An Empirical Analysis of Comparative Advantage Dynamics

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Abstract

This paper uses product-level data to analyze how comparative advantage evolves as per capita income rises in a sample of twenty relatively rapidly growing countries. Evidence that output and exports become more diversified—not more specialized—as per capita income rises has been interpreted to suggest that comparative advantage does not evolve as theory predicts and has been taken as a basis for a revival of industrial policy in developing countries. This paper presents evidence that comparative advantages does evolves as theory predicts and provides a reinterpretation of empirical finding of output and export diversification.

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The venerable principle of comparative advantage is a core concept of economics, yet its policy relevance has often been dismissed. The pioneers of development economics dismissed it in providing intellectual justification for the import-substitution industrialization strategy adopted ubiquitously in the 1960s and 1970s, and it is again being dismissed by those promoting a revival industrial policy in developing countries.

In making the case for a revival of industrial policy in developing countries, it has been argued that comparative advantage leads to a dead end, where prosperity is limited to the level of productivity of unskilled labor in labor-intensive manufacturing (World Bank, 2010).[1] More sophisticated versions of the argument appeal to market failures similar to those invoked to justify the import-substitution strategy, in particular learning and coordination externalities that inhibit spontaneous industrial development and movement up the ladder of comparative advantage (Hausmann and Rodrik, 2003).

Direct empirical evidence of the presence market failures and their potential to inhibit industrial development and dynamic comparative advantage is scant. Externalities are, after all, external, hence difficult to identify, much less measure. As a result, the empirical case for industrial and trade policies that run counter to the principle of comparative advantage has had to rely on indirect evidence that comparative advantage does not evolve as theory predicts.

[1] This is the basis of the World Bank's view that most developing countries are in a "Middle-Income Trap." A 2010 World Bank report argues that "For decades, many economies in Asia, Latin America and the Middle East have been stuck in this middle-income trap, where countries are struggling to remain competitive as high volume, low-cost producers in the face of rising wages costs, but are yet unable to move up the value chain and break into fast-growing markets for knowledge and innovation-based products and services." (World Bank, 2010, p.27)

The most widely cited indirect evidence against comparative advantage dynamics is a study by Imbs and Wacziarg (2003), based on industry-level data, that finds that industrial value-added and employment become more diversified—not more specialized as the theory of comparative advantage supposedly predicts—as per capita income rises up to a relatively high level of about $25,000, after which sectoral re-concentration occurs. Klinger and Lederman (2006), using product-level data, find that exports become increasingly diversified as per capita income rises up to a similar level, after which they become more concentrated. Citing these findings of production and export diversification on the road to higher per capita income, Rodrik (2004, p. 7) suggests that "Whatever it is that serves as the driving force of economic development, it cannot be the forces of comparative advantage as conventionally understood."

This paper provides an empirical analysis of how comparative advantage evolves as per capita income rises in a sample of twenty relatively rapidly growing countries. Our analysis is conducted at the SITC 5-digit level of aggregation, which consists of about 1,200 product categories. The analytical approach followed in this study has only recently become possible with the publication of an UNCTAD study that provides data on factor intensities (capital per worker) at the same SITC 5-digit level of aggregation (Sirotori, Tumurchudur and Cadot, 2010).

After presenting an empirical analysis of comparative advantage dynamics, we revisit the oft-cited indirect evidence that supposedly runs counter to the predictions of the theory of dynamic comparative advantage, offering an interpretation of these finding that is consistent with the conventional understanding of how comparative advantage evolves as per capita income rises.

1. How Comparative Advantage Evolves as Per Capita Income Rises

Theory

The theory of comparative advantage dynamics derives in equal parts from the theories of trade and growth. Mainstream trade theory argues that countries find a comparative advantage in those products that use relatively intensively their relatively abundant factor of production (e.g. relatively labor-intensive goods in relatively labor-abundant countries). Growth theory argues that per capita income rises principally from the accumulation of relatively scarce factors—in developing countries, physical and human capital—and technology change, which in developing countries largely involves investment in imported capital equipment embodying newer technology and attracting foreign direct investment—in other words, technology change in developing counties occurs in large part from capital accumulation. The ever-popular metaphor of "trade as an engine of growth" has no basis in theory.[2] In theory, comparative advantage and per capita income are jointly determined by endowment and technology and so may be expected to move together through time as endowment and technology change.

Data

The strength of a country's comparative advantage in a particular product is measured here by the well-known concept of Revealed Comparative Advantage (Balassa, 1965). According to this concept, a country is revealed to have a comparative advantage in a particular product if the share of that product in the country's exports is greater than the share of the product in world trade. Accordingly the revealed comparative advantage (RCA) of country j, in product i, in year t, is measured as:

[2] See Kravis (1970), Lewis (1980) and Riedel (1984).

(1) $$RCA_{j,i,t} = \frac{X_{j,i,t} \Big/ \sum_i X_{j,i,t}}{\sum_j X_{j,i,t} \Big/ \sum_j \sum_i X_{j,i,t}}$$

where $X_{j,i,t}$ is the value of exports by country j of product i in year t. The numerator is the share of product i in total exports of country j in year t and the denominator is the share of product i in world (sum of all countries) exports in year t. A value of $RCA_{i,j,t} > 1$ indicates that country j had a comparative advantage in product i in year t, the higher the value of RCA the stronger the comparative advantage.[3] We use the UN COMTRADE database managed by the World Bank (WITS) for export data at the SITC 5-digit level (1,162 individual product categories). We use SITC Revision-1 for which data for some of our sample countries, but not all, are available as far back as 1962.

The data used for capital-intensity are from a recent UNCTAD study that provides a measure of "revealed" capital-intensity of products at the SITC 5-digit level (Sirotori, Tumurchudur and Cadot, 2010). A product's capital-intensity (i.e. its capital-labor ratio) is revealed by the weighted average of the ratio of capital to labor endowment of the countries that export the product. In other words, a product is revealed to be relatively capital-intensive if it is exported disproportionately by relatively capital-abundant countries.[4] Specifically, revealed capital intensity of good i is computed as:

[3] A major shortcoming of the data is that it reports the gross value of exports from each country, not domestic value-added exported. The growth of international production fragmentation has created a great discordance between gross and net exports (gross exports minus the value of imported intermediate inputs used in the production of exports). Industry shares in gross exports and in export value-added could in principle—and in all likelihood do in practice—differ significantly. Unfortunately this is a shortcoming of the data that we are unable to correct.

[4] The UNCTAD study provides not only capital-intensities, but also human capital intensities and natural resource intensities. At his stage we restrict our analysis to capital intensity.

$$(2) \qquad k_i = \sum_j \omega_{i,j} \frac{K_j}{L_j}, \quad \omega_{i,j} = \frac{X_{j,i} / \sum_j X_{i,j}}{\sum_j \left(X_{j,i} / \sum_j X_{i,j} \right)}$$

where $\omega_{i,j}$ is the weight of country j for product i ($\sum_i \omega_{i,j}$ =1), K_j and L_j are the capital and labor endowments of country j.

This measure of capital intensity has both advantages and disadvantages relative to the conventional measures of factor intensity that derive from industrial census data. An obvious disadvantage is that the product capital-labor ratio is imputed rather than measured directly by the capital and labor employed per unit output of the product. This disadvantage also carries an advantage, however, since direct measurement of capital and labor employed at the last stage of a product's production is an incomplete measure of capital intensity, since it does not take account of the capital and labor requirements in the production of the intermediate inputs that going into the production of the final product. Computation of the total capital and labor requirements (at the final stage and in the production of intermediate inputs) requires input-output tables, which generally are not available at the product-level of aggregation.

The revealed factor intensity measure does, however, pose a potential issue since the weight in the measure of revealed factor intensity (ω) is a variant of the measure of revealed comparative advantage.[5] This raises a question as to whether a correlation between revealed factor intensity and reveal comparative advantage is spurious. To explore this possibility, we have computed crosswise Spearman rank correlation

[5] The denominator is the sum of product shares across all countries rather than the share of product in world trade, as in the RCA index. This variant is designed so that the weights sum to one.

coefficients of the revealed factor intensity index by year. We find that the Spearman Rank Correlation between indexes of each year yielded coefficients uniformly around 0.9, suggesting that factor intensity rankings are not influenced to any significant extent by the weights. In other words, there are few factor intensity reversals over time—any one year is as good as any other in representing the relative capital intensity of products. In the analysis reported below we use an average of the capital intensity indexes for the years 1997-2007 as our index of capital intensity. Since the factor intensity measure for each product is held constant over time and across countries, all of the changes in the factor intensity of a country's export bundle result from changes in the composition of exports.

Method

If, as theory and ample empirical evidence suggest, capital deepening (a rising endowment of capital relative to labor) leads to higher per capita income, then associated with a rising in per capita income we should observe change in revealed comparative advantage toward ever more capital-intensive products.

Our analysis of this hypothesis involves two steps. First we derive the relationship between revealed comparative advantage and capital-intensity, measured as capital (in constant 2005 PPP dollars) per worker (k_i), at the product level (i) by estimating the following simple linear regression for each country (j) in each year (t):

$$RCA_{j,i,t} = \alpha_{j,t} + \beta_{j,t} \cdot k_i + \varepsilon_{j,i,t} \qquad (3)$$

The relationship between RCA and capital intensity (k) in country j, year t ($\hat{\beta}_{j,t}$) is expected to increase as the level of per capita income increases. If a country's per capita income is relatively low, $\hat{\beta}_{j,t}$ is expected to be negative, indicating a bias toward relatively labor-intensive products. As per capita income rises, $\hat{\beta}_{j,t}$ is expected to rise, as comparative advantage shifts to increasingly more capital-intensive products. As illustrated in Figure 1, the regression line derived from estimating equation (3) is expected to rotate counterclockwise as a country's per capita income rises over time.

The second step in our analysis is a statistical assessment of the relation between annual estimates of β ($\hat{\beta}_t$) and per capita income (y_t) in each country (j). The hypothesis is that the relation between $\hat{\beta}_t$ and y_t is positive and diminishing as countries advance up the ladder of comparative advantage, as illustrated in Figure 2.

Figure 1: The relation between RCA and k_i

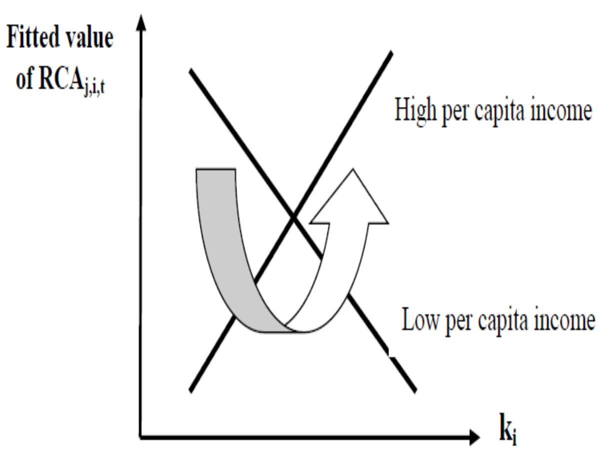
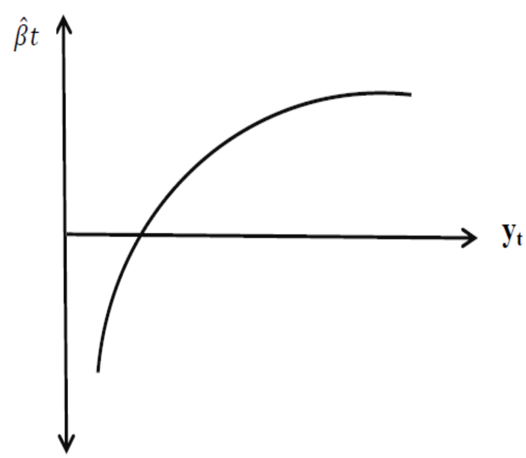


Figure 2: The relation between $\hat{\beta}_{j,t}$ and y_y



In assessing the relation between $\hat{\beta}_{j,t}$ and $y_{j,t}$ we use both non-parametric (lowess smoothing) and OLS regression methods. The parametric relation between the two variables is obtained by a weighted regression with a country fixed-effect (F_j):

(4) $\hat{\beta}_{j,t} = a_j + b_j \ln\left(y_{j,t}\right) + cF_j + \varepsilon_{j,t}$

in which the observations are weighted by inverse of the standard error of the estimates of β, obtained in step one from estimates of equation (3). The weighted regression technique is necessary to mitigate heteroscedasticity, since there is evidence that the quality of the data used to estimate β is not uniform over time, but rather improves over time in terms of coverage and accuracy.[6]

Since $\hat{\beta}_{j,t}$ and $y_{j,t}$ follow a trend over time (i.e. are nonstationary), we test whether they are cointegrated (i.e., move together through time) using the Dickey-Fuller test of the stationarity of the estimated residuals in equation 4. The null hypothesis of the Dickey-Fuller test is that the residuals are nonstationary. If the Dickey-Fuller test-statistic is statistically significant, then we may reject the null hypothesis and conclude that the $\hat{\beta}_{j,t}$ and $y_{j,t}$ are cointegrated (i.e. move together through time).

<u>Illustration: Japan</u>

Japan is the country in our sample for which the data are most complete and the rise in per capita income over the period of analysis (1965-2010) was the greatest. It is, therefore, a good case for the purpose of illustrating our analytical approach. Figure 3 is a scatter plot of estimated values of the revealed comparative advantage (RCA) for Japan of SITC 5-digit products (derived from estimating equation 3) against reveal capital intensity of SITC 5-digit products for selected years. Figure 4 is a scatter plot of $\hat{\beta}_t$ on y_t, together with a lowess estimate of the relationship between $\hat{\beta}_t$ and y_t over the period 1965-2010.

[6] Saxonhouse (1976)

Figure 3:
Estimates of (3) for Japan, Selected Years

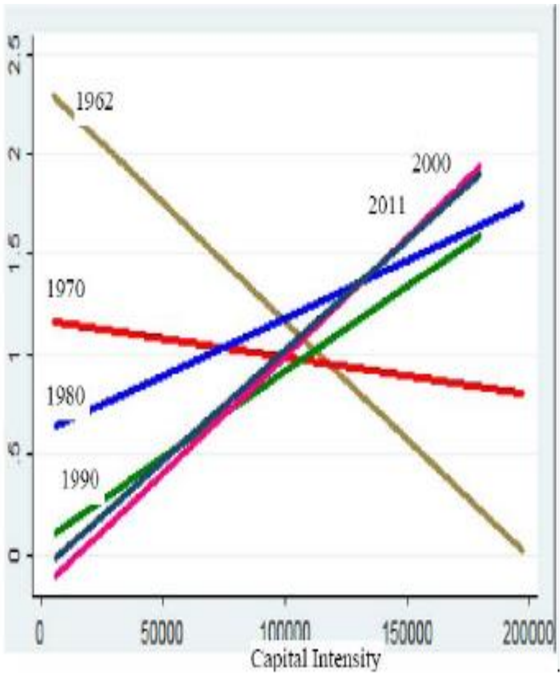
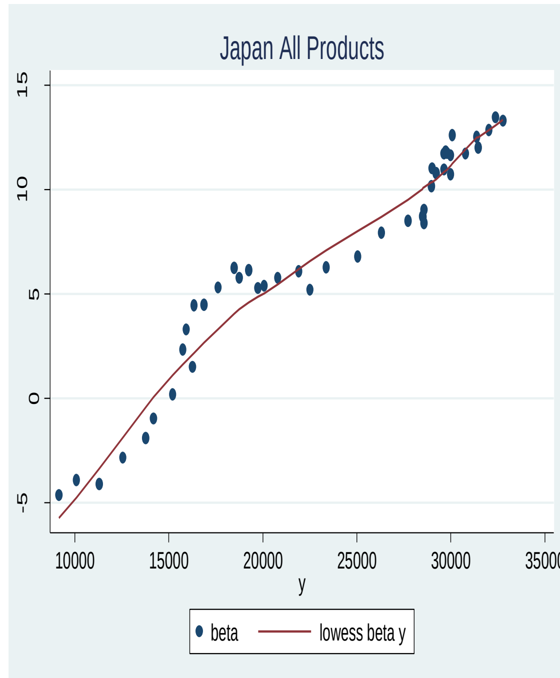


Figure 4
Scatter Plot ($\hat{\beta}$, y) for Japan: 1965-2010



The relationship between $\hat{\beta}$ and per capita income in Japan is clearly positive and appears to diminish with increases in per capita income. Table 1 reports the results of weighted OLS estimates of the relationship, separately for all products and for manufactured products, using a semi-logarithmic specification and weighting observations by the inverse of the standard error of the estimates of $\hat{\beta}$. Figures 5 and 6 are scatter plots of the actual and estimated values of $\hat{\beta}$ on per capita income (y) alternatively for all products and manufactures.

Table 1: Regression Results for Japan, All Products and Manufactures, 1965-2010

Dependent Variable: $\hat{\beta}$	All Products	Manufactures
ln(y) *(t-statistic)*	14.14 *(26.50)*	19.28 (27.41)
Constant *(t-statistic)*	-134.95 *(-25.20)*	-188.08 (-26.58)
R-squared	0.93	0.95
Root MSE	1.87	1.37
Number of observations	45	45
F	707	751
DF test for cointegration	-2.13**	-2.83***
y at which $\hat{\beta}$ =0	$13,958	$17,243

Critical values for DF test: (*)10%= -1.61: (**)5%=-1.95; (***)1%=-2.60

Figures 5 and 6: Scatter Plot of Actual and Estimated $\hat{\beta}$ on Per Capita Income

Fig. 5

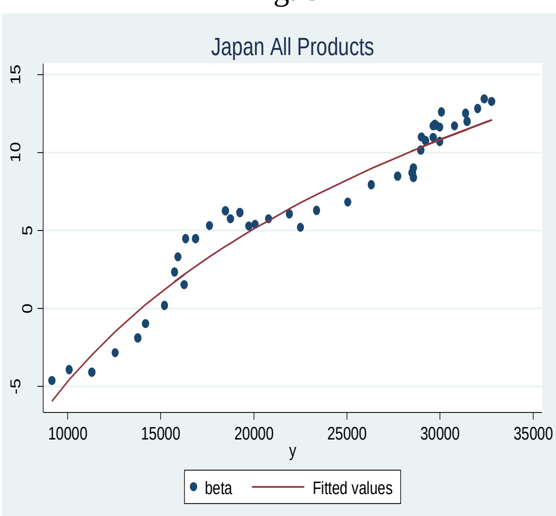
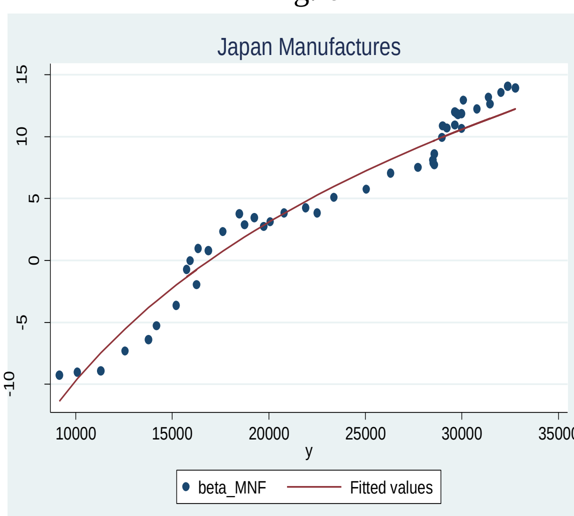


Fig. 6



Dynamic comparative advantage was clearly alive and well in Japan over the past 50 years. In the1960s, Japan's revealed comparative advantage was concentrated in relatively labor-intensive goods—in rank order: fish and shellfish, footwear, wood manufactures, textiles, travel goods, clothing, miscellaneous manufactures—the very same products in which today's relatively poor countries find a comparative advantage. Japan's comparative advantaged shifted from relatively labor-intensive to relatively capital-intensive products at a per capita income level of about $14,000 for all products and about $17,000 for manufactures, which occurred around 1972 and 1978, respectively.

Panel results

Japan experienced dramatic changes in comparative advantage much the way theory predicts, but is Japan's experience representative of other relatively rapidly growing countries? To address that question we have constructed a (unbalanced) panel data set of the twenty fastest growing countries over the past five decades, ten Asian countries (Japan, Korea, Taiwan, Hong Kong, Singapore, China, Malaysia, Thailand, Indonesia, and India) and ten non-Asian countries (Brazil, Mexico, Chile, Spain, Portugal, Greece, Ireland, Turkey, Egypt, and Tunisia). Figures 7 and 8 are a scatter plots of $\hat{\beta}$ against per capita income (y) for the full sample of 20 countries together with a lowess non-parametric estimate of the relationship between the two variables (shown by the red line) for all products and for manufactures, respectively.

The dispersion of data points around the lowess estimate represents both between-country and within-country variation. Our hypotheses relates only to within-country (over time) variation. In estimating the parametric relationship we, therefore, include a country fixed-effect. Table 2 reports the results of weighted regressions of the $\hat{\beta}_{j,t}$ on the logarithm of per capita income ($lny_{j,t}$) with a country fixed-effect (F_j).

Figure 7:

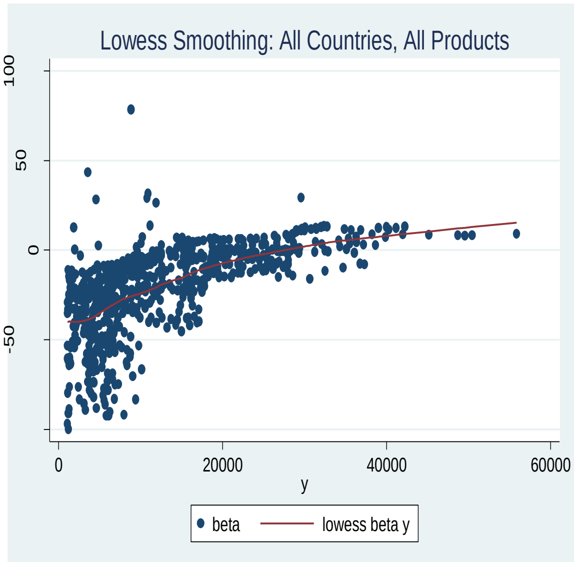


Figure 8

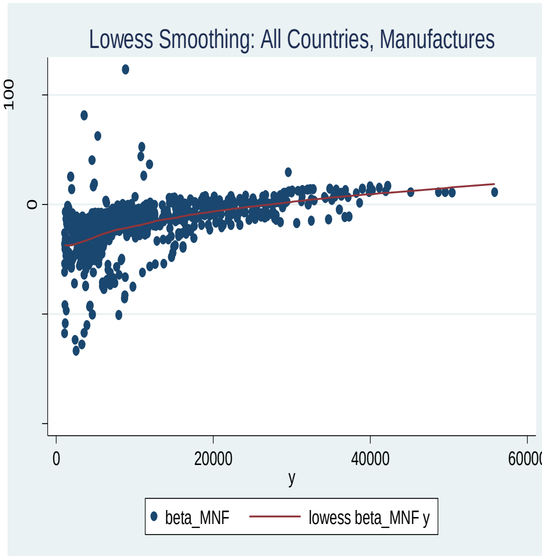


Table 2: Panel Results: All Products and Manufactures

Dependent Variable: $\hat{\beta}$	All Products	Manufactures
ln(y) *(t-statistic)*	16.98 *(37.82)*	18.49 *(34.27)*
Constant *(t-statistic)*	-154.65 *(48.00)*	-174.72 *(-39.48)*
R-squared	0..90	0.89
Root MSE	3.94	4.19
Number of obs	726	726
F-statistic	454	473
DF test for co-integration	-9.30***	-7.60***
y at which $\hat{\beta}$ =0	$9,025	$12,700

Critical values for DF test: (*)10%= -1.61: (**)5%=-1.95; (***)1%=-2.60

As in the case of Japan, so too for the full sample of countries, we find a statistically robust positive relationship between the capital-intensity of revealed comparative advantage and per capita income. Interestingly, the level of per capita income at which the transition in comparative advantage from labor-intensive to capital-intensive products ($\hat{\beta}$ =0) occurs for the panel is at a significantly lower level of per capita income than for Japan, a finding we consider in more detail in the next section.

Country results

The panel regression results indicate that the capital-intensity of comparative advantage and per capita income are positively and statistically significantly related in our sample of 20 countries, but contained within that general finding is a separate story for each of our 20 countries. Telling those stories is beyond the scope of this paper (and the competence of the authors), but it is useful nonetheless to review the estimates for each country, which are presented in Tables 3 and 4 for all products and manufactures, respectively.

Table 3: Country Results: All Products

Dependent Variable: $\hat{\beta}$	ln(y) *(t-statistic)*	Constant *(t-tatistic)*	R^2	y at $\hat{\beta}=0$	DF test-statistic
Japan 1965-2010	14.14 *(26.60)*	-134.96 *(-25.20)*	0.93	13,948	-2.13**
Korea 1970-2010	18.96 *(26.45)*	-188.50 *(-26.39)*	0.95	20,842	-3.44***
Taiwan 1988-2010	28.26 *(12.14)*	-287.43 *(-12.47)*	0.88	26,140	-3.88***
Hong Kong 1965-2010	31.49 *(18.89)*	-330.39 *(-20.06)*	0.87	36,005	-2.31**
Singapore 1965-2010	20.39 *(22.44)*	-211.10 *(-22.62)*	0.93	31,408	-5.13***
Malaysia 1969-2010	18.67 *(19.86)*	-176.06 *(-21.02)*	0.92	12,455	-4.96***
Thailand 1975-2010	63.06 *(8.30)*	-568.17 *(-8.55)*	0.69	8,187	-1.11
China 1987-2010	13.57 *(20.53)*	-126.54 *(-23.59)*	0.95	11,184	-2.89***
Indonesia 1975-2010	-9.14 *(-2.49)*	48.73 *(1.71)*	0.21	207	-2.59**
India 1975-2010	44.30 *(7.28)*	-383.10 *(-8.10)*	0.54	5,695	-4.74***
Brazil 1965-2010	71.02 *(6.89)*	-648.32 *(-7.11)*	0.59	9,212	-2.51**
Chile 1965-2010	20.80 *(5.19)*	-220.60 *(-6.00)*	0.46	40,418	-3.89***
Mexico 1965-2010	38.41 *(7.58)*	-363.03 *(-7.69)*	0.48	12,711	-1.98**

Spain 1965-2010	19.14 *(9.08)*	-194.19 *(-9.13)*	0.63	25,430	-1.85*
Portugal 1965-2010	8.48 *(8.24)*	-86.83 *(-8.72)*	0.39	27,854	-4.05***
Greece 1965-2010	33.55 *(8.38)*	-349.09 *(-8.74)*	0.56	33,034	-2.06**
Ireland 1965-2010	6.47 *(4.55)*	-59.21 *(-4.13)*	0.32	9,437	-4.10***
Turkey 1965-2010	76.07 *(8.74)*	-718.19 *(-9.11)*	0.60	12,594	-2.36**
Egypt 1965-2010	-6.68 *(-0.77)*	22.64 *(0.33)*	0.01	30	-3.39***
Tunisia 1965-2010	2.77 (0.16)	-79.20 *(-0.54)*	0.00	-	-1.92*

Critical values for DF test: (*)10%= -1.61: (**)5%=-1.95; (***)1%=-2.60

Table 4: Country Results: Manufactures

Dependent Variable: $\hat{\beta}$	Ln(y) *(t-statistic)*	Constant *(t-statistic)*	R^2	y at $\hat{\beta}=0$	DF test-statistic
Japan 1965-2010	19.29 *(27.41)*	-188.08 *(-26.58)*	0.95	17,161	-2.83***
Korea 1970-2010	23.38 *(26.72)*	-235.33 *(-26.97)*	0.95	23,529	-9.83***
Taiwan 1988-2010	40.20 *(12.76)*	-413.71 *(-13.26)*	0.90	29,448	-4.40***
Hong Kong 1965-2010	44.03 *(20.49)*	-462.32 *(-21.63)*	0.87	36,341	-2.02**
Singapore 1965-2010	13.82 *(21.90)*	-138.45 *(-21.62)*	0.86	22,342	-3.96***
Malaysia 1969-2010	9.08 *(10.60)*	-85.79 *(-11.34)*	0.72	12,652	-3.69***
Thailand 1975-2010	36.17 *(11.73)*	-329.45 *(-12.12)*	0.78	9,034	-1.77*
China 1987-2010	13.56 *(21.87)*	-134.03 *(-25.51)*	0.93	19,636	-1.83**
Indonesia 1975-2010	-15.89 *(-3.56)*	107.07 *(3.11)*	0.46	845	-3.11***
India 1975-2010	26.39 *(3.99)*	-245.22 *(-4.79)*	0.22	10,854	-5.01***
Brazil 1965-2010	26.71 *(6.72)*	-248.60 *(-7.09)*	0.44	11,023	-3.90***
Chile 1965-2010	33.04 *(8.09)*	-324.88 *(-8.64)*	0.61	18,637	-4.32***
Mexico	29.88	-282.73	0.42	12,856	-1.79*

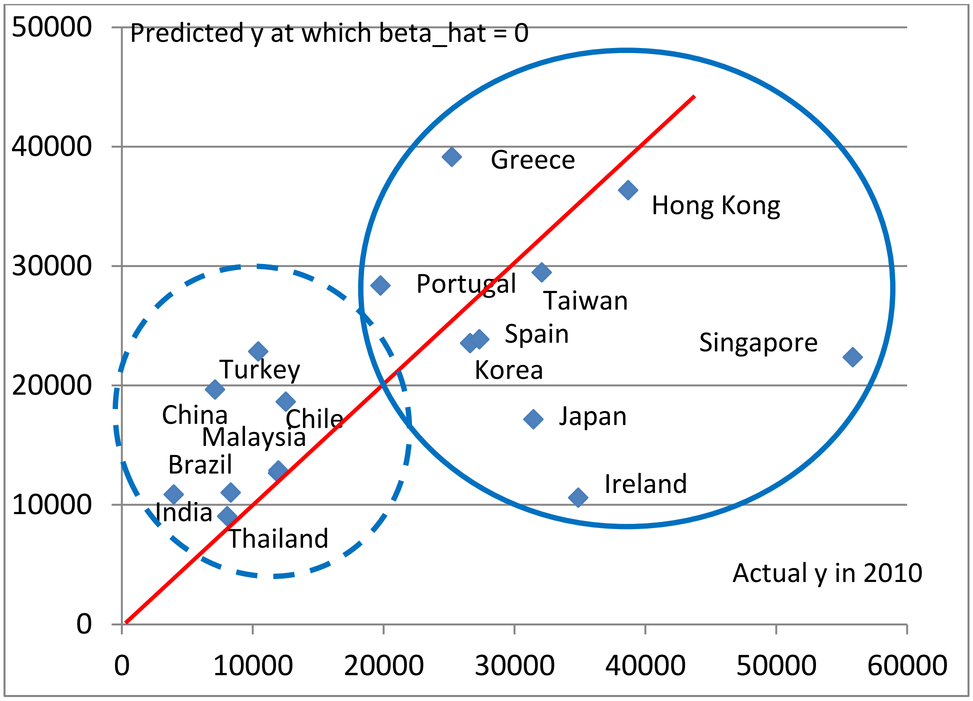
1965-2010	*(6.92)*	*(-7.04)*			
Spain 1965-2010	13.42 *(11.33)*	-135.31 *(-11.30)*	0.71	23,857	-2.21**
Portugal 1965-2010	15.96 *(9.64)*	-163.58 *(-10.17)*	0.73	28,353	-2.23**
Greece 1965-2010	15.52 *(6.07)*	-164.09 *(-6.42)*	0.35	39,119	-2.28**
Ireland 1965-2010	8.82 *(5.81)*	-81.76 *(-5.38)*	0.40	10,579	-3.89***
Turkey 1965-2010	20.06 *(7.18)*	-201.32 *(-7.88)*	0.44	22,841	-5.11***
Egypt 1965-2010	-7.59 *(-0.77)*	38.93 *(0.50)*	0.01	169	-2.92***
Tunisia 1965-2010	25.30 *(2.04)*	-259.14 (2.45)	0.07	28,035	-3.21***

Critical values for DF test: (*)10%= -1.61: (**)5%=-1.95; (***)1%=-2.60

The results in Tables 3 and 4 indicate a positive and statistically significant relation between the capital intensity of comparative advantage and per capita income in 17 or the 20 sample countries. No statistically significant relation is observed in three countries, namely Indonesia, Egypt and Tunisia, whether because of bad data, bad policy, bad history, bad karma or all of the above, we have not ascertained.

Figure 9 presents a scatter plot showing the relation between the predicted per capita income at which comparative advantage shifts from relatively labor-intensive to relatively capital intensive products (i.e. at which the fitted value for $\hat{\beta}=0$) and per capita income in 2010. Countries below the diagonal line are those that have made the transition to relatively capital-intensive exports, while those above the line have not. There are two clusters of countries in our sample, low-middle income countries (grouped inside dashed line) and middle-upper income countries (grouped solid line). All but two (Greece and Portugal) of the higher income countries have made the transition to relatively capital intensive products, as indicated by their position below the diagonal line, none of the lower income countries have yet to do so, as indicated by their position above the line.

Figure 9 (to be revised)



The failure of the lower income countries to make the transition to relatively capital intensive exports has been interpreted as evidence of what the World Bank calls the "middle-income trap" and used to justify industrial policies aimed at pushing developing countries up the ladder of comparative advantage. Our analysis does not support the premise of that argument. The lower income countries in our sample achieved significant increases in per capita income and have seen their comparative advantage change in favor of more capital intensive products, but the fundamental changes in endowment and technology have not yet been sufficient to boost them over the line. Indeed, our results suggest that today's lower-middle income countries face a lower hurdle than those that countries that went before them, as indicated by the finding that the average predicted per capita income at which $\hat{\beta}$ =0 is significantly lower for the later-comers (approximately $15,000) than for those that preceded them (approximately $25,000), a finding that stands in contradiction to the notion of a middle-income trap.

2. Diversification and Comparative Advantage

The finding

The empirical evidence cited to support the revival of industrial policy suggests that comparative advantage does not work as the theory suggests—developing countries do not specialize in fewer products as the theory of comparative advantage supposedly predicts, but rather diversify exports as income rises from relatively low levels. How can this evidence square with our results, which suggest that comparative advantage changes in much the way theory does predicts?

Imbs and Wacziarg (2003) explain that there are theories that predict both a negative and a positive relation between per capita income and sectoral concentration. In closed economies, rising per capita income is expected to lead to sectoral diversification, as demand for a wider range of products rises with per capita income. In open economies, rising per capita income is expected to be associated with sectoral concentration, as countries specialize in accordance with comparative advantage. Imbs and Wacziarg's finding, using sector-level employment and value-added data for a large cross section of countries, is that sectoral concentration follows a U-shaped pattern in relation to per capita income, falling until quite late in the development process, then rising (i.e. re-concentrating).

Klinger and Lederman (2006) find a similar pattern in exports. Klinger and Lederman measure export concentration using the Herfindahl index (H). The Herfindahl index for country j in year t is: $H_{j,t} = \sum_{i=1}^{N} x_{i,j,t}^{2}$, where $x_{i,j,t}$ is the share of product i in exports of country j in year t. The export product concentration was measured for two samples of countries (53 countries using HS 4- and 6-digit data and 99 countries using 3-digit SITC data). Fixed effect regressions of H on y in quadratic form yield a U-shaped relation between the two variables, with the turning point (the minimum value of H) occurring at about $17,400 (in 1996 constant PPP dollars, or about $25,000 in 2005 constant PPP dollars) for the two data sets.

Increasing diversification as measured by the Herfindahl index occurs when export shares of existing products become more uniform and when new products enter the export bundle. Klinger and Lederman were primarily interested in the latter, as they interpret the advent of exporting a product that had not previously been exported as an instance of "export discovery", the term introduced by Hausmann and Rodrik (2003) to describe market failures that inhibit the dynamics of comparative advantage from working as theory predicts. Indeed, their results indicate that much of the observed increase in export diversification (falling H) is explain by the introduction of new export product.

Klinger and Lederman's results are replicated below using our data from the same sources (COMTRADE data for exports and Penn World Tables for per capita income) but at the SITC 5-digit level of aggregation. Figures 10 and 11 are scatter plots of the Herfindahl Index (H) and the number of products entering the export basket (N) , each against per capita income, together with Lowess non-parametric estimates of the relation between per capita income and H and N, respectively. Table 5 reports fixed effect panel regressions of H and N, respectively, on per capita income (y) and its square (y^2)

Figure 10:
Scatter Plot (H, y) and Lowess Estimate

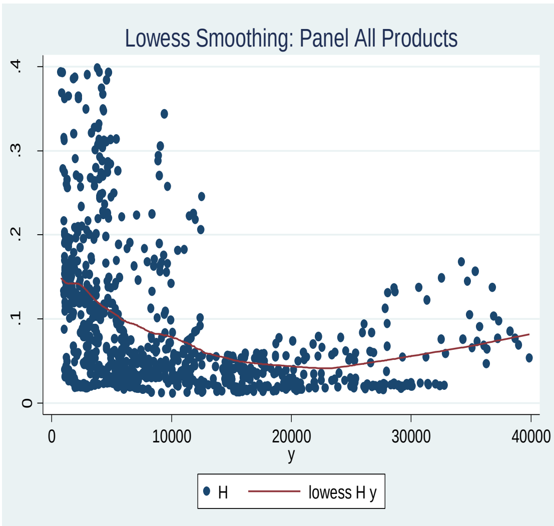


Figure 11:
Scatter Plot (N, y) and Lowess Estimate

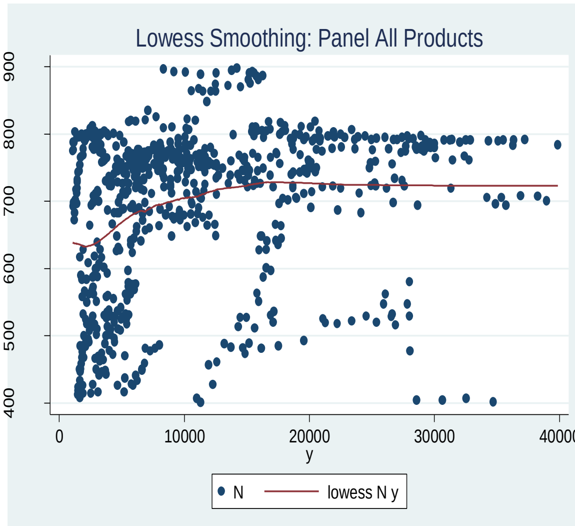


Table 5: Fixed Effect Regression (unbalance panel)

Dependent var.	H	N
y	-0.140 (-7.103)	16.19 (8.18)
y^2	0.030 (5.954)	-0.32 (-6.75)
Constant	0.201 (16.440)	578.97 (39.67)
Minimum/maximum	$23,096	$25,457
Number of obs.	916	916
R^2	0.44	0.51

The Klinger and Lederman finding is well replicated in our data, which is hardly surprising since we use essentially the same data. Exports do become more diversified as income rises up to a relatively high level (about $23,000 in 2005 PPP), after which they become more concentrated. It is also evident that export diversification largely derives from the entry of new products, since H and N bear a close inverse relationship to one another, as the following simple regression indicates.

$$\ln\left(\frac{1}{H}\right) = \underset{(5.85)}{1.52} + \underset{(15.19)}{0.68} \cdot \ln(N) \qquad R^2 = 0.71$$

Re-interpretation

Export product diversification is a robust empirical fact, but does it contradict the predictions of the theory of comparative advantage? Comparative advantage certainly predicts specialization, but not necessarily in fewer products. What the theory predicts, instead, is specialization in products for which the production technology is compatible with the country's resource endowment. As a country's resource endowment changes, the product mix of its exports changes in favor of those products that use more intensively the relatively rapidly expanding resource (capital). Whether or not the number of products exported increases or decreases, lowering or raising the Herfindahl measure of concentration, depends on how the number of products in which a country finds comparative advantage changes at different levels of development.

The number of products at consecutively higher vigintiles of capital-intensity is shown in Figure 12 (for all 1,162 products) and Figure 13 (for 868 manufactured products). The inverted U-shape of these histograms offers an alternative explanation for the U-shaped relation between export concentration (H) and per capita income. They suggest that the U-shape relation between concentration and per capita income may reflect nothing more than that as per capita income rises (as a result of capital accumulation and technology catch-up) the number of products that fall into the zone of comparative advantage rises, but only up to a point after which the number of products in the zone of comparative advantage declines. We have, therefore, a simple explanation for the U-shaped relation between concentration and per capita income that is in accord with, or at least does not contradict, the principle of comparative advantage. A counter argument could be that the inverted U-shaped historgrams of product capital intensity have nothing to do with comparative advantage and everything to do with the way trade data are classified, but this counter argument, if valid, would apply equally to the Klinger-Lederman interpretation as to ours.

Figure 12: Histogram for All Products

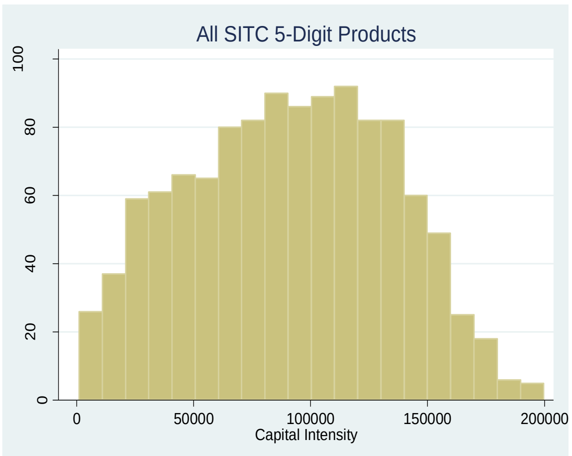
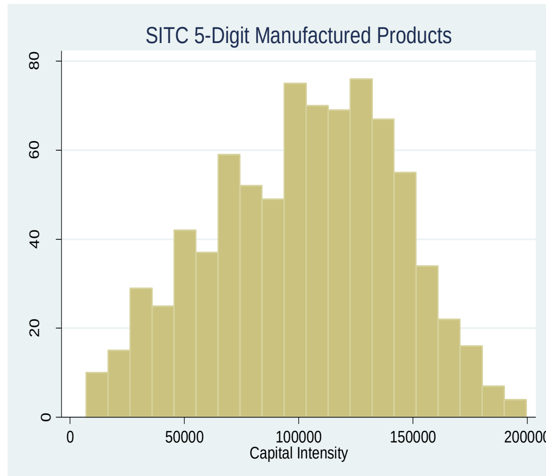


Figure 13: Histogram for Manufactures



3. Conclusion

What we have demonstrated in this paper is that international trade generally behaves in accordance with the principle of comparative advantage. After almost 200 years since Ricardo introduced the theory, this should hardly be question worthy of consideration, but the fact remains that the principal evidence cited to justify a revival of industrial policy in developing countries is the supposed failure of comparative advantage to work as theory suggests it should.

We are no more able to refute the existence of market failures that might thwart the dynamics comparative advantage than are those who allude to market failures as justification for industrial policies able to validate them. If there are market failures, and no doubt there are, they are not so pervasive, our results suggest, as to prevent the dynamics of comparative advantage from operating generally as expected.

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