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Putting Things in Order: Patterns of Trade Dynamics and Growth

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PUTTING THINGS IN ORDER:
PATTERNS OF TRADE DYNAMICS
AND GROWTH

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Putting Things in Order: Patterns of Trade Dynamics and Growth

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Abstract

We develop a procedure to rank-order countries and commodities using dis-aggregated American imports data. We find strong evidence that both countries and commodities can be ranked, consistent with the "product cycle" hypothesis. Countries habitually begin to export goods to the United States according to an ordering; goods are also exported in order. We estimate these orderings using a semi-parametric methodology which takes account of the fact that most goods are not exported by most countries in our sample. Our orderings seem sensible, robust and intuitive. For instance, our country rankings derived from dis-aggregated trade data, turn out to be highly correlated with macroeconomic phenomena such as national productivity levels and growth rates.

I: Introduction

This paper has two goals. The first is methodological; we develop techniques to estimate rank-orderings **from** large dis-aggregated panel data sets. We apply these **techniques** to rank **commodities**, using the order in which they are exported to the United States. The "product cycle" hypothesis of **international** trade suggests that there is an ordering of commodities that a country develops, and begins to export. Country-rankings can be estimated in a comparable fashion. Our methodology accounts for the fact that observations may be **missing** in a non-**random** fashion.

The second objective of this paper is to ask whether countries can be ranked in a **meaningful** way using trade data. Since some theories of international **trade** suggest such **rankings**, we are interested in whether countries can actually be ordered in a systematic and sensible way. We find that they can, providing evidence consistent with the product cycle **hypothesis**. We also investigate the relationships between our country **rankings** and macroeconomic phenomena such as national growth-rates and productivity levels. Our **rankings** (estimated solely with dis-aggregated bilateral trade data) turn out to be closely linked with both **productivity levels** and growth rates. Countries which are "advanced in the sense that they export commodities early, also tend to have both high productivity levels **and** fast growth rates.

Our empirical methods are motivated by the trade and growth **models** in **Grossman** and **Helpman** (1991), which we briefly outline below in section II. After a discussion of our data set, in **section IV** we **develop** a **statistical** methodology to estimate rankings. We then apply our techniques in **section V**, which contains a discussion of empirical results. We estimate and **analyze rankings** for both commodities and countries, and link these to **per-capital** productivity

levels and growth rates. We conclude with a brief discussion of ways in which our analysis **can** be extended. Proofs are provided in the Appendix.

II: Economic Framework

Our work **lies** within the framework of the "product cycle," due to Vernon (1966). Building on the **framework** of endogenous growth, much work has been done recently on models of international trade with dynamic product markets. A comprehensive treatment of these models is provided by **Grossman and Helpman (1991)**, who have linked growth to models of international trade with dynamic product markets.

While the theoretical work often predicts that trade will have dynamic effects over and **above** the static gains from specialization, the empirical evidence points to only a limited role for **trade** in influencing growth. For instance, Frankel and Romer (1996) have introduced "openness" (**measured** by trade relative to GDP) into the extended Solow growth model, and found that while its estimated impact on growth is positive and significantly different **from** zero, it is sometimes just barely so. In this paper we will provide stronger evidence of the link between trade and growth, using a new measure of export orientation. Rather than looking at aggregate measures of openness, such as those considered by **Frankel and Romer (1996)** or **Sachs and Warner (1995)**, **we** instead consider the dis-aggregate trade patterns of countries, and how they evolve over time.

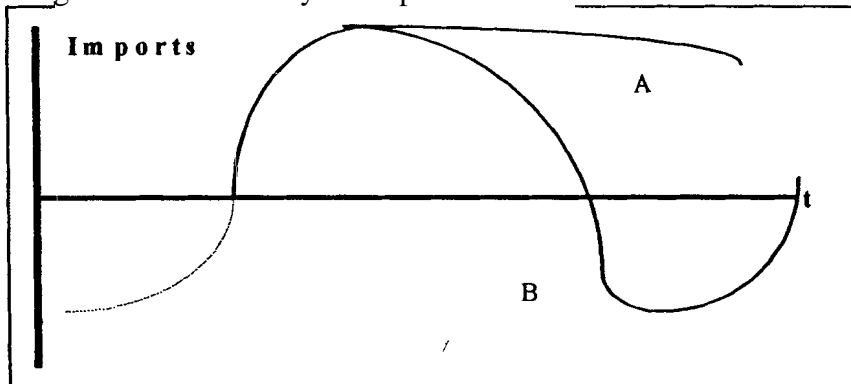
Grossman and Helpman set out two **formalized** models of the product cycle. The first **relies** on the **familiar Krugman** model of intra-industry trade with imperfect substitutes sold by monopolistic competitors. Northern countries innovate by producing new varieties of horizontally differentiated goods. Southern countries eventually imitate these new goods and **begin** to export them to the North, taking advantage of lower costs. In this model, once Southern

countries begin to export a good to the North, Northern production ceases. This is illustrated as case "A" in Diagram 1.

The second model considered by Grossman and Helpman relies on their "quality ladder" model of continued innovation in the same industry. As an example, suppose the Northern country sells and exports personal computers. Eventually the technology is cloned and Southern clones drive the more expensive Northern PCs out of the market. But as North innovates by moving to superior machines based on the next generation of computer chip, the clone manufacturers lose their export base and the North begins to export again. Here, exports by the South are recurring and cyclic; case "B" in Diagram 1.

We are not certain which model of the product cycle best characterizes the data, if indeed there is any evidence of a product cycle at all. Therefore, we rely initially only on a single datum for each country-commodity observation. In particular, we exploit "the year of first export"; the year in which the country in question first exported the commodity in question to the US.¹ This datum does not depend on whether the good is subject to continued quality changes.

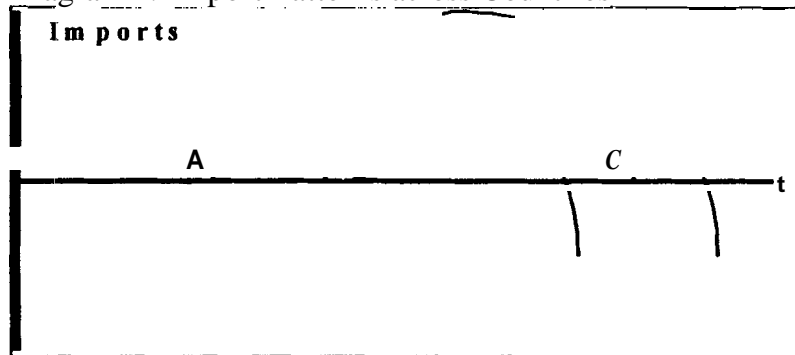
Diagram 1: Product Cycle Import Patterns



¹ In future work, we plan to check the sensitivity of the use of "the year of first import." A number of perturbations are natural. First, one could use the first year that imports reach a given size either in terms of dollars, or as a fraction of the (partner-country) export base. Second, one could use the first time cumulative imports reach a given size.

The intuition behind our technique for rank-ordering both commodities and countries is simple. We assume that goods that are exported earlier are *less "advanced"* than goods exported later. In Diagram 2, product "A" is exported before "B", which in turn **precedes** "C". Thus, the **ranking** of goods in the order they are exported provide a measure of their "sophistication"; we would rank "A" the least advanced good, **followed** by "B", then "C". Alternatively, for each commodity, we consider the order at which *countries* first begin exporting that good (simply consider "A", "B", and "C" to be countries exporting a given good in Diagram 2). Countries that begin exporting earlier are considered to be *more "advanced"* than those exporting later.

Diagram 2: Import Patterns across Countries



To formalize this idea somewhat, let $i=1, \dots, N$ denote the set of **commodities**, and let the (unobserved) rank order of their sophistication be X_i . That is, X_i is a set of integers running from 1 to N , indicating the order that we expect goods to be developed and exported. We do not observe X_i , but instead observe the actual rank-order by year of export, **denoted** by x_{ik} for countries $k=1, \dots, M$. We would **not** expect these orders to be identical to X_i : even in the models of **Grossman** and **Helpman**, a Southern country that adapts a technology **from** the North will generally have a range of possible goods that it can choose from, and it does not necessarily adapt in the same order that goods were developed in the North. The similarity between these **rankings**

in theory will depend on characteristics of the goods (whether they are vertically or horizontally differentiated) and of the countries in question (such as the **difference** in their factor prices, as in **Grossman and Helpman's** "wide gap" and "narrow gap" cases).

We model the imperfect correlation between the ranks x_{ik} and X_i by supposing that there is an integer-value $\rho_k N$ of the observations for which they are equal, **while** for the remaining observations **the ranks** are uncorrelated:

$$x_{ik} = X_i \quad \text{for } \rho_k N \text{ observations, and,} \quad (1a)$$

$$E[x_{ik} - (N+1)/2][X_i - (N+1)/2] = 0 \quad \text{for the remaining } (1-\rho_k)N \text{ observations.} \quad (1b)$$

Note that in (1b) we measure both ranks relative to their mean values, which are $(N+1)/2$. We consider all possible sets of the $(1-\rho_k)N$ observations, of which there are $\binom{N}{(1-\rho_k)N}$. For each of these sets, the ranks X_i are *randomly reassigned* to the country ranks x_{ik} . Then the expectation in (1b) is taken over all possible sets of the $(1-\rho_k)N$ observations, and all possible values for x_{ik} .²

With this specification, the "product cycle" is measured by the rank-ordering of **commodities** X_i , which we shall refer to as the "overall" ranking. Our goal in this paper is to obtain a **meaningful** measure of this overall ranking, using data on the country **rankings** x_{ik} . After **briefly** describing our data in section **III**, we then review methods suggested by **Kendall** and **Dickinson** (1990) to obtain an overall ranking. These methods do not depend on the particular **specification** in (1), but we will argue that they are inadequate to deal **with** the unbalanced nature

of our dataset. Accordingly, we develop alternative methods to estimate the underlying ranking, that allows for an unbalanced panel and also uses the specification in (1).

III: The Data Set

Much of our methodology is driven by features of typical panel data sets. We exploit a data set of American imports by source country, extracted from the CD-ROM data set of Feenstra (1996). In particular, we examine imports at the five-digit level of Standard International Trade Classification (SITC), revision 2, between 1972 and 1994. These span 162 countries and other geographical jurisdictions (which we refer to as "countries" for simplicity); and 1,434 commodities ("goods").³ For each good and each country, we initially use only the *first year of export* to the United States.⁴ There are 88,292 non-zero entries in the data set

One important feature of this data set is that there are many goods that are not exported by countries initially, but become exported during the sample period. That is, there are a great many zero values for imports by source country that become positive later in the sample period. This feature is essential for our empirical methodology, and would not be the case for data sets at higher levels of aggregation (such as United Nations data for country's world-wide exports).

There are also many instances of "missing" observations, by which we mean that a given commodity is never exported by a given country in the sample. If each country had exported each commodity at least once during the sample period, there would be 232,308 entries in our data set. Since we actually have only 88,292 non-zero entries, over 60% of the potential country-commodity observations were censored. This means that even our simple framework in (1) will

² In order for this expectation to be zero, it must be that the set of $(1-p_k)N$ observations contains more than one element, since otherwise we would have to assign $x_k = X_k$ for that element.

³ Examples of such commodities include: "Human Hair" (29191); "Varnish Solvents" (59897); "Cotton Yarn 14-40 KM/KG" (65132), "High Carbon Steel Coils" (67272), and "Piston Aircraft Engines" (71311).

need to be modified to account **from** these "missing" observations. But **the** presence of non-random censoring in many large panel data sets makes our techniques more generally applicable.

IV: A Methodology to Rank Countries and Commodities

IVa: Motivation

Initially suppose that we have a **full** sample of observations without any "missing" observations, so that each good was exported by each country during the sample. An example is provided below, with just two countries (Canada and Mexico) and five goods:

| | | <u>Example 1</u> | | | | | |
|-------------------------|-----------------------------|------------------|---|-----|-----|-----|-----|
| | | Goods: | A | B | C | D | E |
| Canada: | Exports goods in the order: | | 1 | 2 | 3 | 4 | 5 |
| Mexico: | Exports goods in the order: | | 1 | 3 | 4 | 5 | 2 |
| Average of rank orders: | | | 1 | 2.5 | 3.5 | 4.5 | 3.5 |

Consider ranking goods. For each country, we have observations on the year of first export of each good. Each country then provides a relative ranking of goods (by their year of first export), as shown in Example 1. With this balanced and complete panel, Kendall and Dickinson (1990, chaps. 6-7) establish the following procedure for determining the best "overall" **ranking**: average the ranks for each good across countries, and then rank these averages. In the above example, we would therefore assign the goods the ranking A, B, C tied with E, and D. According to this ranking, A would be the least sophisticated, and D is the most sophisticated. **Kendall** and Dickinson show that this method for determining the overall ranking is optimal in the sense of maximizing a certain objective **function** (described below).

⁴ As a weighting variable, we use below **the** presence and/or value of exports subsequent to the year of first export.

The difficulty is that there are no known results for determining an optimal ranking when the sample is non-balanced, i.e. when there are "missing" observations. To see this **difficulty**, suppose that Mexico exports only the first and last goods:

| | | <u>Example 2</u> | | | | | |
|---------|--|------------------|----------|---|---|---|----------|
| | | Goods: | A | B | C | D | E |
| Canada: | Exports goods in the order: | | 1 | 2 | 3 | 4 | 5 |
| Mexico: | Exports goods in the order: | | <u>1</u> | | | | <u>2</u> |
| | Average of rank orders: | | 1 | 2 | 3 | 4 | 3.5 |

In this case, if we applied the method of averaging the rank-orders over the observations in the sample, then we arrive at the ranking indicated the last line of Example 2: the goods would be ranked A, B, C, E, D. We believe this result is nonsensical, because E has a higher rank good D for Canada, and no comparative information is provided for Mexico, so it should not be the case that the ranking of E and D is *reversed* in the overall ranking. We conclude from this example that the simple average-ranking method is not appropriate when there are missing observations. Since this is a pervasive feature of our data set, we need to develop the statistical techniques to deal with this case.

IVb: Notation

To make all this more formal, we begin with some notation. We tackle the problem of ranking goods, although the logic will be identical for ranking countries.

Selecting **from** the entire list of goods $I = \{1, \dots, N\}$, let $I_k \subseteq I$ denote the set of goods **supplied** at any point in the sample by country k . The number of elements in I_k is denoted $N_k \leq N$, where N is the total number of goods (just over 1,400 for the second revision of the 5-digit

Standard International Trade **Classification**). We denote the *rank* of "first year of export to the US" by $x_{ik}(I_k)$ where i denotes the good and k denotes the country. This ranking is done over the goods i , for each country k .⁵

We wish to **determine** an "*overall*" *ranking* of the goods $X_i(I)$. We will sometimes want to restrict $X_i(I)$ to be defined only over those goods supplied by country k . This restricted ranking is **defined** by:

$$X_i(I_k) \equiv \{ \text{the ranking of values } X_i(I) \text{ over the set } I_k \}. \quad (2)$$

With these definitions, we **modify** (1) slightly to account for "missing" observations:

$$x_{ik}(I_k) = X_i(I_k) \quad \text{for } \rho_k N_k \text{ observations, and,} \quad (1a')$$

$$E[x_{ik}(I_k) - (N_k + 1)/2][X_i(I_k) - (N_k + 1)/2] = 0 \quad \text{for the remaining } (1 - \rho_k)N_k \text{ observations.} \quad (1b')$$

We will sometimes want to extend $x_{ik}(I_k)$ to cover the entire set of goods, even those not supplied by country k , by imputing where these "missing" goods appear in the ordering for that country. This extended ranking will be denoted by $x_{ik}(I)$.

IVc: Rank Correlation

For any country k , the (Spearman) *rank correlation* between its **own** ranking $x_{ik}(I_k)$ and the **overall** ranking $X_i(I)$ is **defined** as:

⁵ We handle ties in the following way. Arrange the N_k goods (exported by the country at some point in the sample), in order. For the j goods exported in the first year, assign the rank of $(j/2)$. Assign the next j' goods (exported in the second year) $(j+j'/2)$. And so on.

$$r_k \equiv \frac{12}{(N_k^3 - N_k)} \sum_{i \in I_k} [X_i(I_k) - \frac{1}{2}(N_k + 1)][x_{ik}(I_k) - \frac{1}{2}(N_k + 1)]. \quad (3)$$

The term $(N_k^3 - N_k)/12$ is the highest possible value for the summation in (3), **which is** obtained when $x_{ik}(I_k) = X_i(I_k)$ for all observations (and re-ordering the observation so that $x_{ik}(I_k) = X_i(I_k) = i$):⁶.

$$\sum_{i=1}^{N_k} [i - \frac{1}{2}(N_k + 1)]^2 = \frac{(N_k^3 - N_k)}{12} \quad (4)$$

Dividing (3) by this term, it can be seen that that the rank correlation lies between -1 and 1

Let A denote the $\rho_k N_k$ observations for which (1a') holds. Using (1b') and evaluating the expected value of (3), we find that:

$$E(r_k) = \frac{12}{(N_k^3 - N_k)} E \left\{ \sum_{i \in A} [X_i(I_k) - \frac{1}{2}(N_k + 1)]^2 \right\} = \rho_k \quad (5)$$

To establish this result, note that the expectation in (5) is taken over all possible sets A, of which there are $N_A = \binom{N}{\rho_k N}$. The summation in (5) contains $\rho_k N_k$ terms, so writing the expectation in full over all sets A, there will be total of $\rho_k N_k N_A$ terms. Each of these terms will be of the form $[i - (N_k + 1)/2]^2$, where i is an integer within the set A. But by choosing the sets A randomly, it must be that each of the integers $i=1, \dots, N_k$ appears an *equal number of times*. Thus, each of

⁶ The equality in (4) can be obtained using the formula $\sum_{i=1}^{N_k} i^2 = \frac{1}{6} N_k (N_k + 1) (2N_k + 1)$, which is reported in elementary mathematics textbooks (and can be proved by induction).

these integers will appear $\rho_k N_k N_A / N_k = \rho_k N_A$ times within the expected value summation. It

follows that the expected value consists of $\rho_k N_A$ summations identical to (5), divided by N_A

(which is the probability of each set A occurring), so that:

$$E \left\{ \sum_{i \in A} [X_i(I_k) - \frac{1}{2}(N_k + 1)]^2 \right\} = \left(\frac{\rho_k N_A}{N_A} \right) \frac{(N_k^3 - N_k)}{N_k}$$

Substituting this into (5), we obtain the result $E(r_k) = \rho_k$. That is, *the Spearman rank correlation is an unbiased estimate of the fraction of observations for which the country and overall ranks are equal.*⁷

IVd: Numerical Estimation of the Overall Ranking

Kendall and Dickinson (1990) consider the problem of optimal ranking when the number of goods supplied by each country is the same. The objective **function** that they propose is the *average* of the rank correlations between each country's ranking and the overall ranking.

Adopting this same objective **function** even when the set of goods supplied by each country differs, we can consider choosing the overall ranking $X_i(I)$ to maximize:

$$\sum_{k=1}^M \frac{r_k}{M} = \sum_{k=1}^M \frac{12}{M(N_k^3 - N_k)} \sum_{i \in I_k} [X_i(I_k) - \frac{1}{2}(N_k + 1)][x_{ik}(I_k) - \frac{1}{2}(N_k + 1)], \quad (6)$$

⁷ A **different** result is established in Kendall and Dickinson (1990, chaps. 4-5), where **the** sample **rank** correlation is shown to be a *biased* (but asymptotically consistent) estimate of the population rank **correlation**. In our notation, let ρ denote **the** rank **correlation** computed as in (3) over the entire population $I = \{1, \dots, N\}$. Consider taking a random sample of **size** N_k from that population, and computing **the** sample **rank** correlation r_k as in (3). Then taking the expected value over all possible samples, it turns out that $E(r_k) \neq \rho$.

where M is the number of countries. For any choice of $\mathbf{X}_i(\mathbf{I})$ the restricted **rankings** $X_i(I_k)$ are **readily** computed as in (2), so this is a well-defined optimization problem.

In the case without "missing" observations, so **that** $N_k=N$ for all k , then Kendall and Dickinson (section 7.10, p. 151) show that (6) is maximized by choosing the overall ranks $\mathbf{X}_i(\mathbf{I})$ as the **rank** of the averages $\frac{1}{M} \sum_{k=1}^M \mathbf{x}_{ik}(\mathbf{I})$. However, when there are "missing" observations so that $N_k < N$ for some k , then there is no known analytical solution to maximize (6); our objective in this paper is to provide such a solution.

One possibility is to numerically maximize this objective function. To do so, first **simplify** the objective function in (6) as:

$$\sum_{k=1}^M \frac{I_k}{M} = \sum_{k=1}^M \frac{12}{M(N_k^3 - N_k)} \left[\sum_{i \in I_k} X_i(I_k) x_{ik}(I_k) - \frac{1}{4} N_k^2 (N_k + 1)^2 \right], \quad (7)$$

where this line follows from (6) because $X_i(I_k)$ and $x_{ik}(I_k)$ both sum to $N_k(N_k+1)/2$.

Suppose that the goods have been re-numbered by increasing rank, so that $X_i(\mathbf{I})=i$, and consider reversing the **rank** of goods $i-1$ and i within the overall **ranking** $\mathbf{X}_i(\mathbf{I})$. This will have an impact on the restricted **ranking** $X_i(I_k)$ if and only if both these goods are supplied by country k . Define the indicator variable,

$$\delta_{ik} = \begin{cases} 1 & \text{if } i-1 \in I_k \text{ and } i \in I_k \\ 0 & \text{otherwise.} \end{cases} \quad (8)$$

Then it is immediate that the change in the objective function (7) **from reversing** the **rank** of goods $i-1$ and i within the overall **ranking** $\mathbf{X}_i(\mathbf{I})$ is simply equal to:

$$\Delta_i = \sum_{k=1}^M \frac{12}{M(N_k^3 - N_k)} \delta_{ik} [x_{i-1,k}(I_k) - x_{ik}(I_k)]. \quad (9)$$

If $\Delta_i > 0$ then the objective **function** is increased by reversing the rank of $i-1$ and i . Suppose we do so, and then re-number all the goods by that new ranking so that $X_i(I) = i$. **Then** for each adjoining pair of goods, the change in the objective **can** again be computed as in (9), and whenever $\Delta_i > 0$ **then** the position of goods $i-1$ and i **can** be reversed and the set of goods re-numbered. When it is no **longer** the case that $\Delta_i > 0$ for any **adjoining** pair of goods, the algorithm has converged to a **ranking** $X_i(I)$.

Thus, **from** some initial value for the overall ranking $X_i(I)$, it is easy to compute the (discrete) change in the objective function from swapping the position of two adjoining goods in the overall ranking: whenever this change is positive, the swap should be made. We call this the "numerical approach" to maximizing the objective function (6), and illustrate some results from it in section VI.

One difficulty with the numerical approach is that it may not enough to just check whether the position of all adjoining goods in the ranking should be swapped; it also seems necessary to check whether the position of *any* two goods should be reversed. With about 1,400 goods, this would mean that one would **need** to check about $1,400^2$ possibilities on each iteration. It is not **computationally** feasible to perform all these comparisons, and our program to implement the numerical maximization is limited to comparing the *ten* adjoining goods for each product on each iteration. For these reasons, we cannot establish that our numerical approach necessarily reaches a *global* maximum of the objective function. Accordingly, in the remainder of the paper we will

pursue an alternative approach to determining the overall ranking, suggest# by econometric analogies.

IVe: Analogy to a Regression

We begin by expressing the country and **overall rankings** in (1') as a difference from their means of $(N_k+1)/2$, and re-writing the model as:

$$x_{ik}(I_k)-(N_k+1)/2 = \rho_k[X_i(I_k)-(N_k+1)/2] + \varepsilon_{ik}, \quad i \in I_k, \tag{10}$$

where,

$$\varepsilon_{ik} = (1-\rho_k)X_i(I_k) \quad \text{for } \rho_k N_k \text{ observations, and,} \tag{11a}$$

$$= x_{ik}(I_k) - \rho_k X_{ik}(I_k) \quad \text{for the remaining } (1-\rho_k)N_k \text{ observations,}$$

$$\text{with } E[x_{ik}-(N_k+1)/2][X_i-(N_k+1)/2]=0. \tag{11b}$$

The regression in (10) is identical to the model in (1'), given our definitions of the error terms in (11). Using the standard formula for the least squares estimate of ρ_k , it is immediate that this estimate is identical to the rank correlation coefficient r_k in (3). Since $E(r_k)=\rho_k$ from (5), **least-squares** therefore provides an unbiased estimate of the slope coefficient ρ_k .⁸

⁸ This result is obtained despite that fact that the error terms in (11) are clearly correlated with the regressor $X_i(I_k)$ in each observation. However, summing across the observations, it can be shown that $E\left(\sum_{i \in I_k} \varepsilon_{ik} X_i(I_k)\right) = 0$, by using arguments similar to those used in establishing (5). Thus, the regression satisfies the requirement of least-squares that the errors are orthogonal to the regressor in expected value.

Thus, **minimizing** the **sum** of squared residuals for (10) yields the **rank correlation coefficient** as the estimate for ρ_k . The question is whether this **minimization problem** also be used to **solve** for the overall ranking $X_i(I)$. It turns out that this is indeed the **case**:

Proposition 1 *Suppose that when $X_i(I)$ is chosen to maximize (6), the value of (6) is positive. Then the identical values of $X_i(I)$, when chosen along with the coefficient ρ , will minimize the following weighted sum of squared residuals:*

$$\min_{X_i(I), \rho} \sum_{k=1}^M \frac{12}{(N_k^3 - N_k)} \sum_{i \in I_k} \left[x_{ik} - \frac{(N_k + 1)}{2} - \rho \left(X_i(I_k) - \frac{(N_k + 1)}{2} \right) \right]^2 \quad (12)$$

In other words, there is a very close connection between the objective function in (6) and that obtained by minimizing the weighted sum of squared residuals (SSR) in (12). This SSR is obtained by **pooling** over all goods i and countries k in (10), while **imposing** a common slope **coefficient** for ρ . The weights used in (12) when adding up across countries **reflect** the differing number of observations within each country. This result does not necessarily **provide** an easier **way** to obtain the optimal overall ranking, since the numerical difficulties **that** we noted in **maximizing** (3) apply equally well to minimizing (8). Rather, the **advantage** of using the regression-based framework is that it enables us to think about imputing the **ranks** for goods not supplied by a country, which we turn to next.

IVf: Estimation with Censoring

To avoid the difficulties of dealing with an unbalanced panel, there **are** at least two approaches that can be taken.

Conceptually, we could imagine "shrinking" the panel down to a *balanced* but *incomplete* "Youden" panel. This would be a panel where each country contributed the same number of commodity-observations and each good was observed the same number of times. However, there are two problems with this strategy. First, there is no guarantee that *each* country has exported enough goods to ensure that all commodities are covered and could be **ranked**. Second, much **information** would be lost, and with it, the benefits of our large data set.⁹

Alternatively, we can "stretch" the panel up to a complete balanced panel by imputing missing observations. We now proceed to that issue.

Ng: Accounting for "Missing" Observations

There are three economic reasons why a country might not have exported a good during the sample.

1. First, the country may have been "too advanced to export the good during the sample; it had **exported** the good before the start of the sample and ceased **exporting** before the start of the sample. For each country, we denote by $(1, 2, \dots, x_k^{\min})$ the ranks of all goods (relative to the entire set I) that are too "unsophisticated" for the country to have produced them in the sample, where x_k^{\min} will be estimated.
2. Second, the country may not have been "advanced enough" to export the good during the sample, but will export it at some point in the future. For **each** country, we will denote by $(x_k^{\max}, x_k^{\max} + 1, \dots, N)$ the ranks of **all** good (relative to the entire set I) that

⁹ On a more technical level, it is hard to figure out a scheme for dropping observations randomly that would satisfy the requirements of an incomplete balanced panel.

are too sophisticated for the country to produce them in the sample, where x_k^{\max} will be (implicitly) estimated.

3. Third, trade is driven by other considerations (e.g., factor abundance); we ignore this possibility throughout.

Denote the "filled-in" ranking by $x_{ik}(\mathbf{I})$, which is defined over the entire set of goods. For those goods actually supplied by country k , $x_{ik}(\mathbf{I})$ is related to $x_{ik}(\mathbf{I}_k)$ by:

$$x_{ik}(\mathbf{I}) = x_{ik}(\mathbf{I}_k) + x_k^{\min} \quad \text{for } i \in \mathbf{I}_k. \quad (13)$$

That is, we take the ranking $x_{ik}(\mathbf{I}_k)$, which runs from 1 up to N_k , and increase each of these by the number of goods that we estimate have already been dropped by country k . Since we are supposing that there are no omitted goods "in the middle" of this ranking, given any estimate for x_k^{\min} , the corresponding estimate for x_k^{\max} would be $x_k^{\max} = x_k^{\min} + N_k + 1$.

With this preliminary specification of $x_{ik}(\mathbf{I})$, consider choosing x_k^{\min} and the overall ranking $X_i(\mathbf{I})$ to minimize the (weighted) SSR of the following pooled regression:

$$[x_{ik}(\mathbf{I}) - (N+1)/2] = \rho[X_i(\mathbf{I}) - (N+1)/2] + \varepsilon_{ik}, \quad \text{for } i \in \mathbf{I}_k, k=1, \dots, M. \quad (14)$$

Note that in (14), the right and left-hand side variables are both defined over the entire set \mathbf{I} , so they are expressed relative to their mean values $(N+1)/2$. Making use of (13), we can rewrite (14)

as:

$$[x_{ik}(\mathbf{I}_k) - (N+1)/2] = -x_k^{\min} + \rho[X_i(\mathbf{I}) - (N+1)/2] + \varepsilon_{ik}, \quad \text{for } i \in \mathbf{I}_k, k=1, \dots, M. \quad (14')$$

This is a regression equation in which the left-hand side is data, and the right-hand side variable is simply the overall ranking $X_i(\mathbf{I})$ at some iteration. It follows that $-x_k^{\min}$ can be estimated from the: various country fixed-effects in this regression.

If the overall ranks $X_i(\mathbf{I})$ were not constrained to be the integers $1, \dots, N$, then it would be **possible** to estimate them as commodity fixed-effects in (14'). Indeed, these commodity **fixed-effects** would be chosen to given an average **residual** of zero for each commodity, so the **fixed-effects** would equal $\frac{1}{M_i} \sum_{k \in K_i} [x_{ik}(\mathbf{I}_k) + x_k^{\min}] / \rho$. Then when estimating these as ranks, it seems very plausible that we should simply rank the values of $\frac{1}{M_i} \sum_{k \in K_i} [x_{ik}(\mathbf{I}_k) + x_k^{\min}]$, provided that the estimate of ρ is positive.

In order to demonstrate the optimality of this procedure, we need to apply certain weights to the observations in (14'). For each good i , let $K_i \subseteq \{1, \dots, M\}$ denote the set of countries that supply that good sometime during the sample period. We will denote the number of countries within K_i as $M_i \leq M$. Then we will consider weighting the observations in (14') by the *inverse* of M_i so that goods supplied by only a small number of countries receive the largest weight. By this weighting scheme, we achieve a kind of artificial balance in the **dataset**, and obtain the result:

Proposition 2 *Let $X_i(\mathbf{I})$ denote the overall ranking that, when chosen together with x_k^{\min} and ρ , minimizes the weighted sum of squared residuals:*

$$\min_{X_i(\mathbf{I}), \rho} \sum_{i=1}^N \sum_{k \in K_i} \frac{1}{M_i} \left[x_{ik}(\mathbf{I}_k) - \frac{N+1}{2} + x_k^{\min} - \rho \left(X_i(\mathbf{I}) - \frac{N+1}{2} \right) \right]^2. \quad (15)$$

If the optimal choice for ρ is positive, then $X_i(I)$ equals the rank of $\frac{1}{M_i} \sum_{k \in K_i} [x_{ik}(I_k) + x_k^{\min}]$.

That is, the optimal overall **ranking** is simply obtained as the rank of the average country ranking for each good, computed over those countries that actually **supply** the good. This is a generalization of the Kendall and **Dickinson** recommendation, derived in **the** context of an unbalanced panel. It is obtained in the present framework because we **have** weighted the observations in the unbalanced panel by the inverse of the numbers of **times** each good appears, which creates a kind of artificial balancing.

In order to compute the averages, however, we must have an **estimate** of x_k^{\min} for each country. These coefficients can be obtained as the country-fixed effects from the pooled regression (14), where the left-hand side of (14) is data, and the **right-hand** side uses the overall ranking $X_i(I)$ at some iteration. To obtain the solution values in **Proposition 2**, we use the following iterative estimation strategy:

1. **Start with a guess for the overall ranking $X_i(I)$.**
2. **Run (14') over $i \in I_k$ and $k=1, \dots, M$ to estimate x_k^{\min} , applying weights of $1/M_i$ to each observation.**
3. **Calculate a *new* optimal overall ranking $X_i(I)$ by averaging values of $(x_{ik}(I_k) + x_k^{\min})$ for each commodity over all exporting countries $k \in K_i$, and ranking the results.**
4. **Return to step 2, until convergence is reached.**

This procedure can be illustrated on Example 2 (where Canada **exported** all five goods in consecutive order, but Mexico exported only goods A and E). Given that both countries

exported A before E, it is plausible to **specify** an initial ranking of the five $X(I)=(1,2,3,4,5)$. When regression (14) is run over the observations for Canada and Mexico, **applying** the appropriate weights, we obtain the values $x_{mex}^{min}=1.5$ and $\rho=0.7$. Then according to step 2, we add this value for x_{mex}^{min} to the initial rankings $x_{mex}(I_{mex})=(1,2)$ for Mexico, and calculate the new average ranking as:

| | | <u>Example 3</u> | | | | | |
|---------|-----------------------|------------------|------|---|---|---|------|
| | | Goods: | A | B | C | D | E |
| Canada: | New goods ranking: | | 1 | 2 | 3 | 4 | 5 |
| Mexico: | New goods ranking: | | 2.5 | . | . | . | 3.5 |
| | Average of new ranks: | | 1.75 | 2 | 3 | 4 | 4.25 |

Ranking the averages in the last line, we obtain the new estimate of the overall ranking, $X(I)=(1,2,3,4,5)$. This is the same as its initial value, so the procedure has converged, and this is the optimal ranking.¹⁰

IVh: Three Observations

We conclude this section with three observations about the "regression-based method in steps 1-4.

First, it is immediate from the proof of Proposition 2 that the values of $X_i(I)$ chosen to minimize (15) also maximize (when $\rho > 0$) the weighted correlations,

$$\frac{12}{(N^3 - N)} \sum_{i=1}^N \sum_{k \in K_i} \frac{1}{M_i} [x_{ik}(I_k) + x_k^{min} - \frac{1}{2}(N+1)][X_i(I) - \frac{1}{2}(N+1)] \quad (16)$$

¹⁰ It can be shown that this overall ranking is also obtained for other starting values.

This objective function can be compared to (6), which we attempt to **maximize** with our “**numerical** method.” While the objective functions obviously **differ** in the **weights** used across **observations**, we might expect that the overall ranking that maximizes **one** also does quite well on **the** other. We find that this is indeed the case below.

Second, our procedure can be viewed as an application of the “**EM**” algorithm. The two equations are:

$$x_{ik}(P) = \alpha_k + \beta X_i^j(I) + \epsilon_{ik}, \quad \text{for } i \in I_k \quad \text{at iteration } j$$

$$X_i^{j+1}(I) = f(x_{ik}(P)) + \text{error}$$

One first takes the *expectation* when filling in the missing values (in step 2 above); then *maximizes* (in step 3).

Third, we have outlined this methodology as a way to estimate an overall ranking of goods, using *cross-good* variation in the year of first export. We refer to this technique below as one in which we consider goods-rankings to be “primitive.” From these goods rankings, countries **can** be ordered according to the ranks of their exports; countries with more “advanced exports are more “sophisticated. But it should be clear that an identical methodology can be used to estimate country **rankings as** primitive (with appropriate changes to subscripts), using *cross-country* variation in the year of first export. In our empirical work, **we** pursue both schemes and compare estimates derived using the different techniques.

V: Empirical Results

Va: Estimates of Country Rankings

We have estimated both commodity and country **rankings using the** regression-based method outlined in section IV.

Table 1 presents a number of different sets of *country rankings*; these are easier to interpret than comparable commodity *rankings*. We derive these estimates by first estimating primitive *goods rankings* using the methodology outlined above.¹¹ We then average these goods-*rankings over the good!actually exported* on a country by country basis, and rank the resulting averages. We refer to this as our "baseline goods-based methodology."¹²

Our baseline methodology yields quite sensible results.¹³ The top countries are for the most part advanced rich OECD countries; poor countries tend to be clustered at the bottom. **Unsurprisingly**, Canada is ranked the most sophisticated country (ignoring implicit US leadership), followed by the UK, Germany, Japan and France. Mexico is ranked higher (at position 6) than one might expect; this may well have to do with either Mexico's proximity to the US or special trade arrangements, and is a topic worthy of further investigation.¹⁴ Overall, there is strong evidence of intuitively reasonable orderings of both countries and commodities, consistent with the product cycle hypothesis.¹⁵

¹¹ We actually **use** a slightly more general version, allowing the slope of the relationship between the country-specific ranking and the overall ranking to vary by country, as in (10). This generalization results in some computational economies, but **insignificantly different** results; the overall ranking derived **from** the pooled regression setup of (14)-(15) has a .999 correlation with that derived from the country-specific regression **framework** of equation (10).

¹² The list of goods at the "early" end of the list includes: special mail transactions (**SITC 93 100**); coins (**89605**); **antiques nes (89606)**; **furniture (82100)**; women's **outerwear (84300)**; other wood article manufactures (**63599**); imitation jewelry (**89720**); printed **books (89211)**; **wood manufactures (63549)**; and band **paintings etc. (89601)**. At the other end of the spectrum **are**: vinyl chloride (**51 13 1**); mechanically propelled **cars (79130)**; wine lees (**8 194**); **Linseed (22340)**; **methacrylic acid (51373)**; slag etc. from iron (**27861**); **natural sodium nitrate (27120)**; paper pulp filter-blocks (641%); tin **tubes (68724)**; uranium (**68800**); and **oxy-funct alddhyde derivatives (5 1622)**.

. Our iterative technique **seems** to converge quite quickly. Our default specification **converges** after three iterations. We have also **experimented with** random starting values, and our **procedure** still converges to the same **final estimates** quickly. Also, the **rank** correlation coefficients between this overall ranking and the individual country **rankings** turn out to be positive for essentially all the goods in our sample (well wer **95%**), and significantly for most.

¹⁴ Mexico's ranking may also **reflect** the "806/807" program or **reexports**. China **also** is ranked higher than some of the newly-industrialized Asian countries, which we plan to investigate more carefully in future work. We do not yet have a convenient **method** for estimating the statistical sensitivity of **country rankings**, though presumably some **simulation** technique can **be used**.

¹⁵ For instance, all the country-specific correlations between the overall ranking and the **country-specific rankings** in (10) are positive.

To check the sensitivity of our results, we also **tabulate** in Table 1 **four** perturbations to our basic methodology. First, we restrict the sample of goods ranked to **those** with SITC codes between 60,000 and 80,000, which can be thought of as manufactured **commodities**. Second, we repeat our analysis but weigh each country (in the **Kendall** estimation **procedure**) by the number of **individual** goods it exported in the sample. This ensures that countries **with** a large number of exports are given more weight in determining the overall ranking; without weighting, countries **which** exported few goods to the US will be treated identically with countries which exported **many** goods. Finally, we estimate country **rankings** in the first and last halves of the sample. We do this by weighting the goods-rankings for each country by: 1) only the **goods** the country first exported before 1985; and 2) only those goods first exported by the country after 1984. To ease the comparison of the five different perturbations of the methodology, we also provide cross-scatterplots in Figure 1

Our results appear to be quite robust for the countries at the top of the rankings, but somewhat sensitive towards the bottom of the rankings. This comes as **no** surprise to us; the poor countries that tend to be ranked towards the bottom provide relatively **few** exports to the United States, and are accordingly difficult to rank **precisely**.¹⁶ Still, the **different** rankings are quite highly correlated overall. Spearman rank correlations between the **rankings** are high ($>.9$) and statistically significant, and the **rankings** share essentially one common **factor**.¹⁷

¹⁶ Indeed, there is a strong negative correlation between the number of goods a country exports and its ranking. This comes as no real surprise to us; rich countries tend to be open and diversified exporters, while poor countries tend to be closed and specialized exporters. Sachs and Warner provide evidence on the linkages between openness and growth; Hall and Jones provide evidence on the linkage from openness to productivity.

¹⁷ In passing, we note that the dis-aggregated nature of the data seems critical for the actual estimation of these rankings. When we aggregated our data to the 2-digit SITC level, over a quarter of our countries showed literally no dispersion in "year of first export" across commodities; all commodities exported were exported first in the same year. But manifestly dispersion can be found at finer levels of dis-aggregation; this dispersion also appears to be systematic and meaningful.

We have also compared the results in Table 1 (for manufacturing **goods**) to those obtained **use** the numerical method for maximizing (6). Using the overall goods **ranking obtained from** steps 1-4 as starting values, the average rank correlation in (6) was 0.4404. We then ran the **numerical** method for over 100 iterations until it converged, yielding a **value** for (6) of 0.4480. **Unsurprisingly**, the ordering of individual goods was quite similar for the two techniques. The **correlation** between the **rankings** of the "numerical method and the "regression method" was an **extremely** high 0.999.

Table 2 provides four different estimates of our country rankings, derived from the regression-based method. For these results, we estimate the country ranking as the primitive overall ranking in equation (14), rather than deriving it from some underlying estimate of a goods ranking. We also provide three perturbations to our basic methodology: a) estimates using only manufacturing data; b) weighted estimates; and c) an estimate derived with imputed data (when we actually "fill in" missing data using (13) and (14), and use this imputed data in our estimation). The cross-scatterplots are provided in Figure 2. Again, the results seem sensible and insensitive.

The results in Tables 1 and 2 are similar. That is, when ordering **countries**, it does not matter much whether we treat **goods-rankings** or **country-rankings** as primitive. Table 3 provides a **direct** comparison of the baseline country **rankings** estimated both directly (treating the country ranking as primitive, as in Table 2) and indirectly (*i.e.*, from a **country-specific** weighted average of goods-rankings, as in Table 1). It is comforting to note that the two **rankings** are closely **related**.¹⁸ This can be seen more easily from the graphical analysis in **figures** 3-5. The latter

¹⁸ We can see no reason why the country- and goods-based rankings need necessarily deliver similar results for any statistical reason. Further, the two different applications rely on different economic assumptions, namely whether countries or goods can be ranked in terms of sophistication.

present scatterplots of the country- and goods-based **rankings** derived from our baseline methodology and two perturbations: a) baseline; b) using only **manufacturing** data; and c) **weighted**.

Figure 6 compares the "**early**" and "**late**" country **rankings graphically**. Few countries **changed** places dramatically, though the decline in some of the European **rankings** is interesting (bearing in mind that a country with a low numerical ranking is interpreted as "advanced"). Figure 7 plots the country **rankings** (derived from goods **rankings** by simply averaging the latter over the set of goods exported on any given year) on a year by year basis for sixteen countries. **Each** of the "small multiple" graphics portrays a time-series plot of country ranking from 1972 through 1994. In future work, we plan to analyze the dynamics associated with changes in country **rankings** over time more closely.

Vb: Linking Country **Rankings** with Aggregate Variables

Our country **rankings** appear to be robustly estimated, stable and **sensible**. Derived as they are from dis-aggregated bilateral trade flows, there is no obvious reason why they need **necessarily** be linked to macroeconomic phenomena. Are they?

Figure 8 presents a simple **bivariate** scatterplot of country **rankings** (derived treating **country rankings** as primitive, as in Table 2) **with** the growth rate of real GDP per capita (taken from the **Penn** World Table). A non-parametric data smoother has been included to "connect the dots". An economically and statistically significant negative correlation appears. Sophisticated **countries** (which export first and consequently have "high" rankings) tend to have high growth rates of real GDP per capita. Of course, the causal interpretation of this finding is unclear.

To pursue this matter further, we have merged our data with the Barro-Lee data on economic growth and added our country-rankings to standard **cross-country** growth equations. As is apparent from Table 4, our (ordinal) country **ranking** appears to be **significantly** negatively related to the growth rate of real **GDP per capita**.¹⁹ We have conditioned **growth** rates on the share of **GDP** devoted to investment (one of the few variables consistently **associated** with growth) as well as the initial level of **GDP**; we have also added other **regressors**, including **measures** of human capital, political **stability**, and other proxies for **openness**. Partial correlations between growth rates and country **rankings**, like simple correlations, are **significant** and negative. Countries which export sooner tend to grow faster.

Our **rankings** are not simply highly correlated with the growth *rates* of output; it turns out that they are also correlated with the *levels* of economic activity. Figure 9 is a simple scatterplot of our country **rankings** (again, treating countries as primitive) and the level of 1985 real **GDP per capita**. A strongly negative correlation emerges clearly in the graph. **High-income** countries tend to have low ("advanced") **rankings**.

The same negative correlation characterizes the relationship between the *level* of total *factor* productivity and country ranking. We have added our **rankings** to the Hall and Jones (1996) productivity data set, and found that our country ranking is **significantly** negatively related to productivity. This is true both unconditionally, and when the effects of the Hall-Jones factors have been taken into account. The latter include such measures as the **fraction** of the populace speaking an international **language**, the country's latitude, government **intervention** in the economy, and other measures (**including** the Sachs-Warner openness **indicator**) that **Hall** and Jones found important in determining total factor productivity differentials across countries.

¹⁹ The same is true of our baseline orderings, treating goods-rankings as primitive.

Figure 10 contains the graphical evidence. It contains four **scatterplots, corresponding** to two measures of country **rankings** (derived **from** primitive **orderings** of both goods and countries) **graphed** against two measures of productivity (raw, **and** after the **effects** of the Hall-Jones **variables** have been “**partialled out**”). Table 5 contains the corresponding regression evidence.

VI: Topics for Future Research

Our country **rankings** are derived **from** a complicated **semi-parametric** estimation procedure using only dis-aggregated international trade data. We find it both reassuring and **promising** that they turn out to be related to important economic phenomena such as growth rate and level of real GDP per capita and the level of total factor productivity. Yet much remains to be done.

There is no explicit alternative hypothesis to our product cycle theory. An alternative explanation of these correlations stemming from a factor-endowments theory of international trade is a natural candidate, since factor proportions change slowly over time.

A closer **examination** of both the determinants and effects of country **rankings** is **warranted**. Does government policy (e.g., industrial policy) affect rankings? Is there causality in the reverse direction?

Do our **rankings** depend on the fact that our data covers American imports? America has **been** the richest country in the world for our sample, and (according to the product cycle theory) should be the first country to **develop** new goods. But the **rankings** should be similar when

derived **from** the imports of any country; even though trade volumes **differ** systematically by country (the "gravity" **effect**).²⁰

We could also combine our data with export data, and search for **cycles** in the data. Product cycles occur when a period of net imports follows one of net **exports**; this may, in turn, **lead** to another period of net export. Checking for recurrent cycles could **allow** us to compare the empirical import of "quality ladder" models of international trade with models which rely on an ever-increasing number of goods.

^m It is interesting to note the negative relationship between trade volume and country ranking.

References

- Feenstra, Robert C. (1996) "NBER Trade Database. Disk 1: U.S. Imports, 1972-1994," NBER Working Paper no. 5515.
- Frankel, Jeffrey A. and David Romer, 1996, "Trade and Growth: An Empirical Investigation," NBER Working Paper no. 5476.
- Grossman, Gene M. and Elhanan Helpman (1991) *Innovation and Growth in the Global Economy*, Cambridge: MIT Press.
- Hall, Robert and Charles Jones (1996) "The Productivity of Nations" NBER Working Paper no. 5812.
- Kendall, Maurice and Jean Dickinson (1990) *Rank Correlation Methods*, fifth edition, London: Arnold.
- Sachs, Jeffrey and Andrew Warner (1995) "Economic Reform and the Process of Global Integration" *Brookings Papers on Economic Activity*.
- Vernon, Raymond (1966) "International Investment and International Trade in the Product Cycle" *The Quarterly Journal of Economics* LXXX, 190-207.

Appendix

Proof of Proposition 1

The value of p that minimizes (12) is given by:

$$\hat{\rho} = \frac{1}{M} \sum_{k=1}^M \frac{12}{(N_k^3 - N_k)} \sum_{i \in I_k} [x_{ik}(I_k) - \frac{1}{2}(N_k + 1)][X_i(I_k) - \frac{1}{2}(N_k + 1)], \quad (A1)$$

which equals the average rank correlation in (6). Substituting this back into (12), it is straightforward to show that the objective function equals $M(1 - \hat{\rho}^2)$. Thus, choosing the overall ranking $X_i(I)$ to maximize (6) is equivalent, when $\hat{\rho} > 0$, to minimizing the weighted sum of squared residuals in (12).

Proof of Proposition 2

The value of p that minimizes (15) is given by:

$$\hat{\rho} = \frac{\sum_{i=1}^N \sum_{k \in K_i} \frac{1}{M_i} [x_{ik}(I_k) + x_k^{\min} - \frac{1}{2}(N + 1)][X_i(I) - \frac{1}{2}(N + 1)]}{\sum_{i=1}^N \sum_{k \in K_i} \frac{1}{M_i} [X_i(I) - \frac{1}{2}(N + 1)]^2} \quad (A2)$$

Substituting this back into (15), the objective function equals:

$$\sum_{i=1}^N \sum_{k \in K_i} \frac{1}{M_i} \left[x_{ik}(I_k) + x_k^{\min} - \frac{N+1}{2} \right]^2 - \hat{\rho}^2 \sum_{i=1}^N \sum_{k \in K_i} \frac{1}{M_i} \left[X_i(I) - \frac{N+1}{2} \right]^2. \quad (A3)$$

The first double-summation that appears in (A3) does not depend on the choice for $X_i(I)$. The second double-summation can be simplified by noting that there are M_i elements in each set K_i , and that the terms being summed do not depend on the index k . Thus, the second double-summation simplifies to,

$$\sum_{i=1}^N \sum_{k \in K_i} \frac{1}{M_i} \left[X_i(I) - \frac{N+1}{2} \right]^2 = \frac{(N^3 - N)}{12}, \quad (\text{A4})$$

which is similar to the summation given in (4). Since this term is constant, it follows that choosing $X_i(I)$ to minimize (15) is equivalent to choosing $X_i(I)$ to maximize $\hat{\rho}^2$ in (A3). Provided that $\hat{\rho} > 0$, this is equivalent to maximizing the numerator of (A3), since the denominator is constant by (A4).

The numerator of (A4) can be rewritten as:

$$\sum_{i=1}^N \sum_{k \in K_i} \frac{1}{M_i} [x_{ik}(I_k) + x_k^{\min}] [X_i(I) - \frac{1}{2}(N+1)], \quad (\text{A5})$$

where we have used the fact that $X_i(I)$ has the average value of $(N+1)/2$ over $i=1, \dots, N$. It is evident that in order to maximize (A5), we should let the highest rank $X_i(I)$ multiply the highest value for $\sum_{k \in K_i} \frac{1}{M_i} [x_{ik}(I_k) + x_k^{\min}]$, the second-highest rank multiply the second-highest value, and so on. In other words, $X_i(I)$ equals the ranks of the averages $\sum_{k \in K_i} \frac{1}{M_i} [x_{ik}(I_k) + x_k^{\min}]$.

Table 1: Goods-Based Rankings

| | Base | Mnfg | Wghtd | Early | Late |
|----------|------|------|-------|-------|------|
| CANADA | 1 | 3 | 1 | 1 | 1 |
| UKINGDOM | 2 | 4 | 2 | 2 | 11 |
| GERMAN | 3 | 2 | 3 | 3 | 15 |
| JAPAN | 4 | 1 | 4 | 4 | 6 |
| FRANCE | 5 | 5 | 5 | 5 | 2 |
| MEXICO | 6 | 9 | 6 | 6 | 3 |
| NETHLDS | 7 | 8 | 7 | 7 | 7 |
| ITALY | 8 | 6 | 8 | 8 | 8 |
| BEL LUX | 9 | 11 | 9 | 9 | 14 |
| SWITZLD | 10 | 7 | 10 | 11 | 18 |
| CHINA | 11 | 17 | 13 | 21 | 17 |
| SWEDEN | 12 | 13 | 11 | 10 | 19 |
| TAIWAN | 13 | 12 | 12 | 12 | 5 |
| SPAIN | 14 | 14 | 16 | 13 | 4 |
| BRAZIL | 15 | 15 | 14 | 14 | 9 |
| AUSTRAL | 16 | 20 | 15 | 15 | 10 |
| HONGKONG | 17 | 19 | 17 | 17 | 13 |
| KOREA S | 18 | 18 | 18 | 20 | 16 |
| DENMARK | 19 | 21 | 19 | 16 | 20 |
| AUSTRIA | 20 | 16 | 20 | 18 | 24 |
| S AFRICA | 21 | 25 | 22 | 23 | 21 |
| ISRAEL | 22 | 22 | 23 | 25 | 22 |
| NORWAY | 23 | 23 | 21 | 22 | 27 |
| INDIA | 24 | 24 | 24 | 24 | 12 |
| IRELAND | 25 | 26 | 25 | 27 | 23 |
| FINLAND | 26 | 27 | 28 | 26 | 29 |
| ARGENT | 27 | 31 | 26 | 28 | 26 |
| SINGAPR | 28 | 28 | 29 | 32 | 25 |
| USSR | 29 | 34 | 30 | 38 | 39 |
| VENEZ | 30 | 29 | 32 | 33 | 38 |
| UNKNOWN | 31 | 10 | 27 | 19 | 160 |
| NEW ZEAL | 32 | 33 | 31 | 30 | 36 |
| THAILAND | 33 | 30 | 33 | 37 | 31 |
| PHIL | 34 | 32 | 34 | 29 | 28 |
| PORTUGAL | 35 | 35 | 35 | 31 | 33 |
| CHILE | 36 | 41 | 38 | 41 | 43 |
| COLOMBIA | 37 | 40 | 36 | 39 | 30 |
| POLAND | 38 | 39 | 37 | 36 | 35 |
| DOM REP | 39 | 44 | 39 | 35 | 41 |
| MALAYSIA | 40 | 38 | 40 | 42 | 34 |
| YUGOSLAV | 41 | 37 | 41 | 40 | 32 |
| CZECHO | 42 | 36 | 42 | 46 | 45 |
| GERMAN E | 43 | 43 | 43 | 34 | 50 |
| GREECE | 44 | 42 | 44 | 45 | 37 |
| PERU | 45 | 46 | 45 | 44 | 40 |
| HUNGARY | 46 | 45 | 46 | 47 | 44 |
| INDONES | 47 | 48 | 47 | 54 | 42 |
| TURKEY | 48 | 49 | 48 | 57 | 49 |
| ST K NEV | 49 | 47 | 51 | 76 | 55 |
| COS RICA | 50 | 50 | 49 | 52 | 51 |
| ROMANIA | 51 | 51 | 50 | 43 | 52 |
| JAMAICA | 52 | 56 | 52 | 49 | 48 |
| GUATMALA | 53 | 54 | 53 | 48 | 46 |
| PANAMA | 54 | 52 | 54 | 53 | 53 |
| ECUADOR | 55 | 57 | 55 | 59 | 54 |
| SD ARAB | 56 | 53 | 60 | 70 | 68 |
| EGYPT | 57 | 62 | 62 | 69 | 60 |
| PAKISTAN | 58 | 55 | 56 | 61 | 57 |
| NIGER | 59 | 59 | 67 | 113 | 77 |
| TRINIDAD | 60 | 71 | 59 | 63 | 62 |
| HONDURA | 61 | 69 | 58 | 56 | 67 |
| HAITI | 62 | 61 | 57 | 50 | 47 |
| MOROCCO | 63 | 67 | 61 | 75 | 65 |

| | | | | | |
|----------|-----|-----|-----|-----|-----|
| N ANTIL | 64 | 65 | 64 | 60 | 58 |
| KENYA | 65 | 60 | 65 | 74 | 70 |
| BAHAMAS | 66 | 76 | 63 | 55 | 61 |
| BULGARIA | 67 | 68 | 69 | 87 | 71 |
| SALVADR | 68 | 66 | 70 | 62 | 56 |
| ICELAND | 69 | 63 | 68 | 64 | 72 |
| URUGUAY | 70 | 73 | 66 | 66 | 59 |
| MRITIUS | 71 | 58 | 75 | 142 | 79 |
| MACAU | 72 | 64 | 76 | 78 | 63 |
| IVY CST | 73 | 80 | 74 | 105 | 85 |
| SRI LKA | 74 | 79 | 72 | 72 | 69 |
| ARAB EM | 75 | 72 | 78 | 67 | 84 |
| JORDON | 76 | 74 | 84 | 132 | 83 |
| IRAN | 77 | 81 | 71 | 73 | 64 |
| GABON | 78 | 93 | 77 | 128 | 109 |
| LEBANON | 79 | 75 | 81 | 81 | 66 |
| GILBRALT | 80 | 70 | 73 | 58 | 73 |
| KIRIBATI | 81 | 95 | 89 | 118 | 101 |
| YEMEN S | 82 | 107 | 79 | 51 | 150 |
| GUYANA | 83 | 108 | 83 | 65 | 103 |
| NIGERIA | 84 | 91 | 85 | 82 | 78 |
| BARBADO | 85 | 78 | 86 | 80 | 75 |
| MOZAMBQ | 86 | 89 | 82 | 71 | 122 |
| NICARAGA | 87 | 101 | 80 | 68 | 80 |
| CYPRUS | 88 | 84 | 90 | 77 | 82 |
| BOLIVIA | 89 | 85 | 87 | 88 | 74 |
| MONGOLA | 90 | 145 | 88 | 131 | 125 |
| SURINAM | 91 | 82 | 94 | 79 | 104 |
| ZIMBABWE | 92 | 90 | 91 | 91 | 102 |
| GUINEA | 93 | 88 | 106 | 147 | 110 |
| NEW CALE | 94 | 106 | 93 | 127 | 96 |
| BAHRAIN | 95 | 96 | 105 | 93 | 114 |
| BELIZE | 96 | 104 | 96 | 83 | 107 |
| BERMUDA | 97 | 83 | 100 | 84 | 100 |
| GHANA | 98 | 100 | 92 | 111 | 86 |
| MALI | 99 | 86 | 107 | 145 | 105 |
| SEYCHEL | 100 | 77 | 111 | 102 | 113 |
| CAMEROON | 101 | 109 | 101 | 133 | 97 |
| ALGERIA | 102 | 116 | 97 | 99 | 93 |
| TUNISIA | 103 | 94 | 104 | 119 | 94 |
| SYRIA | 104 | 110 | 99 | 94 | 81 |
| GUADLPE | 105 | 98 | 110 | 92 | 76 |
| FIJI | 106 | 105 | 108 | 129 | 89 |
| ZAIRE | 107 | 134 | 98 | 86 | 106 |
| BNGLD SH | 108 | 87 | 103 | 95 | 92 |
| ALBANIA | 109 | 112 | 95 | 124 | 87 |
| LIBERIA | 110 | 115 | 109 | 85 | 115 |
| NEPAL | 111 | 92 | 112 | 107 | 88 |
| AFGHAN | 112 | 99 | 113 | 97 | 99 |
| MALTA | 113 | 97 | 114 | 104 | 95 |
| SENEGAL | 114 | 102 | 123 | 143 | 117 |
| PARAGUA | 115 | 124 | 102 | 89 | 123 |
| BURMA | 116 | 103 | 116 | 112 | 120 |
| SIER LN | 117 | 136 | 121 | 110 | 118 |
| G BISAU | 118 | 120 | 122 | 90 | 138 |
| MADAGAS | 119 | 125 | 115 | 109 | 124 |
| OMAN | 120 | 117 | 124 | 122 | 112 |
| KUWAIT | 121 | 111 | 130 | 116 | 116 |
| CONGO | 122 | 127 | 118 | 141 | 108 |
| QATAR | 123 | 137 | 127 | 115 | 128 |
| FR GULAN | 124 | 118 | 134 | 101 | 121 |
| KOREA N | 125 | 133 | 117 | 96 | 146 |
| FR IND O | 126 | 114 | 142 | 148 | 126 |
| TANZANIA | 127 | 147 | 119 | 103 | 139 |
| LIBYA | 128 | 146 | 120 | 100 | 144 |

| | | | | | |
|----------|-----|-----|-----|-----|-----|
| SUDAN | 129 | 126 | 135 | 117 | 144 |
| GREENLD | 130 | 121 | 125 | 106 | 136 |
| US NES | 131 | 131 | 139 | 144 | 129 |
| NEW GUIN | 132 | 142 | 126 | 135 | 98 |
| LAO | 133 | 144 | 131 | 140 | 90 |
| ZAMBIA | 134 | 129 | 129 | 108 | 151 |
| YEMEN N | 135 | 119 | 136 | 121 | 149 |
| ANGOLA | 136 | 143 | 128 | 114 | 133 |
| S HELNA | 137 | 113 | 140 | 123 | 145 |
| SP MQEL | 138 | 132 | 145 | 120 | 143 |
| MALAWI | 139 | 151 | 138 | 125 | 141 |
| VIETNAM | 140 | 140 | 133 | 134 | 111 |
| UGANDA | 141 | 139 | 132 | 137 | 127 |
| ASIA NES | 142 | 128 | 146 | 150 | 140 |
| SAMOA | 143 | 152 | 144 | 136 | 130 |
| SOMALIA | 144 | 123 | 149 | 138 | 154 |
| IRAQ | 145 | 141 | 141 | 130 | 91 |
| GAMBIA | 146 | 122 | 151 | 151 | 132 |
| MAURITN | 147 | 135 | 143 | 126 | 134 |
| BURUNDI | 148 | 158 | 137 | 98 | 156 |
| C AFRICA | 149 | 153 | 148 | 139 | 142 |
| TOGO | 150 | 149 | 153 | 153 | 137 |
| BURKINA | 151 | 130 | 152 | 156 | 147 |
| RWANDA | 152 | 138 | 150 | 146 | 131 |
| ETHIOPIA | 153 | 150 | 147 | 152 | 119 |
| BENIN | 154 | 154 | 155 | 154 | 135 |
| CHAD | 155 | 156 | 154 | 149 | 153 |
| CAMBOD | 156 | 148 | 157 | 157 | 152 |
| FALK IS | 157 | 155 | 159 | 160 | 157 |
| DJIBOUTI | 158 | 157 | 158 | 159 | 155 |
| CUBA | 159 | 160 | 156 | 155 | 158 |
| EQ GNEA | 160 | 159 | 160 | 158 | 159 |

Table 2: Country-Based Rankings

| | Base | Mnfg | Wghtd | Imputed |
|----------|------|------|-------|---------|
| CANADA | 1 | 1 | 1 | 1 |
| UKINGDOM | 2 | 2 | 2 | 2 |
| GERMAN | 3 | 3 | 3 | 3 |
| JAPAN | 4 | 4 | 4 | 4 |
| FRANCE | 5 | 5 | 5 | 5 |
| ITALY | 6 | 6 | 7 | 6 |
| MEXICO | 7 | 7 | 6 | 7 |
| NETHLS | 8 | 8 | 8 | 8 |
| BEL LUX | 9 | 9 | 9 | 9 |
| SWITZLD | 10 | 10 | 10 | 10 |
| SWEDEN | 11 | 11 | 11 | 11 |
| SPAIN | 12 | 13 | 13 | 12 |
| TAIWAN | 13 | 12 | 12 | 13 |
| HONGKONG | 14 | 14 | 14 | 14 |
| DENMARK | 15 | 15 | 17 | 15 |
| BRAZIL | 16 | 16 | 15 | 17 |
| AUSTRIA | 17 | 18 | 18 | 16 |
| AUSTRAL | 18 | 17 | 16 | 19 |
| INDIA | 19 | 19 | 20 | 18 |
| KOREA S | 20 | 20 | 19 | 20 |
| ISRAEL | 21 | 21 | 21 | 21 |
| NORWAY | 22 | 22 | 23 | 22 |
| IRELAND | 23 | 23 | 24 | 24 |
| PORTUGAL | 24 | 25 | 28 | 23 |
| CHINA | 25 | 24 | 22 | 34 |
| FINLAND | 26 | 28 | 27 | 27 |
| S AFRICA | 27 | 26 | 25 | 30 |
| ARGENT | 28 | 27 | 26 | 31 |
| COLOMBIA | 29 | 29 | 31 | 29 |
| SINGAPR | 30 | 31 | 29 | 33 |
| PHIL | 31 | 30 | 30 | 32 |
| POLAND | 32 | 32 | 35 | 37 |
| YUGOSLAV | 33 | 33 | 34 | 36 |
| UNKNOWN | 34 | 45 | 88 | 28 |
| THAILAND | 35 | 35 | 32 | 42 |
| GREECE | 36 | 34 | 37 | 38 |
| NEW ZEAL | 37 | 36 | 33 | 43 |
| DOM REP | 38 | 37 | 40 | 46 |
| VENEZ | 39 | 38 | 36 | 53 |
| HAITI | 40 | 39 | 52 | 35 |
| GERMAN E | 41 | 43 | 42 | 49 |
| MALAYSIA | 42 | 40 | 38 | 54 |
| USSR | 43 | 42 | 39 | 62 |
| CZECHO | 44 | 48 | 43 | 58 |
| JAMAICA | 45 | 41 | 48 | 44 |
| ROMANIA | 46 | 47 | 51 | 47 |
| PERU | 47 | 44 | 41 | 55 |
| GUATMALA | 48 | 46 | 50 | 52 |
| PAKISTAN | 49 | 49 | 54 | 48 |
| HUNGARY | 50 | 51 | 44 | 61 |
| TURKEY | 51 | 50 | 46 | 60 |
| IRAN | 52 | 53 | 57 | 45 |
| INDONES | 53 | 54 | 47 | 71 |
| PANAMA | 54 | 57 | 53 | 66 |
| COS RICA | 55 | 58 | 49 | 70 |
| SALVADR | 56 | 59 | 58 | 56 |
| ECUADOR | 57 | 55 | 55 | 64 |
| CHILE | 58 | 56 | 45 | 83 |
| NICARAGA | 59 | 52 | 78 | 41 |
| LEBANON | 60 | 61 | 65 | 57 |
| GILBRALT | 61 | 65 | 72 | 59 |
| BAHAMAS | 62 | 60 | 68 | 63 |
| MOROCCO | 63 | 62 | 59 | 68 |

| | | | | |
|----------|-----|-----|-----|-----|
| TRINIDAD | 64 | 63 | 62 | 74 |
| HONDURA | 65 | 64 | 61 | 78 |
| URUGUAY | 66 | 66 | 63 | 77 |
| N ANTIL | 67 | 67 | 64 | 80 |
| KENYA | 68 | 69 | 60 | 88 |
| SYRIA | 69 | 68 | 81 | 72 |
| ST K NEV | 70 | 70 | 56 | 98 |
| MACAU | 71 | 74 | 71 | 85 |
| MALTA | 72 | 83 | 83 | 73 |
| BARBADO | 73 | 76 | 73 | 81 |
| SRI LKA | 74 | 72 | 70 | 89 |
| ICELAND | 75 | 75 | 66 | 90 |
| EGYPT | 76 | 73 | 67 | 94 |
| AFGHAN | 77 | 80 | 90 | 69 |
| BOLIVIA | 78 | 78 | 79 | 87 |
| GUYANA | 79 | 71 | 97 | 84 |
| YEMEN S | 80 | 77 | 116 | 67 |
| GHANA | 81 | 81 | 91 | 93 |
| NIGERIA | 82 | 79 | 85 | 97 |
| PARAGUA | 83 | 84 | 103 | 82 |
| CYPRUS | 84 | 85 | 82 | 99 |
| SD ARAB | 85 | 91 | 69 | 111 |
| VIETNAM | 86 | 86 | 108 | 76 |
| BULGARIA | 87 | 93 | 74 | 109 |
| GUADLPE | 88 | 92 | 87 | 95 |
| TANZANIA | 89 | 82 | 111 | 79 |
| NEPAL | 90 | 105 | 95 | 96 |
| BNGLD SH | 91 | 100 | 80 | 101 |
| GREENLD | 92 | 99 | 115 | 75 |
| BELIZE | 93 | 89 | 93 | 102 |
| BERMUDA | 94 | 103 | 92 | 103 |
| LIBERIA | 95 | 95 | 105 | 91 |
| MOZAMBQ | 96 | 88 | 101 | 114 |
| IRAQ | 97 | 90 | 127 | 50 |
| ETHIOPIA | 98 | 96 | 120 | 65 |
| ARAB EM | 99 | 106 | 76 | 117 |
| TUNISIA | 100 | 110 | 84 | 105 |
| LIBYA | 101 | 94 | 150 | 26 |
| NEW CALE | 102 | 107 | 94 | 115 |
| IVY CST | 103 | 104 | 77 | 121 |
| ZAIRE | 104 | 97 | 113 | 110 |
| ALGERIA | 105 | 98 | 123 | 112 |
| NEW GUIN | 106 | 102 | 121 | 100 |
| MADAGAS | 107 | 101 | 117 | 113 |
| LAO | 108 | 113 | 112 | 104 |
| SURINAM | 109 | 114 | 96 | 122 |
| ANGOLA | 110 | 87 | 146 | 39 |
| MRITIUS | 111 | 121 | 75 | 126 |
| FIJI | 112 | 111 | 100 | 119 |
| NIGER | 113 | 120 | 89 | 136 |
| KOREA N | 114 | 128 | 155 | 86 |
| JORDON | 115 | 124 | 86 | 132 |
| CAMEROON | 116 | 118 | 99 | 128 |
| KUWAIT | 117 | 131 | 106 | 116 |
| UGANDA | 118 | 108 | 145 | 108 |
| SIER LN | 119 | 119 | 118 | 125 |
| MALI | 120 | 129 | 98 | 130 |
| BURMA | 121 | 121 | 114 | 127 |
| CONGO | 122 | 109 | 143 | 120 |
| ZAMBIA | 123 | 123 | 130 | 107 |
| BENIN | 124 | 117 | 147 | 40 |
| ZIMBABWE | 125 | 132 | 104 | 141 |
| ALBANIA | 126 | 112 | 153 | 148 |
| GABON | 127 | 126 | 109 | 153 |
| S HELNA | 128 | 127 | 129 | 118 |

| | | | | |
|----------|-----|-----|-----|-----|
| KIRIBATI | 129 | 130 | 102 | 142 |
| OMAN | 130 | 136 | 122 | 135 |
| SENEGAL | 131 | 137 | 107 | 134 |
| MAURITN | 132 | 133 | 134 | 106 |
| BAHRAIN | 133 | 140 | 119 | 145 |
| G BISAU | 134 | 135 | 126 | 140 |
| BURUNDI | 135 | 115 | 154 | 51 |
| FR GULAN | 136 | 134 | 141 | 131 |
| SAMOA | 137 | 116 | 139 | 124 |
| SEYCHEL | 138 | 144 | 110 | 146 |
| BURKINA | 139 | 148 | 133 | 137 |
| MALAWI | 140 | 125 | 137 | 123 |
| QATAR | 141 | 143 | 144 | 149 |
| YEMEN N | 142 | 139 | 128 | 151 |
| SUDAN | 143 | 138 | 131 | 150 |
| RWANDA | 144 | 151 | 142 | 143 |
| ASIA NES | 145 | 149 | 125 | 144 |
| GUINEA | 146 | 146 | 124 | 155 |
| US NES | 147 | 153 | 132 | 152 |
| SP MQEL | 148 | 141 | 152 | 129 |
| CUBA | 149 | 142 | 160 | 25 |
| TOGO | 150 | 150 | 136 | 133 |
| CAMBOD | 151 | 156 | 138 | 139 |
| MONGOLA | 152 | 147 | 149 | 160 |
| GAMBIA | 153 | 157 | 140 | 154 |
| C AFRICA | 154 | 154 | 151 | 156 |
| SOMALIA | 155 | 155 | 148 | 157 |
| FR IND O | 156 | 158 | 135 | 158 |
| CHAD | 157 | 152 | 157 | 147 |
| DJIBOUTI | 158 | 145 | 158 | 138 |
| FALK IS | 159 | 160 | 156 | 159 |
| EQ GNEA | 160 | 159 | 159 | 92 |

Table 3: Comparison of Goods- and Country-Based Rankings

| | Country-Based | Goods-Based |
|----------|---------------|-------------|
| CANADA | 1 | 1 |
| UKINGDOM | 2 | 2 |
| GERMAN | 3 | 3 |
| JAPAN | 4 | 4 |
| FRANCE | 5 | 5 |
| ITALY | 6 | 8 |
| MEXICO | 7 | 6 |
| NETHLDS | 8 | 7 |
| BEL LUX | 9 | 9 |
| SWITZLD | 10 | 10 |
| SWEDEN | 11 | 12 |
| SPAIN | 12 | 14 |
| TAIWAN | 13 | 13 |
| HONGKONG | 14 | 17 |
| DENMARK | 15 | 19 |
| BRAZIL | 16 | 15 |
| AUSTRIA | 17 | 20 |
| AUSTRAL | 18 | 16 |
| INDIA | 19 | 24 |
| KOREA S | 20 | 18 |
| ISRAEL | 21 | 22 |
| NORWAY | 22 | 23 |
| IRELAND | 23 | 25 |
| PORTUGAL | 24 | 35 |
| CHINA | 25 | 11 |
| FINLAND | 26 | 26 |
| S AFRICA | 27 | 21 |
| ARGENT | 28 | 27 |
| COLOMBIA | 29 | 37 |
| SINGAPR | 30 | 28 |
| PHIL | 31 | 34 |
| POLAND | 32 | 38 |
| YUGOSLAV | 33 | 41 |
| UNKNOWN | 34 | 31 |
| THAILAND | 35 | 33 |
| GREECE | 36 | 44 |
| NEW ZEAL | 37 | 32 |
| DOM REP | 38 | 39 |
| VENEZ | 39 | 30 |
| HAITI | 40 | 62 |
| GERMAN E | 41 | 43 |
| MALAYSIA | 42 | 40 |
| USSR | 43 | 29 |
| CZECHO | 44 | 42 |
| JAMAICA | 45 | 52 |
| ROMANIA | 46 | 51 |
| PERU | 47 | 45 |
| GUATMALA | 48 | 53 |
| PAKISTAN | 49 | 58 |
| HUNGARY | 50 | 46 |
| TURKEY | 51 | 48 |
| IRAN | 52 | 77 |
| INDONES | 53 | 47 |
| PANAMA | 54 | 54 |
| COS RICA | 55 | 50 |
| SALVADR | 56 | 68 |
| ECUADOR | 57 | 55 |
| CHILE | 58 | 36 |
| NICARAGA | 59 | 87 |
| LEBANON | 60 | 79 |
| GILBRALT | 61 | 80 |
| BAHAMAS | 62 | 66 |

| | | |
|----------|-----|-----|
| MOROCCO | 63 | 63 |
| TRINIDAD | 64 | 60 |
| HONDURA | 65 | 61 |
| URUGUAY | 66 | 70 |
| N ANTIL | 67 | 64 |
| KENYA | 68 | 65 |
| SYRIA | 69 | 104 |
| ST K NEV | 70 | 49 |
| MACAU | 71 | 72 |
| MALTA | 72 | 113 |
| BARBADO | 73 | 85 |
| SRI LKA | 74 | 74 |
| ICELAND | 75 | 69 |
| EGYPT | 76 | 57 |
| AFGHAN | 77 | 112 |
| BOLIVIA | 78 | 89 |
| GUYANA | 79 | 83 |
| YEMEN S | 80 | 82 |
| GHANA | 81 | 98 |
| NIGERIA | 82 | 84 |
| PARAGUA | 83 | 115 |
| CYPRUS | 84 | 88 |
| SD ARAB | 85 | 56 |
| VIETNAM | 86 | 140 |
| BULGARIA | 87 | 67 |
| GUADLPE | 88 | 105 |
| TANZANIA | 89 | 127 |
| NEPAL | 90 | 111 |
| BNGLD SH | 91 | 108 |
| GREENLD | 92 | 130 |
| BELIZE | 93 | 96 |
| BERMUDA | 94 | 97 |
| LIBERIA | 95 | 110 |
| MOZAMBQ | 96 | 86 |
| IRAQ | 97 | 145 |
| ETHIOPIA | 98 | 153 |
| ARAB EM | 99 | 75 |
| TUNISIA | 100 | 103 |
| LIBYA | 101 | 128 |
| NEW CALE | 102 | 94 |
| IVY CST | 103 | 73 |
| ZAIRE | 104 | 107 |
| ALGERIA | 105 | 102 |
| NEW GUIN | 106 | 132 |
| MADAGAS | 107 | 119 |
| LAO | 108 | 133 |
| SURINAM | 109 | 91 |
| ANGOLA | 110 | 136 |
| MRITIUS | 111 | 71 |
| FIJI | 112 | 106 |
| NIGER | 113 | 59 |
| KOREA N | 114 | 125 |
| JORDON | 115 | 76 |
| CAMEROON | 116 | 101 |
| KUWAIT | 117 | 121 |
| UGANDA | 118 | 141 |
| SIER LN | 119 | 117 |
| MALI | 120 | 99 |
| BURMA | 121 | 116 |
| CONGO | 122 | 122 |
| ZAMBIA | 123 | 134 |
| BENIN | 124 | 154 |
| ZIMBABWE | 125 | 92 |
| ALBANIA | 126 | 109 |
| GABON | 127 | 78 |

| | | |
|-----------------|-----|-----|
| S HELNA | 128 | 137 |
| KIRIBATI | 129 | 81 |
| OMAN | 130 | 120 |
| SENEGAL | 131 | 114 |
| MAURITN | 132 | 147 |
| BAHRAIN | 133 | 95 |
| G BISAU | 134 | 118 |
| BURUNDI | 135 | 148 |
| FR GUIAN | 136 | 124 |
| SAMOA | 137 | 143 |
| SEYCHEL | 138 | 100 |
| BURKINA | 139 | 151 |
| MALAWI | 140 | 139 |
| QATAR | 141 | 123 |
| YEMEN N | 142 | 135 |
| SUDAN | 143 | 129 |
| RWANDA | 144 | 152 |
| ASIA NES | 145 | 142 |
| GUINEA | 146 | 93 |
| US NES | 147 | 131 |
| SP MQEL | 148 | 138 |
| CUBA | 149 | 159 |
| TOGO | 150 | 150 |
| CAMBOD | 151 | 156 |
| MONGOLA | 152 | 90 |
| GAMBIA | 153 | 146 |
| C AFRICA | 154 | 149 |
| SOMALIA | 155 | 144 |
| FR IND O | 156 | 126 |
| CHAD | 157 | 155 |
| DJIBOUTI | 158 | 158 |
| FALK IS | 159 | 157 |
| EQ GNEA | 160 | 160 |

Table 4: Cross-Country Growth Equations

| | | |
|---|-------------|-------------|
| Ranking(x100) | -0.02 (3.4) | -0.02 (3.8) |
| Log of 1960 GDP (x100) | -1.0(3.8) | -1.2 (3.4) |
| Investment/GDP | .15 (5.9) | .13 (4.5) |
| Average Years of School in the Population over 25 (1985) | | .00 (.3) |
| Percentage of the Population without Schooling (1985) | | .00 (.3) |
| Assassinations per million population (1985) | | -.01 (1.4) |
| Average Annual Number of Revolutions and Coups | | .002 (.3) |
| Exports/GDP | | .02 (1.4) |
| Own Import-Weighted Tariffs on Intermediate Inputs and Capital Goods | | -.07 (3.9) |
| Measure of Tariff Restriction | | .66 (4.4) |
| Black Market Premium (1985) | | -.001 (1.6) |
| Observations | 82 | 62 |
| R² | .50 | .61 |

Country Rankings estimated treating countries as primitive.
 Absolute value of t-statistics in parentheses.
 OLS with an unreported constant.

Table 5: Hall-Jones Cross-Country Productivity Equations

| | | | |
|---------------------------------------|-------------|--------------|--------------|
| Economic Organization | .02 (.03) | .02 (.03) | .03 (.03) |
| Openness | .55 (.15) | .53 (.15) | .50 (.14) |
| GADP | .88 (.27) | .21 (.30) | .31 (.28) |
| International Language | .55 (.09) | .43 (.10) | .46 (.09) |
| Latitude | .003 (.002) | .002 (.002) | .002 (.002) |
| Country-Ranking: Goods-Based | | -.005 (.001) | |
| Country-Ranking: Country-Based | | | -.005 (.001) |
| Observations | 122 | 122 | 122 |
| R² | .57 | .62 | .62 |
| RMSE | .432 | .404 | .407 |

Regressand is log-level of total factor productivity.
 Huber-consistent standard errors in parentheses.
 OLS with an unreported constant.

Figure 1: Perturbations of Goods-Based Rankings

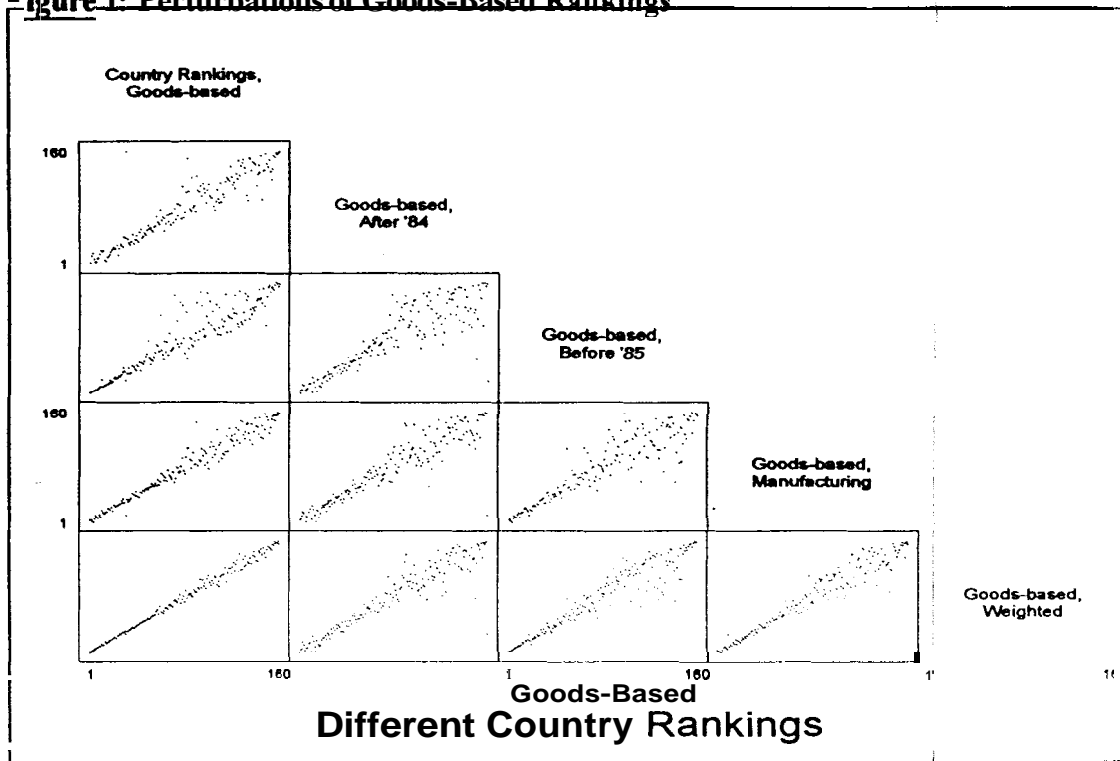


Figure 2: Perturbations of Country-Based Rankings

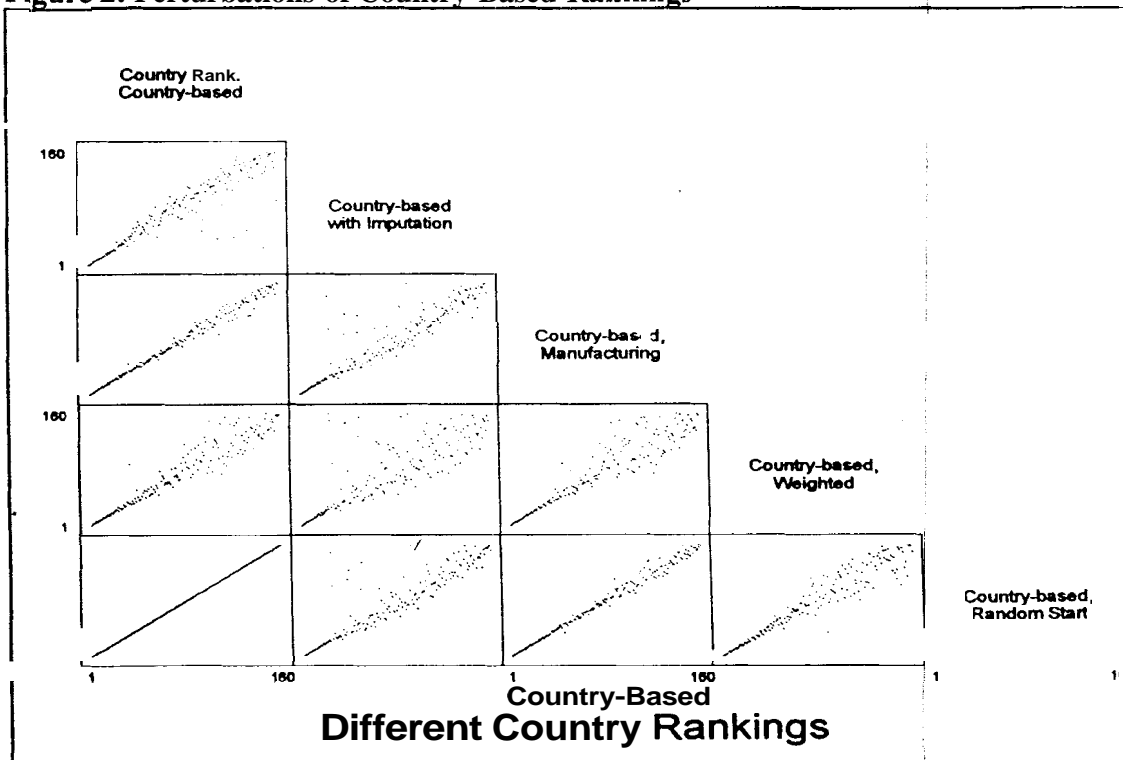


Figure 3: Comparison of Goods- and Country-Based Rankings

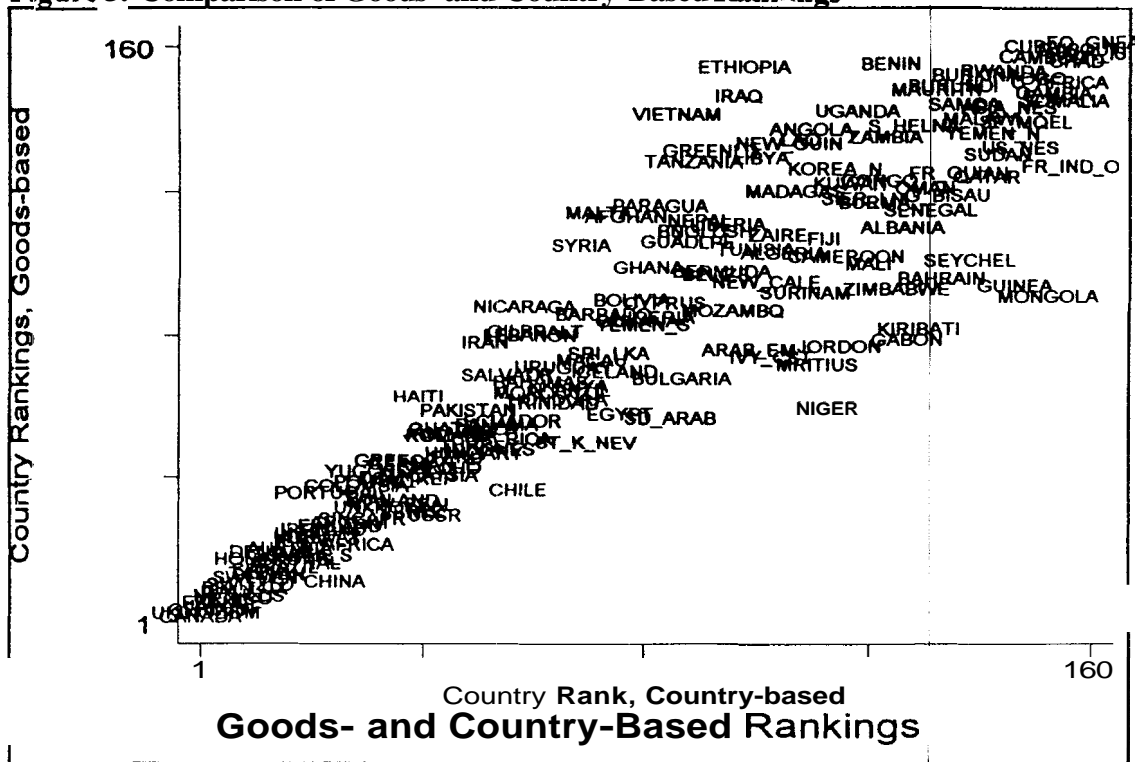


Figure 4: Comparison of Goods- and Country-Based Rankings, Manufacturing Data

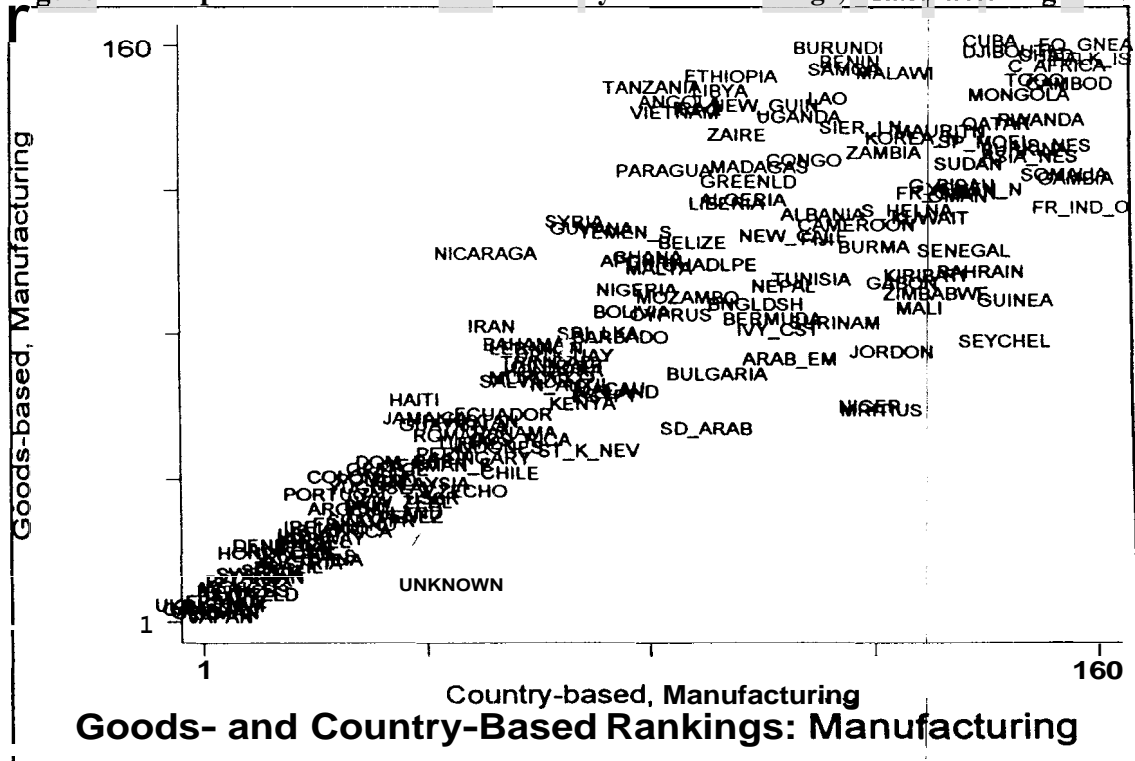


Figure 7: Country Rankings over Time

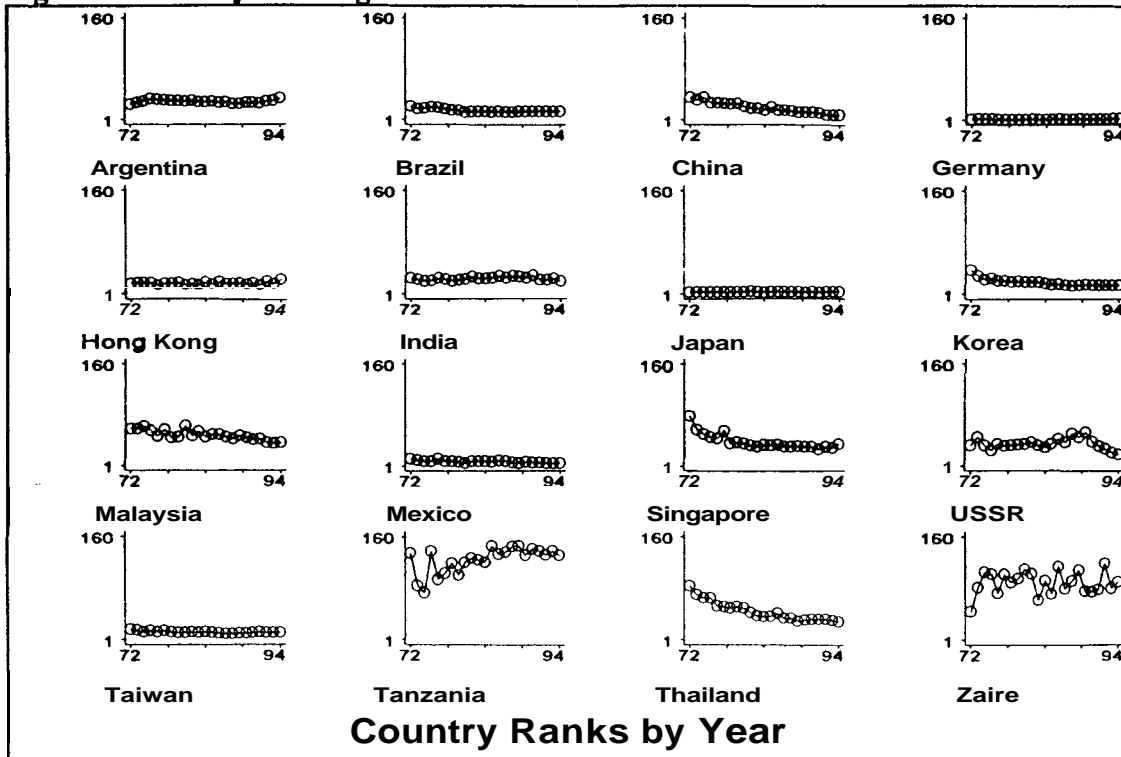


Figure 8: Country Rankings and Real GDP per capita Growth

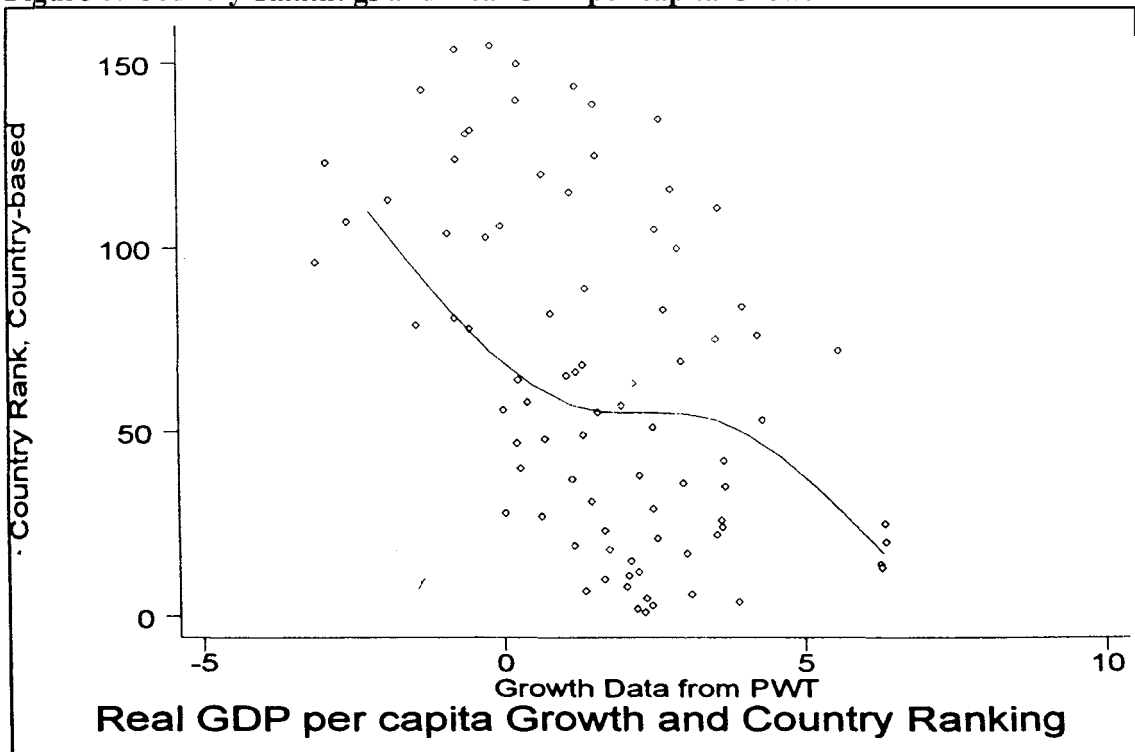


Figure 9: Country Rankings and Real GDP per capita in 1985

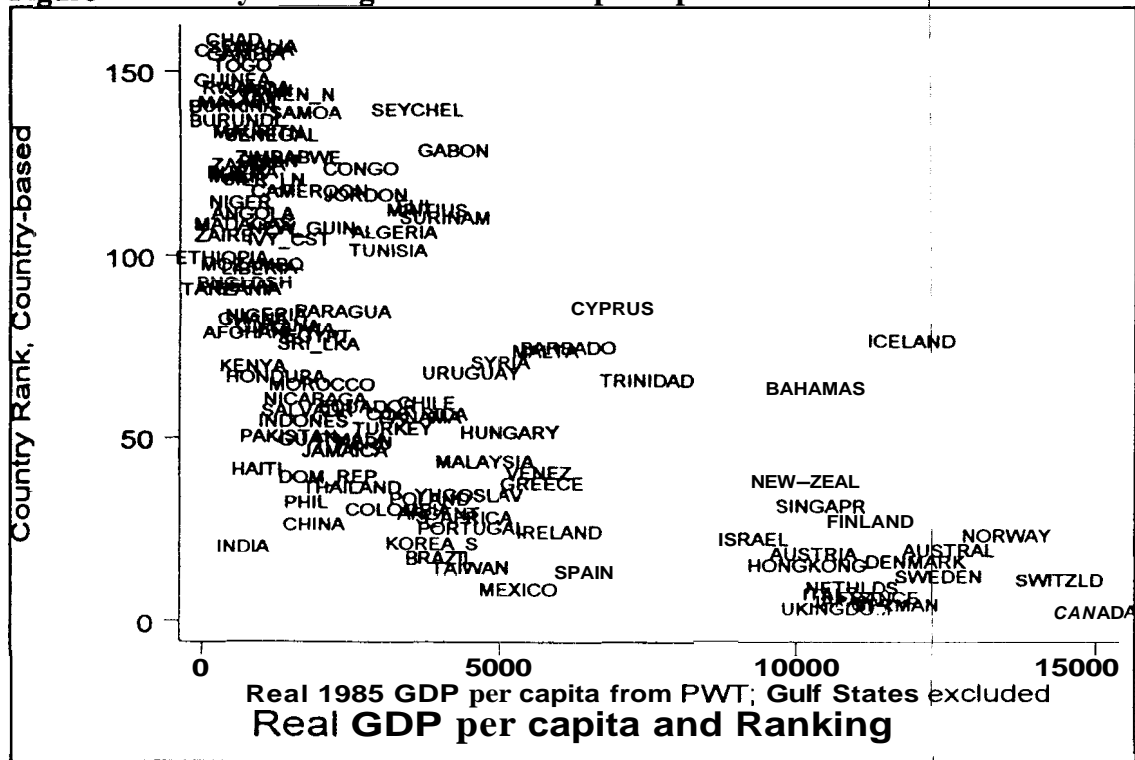


Figure 10: Country Rankings and the Log-Level of Total Factor Productivity

