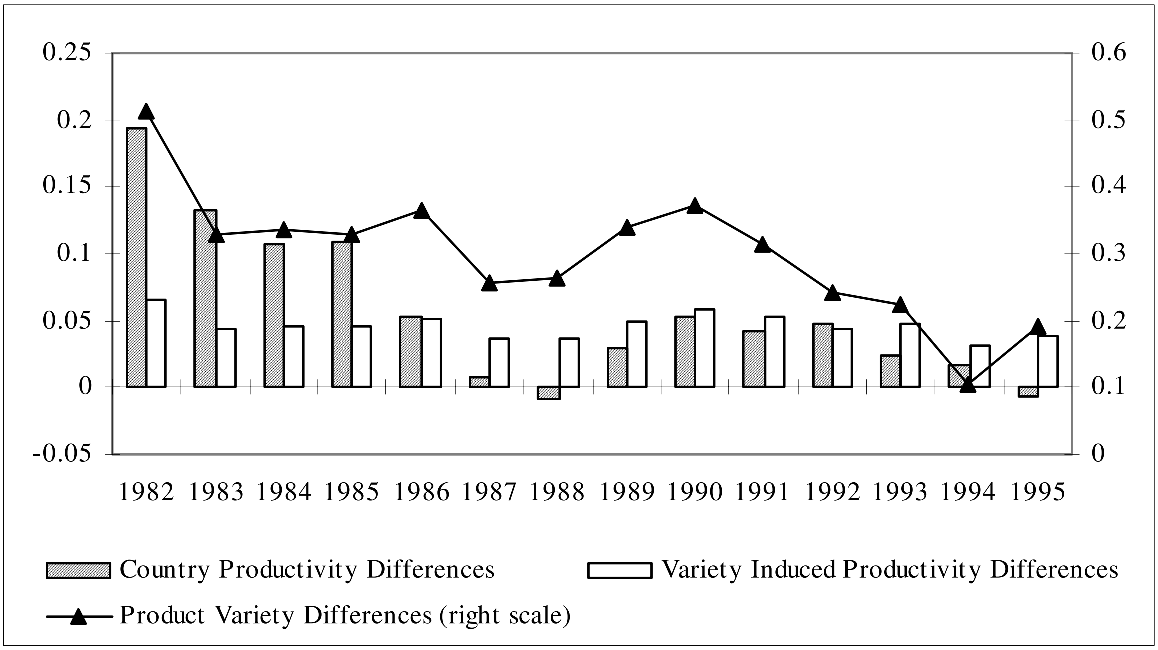

Figure 7: Japan Compared to South Korea

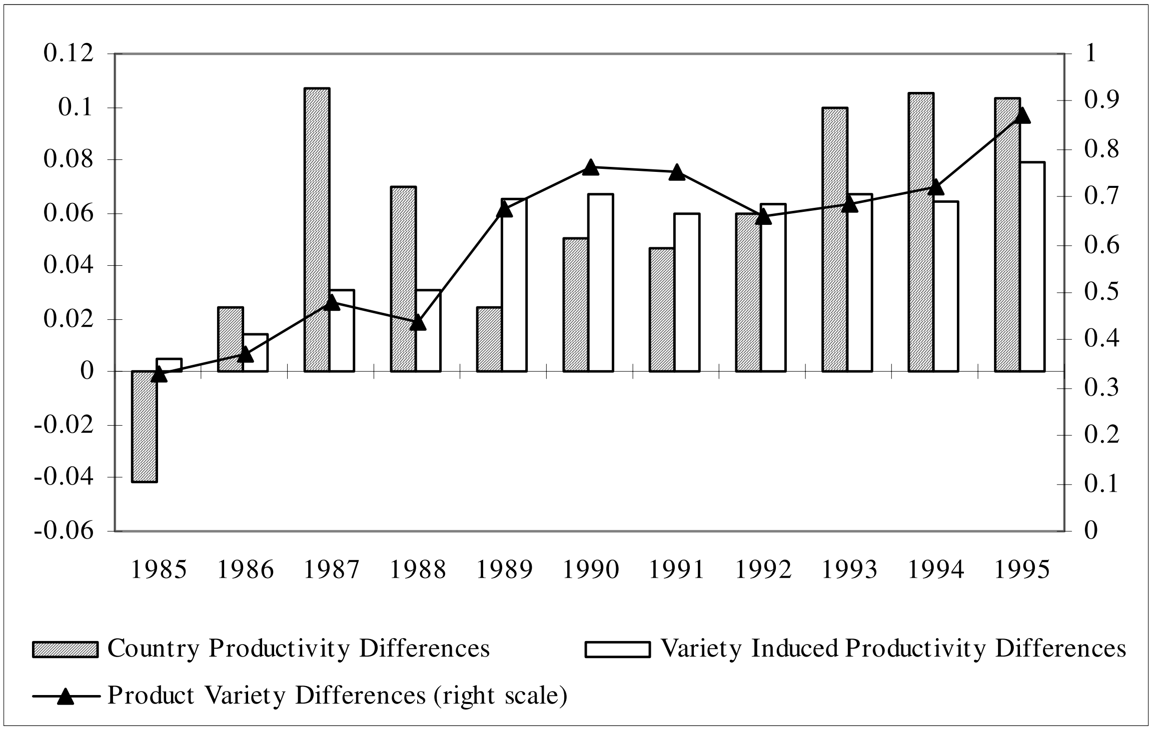

Figure 8: Israel Compared to Greece