Productivity and Manufacture Export Causality among World Regions: 1989-1999

Li, Kui-Wai and Bender, Seigfried
City University of Hong Kong

July 2007

International Trade Journal (2007), Vol XXI, No. 2, Summer, pp. 121-159.

Productivity and Manufacture Export Causality among World Regions: 1989-1999*

Kui-Wai Li
City University of Hong Kong
And
Siegfried Bender
University of Sao Paulo

Abstract

This paper examines the causality relationships between manufacturing exports and productivity for five industry groups and six world regions for the period 1989-1999. Productivity is estimated by using value-added figures, and manufacture export data are adjusted by the revealed comparative advantage index. The causality tests between export and factor productivity concluded that the more industrialized European economies are more export-driven than productivity-driven than the other less industrialized European economies. East Asia economies showed improvements in both export and productivity, and the United States had an advantage in productivity and a balance growth in trade. The export performance of countries in South Asia and South East Asia were average, though their productivity has improved. Latin American countries are still in the exporting stage.

JEL Classification: F14

Keywords: total factor productivity, revealed comparative advantage, causality.

Corresponding author: Kui-Wai Li, Department of Economics and Finance, City University of Hong Kong, 83 Tat Chee Avenue, Kowloon, Hong Kong.
Telephone: (852) 2788 8805, fax: (852) 2788 8418. E-mail: EFKWLI@CITYU.EDU.HK

---

* This paper is an extension of the Discussion Paper published by the Economic Growth Center in Yale University in 2002. We thank the comments from the two anonymous referees, Robert Evenson, T.N. Srinivasan, Sugata Marjit, Hamid Beladi, Kwan Choi, Nick Tsitsianis, Michael Ryan, Edward K.Y. Chen, Eden Yu, Leonard Cheng, Larry Qiu, Thomas Voon, Isabel Yan, Ting Gao and participants of conferences in Mainland China, Hong Kong SAR and Great Britain. Data clarification from Tetsuo Yamada of UNIDO is appreciated. We are grateful to the Economic Growth Center at Yale, the APEC Study Center and the Research Center for International Economics of the City University of Hong Kong for their institutional and financial support. The two research assistants, Ming-Lok Kwok and Benly Lui, have been helpful. The usual disclaimer applies.

1. Introduction

There are various debates in the studies on international trade. In the area of globalization, trade is an essential element in economic openness and at the same time trade promotes growth in developing economies (Bhagwati 2002, 2004). Recent studies reckoned that globalization extended beyond trade and has non-economic consequences, and that indigenous factors are equally important to openness factors in growth and globalization (Fischer 2003, Dreher 2006, Kearney 2005, Li, Pang and Ng 2006). Other studies showed that trade help a developing economy to "catch up" and lead to economic structural change that involved a shift from labor-intensive to more advanced production techniques (Lee 1986, Rana 1990, Carolan *et al* 1998). On the contrary, studies by Lutz (1987) and Chow (1990) showed that manufacture exports from different industrialized and developing economies complement each other, and that the industrialized economies increasingly concentrate on technology-intensive industries while labor-intensive manufacturing is "exported" to less developed countries. Studies using country-wide panel data (Edwards 1998, Dar and Amirkhalkhali 2003) concluded that open economies experienced a faster productivity growth because they have a greater ability to absorb advance technology (Grossman and Helpman 1991, Romer 1992, Barro and Sala-i-Martin 1995).

This paper aims to provide additional vigor to the trade debates by empirically examining the causality relationship between manufacture exports and factor productivity of different economies and world regions. Due obviously to numerous measurement and data problems of different world economies, the causality relationship between factor productivity and trade has not been sufficiently captured in existing literature. Productivity can either be home-grown or acquired through economic openness. Typically, the productivity of technology-advanced, industrialized economies is likely to be home-grown and not trade-dependent, while the productivity of low-technology, developing economies depends considerably on economic openness and trade. Improvement in productivity does allow an economy to move away from low-technology manufacturing and/or devote more resources to highly value-added production.

Otherwise stated, the major sources of data are the UNIDO Industrial Statistics Database (2002) (INDSTAT) supplemented by INSTAT-REV2 (revision 2), INSTAT-

REV3 (revision 3) and the UNIDO Industry Demand-Supply Balance data (2002) (IDSB).[1] The INDSTAT data contained data on output, value-added, number of employees, gross fixed capital formation, wage and number of industrial establishments classified in four-digit ISIC categories. The IDSB database provided the four-digit ISIC code of industrial sector annual exports and imports comprising eighty one manufacturing industries for over seventy three economies for the period 1981-1999.[2] The four-digit data are aggregated into three-digit classification, giving a total of twenty eight export sectors, which are conveniently being grouped into five industry groupings of primary product industries (Group 1), labor-intensive industries (Group 2), raw-material product industries (Group 3), producer goods industries (Group 4) and fabric metal industries (Group 5) (see the definitions in Appendix 1). Economic data for gross fixed capital formation or investment is available only for the period 1989-1999.

In order to be data-consistent across different world economies and regions, the data from the same UNIDO source are used throughout the analysis. The advantage of data-consistency does result in the exclusion of some economies in different world regions and the limitation and choice of variables available in the UNIDO database. From the UNIDO database, we work on the maximum number of world economies that contained most or all of the data variables used in the analysis. As such, the major world trading economies are divided into six regions grouped either under a similar economic background or geographically close to each other or both. They are:

a) France, Italy and United Kingdom (EU3): these are the three conventionally strong industrialized European members;
b) Austria, Netherlands, Spain, Portugal, Greece, Norway, Finland and Denmark (EUR): these eight economies composed the rest of the European Union countries;
c) United States (US), being the most powerful economy in the world, represented North America;

[1] The revisions 2 and 3 are not fully convertible, but relevant industrial sectors are combined. For example, sector 311 and 312 in revision 2 are combined into sector 311 (see Appendix 1).
[2] The data excluded, for example, Brazil in Latin America and the People's Republic of China and Chinese Taipei in Asia.

d) Colombia, Peru, Mexico, Bolivia and Ecuador (LA): these are the five Latin American countries that provided a complete data set, and they have similar economic background;
e) Japan, Hong Kong, South Korea and Singapore (EA) are the economically progressive East Asia economies in the sample period; and
f) India and Sri Lanka represented the two countries in South Asia, while Indonesia, Malaysia, Philippines and Thailand are the four strong economies in the Association of Southeast Asian Nations (ASEAN). These six economies formed the South and Southeast Asia (SSEA) region.

Section 2 works out the total factor productivity estimates of different world regions. Value added figures from individual economies are used to estimate the capital stock of manufacturing industries in different economic regions. Section 3 shows that the revealed comparative advantage indices are used as weights to adjust the level of manufacture exports and attempts are made to find the gainers and losers in trade. The Granger causality tests are applied in Section 4 to show the directional relationship between total factor productivity and the level of manufacture exports. Conclusions are presented in Section 5.

2. Constructing Total Factor Productivity

The estimation of total factor productivity typically begins by using a Cobb-Douglas production function of the following form:

(1) $$Y_{it} = A_{it} K_{it}^{\beta_1} L_{it}^{\beta_2}, \qquad i = 1, \ldots, N;\ t = 1, \ldots, T,$$

where Y_{it} denotes output of industrial sector i at time t, and K and L stand for capital stock and labor, respectively.[3] The residual A_{it} represents total factor productivity (TFP). Taking logarithms and assuming a constant return to scale[4], we obtain:

[3] Numerous studies on endogenous growth models used additional variables, such as human capital in their production with GDP as the dependent variable (Barro and Sala-i-Martin 1992, Romer 1990). The dependent variable in this analysis is industrial output, and we assume such input as human capital is embodied in the quality of labor, and that the Cobb-Douglas production function is the more direct method to show the level of total factor productivity that is used in the causality test exercise.

(2) $$\ln \frac{Y_{it}}{L_{it}} = \alpha + \beta \ \ln \frac{K_{it}}{L_{it}} + \varepsilon_{it} \ .$$

The capital stock series of individual world economies is constructed from the following perpetual inventory identity:

(3) $$K_t = (1 - \delta)\, K_{t-1} + I_t \ ,$$

where I_t is the amount of gross fixed investment expenditure at time t and δ is the rate of depreciation of the capital stock. Identifying the rate of depreciation and the initial capital stock K_0 are essential for Equation (3).

Different methods have been used in the construction of an initial capital stock, and investment data have been commonly used (Kim and Lau 1994). Harrigan (1999), for example, suggested a "distributed lag of past investment flows" approach by using the "delayed linear scrapping rule". When the study is involved with panel data from regional economies, the value of the initial capital stock serves effectively the initial point only. The more relevant discussion is the estimates based on trend analysis. The measurement of the capital stock is theoretically sound, but variation existed in empirical studies. There is, thus, no perfection in the empirical measurement of an economy's capital stock. We used an alternative value added approach to estimate the capital stock, and assumed that all business entities maximize their returns based on the value added data. One advantage of the value added approach is that instead of using investment input figures, the value added date reflected the output end of investment. Value added is primarily market-driven and reflected the business and investment outcome of capital usage. In the INDSTAT database (2002), value added (*VA*) is "defined as the value of census output less the value of census input". These value added figures are proportional to the amount of capital stock in an industry, namely:

(4) $$rK = VA \ ,$$

where r is the rate of return to capital.

[4] Although other forms of production functions have been used in various productivity studies, but given the potential complication among different world economies, we assumed a constant return to scale, which has been established in numerous studies. Studies that used a constant return to scale included, for example, Collins and Bosworth (1996) whom calculated the total factor productivity in East Asia, South Asia and Latin America by the residuals in a constant to return production function, and Basu and Fernald (1997) observed that the return to scale of firms in the US was generally constant.

Next, we estimated a proxy depreciation rate for Equation (3) by letting the market interest rates in the *International Financial Statistics* (IFS) as proxy rates of return to capital for Equation (4). Intuitively, the market interest rates incorporated all business movements and would be closer reality than any other estimated rates for depreciation. The proxy capital so generated from Equation (4) is used to calculate the proxy depreciation rates in Equation (3). We take the geometric means of all the positive depreciation proxies in the ten years period (1990-1999) as the depreciation rate for each industrial sector in each economy.

We further assumed that the rate of return to capital in all sectors of a specific economy is the same.[5] In a competitive economy, the rate of return to capital can be approximated by the rate of interest of long term bonds. Since not all economies have long term bonds, we took as proxy the average long term US bond interest rate, r (US), for the period 1990 – 1996 (*Financial Statistics Monthly*, Sections I and II) as the base rate and the rate of return in economy "*j*" is calculated from the following:

(5) $r(j) = r(\text{US}) \,.\, J$,

where J is the risk premium of economy "*j*". Diamonte, Liew and Stevens (1996) provided the political risk data of world economies, and the average for the period from January 1985 to June 1995 was used as the economy's risk premium. We normalized the risk premium by setting the United States premium to unity. A more risky economy relative to the United States will have a risk premium greater than unity, and vice versa for a less risky economy.[6]

The initial capital stock is constructed from the following:

(6) $K_{t-1}(i,j) = VA_{t-1}(i,j) / r(j)$.

The country purchasing power parity figures in *International Financial Statistics* are used as output deflators.

We find that the Ordinary Least Squares (OLS) estimation method is inefficient because both capital and labor can correlate with the residual, namely $E(x'\varepsilon) \neq 0$, where $x' = (K, L)$. Studies show that the generalized method of moment estimation method (GMM) is an improvement (Hansen 1982, Alonso-Borrego and Sanchez-Mangas

[5] Namely, for each sector "*i*" and economy "*j*", we have $r(i, j) = r(j)$ for all sectors "*i*".
[6] For example, the political risk index of the United States and Japan are 81.8 and 84.4, respectively. The normalized risk premiums become 1 and 1.032, respectively.

2001, Ferreira and Rossi 2003). We adopt the instrumental variables with GMM procedure estimation technique. The standard GMM estimator specified a set of first order or orthogonal conditions, $E[g(y,x,\theta)]=0$, where $g(y,x,\theta)=n^{-1}Z'(y-X\hat{\theta})$. In our case, $X=\begin{bmatrix}1 & K/L\end{bmatrix}$ and the standard GMM estimator is $\theta=\begin{bmatrix}\alpha & \beta\end{bmatrix}$. In principle, the instrumental variables, *Z*, must correlate with $\boldsymbol{x}$ but not with $\boldsymbol{\varepsilon}$, namely $E(Z'\varepsilon)=0$. The value of $\hat{\theta}$ is obtained by identifying the minimum of $[\sum_t g(\theta)]'W^{-1}[\sum_t g(\theta)]$, where *W* is the covariance matrix of $\sum_t g$ (Hansen 1982). From the UNIDO data set, the data on real wages, real export and the number of industrial establishments are available and used as the instrument variables in the GMM estimation since these three variables were supposed to correlate with the regressor (industrial output of individual economies) but not with the error term (Ferreira and Rossi 2003, p. 1390). Intuitively, real wage varies inversely with industrial output, while the level of real export and the number of industrial establishments have a positive impact on industrial output.[7]

The GMM estimates presented in Table 1 give powerful results. The high k_{it} coefficients of SSEA (0.9537), EU3 (0.8542), EUR (0.9293) and LA (0.9666) provided different interpretations for different regions. Given that EU3 and EUR are more industrialized, their capital stock probably had contributed much more than their labor. On the contrary, characterized as developing economies, the low contribution by labor in SSEA and LA suggested that capital was the most important factor contributing to industrial output. The similarity in the coefficients for EA and US are more acceptable.

The GMM coefficients in Table 1 are used to work out the total factor productivity (TFP) in each ISIC category of the six world regions. Table 2 shows the growth rates of TFP for each industry group and regional group between the beginning (1989-1991) and the end (1997-1999) of the three-year periods. EU3 is the worst performer with only eleven TFP improvements among the twenty eight ISIC categories. With the exception of 353 (petroleum refinery) and 354 (petroleum and coal products), EU3's decline in TFP is evenly spread among the five industry groups. LA also suffered

[7] An alternative to the use of instrument variables are the first and second lag of the regressor, but since the sample period is short and panel data are used, the alternative values of the lagged regressor are not used s instrument variables.

considerably, especially in Group 5 (fabric metal industries) and Group 2 (labor-intensive industries).

Table 1 Estimates of Production Functions in Six World Regions, 1989-1999

		OLS	GMM
EA	k_{it}	0.7666 (<0.0001)	0.7138 (<0.0001)
	Adjusted R^2	0.7623	0.7501
	Hausman test		85.99
	p-values		(<0.0001)*
SSEA	k_{it}	0.7388 (<0.0001)	0.9537 (<0.0001)
	Adjusted R^2	0.5042	0.4630
	Hausman test		7.86
	p-values		(0.0489)*
US	k_{it}	0.7978 (<0.0001)	0.7439 (<0.0001)
	Adjusted R^2	0.8450	0.8371
	Hausman test		78.13
	p-values		(<0.0001)*
EU3	k_{it}	0.8644 (<0.0001)	0.8542 (<0.0001)
	Adjusted R^2	0.6308	0.6159
	Hausman test		18.73
	p-values		(0.0003)*
EUR	k_{it}	0.9024 (<0.0001)	0.9293 (<0.0001)
	Adjusted R^2	0.8649	0.8630
	Hausman test		4.36
	p-values		(0.2248)
LA	k_{it}	0.7448 (<0.0001)	0.9666 (<0.0001)
	Adjusted R^2	0.6604	0.6097
	Hausman test		11.34
	p-values		(0.0100)*

Notes: k = capital/labor. The asterisks indicate that the hypothesis of OLS estimation consistency is rejected at 5% level of significance.

Out of the twenty-eight ISIC categories, the US is the best performer in TFP growth with sixteen improvements evenly spread among the five industry groups, though these TFP improvements are small, with the exception of 354 (petroleum and coal product). SSEA has fifteen increases. TFP improvements in EA mainly concentrated in Group 2 (labor-intensive industries), but lost completely in Group 4 (producer goods industry). Both EA and EUR have fourteen improvements. The two strong improvements in EUR are 314 (tobacco industries) and 354 (petroleum and coal products). The two weaker performers are EU3 and LA. Concerning the extent of increases, SSEA performed well with ten TFP improvements exceeded unity, followed by EU3 with three, EUR with two and the US with one. Both EA and LA have none.

Table 2 Annual Growth Rates of the TFP between 1989-91 and 1997-99

Industry Group	ISIC Categories	EU3	EUR	EA	SSEA	US	LA
1	311	-0.2706	0.0997	0.0689	-0.6503	-0.2137	0.2346
1	313	-0.2121	-0.0624	0.2439	3.0899	0.1890	0.3183
1	314	2.2651	1.2380	-0.0722	-0.4975	0.8419	0.1202
2	321	0.0047	-0.2549	0.0241	2.1678	-0.3482	-0.1135
2	322	-0.0464	-0.0193	0.7740	-0.6244	0.3147	0.6951
2	323	0.0171	0.0211	0.1017	0.3310	0.4505	0.4635
2	324	-0.2131	0.0472	0.5352	0.1964	0.8501	-0.3079
2	331	-0.0525	-0.0616	-0.0037	-0.6435	-0.2034	-0.6595
2	332	-0.1763	0.0565	0.3579	-0.4780	0.2813	0.3032
2	341	-0.1364	0.3004	0.1032	2.6129	-0.1358	-0.3739
2	342	0.3321	-0.2714	0.2397	1.6694	-0.1565	-0.4151
3	351	-0.0572	-0.5497	-0.2495	3.0603	-0.2868	-0.1017
3	352	-0.1706	0.2599	0.1248	1.3598	0.3659	0.0390
3	353	1.3404	0.3078	0.1196	-0.8942	-0.2398	0.2033
3	354	1.4605	1.9338	-0.0556	-0.0195	7.8502	-0.3664
3	355	-0.1021	-0.1828	-0.3597	0.7455	-0.2619	-0.1441
3	356	-0.3052	-0.0836	-0.1480	-0.7209	0.0270	0.5151
4	361	-0.2958	0.5721	-0.1131	4.5716	-0.1289	0.1510
4	362	-0.2555	-0.2546	-0.4096	-0.5386	0.0884	0.3704
4	369	-0.2876	0.2181	-0.0813	0.8266	0.0772	-0.1759
4	371	0.1459	-0.3615	-0.3764	-0.5238	-0.1852	-0.4995
4	372	0.0360	-0.1246	-0.0619	-0.7935	0.3038	-0.3231
5	381	0.0348	-0.2275	-0.0001	2.3375	0.0592	-0.3060
5	382	-0.0597	0.0531	0.0931	0.0554	-0.0160	-0.3839
5	383	-0.2662	-0.0979	-0.1801	-0.6546	-0.2825	-0.2468
5	384	0.1328	0.0172	-0.0809	-0.6535	0.2005	-0.4130
5	385	-0.0398	-0.0352	0.1742	4.1732	0.4457	-0.2047
5	390	0.1710	0.0682	0.1929	1.9855	0.4190	2.0880
	Overall	0.1069	0.0931	0.0343	0.7675	0.3681	0.0167
No. of increases		11	14	14	15	16	12
No. of increases > 1		3	2	0	10	1	0

3. Revealed Comparative Advantage of Manufacture Export

The revealed comparative advantage (RCA) index (Balassa 1965, 1977, 1979 and 1986) compares the export share of a given sector in an economy with the export share of that sector in the world market. The RCA index considers the intrinsic advantage of a particular export commodity and is consistent with changes in an economy's productivity (Hillman 1980, Marchese and Simone 1989). Vollrath's (1991) improved the RCA formula by considering the significance of both the country export in a given sector and the country's total export at the world level. It is useful for comparisons based on country groups as it eliminates the double counting of country and commodity in world trade and is defined as follow:

$$(7) \quad RCA_i = \left\{ \frac{X_{ij}}{(\sum_i X_{ij}) - X_{ij}} \right\} \Bigg/ \left\{ \frac{\left((\sum_j X_{ij}) - X_{ij} \right)}{\left((\sum_j \sum_i X_{ij}) - (\sum_j X_{ij}) \right) - \left((\sum_i X_{ij}) - X_{ij} \right)} \right\},$$

where X_{ij} are the exports of sector "*i*" at country "*j*", $\sum_i X_{ij}$ are the total exports of country "*j*", $\sum_j X_{ij}$ are the world exports of sector "*i*", and $\sum_j \sum_i X_{ij}$ are the total world exports. The unit values of exports data from the *International Financial Statistics* are used to deflate the nominal export values. The estimated RCA coefficients ranged from 0 to infinity, but the problem of using this standard measure is that the distribution of RCA is skewed (Laursen 2000). To make it symmetric, we adjusted the RCA as:

$$(8) \quad RSCA_i = (RCA_i - 1 \big/ RCA_i + 1) + 1,$$

where *RSCA* stands for symmetric-adjusted RCA. The scale of RSCA now ranges from 0 to 2, implying a disadvantage (advantage) if the value of RSCA is below (above) 1.

The mean values of RSCA indices between the two time periods of 1989-1991 and 1997-1999 (see Appendix 2) show that SSEA and US are the two regions that have the same number of RSCA indices exceeding unity in the two periods. All the other four regions (EA, EU3, EUR and LA) faced a decline in the number of larger-than-one RSCA indices. In terms of difference in RSCA between the two periods (see Appendix 3), EUR performed best with a total of seventeen ISIC categories, followed by US with sixteen. Both EA and LA have the smaller number of difference in RSCA.

Equation (9) is used to calculate the adjusted export figures for country *j* with the RSCA indices serving as weights:

(9) $$AE_i = \frac{RSCA_i}{\sum RSCA} \times E_i \,,$$

where AE_i is the adjusted-export, E_i is the export value.

As shown in Appendix 3, LA and SSEA are the two regions that have experienced growth in RSCA-adjusted manufacture exports in all categories in the sample period of 1989-1999. Although EA only has twenty two categories with increase in adjusted export, EA ranked third in the overall growth rate, implying that growth in some industries (Group 1 and 3) overweighed the loss in other groups. Although the other three regions (EU3, EUR and US) all have high number increases, their overall growth rates were moderate with less than ten percent.

The homogeneity of the RSCA index can provide indications that a gain or loss in comparative advantage of a given industry group in one region can occur at the expense of another region. The sector's "substitution" or "complementary" relationship between the different economy groups can help to identify where the gain in revealed comparative advantage comes from, or where the loss goes to. This is done by employing, for each industry group, the following "explicative" model:[8]

(10) $$R^{i}_{n,t} = \eta_{i0} + \sum_{\substack{j=1 \\ j \neq i}}^{5} \eta_{ij} R^{j}_{n,t} + \beta_{ii} R^{i}_{n,t-1} + \varepsilon_{it} \,,$$

where R stands for the RSCA index, i and j represent region groups, and n indicates the number of industry groups with ε_{it} is the residual. When $i = j$, a positive coefficient β_{ii} means that there is an occurrence of indigenous improvement in the region's trade, otherwise the coefficient is zero. When $i \neq j$, a positive value of η_{ij} means a "complementary" relationship between the two regions, while a negative value suggests a "substitution" relationship. We assume there is no inconsistency in the relationship, namely a gainer economy group cannot be a loser at the same time. The gain in RSCA can also be due to endogenous improvement in that particular industry group, resulting in

[8] Since the gain and loss of revealed comparative advantage among the regions are related to one another, the "explicative" variables in each equation (and for each industry group) are not truly independent from the "dependent" variable. The estimated coefficients that obtained by the simultaneous equation procedure are partial correlation estimates among those variables.

a situation in which there is no corresponding loss of RSCA in other region, or that the improvement comes from another world region not included.

We utilized the information on the performance and the percentage change in RSCA to identify the net gainers and losers of RSCA for each industry group. First, we consider those economy groups that have an overall positive RSCA growth in each industry group as the gainers (see Appendix 3). The independent variables with negative coefficients in the explicative model estimation are said to have a substitute relationship with the dependent variables. The country groups that have a substitute relationship with the gainers are defined as losers.

Table 3 RSCA Gainers and Losers

Industry Group	Gainers	Losers					
		EU3	EUR	EA	LA	US	SSEA
Primary Products	EU3					L	
	EUR				L	L	L
	EA				L	L	
Labor-intensive	LA		L	L			L
	US		L				L
Raw Materials	EA	L			L	L	L
Producer Goods	EUR			L	L	L	
	US			L	L		L
Fabric Metal	EU3			L			
	EUR						
	LA			L		L	
	SSEA					L	

Table 3 shows the three-dimension outcome for the five industry groups, with Ls representing the losers. The results of the coefficient estimation are given in Appendix 4. The data covers 11 years and we have 6 explanatory variables with only 5 degrees of freedom. The critical value for rejection of the null hypothesis is quite high and we predict that not many coefficient estimates are statistically different from zero. Hence, we confirm the results (shown in Appendix 5) by defining losers as the country groups with negative RSCA growth and the substitute groups are gainers and the result concurs with the picture shown in Table 3. There are a number of occasions where no loser is matched with the gainer. Among the six regions, EUR emerged as the biggest gainer with positive growth in RSCA for three industry groups (primary products, producer goods and fabric metal).[9] The four regions of EA, LA, EU3 and US had achieved gains in two industrial groups. SSEA has gained in only one industry group. EA is the only gainer in the raw materials group. The US is the largest loser, followed by SSEA, LA and EA. The overall picture suggests that SSEA has gained least and probably is the largest loser. This could be due to a lack of indigenous improvement, or due to the rise of the People's Republic of China that competed away the manufacture export of SSEA, especially since the 1990s.

4. Causality Relationships

This section shows the causality relationship between productivity and manufacture export. The hypothesis of trade substitution will produce a causality relationship that runs from manufacture export to productivity. Economic openness through trade allows technological improvement in a developing economy, which in turn promoted factor productivity. The hypothesis of trade complement will give a contrary result in their causality relationship. Increase in factor productivity enabled the advanced economies to move up technologically, and as more resources were engaged in high productivity activities, trade would increase. Since the manufacture of low-technological products was exported to less developing economies, imports of low-technological products for the domestic market consumption will rise.

Granger's (1969) causality test helps to work out the causality relationship between trade and productivity in different world regions. To ask the question of whether X causes Y is to see how much of the current Y can be explained by past values of Y and whether adding lagged values of X can improve the explanation. Y is said to be Granger-caused by X if X helps in the prediction of Y, or equivalently if the coefficients on the lagged X's are statistically significant. We can test whether Y Granger-causes X by the same method. We test the bivariate regressions in the form of:

(11) $$Y_t = c_0 + \sum_{i=1}^{n} \alpha_i Y_{t-i} + \sum_{i=1}^{n} \beta_i X_{t-i} + \varepsilon_0$$, and

[9] This result, shown in Appendix 5, is confirmed by using losers to find the winners.

(12) $X_t = c_1 + \sum_{i=1}^{n} \sigma_i X_{t-i} + \sum_{i=1}^{n} \delta_i Y_{t-i} + \varepsilon_1$.

To understand the bivariate system, X Granger-causes Y if some β_i in Equation (11) are non-zero. Similarly, Y Granger-causes X if some δ_i in Equation (12) are non-zero. In implementing the test, the F-statistics are calculated under the null hypothesis that all the coefficients of β_i and δ_i equal to zero in both Equations (11) and (12). If the resulting F-statistics are higher than the critical value, the hypothesis of non-Granger causality is rejected. For comparison of results, we will perform the tests in both 1 and 2 lags.

To check the stationarity of the series is the prerequisite of testing causality. Tests for unit roots, also known as Dickey-Fuller (DF) and augmented Dickey-Fuller (ADF) tests (Dickey and Fuller 1979) are performed. Typically, the ADF test is based on the following formulation:

(13) $\Delta Y_t = u + \delta T + \alpha Y_{t-1} + \sum_{k=1}^{n} \beta_k \Delta Y_{t-k} + \varepsilon_t$,

where Δ is the difference operator, Y is the natural logarithm of the time series, T is the time trend, n is the number of lags necessary to obtain white noise for the error term, ε_t. The simpler DF test removes the summation term. We introduce the lags of ΔY_t as additional regressors for the ADF test because they allow for possible serial correlation in $\{\varepsilon_t\}$. Both with and without the time trend are included in the unit root test. Introducing the time trend into the regression equation allows the alternative of the hypothesis to be trend-stationary. The results of the unit root test are shown in Appendix 6. Except for a few variables, most of them are integrated of order 1, or first-difference stationary.

Table 4 displays the result of the Granger causality test, with the detailed test statistics shown in Appendix 6. The causality test performance on the basis of industry group shows that although EA is the only economy group that has a significant two-way relationship between adjusted-export and factor productivity, especially in primary products and fabric metal, EA has performed best in both manufacture exports and productivity in the sample period. LA has a weak bilateral relationship in labor-intensive products, but enjoyed in the producer goods a causal relationship that runs from productivity to manufacture exports. The economies in EU3 have little to show and have only one causality relationship from adjusted-export to productivity in the labor-intensive industry group. Economies in EUR satisfied the trade complementing theory in the two industry groups of raw materials and producer goods. The US gives a more balance causality relationship, in that TFP causes AE for primary products while AE causes TFP for fabric metal. As for SSEA, surprisingly, no causality relationship is observed in all industry groups.

Table 4 Results of Granger Causality Tests on Six World Regions

Industry Groups	AE Causes TFP	TFP Causes AE
Primary Products:		
1-Lag		EA US
2-Lag	EA	EA US
Labor-intensive:		
1-Lag	EA	
2-Lag	EU3 LA#	LA#
Raw Materials:		
1-Lag		EA# EUR#
2-Lag		EUR#
Producer Goods:		
1-Lag		
2-Lag	EA#	EUR# LA
Fabric Metal:		
1-Lag	EA US	EA
2-Lag	EA# US#	EA#

Sources: Appendix 7, # = marginally acceptable with 15% level of significance

5. Conclusion

Information shown in Tables 2, 3 and 4, together with those in the appendices, provide the discussion on manufacture export and productivity according to both regional and industry group divisions. To provide an overall discussion, we specify four criteria of productivity performance, benefit from export, and gains in RSCA and causality direction to draw conclusion on regional performance, as summarized in the upper portion of Table 5. Evidences seem to suggest that the US performed strong in productivity and average in export performance. Economies in EA, primarily led by Japan, achieved gains in both export and productivity, but their advantage edge decreased. The productivity of the three economies in EU3 is driven by the level of exports, but their export industries have not been strong to promote productivity. By contrast, economies in EUR indicated that their performance in productivity was average, even though they have gained some trade competitiveness in the 1990 decade. Economies in SSEA have strong productivity growth but that had not benefited their export trade. Probably, the export-driven nature of economies in SSEA faced increased competition from a rapidly growing China trade since the 1990 decade. A number of SSEA economies suffered considerably in the Asian financial crisis in 1997-1999, and their trade performance in both trade and productivity would be affected. The overall performance of economies in LA is rather weak, but there is room for expansion in both export and productivity.

Table 5 Productivity and Trade Performance of World Regions and Industry Groups

World Regions						
Criteria	US	EA	EU3	EUR	SSEA	LA
Productivity Performance	Strong	Strong	Weak	Average	Strong	Weak
Benefit from Export	Mix	Mix	Neutral	Yes	No	Mix
Gain in RCA	Average	Weak	Average	Strong	Average	Weak
Causality:						
AE → TFP	Strong	Very Strong	Strong	None	None	Very Weak
TFP → AE	Strong	Very Strong	None	Weak	None	Strong
Remarks	Strong productivity balanced trade	Gain in trade and productivity	Export drives productivity	Productivity driven	Productivity not helpful to export	Weak productivity driven

Industry Groups		
Industry Group	Features	Remarks
(1) Primary Products	TFP improvements, mainly TFP → AE with RSCA loss	Need to improve TFP in order to gain RSCA
(2) Labor-intensive	Mainly AE→TFP and RSCA losses, some TFP improvements	Large export may not lead to RSCA gains. Industry is competitive
(3) Raw Materials	TFP improvements, TFP → AE in EA &EUR, balanced performance in RSCA	Clearly productivity lead
(4) Producer Goods	TFP improvements & RSCA gains in US & EUR, weak causality	EUR and US are the two winners
(5) Fabric Metal	EUR & EU3 lose in TFP, AE → TFP in EA & US	LA is the better performer, but it does not lead to productivity gain

Source: Tables 2, 3 and 4, and Appendices 2 and 3.

Conclusions based on industry group shown in the lower portion of Table 5 are less clear-cut. In the primary products industry, one observation is that productivity improvement is needed if an economy wanted to have an improvement in comparative advantage. This is because all the affected regions have gained in TFP improvements, but their causality relationship is mainly TFP → AE. In the labor intensive industry group, the causality relationships are mainly AE→TFP and losses in RSCA are common. This suggests that despite an improvement in TFP, labor-intensive industries are competitive, and the rise in export might not necessarily lead to gains in RSCA. Economies that export labor-intensive industries have faced strong competition. In the raw materials industry group, improvements in TFP are needed in order to achieve higher export and gains in comparative advantage. The producer goods industry group is quite clear-cut, as EUR and the US are the two key performers with improvements in TFP and gains in RSCA. In the fabric metal industry group, the two European regions actually lose in TFP. LA performs quite well in export but does not contribute to rise in productivity. Export-led appears in EA and US while the feedback is only observed in EA.

This paper looks at the consequences of trade in relation to total factor productivity. The argument that economic openness promoted trade, which in turn helped to expand the productivity frontier, related largely to export-driven economies. The conclusion one can draw from the findings of industry groups is that export of labor-intensive industry is competitive. One implication is that those developing economies that are engaged in labor-intensive industries should move up their technology ladder as son as possible, otherwise increasing competition probably from late-comers could quickly erode their exports. The lesson to developing economies is that productivity in labor-intensive industries has to be improved as export increased. Productivity improvement is needed in both primary product and raw material industries if an economy wants to achieve a gain in comparative advantage. Producer goods are the less competitive, suggesting that high technology and large resource input are required. There is room for more trade in fabric metal industry, and countries in LA will benefit more with further trade liberalization.

Economies in EU3 showed little possibility in trade substitute due to their leading trade position, while economies in SSEA and LA do not show any trade complement relationships as they are still remained in the "catch up" stage. Trade complement appeared only in the four industrialized world regions since their causality relationship began from TFP to export, especially the US and EA. Economies in both SSEA and LA have gained most in RSCA-adjusted exports in the sample period, confirming their improvement in economic openness has benefited their export.[10]

A key lesson from the various evidences shown in this paper is the important role of productivity. While many developing economies engaged in their export, improvement in productivity probably is the long term solution to promote both trade and development. The essence of productivity is either technological improvement or improvement in factor quality, such as advancement in human capital that is incorporated in the labor input. Although trade does promote technological improvement, the more important aspect is the ability and capacity of potential home-grown technology. Thus, while trade contains economic openness, recent studies in globalization (for example, Li, Pang and Ng 2006, Kearney 2005, and Dreher 2006) conclude that indigenous factors play an equally, if not more, important position. East Asia economies produced an excellent growth example of success in both trade and productivity improvement. In other words, economic openness through trade is a necessary condition; productivity improvement is both the necessary and sufficient condition to growth and development.

In policy terms, evidences in this paper clearly suggest that trade, especially in labor-intensive industries, is competitive and the comparative advantage of a labor-intensive export economy can easily be eroded. Appropriate economic policies should cater for a rapid change in labor-intensive manufacture exports. In other industrial groups, economic policies, especially for the developing economies, should equally provide ample room for productivity development so as to upgrade their export quality and promote competitiveness. For industrialized economies where a high technological level has been achieved, their national policies would concentrate on upgrading their

[10] Studies using firm data show that firms engaging in export usually enjoyed high productivity, while studies using country data concluded that a higher level of export and productivity are associated with a more liberalized economy (Bernard and Jensen 1999a, 1999b, Alonso-Borrego and Sanchez-Mangas 2001, Baldwin and Gu 2003, Thangavelu and Owyong 2003 and Ferreira and Rossi 2003).

productivity and technology, while trade expansion concentrated on labor-intensive and other secondary manufacture goods. One possible dilemma among the industrialized economies could be the decision to export high-technological products in order to address their trade imbalance.

Appendix 1: The ISIC Three-Digit Aggregation

3-digit (industries)	4-digit	Group	Industries
311 (food products)	3111, 3112, 3113, 3114, 3115, 3116, 3117, 3118, 3119, 3121, 3122	1	Primary product industries
313 (beverages industries)	3131, 3132, 3133, 3134		
314 (tobacco industries)	3140		
321 (textiles)	3211, 3212, 3213, 3214, 3215, 3219	2	Labor intensive industries
322 (wearing apparel)	3220		
323 (leather and leather products)	3231, 3232, 3233		
324 (footwear)	3240		
331 (wood and wood products)	3311, 3312, 3319		
332 (wood furniture and fixtures)	3320		
341 (paper and paper products)	3411, 3412, 3419		
342 (printing and publishing)	3420		
351 (industrial chemicals)	3511, 3512, 3513	3	Raw-material product industries
352 (chemical products)	3521, 3522, 3523, 3529		
353 (petroleum refinery)	3530		
354 (petroleum and coal products)	3540		
355 (rubber products)	3551, 3559		
356 (plastic products)	3560		
361 (china, pottery and earthenware)	3610	4	Produced goods industries
362 (glass and glass products)	3620		
369 (non-metallic mineral products)	3691, 3692, 3699		
371 (iron and steel basic industries)	3710		
372 (non-ferrous metal basic industries)	3720		
381 (fabricated metal products)	3811, 3812, 3813, 3819	5	Fabric metal industries
382 (machinery & equipment except electrical)	3821, 3822, 3823, 3824, 3825, 3829		
383 (electrical machinery & appliances)	3831, 3832, 3833, 3839		
384 (transport equipment)	3841, 3842, 3843, 3844, 3845, 3849		
385 (professional & scientific equipment)	3851, 3852, 3853		
390 (other manufacturing industries)	3901, 3902, 3903, 3909		

Appendix 2 The Revealed Symmetric Comparative Advantage Values of World Regions between 1989-91 and 1997-99.

Industry Group	ISIC Categories	EU3		EUR		EA		SSEA		US		LA	
		89-91	97-99	89-91	97-99	89-91	97-99	89-91	97-99	89-91	97-99	89-91	97-99
1	311	0.9324	0.9847	1.4435	1.3895	0.1950	0.2312	1.5697	1.4582	0.8587	0.8644	1.4954	1.0272
1	313	1.6194	1.5652	1.0690	1.2404	0.1493	0.2754	0.2529	0.2539	0.4105	0.4867	1.1876	0.9809
1	314	0.7436	0.8961	1.2762	1.4355	0.3977	0.8726	0.7728	0.8019	1.6255	1.4166	0.2580	0.2524
2	321	1.1236	0.9796	0.9504	0.9138	1.0959	0.9464	1.4037	1.2972	0.5503	0.5725	1.1466	0.9283
2	322	1.1561	0.9724	1.2357	0.8535	1.3933	0.8211	1.8294	1.5075	0.4269	0.5333	1.2926	1.3208
2	323	1.4101	1.3905	0.8939	0.7720	0.5321	0.9135	1.2711	1.3190	0.7230	0.6058	1.0093	0.8913
2	324	1.4734	1.4512	1.4059	1.4367	1.4179	0.4781	1.7237	1.5494	0.3357	0.3333	1.2038	0.8400
2	331	0.4896	0.5623	1.3146	1.2935	0.1395	0.1512	1.5140	1.6821	0.9968	0.8220	0.1498	0.5990
2	332	1.2362	1.2788	1.1776	1.2238	0.4839	0.2425	1.3330	1.3276	0.6523	0.8465	0.4771	1.2683
2	341	0.6820	0.8168	1.3571	1.3411	0.3092	0.3880	0.4843	0.9017	0.9326	0.9425	0.4866	0.4341
2	342	1.1288	1.2267	1.0591	1.1310	0.6708	0.6350	0.6374	0.5788	1.1269	1.1619	1.1004	0.9138
3	351	0.9979	0.9375	1.1011	1.0645	0.6790	0.9453	0.5820	0.8369	1.1239	1.1356	1.1326	0.6260
3	352	1.3017	1.3956	1.0628	1.1572	0.6271	0.5998	0.7606	0.5696	0.9899	0.9722	0.7822	0.6560
3	353	1.0181	0.9201	1.5811	1.4563	0.3890	1.3252	1.4248	1.1010	0.9526	0.7102	1.5610	0.7519
3	354	0.8519	0.8343	1.1821	1.1235	0.8591	0.7393	0.2659	0.3982	1.3268	1.2245	0.8861	0.4711
3	355	1.1057	1.0956	0.9728	0.9957	1.1100	0.9983	1.0738	1.0068	0.7500	0.8765	0.5230	0.5617
3	356	1.1249	1.2011	1.2004	1.2328	0.9300	0.6448	1.2225	1.0815	0.8345	1.0420	0.7346	1.0554
4	361	1.2013	1.2278	1.0576	1.2376	1.0321	0.7245	1.2017	1.0972	0.4620	0.6278	1.2174	1.1396
4	362	1.1697	1.1297	1.0598	1.0892	0.6956	0.7564	0.9122	0.8548	0.8469	0.9363	1.3798	1.1087
4	369	1.2438	1.2727	1.2553	1.2868	0.7207	0.5706	0.9588	0.9073	0.5591	0.5931	1.2430	0.9243
4	371	1.0339	1.0099	1.0946	1.1099	1.1164	1.0410	0.6056	0.6689	0.4555	0.5050	1.1295	0.8197
4	372	0.8963	0.8558	1.2557	1.2742	0.4478	0.7295	1.2021	0.9103	0.8526	0.7598	1.6623	1.1869
5	381	1.0709	1.1333	1.1136	1.1357	0.8071	0.7167	0.7120	0.7851	0.7402	0.9034	0.9112	1.0101
5	382	1.0481	0.9405	0.6874	0.6709	1.0245	1.1938	0.2219	0.6646	1.1530	1.1374	0.2924	0.7838
5	383	0.7700	0.7670	0.6774	0.7764	1.4225	1.3779	0.9251	1.3006	1.0392	1.0606	0.3951	1.3414
5	384	0.8927	1.0181	0.5980	0.8215	1.0876	0.9415	0.1251	0.1955	1.1073	1.1031	0.9955	1.0581
5	385	0.9445	0.9610	0.8152	0.8677	1.4155	1.1290	0.4594	0.4828	1.3620	1.2633	0.0625	0.8795
5	390	0.9735	1.0730	0.9398	0.7536	1.3213	1.0027	1.3543	1.5113	1.0961	0.8405	1.0977	1.0108
Overall		1.0586	1.0678	1.1014	1.1101	0.8025	0.7640	0.9571	0.9661	0.8675	0.8670	0.9219	0.8872
No. of RSCA > 1		17	15	20	19	11	6	13	13	9	9	15	11

Appendix 3 Difference of RSCA and Growth of RSCA-adjusted Exports

		Difference of RSCA of World Regions between 1989-91 and 1997-99						Average Annual Growth of RSCA-adjusted Exports in 1989-1999					
Industry Group	ISIC Categories	EU3	EUR	EA	SSEA	US	LA	EU3	EUR	EA	SSEA	US	LA
1	311	0.0523	-0.0540	0.0362	-0.1114	0.0057	-0.4682	0.0442	0.0300	0.1704	0.0696	0.0504	0.0558
1	313	-0.0542	0.1713	0.1261	0.0010	0.0762	-0.2068	0.0516	0.1131	0.4515	0.1635	0.1097	0.1927
1	314	0.1525	0.1593	0.4749	0.0291	-0.2089	-0.0056	0.1142	0.0996	0.7285	0.1693	-0.0005	0.7931
2	321	-0.1440	-0.0366	-0.1495	-0.1065	0.0221	-0.2183	0.0014	0.0230	0.0666	0.1431	0.1091	0.1753
2	322	-0.1837	-0.3822	-0.5723	-0.3219	0.1065	0.0282	0.0096	-0.0346	-0.0612	0.0042	0.1553	0.3000
2	323	-0.0196	-0.1219	0.3814	0.0479	-0.1172	-0.1180	0.0323	0.1021	0.3308	0.3637	0.0330	0.2195
2	324	-0.0222	0.0308	-0.9398	-0.1743	-0.0024	-0.3638	0.0233	0.0483	-0.2037	0.0475	0.0577	0.1443
2	331	0.0726	-0.0210	0.0117	0.1681	-0.1748	0.4492	0.0734	0.0492	0.2854	2.1772	0.0057	1.2685
2	332	0.0425	0.0461	-0.2414	-0.0054	0.1942	0.7912	0.0652	0.0932	-0.0549	0.1951	0.2369	1.1033
2	341	0.1348	-0.0159	0.0788	0.4173	0.0099	-0.0525	0.0736	0.0455	0.1650	0.3716	0.0495	0.4501
2	342	0.0979	0.0719	-0.0357	-0.0586	0.0350	-0.1866	0.0496	0.0562	0.0613	0.1338	0.0653	0.1871
3	351	-0.0603	-0.0365	0.2663	0.2549	0.0117	-0.5066	0.0114	0.0020	0.1890	0.2331	0.0517	0.0737
3	352	0.0939	0.0944	-0.0274	-0.1911	-0.0177	-0.1262	0.1076	0.1708	0.1210	0.0823	0.1025	0.2503
3	353	-0.0979	-0.1249	0.9363	-0.3238	-0.2423	-0.8091	0.0361	0.0347	0.9642	0.0110	0.0046	0.0288
3	354	-0.0175	-0.0586	-0.1198	0.1323	-0.1023	-0.4150	0.0331	0.0088	0.0204	0.3868	0.0271	0.0700
3	355	-0.0101	0.0229	-0.1117	-0.0670	0.1266	0.0387	0.0364	0.0592	0.0551	0.1012	0.1536	0.2900
3	356	0.0762	0.0324	-0.2853	-0.1411	0.2075	0.3208	0.0800	0.0958	-0.0012	0.1621	0.1673	0.8362
4	361	0.0265	0.1799	-0.3076	-0.1044	0.1658	-0.0778	0.0223	0.0936	-0.0482	0.0892	0.1338	0.3263
4	362	-0.0400	0.0294	0.0608	-0.0574	0.0895	-0.2710	0.0334	0.0695	0.1288	0.1257	0.1203	0.1879
4	369	0.0289	0.0315	-0.1501	-0.0516	0.0340	-0.3187	0.0373	0.0596	-0.0028	0.1196	0.0760	0.1240
4	371	-0.0240	0.0154	-0.0754	0.0633	0.0495	-0.3098	-0.0032	0.0201	0.0223	0.1299	0.0997	0.1358
4	372	-0.0405	0.0184	0.2817	-0.2918	-0.0929	-0.4754	-0.0039	0.0240	0.2542	0.0025	0.0274	0.0501
5	381	0.0624	0.0221	-0.0903	0.0730	0.1632	0.0990	0.0593	0.0777	0.0406	0.1610	0.1344	0.3390
5	382	-0.1076	-0.0165	0.1693	0.4428	-0.0157	0.4914	0.0365	0.1850	0.1537	0.7515	0.0609	2.8243
5	383	-0.0030	0.0990	-0.0445	0.3755	0.0214	0.9462	0.0893	0.1163	0.1242	0.8917	0.1196	27.2497
5	384	0.1255	0.2234	-0.1461	0.0704	-0.0042	0.0626	0.0945	0.2269	0.0433	0.3077	0.0765	32.9119
5	385	0.0165	0.0524	-0.2865	0.0234	-0.0987	0.8170	0.2185	0.0828	0.1385	0.4230	0.0806	4.4952
5	390	0.0995	-0.1862	-0.3186	0.1570	-0.2556	-0.0869	0.0938	0.0047	0.0519	1.3294	0.0135	0.2545
	Overall	0.0092	0.0088	-0.0385	0.0089	-0.0005	-0.0347	0.0543	0.0699	0.1498	0.3266	0.0829	2.6906
No. of increases		14	17	11	14	16	10	26	27	22	28	26	28

Note: There are some large changes in adjusted export in LA for electrical appliances due to the fast growing export in Mexico in the late 1990’s.

Appendix 4 Regression Results on Equation (10)

Group 1	EA	EU3	EUR	LA	SSEA	US
EA	0.0730	0.9569	-0.7042	-0.8890	-1.1054	0.2880
	(0.0397)	(0.7983)	(-0.4603)	(-0.6241)	(-0.7237)	(0.1131)
EU3	0.2846	-0.6187	0.7777	0.4013	1.2736	-0.7278
	(1.7914)	(-1.9926)	(2.8163)	(2.3853)	(4.8373)	(-1.0049)
EUR	-0.2228	0.9001	0.6052	-0.2078	-0.7855	-0.0812
	(-0.9513)	(2.6505)	(0.8813)	(-1.1180)	(-2.5934)	(-0.1196)
LA	-0.5593	1.1505	-1.1966	0.2970	-1.2919	-0.3491
	(-1.5080)	(1.3042)	(-1.1079)	(0.5841)	(-1.2046)	(-0.2163)
SSEA	0.0743	0.3921	-0.3386	-0.1267	0.4835	0.0556
	(0.5388)	(2.1298)	(-1.3094)	(-1.0656)	(2.5483)	(0.1468)
US	0.0270	0.2086	-0.4056	0.0126	-0.3733	-0.0601
	(0.1391)	(0.4439)	(-0.6820)	(0.0570)	(-0.7050)	(-0.0908)

Group 2	EA	EU3	EUR	LA	SSEA	US
EA	0.9895	-0.6264	-0.0877	-0.2291	-0.5943	0.4405
	(6.3898)	(-1.5666)	(-0.1074)	(-1.3992)	(-1.6262)	(0.5567)
EU3	-0.1192	0.9147	0.9027	0.2873	-0.4715	0.0137
	(-1.1555)	(1.9966)	(1.7464)	(2.4890)	(-1.1415)	(0.0199)
EUR	0.1252	0.3630	-0.0142	-0.1281	0.0691	-0.2598
	(0.8186)	(1.3593)	(-0.0286)	(-1.3086)	(0.1504)	(-0.4539)
LA	-0.1164	1.3203	-3.5858	0.5233	-0.5294	-0.6460
	(-0.1074)	(0.8216)	(-1.6099)	(0.7736)	(-0.3691)	(-0.1835)
SSEA	-0.0810	-0.3882	0.9073	-0.0578	-0.6062	0.6212
	(-0.3232)	(-0.4480)	(0.7376)	(-0.2873)	(-1.1554)	(0.3700)
US	0.0695	0.3649	-0.5853	-0.0126	-0.2563	-0.4443
	(0.6559)	(0.8840)	(-0.7380)	(-0.1139)	(0.9146)	(-0.5621)

Group 3	EA	EU3	EUR	LA	SSEA	US
EA	0.8407	-0.8443	0.2541	-0.0602	-0.2161	-1.2965
	(9.1486)	(-4.6055)	(2.4102)	(-1.8587)	(-3.3542)	(-5.3421)
EU3	0.2303	-0.0887	0.2552	0.0981	0.0700	-0.2079
	(0.5093)	(-0.1221)	(0.5878)	(0.6067)	(0.1709)	(-0.1500)
EUR	0.3723	-1.3561	1.6661	0.1797	-1.0867	2.2626
	(0.8308)	(-1.0753)	(1.5416)	(1.2187)	(-1.8496)	(1.8516)
LA	-2.5499	1.1909	0.9396	0.0317	-0.1919	-6.0332
	(-2.1013)	(0.5994)	(0.5447)	(0.0665)	(-0.1831)	(-1.6501)
SSEA	-0.5394	-0.2179	-1.1853	0.0320	-0.4107	1.5096
	(-0.6557)	(-0.1629)	(-0.8403)	(0.0871)	(-0.4585)	(0.3996)
US	-0.2351	-0.0289	0.1708	-0.0895	0.0080	-0.0985
	(-1.6280)	(-0.1183)	(1.0138)	(-1.9443)	(0.0639)	(-0.2962)

Group 4	EA	EU3	EUR	LA	SSEA	US
EA	-1.2926	0.6065	-0.8704	-0.0064	-0.3757	-1.2518
	(-1.1357)	(1.1926)	(-1.8224)	(-0.0458)	(-1.3214)	(-1.6088)
EU3	0.2559	0.2385	0.7533	0.2195	0.3658	1.0771
	(0.4961)	(0.5270)	(1.9205)	(2.6128)	(1.7334)	(2.0305)
EUR	-0.5094	0.6246	0.0955	-0.1800	-0.4217	-1.0982
	(-1.2078)	(0.8229)	(0.1370)	(-1.1629)	(-2.4345)	(-2.0534)
LA	-0.6833	2.9227	-3.0267	0.0709	-1.6144	-4.5562
	(-0.3193)	(1.7312)	(-2.0611)	(0.1280)	(-2.1839)	(-2.0137)
SSEA	0.5961	0.9657	-0.3152	-0.4391	0.4319	-1.6658
	(0.5512)	(1.6134)	(-0.3229)	(-3.5635)	(1.5480)	(-2.3044)
US	-0.2967	0.5845	-0.6058	-0.1744	-0.3355	-0.0451
	(-0.5949)	(1.9968)	(-2.5719)	(-0.8595)	(-1.2257)	(-0.0602)

Group 5	EA	EU3	EUR	LA	SSEA	US
EA	0.5090 (2.1060)	-0.5349 (-0.9243)	0.1034 (0.3046)	-0.0028 (-0.0414)	-0.3231 (-1.2988)	0.5727 (0.6411)
EU3	-0.3514 (-4.4064)	-0.5565 (-7.3051)	0.2011 (2.5713)	-0.1397 (-6.6513)	0.4868 (6.5385)	0.8921 (6.2716)
EUR	0.0437 (0.9487)	0.0415 (0.9720)	-0.0527 (0.9589)	0.0266 (0.8293)	0.0829 (0.9190)	0.0416 (0.9820)
LA	-2.1753 (-1.1796)	-0.2983 (-0.0906)	0.1132 (0.0619)	-0.8651 (-2.2905)	-0.7378 (-0.4449)	-1.4718 (-0.2934)
SSEA	0.4687 (1.0541)	0.7652 (1.4971)	-0.2099 (-0.6683)	0.1096 (1.7232)	0.4703 (3.3660)	-1.0139 (-1.2453)
US	0.1447 (0.6990)	0.5246 (1.9427)	-0.0117 (-0.0568)	0.0161 (0.2033)	-0.0633 (-0.3556)	0.2911 (0.3845)

Appendix 5 Using Losers to Identify Gainers

Industry Group	Losers	Gainers					
		EU3	EUR	EA	LA	US	SSEA
Primary Products	LA		G	G			
	US		G				
	SSEA		G				
Labor Intensive	EU3						
	EUR				G	G	
	EA				G		
	SSEA				G		
Raw Materials	EU3						
	EUR						
	LA			G			
	US			G			
	SSEA			G			
Producer Goods	EU3						
	EA		G			G	
	LA		G			G	
	SSEA		G			G	
Fabric Metal	EA	G			G		G
	US		G				G

Note: Gs represent the gainers

Appendix 6 Results of Unit Root Tests on AE and TFP

	AE				TFP			
Industry/ Country	Level		First difference		Level		First difference	
	Intercept	Intercept with trend	Intercept	Intercept with trend	Intercept	Intercept with trend	Intercept	Intercept with trend
1. Primary Products								
EA	-0.9484	-1.9516	-2.8898*	-4.5111**	-2.3786	-2.7559	-3.9024**	-2.3034
EU3	-0.1694	-3.5545	-5.5850***	-5.1646**	-1.7880	-1.9973	-2.8744*	-18.834***
EUR	1.1990	-3.0703	-3.7089**	-10.828***	-0.3839	-3.4558	-2.9398**	-3.9962*
LA	-1.7710	-2.7959	-5.8275***	-6.7530**	-1.7439	-2.3980	-3.0194*	-2.8037
SSEA	-0.8105	-2.2734	-5.5997***	-3.7372*	-2.2520	-1.6352	-2.8397*	-2.3066
US	-1.9785	-1.2124	-3.5262**	-4.0026*	1.5950	-1.0153	-2.6408	-5.9298**
2. Labor-intensive								
EA	-2.6016	-2.2165	-5.5420***	-6.6034***	-0.5572	-3.2680	-3.8003**	-3.3063
EU3	-1.3755	-0.7709	-2.3909	-1.3273	-2.1311	-2.5156	-2.4841	-2.2118
EUR	-0.5423	-2.0652	-2.9649*	-3.0444	-1.9594	-1.7202	-4.6046**	-2.8064
LA	-1.7048	-0.7785	-1.7534	-3.5384	-2.0220	-2.6570	-5.0108***	-4.3674**
SSEA	-1.9068	-2.3206	-3.1061*	-3.4857	-2.0240	-2.5714	-7.4146***	-7.2536***
US	-2.5456	-1.2616	-3.2430*	-5.0015**	-1.6745	-1.4066	-2.5962	-2.7006
3. Raw Materials								
EA	-0.0371	-1.6652	-2.2075	-2.1658	-1.5276	-1.7722	-1.0559	-2.0926
EU3	-0.1550	-2.5887	-3.5896**	-3.3475	-0.6776	-3.0146	-15.419***	-1.7617
EUR	-0.1309	-2.4076	-3.3592**	-2.8219	-0.5460	-2.7846	-4.6358**	-1.7810
LA	-1.8767	-2.8248	-10.832***	-3.5716*	-1.2314	-0.3506	-1.1803	-5.6924**
SSEA	-0.7345	-1.2909	-9.1476***	-2.8265	-1.7473	-1.5682	-4.3120**	-4.0484*
US	-0.1953	-2.9797	-5.2628**	-4.9674**	-0.6495	-3.1417	-2.4513	-4.9447**
4. Producer Goods								
EA	-0.5584	-2.4731	-3.3444**	-2.4934	-2.9147*	-2.5420	-3.1202*	-2.6237
EU3	-1.2098	-1.3406	-5.2927***	-2.0643	-2.5998	-3.4798	-5.9738*	-1.3567
EUR	-1.6300	-1.4375	-2.7023	-2.1008	-2.2446	-2.2820	-4.1376**	-3.9785*
LA	-2.4496	-1.6895	-3.4780**	-5.0307**	-1.9572	-1.2583	-10.122*	-3.2609
SSEA	0.3674	-2.2170	-4.0763**	-3.3581	-2.6719	-2.5425	-3.5296**	-3.2858
US	-1.4957	-2.1213	-2.7344	-2.5412	-2.0482	-2.4364	-1.6991	-0.6173
5. Fabric Metal								
EA	-0.1600	-2.1743	-2.7949*	-2.6423	-1.7985	-2.8436	-3.0709*	-2.9709
EU3	-0.4160	-2.2144	-2.2717	-2.1288	-2.4770	-1.4905	-2.5627	-2.3147
EUR	-2.3786	-2.3626	-3.8624**	-3.5655*	-1.4918	-0.7357	-3.0496*	-2.6529
LA	-0.9326	-2.6685	-3.2845**	-3.0923	-1.3327	-2.2010	-3.8957**	-5.2588**
SSEA	-1.9898	-2.3926	-3.4488**	-1.7911	-0.7320	-1.6767	-3.0052*	-1.7130
US	-0.7451	-2.3829	-3.0551*	-2.8355	-1.9659	-1.9714	-3.5150**	-3.5322

Notice: Lag lengths are determined by the Schwarz Information Criteria. ***, **, and * indicate significance at 1%, 5% and 10 % level, respectively. The results indicate that almost all variables are I (1), with the exception of EU3 2 & 5, EA 3, US 4. It is checked that they are I (2) and their second differences are used to perform the causality tests. For LA 2-AE and EUR 4-AE, we marginally reject the unit root for the first difference test with 15% level of significance. For EA 4-TFP, it seems to be I (0), but we still use the first difference to perform the causality test for consistency.

Appendix 7 Results of Granger Causality Tests on Six World Regions

Industry / Country	1-Lag AE does not cause TFP F-statistics	P-value	1-Lag TFP does not cause AE F-statistics	P-value	2-Lag AE does not cause TFP F-statistics	P-value	2-Lag TFP does not cause AE F-statistics	P-value
1. Primary Products								
EA	1.0854	0.3376	8.2160**	0.0286	7.8339*	0.0644	15.549**	0.0261
EU3	2.2079	0.1879	0.7759	0.4123	3.6278	0.1582	1.3331	0.3853
EUR	0.1724	0.6924	0.1179	0.7430	0.0691	0.9347	0.2023	0.8272
LA	0.1808	0.6855	0.0035	0.9551	1.4966	0.3542	0.2556	0.7898
SSEA	0.0090	0.9277	1.0031	0.3552	1.0801	0.4433	0.6535	0.5813
US	0.0253	0.8788	8.7550**	0.0253	2.9505	0.1957	11.810**	0.0378
2. Labor-intensive								
EA	6.3804**	0.0449	0.9261	0.3730	16.046**	0.0250	0.2733	0.7780
EU3	1.1695	0.3289	0.1342	0.7291	38.864**	0.0251	0.0668	0.9376
EUR	0.1355	0.7254	0.7917	0.4078	0.3011	0.7600	0.1469	0.8692
LA	0.7526	0.4190	0.1616	0.7016	4.7580#	0.1174	4.0445#	0.1407
SSEA	0.6253	0.4592	0.2110	0.6622	0.2183	0.8157	1.1871	0.4171
US	2.2647	0.1831	0.1456	0.7160	3.6715	0.1562	0.0793	0.9257
3. Raw Materials								
EA	1.1423	0.3340	3.5631#	0.1172	0.2494	0.8004	2.3345	0.2300
EU3	1.1917	0.3169	0.1189	0.7420	0.0425	0.9590	0.4172	0.6920
EUR	0.0076	0.9333	3.3652#	0.1163	0.4814	0.6587	4.4925#	0.1252
LA	0.0968	0.7663	1.8560	0.2216	0.3409	0.7355	0.5221	0.6389
SSEA	0.0097	0.9248	1.1623	0.3224	0.3659	0.7208	0.4246	0.6881
US	1.1134	0.3320	1.0616	0.3426	0.3241	0.7457	0.4647	0.6671
4. Producer Goods								
EA	0.3815	0.5595	0.5028	0.5049	4.1278#	0.1376	0.1653	0.8549
EU3	0.6110	0.4641	0.4378	0.5328	0.3857	0.7094	1.3027	0.3915
EUR	0.9817	0.3600	0.4166	0.5425	0.3196	0.7485	4.3327#	0.1304
LA	0.4268	0.5378	0.0387	0.8505	0.4296	0.6854	247.42*	0.0005
SSEA	0.0163	0.9026	0.5212	0.4975	0.0868	0.9190	1.6707	0.3254
US	0.3915	0.5590	0.6882	0.4446	0.6621	0.6017	0.3821	0.7235
5. Fabric Metal								
EA	10.676**	0.0171	7.3462**	0.0351	3.8669#	0.1478	5.1314#	0.1076
EU3	0.3477	0.5811	0.0386	0.8520	0.3669	0.7316	1.1324	0.4690
EUR	0.3233	0.5902	0.5879	0.4723	2.3434	0.2438	0.0044	0.9957
LA	0.2052	0.6665	1.5305	0.2623	0.8591	0.5070	0.7920	0.5294
SSEA	0.0659	0.8060	0.3523	0.5745	0.8330	0.5156	0.6389	0.5873
US	4.1381*	0.0882	0.0402	0.8477	4.1643#	0.1363	3.0573	0.1888

Notes: ***, **, and * indicate significance at 1%, 5% and 10 % level, respectively, and # indicates marginally acceptable at 15% level of significance.

References

Alonso-Borrego, Cesar, and Rocio Sanchez-Mangas, "GMM Estimation of a Production Function with Panel Data: An Application of Spanish Manufacturing Firms," Working Paper 01-55, Statistics and Econometrics Series 27, Universidad Carlos III de Madrid, 2001.

Balassa, Bela, "Trade Liberalization and 'Revealed' Comparative Advantage," *The Manchester School of Economic and Social Studies*, 33 (1965), 99-123.

Balassa, Bela, "'Revealed' Comparative Advantage Revisited: An Analysis of Relative Export Shares of the Industrial Countries, 1953-1971", *The Manchester School of Economic and Social Studies*, 45 (1977), 327-344.

Belassa, Bela, "The Changing Pattern of Comparative Advantage in Manufactured Goods", *Review of Economics and Statistics*, 61 (May 1979), 259-266.

Belassa, Bela, "Comparative Advantage in Manufactured Goods: A Reappraisal", *Review of Economics and Statistics*, 68 (May 1986), 315-319.

Bhagwati, J., *Free Trade Today*, (Princeton: Princeton University Press, 2002)

Bhagwati, J., *In Defense of Globalization*, (New York: Oxford University Press, 2004)

Carolan, Terrie, Nirvikar Singh, and Cyrus Talati, "The Composition of U.S.-East Asia Trade and Changing Comparative Advantage", *Journal of Development Economics*, 57 (1998), 361-389.

Barro, Robert J., and Xavier Sala-i-Martin, "Convergence", *Journal of Political Economy*, 100 (1992), 223-251.

Barro, Robert J., and Xavier Sala-i-Martin, *Economic Growth*, (New York: McGraw-Hill, 1995).

Bernard, Andrew B., and J. Bradford Jensen, "Exceptional Exporter Performance: Cause, Effects or Both?", *Journal of International Economics*, 47 (1999a), 1-25.

Bernard, Andrew B., and J. Bradford Jensen, *Exporting and Productivity*, Working Paper 7135, National Bureau of Economic Research, Cambridge (May 1999b).

Chow, Peter C. Y., "The Revealed Comparative Advantage of the East Asia NICs", *The International Trade Journal*, 5 (2) (Winter 1990), 235-262.

Collins S. M. and B. P. Bosworth, "Economic Growth in East Asia: Accumulation versus Assimilation", *Brookings Papers on Economic Activity*, (2) (1996), 135-203

Dar, Atul, and Sal Amirkhalkhali, "On the Impact of Trade Openness on Growth: Further Evidence from OCED Countries", *Applied Economics*, 35 (2003), 1761-1766.

Diamonte, Robin L., John M. Liew, and Ross L. Stevens, "Political Risk in Emerging and Developed Markets", *Financial Analysts Journal*, 52 (3) (May/June 1996), 71-76.

Dickey, D.A. and W. A. Fuller, "Distribution of the Estimators for Autoregressive Time-Series with a Unit Root", *Journal of the American Statistical Association*, 74 (366) (1979), 427-431

Dreher, A., "Does Globalization Affect Growth? Evidence from a New Index of Globalization", *Applied Economics*, (2006).

Edwards, Sabastian, "Openness, Productivity and Growth: What do We Really Know?", *The Economic Journal*, 108 (March 1998), 383-398.

Ferreira, Pedro Cavalcanti, and Jose Luiz Rossi, "New Evidence from Brazil on Trade Liberalization and Productivity Growth", *International Economic Review*, 44 (4) (November 2003), 1383-1405.

Fischer, Stanley, *Globalization and Its Challenge*, Ely Lecture, American Economic Association Meeting, Washington D.C., January (2003).

Granger, Clive W. K., "Investigating Causal Relations by Econometric Models and Cross-Spectral Methods" *Econometrica*, 27(3) (1969), 424-438.

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

Hansen, L., "Large Sample Properties of Generalized Method of Moments Estimators", *Econometrica*, 50 (1982), 1029-1052.

Harrigan, J., "Estimation of Cross-country Differences in Industry Production Functions", *Journal of International Economics*, 47 (1999), 267-293.

Hillman, Arye, "Observations on the Relation between 'Revealed Comparative Advantage' and Comparative Advantage as Indicated by Pre-Trade Relative Prices", *Weltwirtschaftliches Archiv*, 116 (1980), 315-321.

International Monetary Fund, *International Financial Statistics*, (Washington D. C., 1997).

Kearney, A., *Measuring Globalization: Economic Reversals, Forward Momentum*, Foreign Policy (Washington D.C., 2005).

Kim, Jong I., and Lawrence J. Lau, “The Sources of Economic Growth of the East Asian Newly Industrialized Countries”, *Journal of the Japanese and International Economies*, 8 (3) (1994), 235-271.

Laursen, K., “Do Export and Technological Specialisation Patterns Co-evolve in terms of Convergence or Divergence? Evidence from 19 OECD countries, 1971–1991”, *Journal of Evolutionary Economics*, (Spring 2000), 415-436

Lee, Young Sun, “Changing Export Patterns in Korea, Taiwan and Japan”, *Weltwirtschaftliches Archiv*, 122 (1) (1986), 150-163.

Li, Kui-Wai, Iris A. J. Pang and Michael C. M. Ng, *Impact of Openness and Indigenous Factors on Growth among World Economies*, APEC Study Center Annual Consortium Conference (Vietnam: Ho Chi Ming City, May 2006).

Lutz, James M., “Shifting Comparative Advantage, the NICs and the Developing Countries”, *The International Trade Journal*, 1 (4), (Summer 1987), 339-358.

OECD, *Financial Statistics Monthly*, Sections I and II, (Paris: OECD, 1997).

Rana, Pradumna B., “Shifting Comparative Advantage among Asian and Pacific Countries”, *The International Trade Journal*, 4 (3), (Spring 1990), 243-258.

Rodrik, Dani, “Trade Policy and Industrial Policy Reform”, in Jere Behrman and T. N. Srinivasan (ed), *Handbook of Development Economics*, Vol. 3B, (Amsterdam: North Holland, 1995), 2926-2982.

Romer, Paul M., “Endogenous Technological Change”, *Journal of Political Economy*, 98 (5) (1990), 71-102.

Romer, Paul M., *Two Strategies for Economic Development: Using Ideas and Producing Ideas*, World Bank Annual Conference on Economic Development, (Washington D.C.: The World Bank, 1992).

Basu, Susanto and John G. Fernald, “Returns to Scale in U.S. Production: Estimates and Implications”, *The Journal of Political Economy*, 105 (2) (April 1997), 249-283.

Thangavelu, S. M., and David T. Owyong, “The Impact of Export Growth and Scale Economies on Productivity in Singapore’s Manufacturing Industries”, *Journal of Economic Studies* 30 (6) (2003), 623-635.

UNIDO, *Industry Demand-Supply Balance Database*, (Geneva: UNIDO, 2002).

UNIDO, *Industrial Statistics Database*, (Geneva: UNIDO, 2002).

Vollrath, Thomas L., “A Theoretical Evaluation of Alternative Trade Intensity Measures of Revealed Comparative Advantage”, *Weltwirtschaftliches Archiv*, 127 (1991), 265-280.

Ward, D., and R. Zurbruegg, “Does Insurance Promote Economic Growth? Evidence from OECO Countries”, *The Journal of Risk and Insurance*, 67(4) (2000), 489-506.