The Substitution among the Exports of Taiwan, China, and Other Countries to the United States*

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Abstract
The substitution among the exports of countries is a major phenomenon and foundation of the fast-changing global economy. However, the econometric method using aggregate data can usually estimate the extent of substitution only several years after the substitution has happened. This paper designed a detailed market share (DMS) analysis method that uses detailed trade data to document the actual replacement among the exports of different countries. The DMS indicators can measure the replacement that happened in every product or product group for every year. Therefore, DMS indicators can also be used as variables in further econometric research. This paper employed indicators to analyze the exports of Taiwan and China to the United States during 1990 and 2006. We found that the proportion of Taiwan's exports to the United States that was replaced by China during this period was about 71 percent to 85 percent. Taiwan, Japan, and other developed countries were the major sources of China's export growth. China also replaced a great part of developing countries' exports. China has also started to replace the high-end products of advanced countries. We found that 63 percent, 60 percent, and 33 percent of the highly human capital–intensive exports from Taiwan, Korea, and Japan, respectively, have been replaced by China. Most of these replacements happened in high-end products after 2000. Therefore, more products from advanced countries will be replaced by China in the near future.

1. Flying geese are not flying one after another now

During the 1960s and 1970s, it was widely believed that export opportunities moved from high-income countries to low-income countries and then to even lower-income

* I would like to thank Chen Yi Chen and Hsiao Hui Wu for their helpful assistance and suggestions.

countries. This view is called the *flying geese hypothesis* (Morris-Suzuki 1989, 151). Therefore, many products exported by Japan were expected to become the exports of the four newly industrialized countries (NICs) in Asia, which were Hong Kong, Singapore, South Korea, and Taiwan, some years later. Industrial development in the NICs did follow the route of Japan, especially Taiwan and Korea. Executives in Taiwan often looked for their new products from existing Japanese products.

Successful economic growth led by export expansion in the Asian NICs attracted the attention of other countries, and other East Asian developing countries started their own export-oriented growth strategy in the 1980s. At first, they followed the route of the four NICs. They attracted investment from the four NICs and Japan and replaced the exports of the four NICs and Japan in the world market. The flying geese hypothesis was still valid.

However, because the population of the developing countries today is almost 100 times larger than the population of the four NICs in 1960s, the process of export replacement after the 1980s is not happening as gradually and orderly as before. Competition among the developing countries resulted in developing countries replacing not only the exports of NICs, but also the exports of other developing countries. It is believed that the 1997 East Asian financial crisis was at least partly caused by the rise of China and the significant depreciation of the RMB in the early 1990s. The trade data show that the share of Thailand, Malaysia, and Indonesia in the U.S. market was increasing rapidly before 1995, but decreased after 1995. In other words, some of the export opportunities for these three countries were taken away by other countries, including China, around 1995. The relative decline of the export growth rate in these countries then decreased their economic growth rates.

The huge labor supply of developing countries also means that simply replacing the exports of the four NICs is not sufficient to maintain the fast economic growth of developing countries, they also had to replace some of the exports of the advanced countries directly. The free and more convenient international flow of goods, capital, technology, and business organization under globalization has also enabled developing countries to attract investment and cooperation directly from advanced countries. Many geese are now flying directly from the advanced countries to the developing countries. The flying geese hypothesis can no longer explain much of the shifts of production sites.

This paper has two aims. The first aim is to capture the substitution of exports among East Asian countries, by developing a model that can represent the replacement among exporting countries. The second aim is to employ these indicators to

analyze the export replacement among Taiwan, China, and other countries in U.S. imports.

2. Detailed market share analysis of substitution

When there are only two producers for one product, it is quite natural to assume that the reduction in the sale of one producer must mean that there has been an increase in the sale of the other producer. When there are many producers, it becomes harder or even impossible to identify who replaced whose products. If we are interested in a single product, we may trace everything that happened in the market to find out the actual substitution. If we are interested in a limited number of industries, we may use the information about prices and supply capacity in some econometric model to guess the actual substitution. However, the data might not be available, the models might not be able to catch the structural changes, and the results would change drastically with changes in model assumptions.

Fortunately, when we look at a single product or a small category of products in the imports of a country, we may find that there is usually only a small number of major exporting countries. We may also find that major changes of market share in a single period often happen among an even smaller number of countries. Therefore, when the market share of a country increases or decreases, it is often not so difficult to identify or guess the sources or destinations of the changes in this market share. When we do not have any information other than the changes in market share, a simple and neutral guess is to assume that the reduction in the share of any country is divided by all countries whose share increased in the same period. It is also natural to assume that the share lost by any country is divided by the gaining countries according to the size of each country's actual increase in the market share.

Similar to the method used by Chen (1999), we will use the following symbols to illustrate the method for estimating the substitution among countries:

$S(i,t,n)$: Country i's share in the U.S. import of product n in period t.
$\Delta S(i,t,n)$: The increase of $S(i,t,n)$ in period t.
$r(i,j,t,n)$: The share of country i replaced by country j in period t.
$A(i,t,n)$: The set of countries with $\Delta S(i,t,n) > 0$.
$B(i,t,n)$: The set of countries with $\Delta S(i,t,n) \leq 0$.
$M(t)$: U.S. total imports in period t.
$M(t,n)$: U.S. total imports of product n in period t.
$R(i,j,t,n)$: Country i's export value of product n replaced by country j in period t.

We will assume:

$$r(i,j,t,n) = -\Delta S(i,t,n) \cdot \frac{\Delta S(j,t,n)}{\sum_{k \in A(i,t,n)} \Delta S(k,t,n)}; \; i \in B, j \in A(i,t,n) \tag{1}$$

$$= 0 \qquad \text{otherwise.}$$

Then country i's export value of n replaced by country j is assumed to be:

$$R(i,j,t,n) = r(i,j,t,n) \cdot M(t,n). \tag{2}$$

$R(i,j,t,n)$ will be the basic data for the indicators of replacement in the following analysis. It is true that $R(i,j,t,n)$ may not be an accurate estimator for the actual substitution. The most detailed trade statistics contain more than 10,000 commodity categories; many categories still contain more than a single product. When the statistics of product n actually contain a number of different products, substitution among exporting countries might be quite specific, such as country P replacing country Q, and country X replacing country Y, rather than PQ together replacing XY, as assumed in equation (1). Because our interest is in the general trend and characteristics of substitution rather than the substitution in any specific product, we will add the $R(i,j,t,n)$ of all products or of products with similar characteristics together in our analysis. This aggregation process is expected to reduce the possible estimation errors in equation (2) through the law of large numbers.

The idea here is similar to the constant market share (CMS) analysis of international competitiveness (see Leamer and Stern 1970, ch. 7). It is assumed in CMS that a decrease (increase) in the market share of any product implies a decrease (increase) in the competitiveness. Therefore, the sum of changes in the export of all products due to the changes in the market share of each product can be a measure for the changes in competitiveness. The method in equations (1) and (2) is to further attribute the decrease in one country's market share of each product to countries with increasing share in that product, so that we can measure the substitution among countries.

When we add the $R(i,j,t,n)$ of all products together, we have

$$R(i,j,t) = \sum_n R(i,j,t,n), \tag{3}$$

which is the estimated total exports of country i replaced by country j in this period. We can also calculate the gross replacement ratio in terms of U.S. total imports as

$$G(i,j,t) = R(i,j,t)/M(t). \tag{4}$$

3. The replacement between Taiwan and other countries

We classified other countries exporting to the United States into some individual countries and some country groups, as shown in Table 1.

We calculated the $r(i,j,t,n)$ for each of the most detailed product categories in the U.S. trade statistics from 1990 to 2006. Then we calculated the $R(i,j,t)$ and $G(i,j,t)$ of Taiwan. We found that the share replaced by China was not only the highest, but also much higher than other countries or country groups in all periods.

To make the data easier to read, the $G(i,j,t)$ of each period from 1990 to 2006 was summed to show the total replacement in the past 17 years. The results are shown in the first column of Table 1. Taiwan's exports to the United States replaced by China in the whole period are equivalent to 3.14 percent of the total imports of United States. Japan and other developed countries also replaced significant shares of Taiwan's export. Japan replaced 0.75 percent and other developed countries replaced 1.30 percent. However, it might be a surprise to some people in East Asia that Mexico replaced more Taiwanese exports to the United States than any Asian country except China. The total amount replaced by Mexico is 1.03 percent, which is about one-third of the amount replaced by China.

Taiwan's exports were also replaced by Korea, Hong Kong, and Singapore. The total share replaced by these three together is higher than the share replaced by Japan. Malaysia replaced more of Taiwan's products than Thailand did. Indonesia and the Philippines replaced roughly the same amount (0.25 percent) of Taiwan's share, with Indonesia replacing more in the early periods. Vietnam started its exports to the United States later than other countries. Despite the significant development in Vietnam, Taiwan's share replaced by Vietnam until 2006 is only 0.03 percent. Adding these five South East Asian countries together, the share they replaced is only half of the share replaced by China in the same period. Despite economists' high expectations of India, East Europe, and Brazil, the share of Taiwan's export to the United States replaced by them is only 0.11 percent, 0.08 percent, and 0.10 percent, respectively, in the past 17 years. The total amount replaced by them is less than Taiwan's export replaced by Thailand alone, and is only about one-tenth of the share replaced by China. Taiwan's share replaced by all other developing countries together is only 0.6 percent, which is just a little bit higher than the share replaced by Malaysia and is only one-fifth of the share replaced by China.

Table 1. Taiwan's exports to the United States replaced by other countries (1990–06)

Item / Country	(1) Taiwan's share replaced by other countries, % of U.S. total imports	(2) Other countries' share replaced by Taiwan, % of U.S. total imports	(3) Net replacement of Taiwan's export by other countries, % of U.S. total imports	(4) Relative replacement ratio
Japan	0.7546	1.3405	−0.5893	1.7764
Korea	0.4455	0.5022	−0.0583	1.1274
China	3.1475	0.3358	2.8091	0.1067
Singapore	0.2134	0.2901	−0.0775	1.3592
Hong Kong	0.2415	0.1982	0.0416	0.8209
Thailand	0.3694	0.1242	0.2446	0.3362
Vietnam	0.0309	0.0032	0.0277	0.1036
Malaysia	0.5693	0.1972	0.3718	0.3464
Indonesia	0.2576	0.0668	0.1905	0.2593
Philippines	0.2549	0.1202	0.1344	0.4715
India	0.1188	0.0445	0.0743	0.3747
Eastern Europe	0.0832	0.0385	0.0445	0.4627
Mexico	1.0337	0.5489	0.4837	0.5310
Brazil	0.1033	0.0768	0.0259	0.7434
Other developed countries	1.3016	1.2471	0.0494	0.9581
Other developing countries	0.6089	0.3031	0.3038	0.4978

Source: *1. U.S. Imports of Merchandise.*

2. Calculated by Taiwan Institute of Economic Research.

4. The net substitution of Taiwan exports by other countries

When Taiwan's exports were replaced by the exports of other countries in one category, Taiwan's exports were also replacing the exports of other countries in other categories. In fact, Taiwan has been replacing many exports of Japan and other developed countries for several decades, as expected by the flying geese hypothesis. Using equation (4), with *j* representing Taiwan and *i* representing other countries, we found Taiwan is still replacing the exports from developed countries in the U.S. market. Table 1 shows that Japan's export to the United States replaced by Taiwan during the past 17 years was equivalent to 1.34 percent of U.S. total imports.

The exports of other developed countries replaced by Taiwan during the same period also reached 1.24 percent of U.S. total imports. We can also find from the replacement ratios of each year that the ratio of Taiwan replacing Japan was declining and the ratio of Taiwan replacing other developed countries was fluctuating but stayed roughly the same in 1990 and 2006.

Let's define the net replacement ratio country *i* replaced by country *j* as

$$N(i,j,t) = G(i,j,t) - G(j,i,t). \tag{5}$$

Using equation (5) to deduct the ratio of Taiwan replacing another country from the ratio of that country replacing Taiwan, we have the net ratio of Taiwan replaced by that country. The net ratio was always negative in the case of Japan in the past 17 years, except in the year 2000. In other words, Taiwan is still replacing Japan's export as expected by the flying geese hypothesis. However, the absolute value of the net replacement ratio is declining. The total net replacement ratio during the past 17 years is only −0.59 percent of U.S. total imports. In other words, the share Japan replaced Taiwan was 56 percent of the share Taiwan replaced Japan. The relationship between Taiwan and Japan is not a simple one-way replacement but a two-way competition, which is not expected by the flying geese hypothesis.

Developed countries replaced more exports of Taiwan than Japan, but Taiwan replaced more exports of Japan than of other developed countries. The net result was that the exports of other developed countries were replacing Taiwan's exports rather than being replaced by Taiwan's exports. However, the net ratio was small and was sometimes positive and sometimes negative in the data period. In order to compare the relative importance of the exports replaced by other countries and the exports taken from the same country, we can define the relative replacement ratio I as

$$I(i,j) = \sum_t G(i,j,t) \,/\, \sum_t G(j,i,t)\,. \tag{6}$$

$I(i,j)$ will be close to zero if the exports of i rarely replaced the exports of j. $I(i,j)$ will be large if j rarely replaced the exports of i. When i and j are close competitors, $I(i,j)$ will be close to one. We can find from the fourth column of Table 1 that the relative replacement ratio of Taiwan replaced by other developed countries is 0.95. They were replacing each other by almost the same amount. Therefore, we may say that Taiwan and the developed countries, other than Japan, are competitors in the U.S. market.

Besides the exports of Japan, the exports of Singapore and Korea were also replaced by the exports of Taiwan. The cumulative net replacement ratio in the past 17 years was 0.0583 percent and −0.0773 percent for Korea and Singapore, respectively (Table 1). The scales are much smaller than in the case of Japan. The relative replacement ratio with Taiwan is 1.36 for Singapore and 1.13 for Korea. Both of them are lower than the ratio of 1.78 for Japan, but higher than the ratio of 0.96 for other developed countries. Taiwan seems to have paid more attention in replacing the exports of neighboring developed countries than replacing the exports of other developed countries. The pattern between Taiwan and Hong Kong is different. Like the case of developing countries, the exports of Hong Kong replaced more exports of Taiwan than the amount of Hong Kong exports replaced by Taiwan. This difference is probably caused by the fact that a great part of Hong Kong's exports to the United States is actually Chinese products.

Table 1 shows the relative replacement ratio of each country in the data period. There is a tendency that the relative replacement ratio (I) is higher in the higher income countries. The share of exports of each developing country replaced by Taiwan's exports is generally much smaller than the share that that country replaced of Taiwan. However, the relative replacement ratio is still higher than 33 percent in most of the developing countries. We may say that Taiwan did not give up competing in many products that developing countries were exporting. However, Taiwan's relative replacement ratio with China and Vietnam is only 0.1067 and 0.1036, respectively. Geese flying from Taiwan to China and Vietnam rarely fly back to Taiwan. One of the reasons is probably because China and Vietnam are more competitive than other developing countries in production costs. Another possible reason is the more important role Taiwan's investment has in these two countries. A great part of Taiwan's replacement by these two countries is actually caused by Taiwanese companies that have moved their production and exports from Taiwan to these two countries. If the export share was taken away by foreign competitors, producers in Taiwan might be able to take back some of the markets later. When Taiwan's own

firms moved to foreign countries and took the export share, Taiwan could hardly take the markets back because it had already lost the production facilities.

China replaced more shares from Taiwan than other countries did. Moreover, Taiwan's relative replacement ratio with China is also much lower than the replacement ratio between Taiwan and other countries. Consequently, Taiwan's net replacement by China is even more significant. Taiwan's net share replaced by China in the past 17 years is 2.80 percent of total U.S. imports. This is higher than the total net shares Taiwan replaced by other countries. China obtained almost 70 percent of the shares Taiwan lost to all countries in the past 17 years. The second biggest winner, Mexico, obtained only 17.4 percent of the shares obtained by China, despite the fact that Mexico is so close to the United States and has a signed free trade agreement (FTA) with the United States.

5. The replacement between China and other countries

We found that China replaced huge amounts of Taiwan's export in the last two sections. It is also interesting to see what happened between China and other countries. Column (2) of Table 2 shows the cumulated shares of other countries replaced by China in the past 17 years. The share of Japan replaced by China (0.514 percent) is very close to Taiwan's share replaced by China (0.3358 percent). The share of other developed countries replaced by China is even higher (1.1956 percent). Developed countries together lost 6.92 percent of total U.S. imports to China, the four Asian NICs lost 7.04 percent, Mexico lost 0.7550 percent, and other developing countries together lost 0.7561 percent. In other words, China has been replacing exports from all kinds of countries. China did not just replace the exports of NICs or middle-income countries, as predicted by the flying geese hypothesis. Many geese now fly to China directly without stopping in middle-income countries. The fact that China can replace so many exports from countries with different factor costs and at different stages of economic development is also a challenge to the conventional Heckscher-Ohlin theory of international trade.

Some years ago when the impacts of the huge labor supply from developing countries were not so obvious, there were researchers saying that the rise of China and other developing countries would not hurt the advanced countries because the products that developing countries can produce had moved to NICs already. More recently, Bhagwati (2004) also argued that the export growth of low-income countries could be offset by the decline of the exports from middle-income countries. However, the data here clearly indicate that advanced countries were also hurt by the export growth from both lower- and middle-income countries, even though the

Table 2. Export of other countries to the United States replaced by China (1990–06)

Item / Country	(1) China's share replaced by other countries, % of U.S. total imports	(2) Other countries' share replaced by China, % of U.S. total imports	(3) Net replacement of other countries' exports by China, % of U.S. total imports	(4) Relative replacement ratio
Taiwan	3.1475	0.3358	2.8091	0.1067
Japan	3.0430	0.5140	2.5279	0.1689
Korea	2.2690	0.2727	1.9948	0.1202
China	0.0000	0.0000	0.0000	0.0000
Singapore	0.5553	0.0794	0.4755	0.1430
Hong Kong	1.0141	0.2184	0.7933	0.2154
Thailand	0.7877	0.2773	0.5071	0.3520
Vietnam	0.0537	0.0804	−0.0266	1.4970
Malaysia	0.8742	0.2654	0.6080	0.3036
Indonesia	0.5297	0.1946	0.3330	0.3673
Philippines	0.5839	0.1370	0.4457	0.2346
India	0.2611	0.1710	0.0901	0.6549
Eastern Europe	0.2229	0.0767	0.1455	0.3442
Mexico	2.3848	0.7550	1.6272	0.3166
Brazil	0.4264	0.0926	0.3321	0.2171
Other developed countries	3.9031	1.1956	2.6650	0.3063
Other developing countries	1.4480	0.7561	0.6821	0.5222

Source: *1. U.S. Imports of Merchandise.*

2. Calculated by Taiwan Institute of Economic Research.

middle-income countries, especially Taiwan, seemed to have been hurt more. The analysis on the structure of the exports replaced by China in later sections will show the tendency that advanced countries would face an even higher challenge from China very soon.

Other countries also replaced some exports of China. However, we can see from Table 2 that the shares other countries replaced China's export are much lower than the shares of their exports replaced by China's exports, except in the case of Vietnam. Taiwan's cumulative net shares replaced by China are the highest among all countries. The net loss of Japan and other developed countries is slightly lower than Taiwan's net loss. Korea's net replacement by China is about two-thirds of Taiwan's net replacement by China. The net replacement ratios in Table 2 are all positive except for Vietnam.

Dividing the cumulated share of China replaced by other countries by the cumulated share of other countries replaced by China, we obtained the relative replacement ratio (I) in column (4) of Table 2, but ratios for other countries (both developed and developing) are less than one. Vietnam's ratio is 1.49. This is because Vietnam is the only country in this table that replaced more of the Chinese export share than had been replaced by China. This ratio is the lowest in the case of Taiwan. The share of Taiwan replaced by China is only one-tenth of China's share replaced by Taiwan.

China's relative replacement ratio with Korea, Singapore, and Japan is 0.1202 percent, 0.1430 percent, and 0.1689 percent, respectively. This ratio is higher in Hong Kong than in other NICs possibly because some exports from China were reported as exports from Hong Kong so that the share China replaced by Hong Kong was exaggerated. The relative replacement ratio is about one-third in many countries including Thailand, Malaysia, Indonesia, East European countries, Mexico, and other developed countries. The share replaced by India is only 0.1710 percent. India and Vietnam did not replace Chinese exports as rapidly as some people expected. However, the relative replacement ratio for India is 0.6549 percent, which is higher than all the other countries except Vietnam. Therefore, Vietnam and India might have the potential to attract more geese from China in the future.

If we apply $I(i,j)$ of equation (6) for a shorter period or for each year, we may also find that the relative replacement ratio also tends to decline in the past 10 years. Before 2000, there were several developing countries having the experience of replacing more of China's export share than the share replaced by China in some of the years. Vietnam is the only country to have this experience after 2001. China is taking export market shares from almost all countries. Generally speaking, a country with

a higher income and that is closer to China tends to have a lower relative replacement ratio with China.

6. The effects of the replacement between Taiwan and other countries

We used the share in the total imports of the United States as a common scale to analyze the replacement among all countries. The benefit of this common scale is to facilitate cross-country comparison. However, the exporting countries are diversified in export size; a loss of small market share by a small country might be much more harmful to that country than a loss of larger market share by a large country. This section will use the total exports of the replaced country as the denominator to show the impact of export replacement on the replaced country. Therefore, we define

$$H(i,j,t) = R(i,j,t)/X(i,t)\ , \tag{7}$$

where $X(i,t)$ is the U.S. import from country i in year t.

We can also use the export of the country replacing others as the denominator to show the benefit of replacing other countries' exports:

$$F(i,j,t) = R(i,j,t)/X(j,t). \tag{8}$$

Then the net replacement ratio using the export of the replaced country as the denominator is

$$T(i,j,t) = H(i,j,t) - F(i,j,t). \tag{9}$$

$T(i,j,t)$ can represent the net impact effect of the replacement between i and j on i. The net effect on j is

$$T(j,i,t) = H(j,i,t) - F(j,i,t), \tag{10}$$

which represents the same net replacement as $T(i,j,t)$ but in a different sign and using the export of country j as the denominator.

In the case between Taiwan and China, Taiwan's exports replaced by China (H) was a large proportion of Taiwan's exports in the past 17 years. On the other hand, China's exports replaced by Taiwan (F) were much smaller.

Consequently, Taiwan's net replacement by China every year was a significant proportion of Taiwan's total exports to the United States (Table 3). The ratio is 4.64 per-

Table 3. Net replacement of Taiwan's exports to the United States by other countries (% of U.S. total imports from Taiwan)

Replacing countries	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Taiwan	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Japan	−1.3548	−0.7987	−1.3380	−0.2230	−0.9843	−1.6589	−0.8404	−1.0381	−0.6598	−1.5042	0.2933	−1.2793	−0.6275	−1.3715	−1.0130	−0.7329	−1.1997
Korea	0.0983	−0.5669	0.0115	0.2120	−0.1408	−0.1810	−0.2655	−0.1587	0.2213	1.1138	−0.3646	−0.2690	0.5001	0.2337	−0.2207	−1.5460	−1.1607
China	4.6423	3.2668	4.5814	4.9857	3.3678	3.2060	2.0889	2.6683	2.2795	4.5910	2.6153	3.6793	6.7790	11.0322	11.7568	9.0272	5.0863
Singapore	0.3397	−0.2817	−0.0976	0.5760	0.0936	−0.5744	−0.1034	−0.7139	−0.0736	−0.6679	−0.5026	0.0360	0.0206	−0.2269	−0.0848	0.0370	−0.0096
Hong Kong	0.3150	−0.0872	0.2354	0.0624	0.1614	−0.0024	−0.0100	−0.1085	0.0714	−0.0754	0.1201	0.1807	0.0807	0.0597	−0.0128	0.0745	−0.0172
Thailand	1.1800	0.4663	0.7215	0.6397	0.4092	0.3240	0.0369	0.1622	0.2290	0.1846	0.1838	0.3305	0.4520	0.1215	0.3047	0.2715	0.0668
Vietnam	0.0000	0.0000	0.0000	0.0000	0.0000	0.0056	0.0148	0.0181	0.0015	0.0157	0.0157	0.0110	0.2600	0.2666	0.1427	0.1926	0.1327
Malaysia	0.8312	0.4694	0.5258	0.8085	0.4517	0.2549	0.3418	−0.2370	0.4841	0.2911	0.5502	1.8211	1.9666	0.2512	0.1966	1.2649	0.7278
Indonesia	0.6942	0.3275	0.7642	0.5417	0.2904	0.2955	0.0954	0.2967	0.0509	0.1356	0.1901	0.3648	0.0960	−0.0650	0.0105	0.5350	0.1073
Philippines	0.4937	−0.0086	0.2357	0.3027	0.2538	0.2103	0.0550	0.2704	0.3452	0.2422	0.0405	0.9179	0.3137	−0.0400	−0.4165	0.1123	0.1274
India	0.1315	0.0149	0.1210	0.1711	0.1680	0.1210	0.0607	0.1038	0.0780	0.0014	0.0835	0.1125	0.2698	0.1222	0.0877	0.3795	0.2237
Eastern Europe	0.0459	0.0236	0.0674	0.0964	0.0611	0.0837	0.0267	0.0795	0.0282	0.0432	0.1747	0.0701	0.0526	0.1397	0.1445	0.1713	0.0114
Mexico	0.8007	0.4927	0.4601	0.8053	1.3660	1.0566	1.0468	1.1323	1.2716	1.8330	1.2687	1.6385	−1.0552	0.1201	0.4720	−0.0517	−0.7169
Brazil	0.0534	−0.0100	0.1708	0.2061	0.0916	0.0765	0.0029	−0.0236	−0.0062	0.0010	0.0484	0.0356	0.2041	0.0219	−0.1303	0.1461	−0.4223
Other developed countries	0.9199	−0.4317	0.0326	0.6694	1.7400	1.1256	0.0030	−0.1161	0.6412	−1.5650	−1.1685	0.2862	0.5198	0.4315	−2.2434	0.6905	−2.0800
Other developing countries	0.9951	0.1132	0.6930	0.6981	0.6436	0.6391	0.3377	0.3794	0.2489	1.1872	0.8198	0.2564	0.0321	0.5972	−0.3348	0.5295	−0.1899

Source: *U.S. Imports of Merchandise.*

Note: *Figures in Table 2 are ratios using the total imports of U.S. as the denominator, but figures in Table 4 use U.S. imports from Taiwan as the denominator, therefore figures for each year in Table 4 cannot be added to produce the figures in Table 2.*

cent for 1990 and 5.08 percent for 2006. The ratio fluctuated between these two years. The lowest and highest ratio is 2.08 percent in 1996 and 11.75 percent in 2004.

From China's point of view, the importance of replacing Taiwan's exports was declining because the total exports of China to the United States were growing faster than the exports of Taiwan to the Unites States. The net replacement accounted for 6.95 percent of China's total exports to the United States in 1990 (Table 4). Taiwan was an important source for China to fetch export opportunities. However, the ratio declined gradually to slightly above 1 percent in 2000, then rose again because Taiwanese companies moved the production and export of more products, such as notebook computers, to China. After the major movement ended, the ratio declined again, and became only 0.66 percent of China's total exports to the United States in 2006. From China's point of view, Taiwan's share is much less important now than in the early 1990s.

Although Taiwan's exports replaced by other countries were mainly taken by China, the part taken by other countries was still a significant gain from some countries' point of view. More than 5 percent of the exports of Thailand and Indonesia to the United States were taken from Taiwan in 1990 (Table 4). The ratio is also higher than 3 percent in Malaysia and the Philippines in 1990. However, the ratios were declining in general.

A method to capture the accumulated replacement in terms of the exports of the replaced country is to divide the sum of the net value replaced during the period by the export value of the final year:

$$CW(i,j) = \sum_{t=1990}^{2006} [R(i,j,t) - R(j,i,t)] \,/\, X(i,2006)\,. \tag{11}$$

The negative value of the accumulated replacement in terms of the export of the replacing country is

$$CW(j,i) = \sum_{t=1990}^{2006} [R(j,i,t) - R(i,j,t)] \,/\, X(j,2006)\,. \tag{12}$$

Table 5 summarizes the net replacement between Taiwan and other countries during 1990 and 2006. China replaced 71.21 percent of Taiwan's exports to the United States during this period. In other words, Taiwan's exports to the United States in 2006 could have been 71.21 percent higher if Taiwan's exports had not been replaced by China, even if the replaced part of the exports could not grow with other exports and the imports of the United States.

Table 4. Net replacement of Taiwan's exports to the United States by other countries (% of U.S. total imports from the replacing countries)

Replacing countries	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Japan	−0.3437	−0.2014	−0.3402	−0.0524	−0.2210	−0.3900	−0.2187	−0.2797	−0.1791	−0.4028	0.0809	−0.3361	−0.1656	−0.3653	−0.2700	−0.1840	−0.3081
Korea	0.1200	−0.7649	0.0169	0.3102	−0.1905	−0.2166	−0.3519	−0.2237	0.3048	1.2419	−0.3619	−0.2517	0.4471	0.1966	−0.1634	−1.2131	−0.9515
China	6.9570	3.9841	4.4178	3.9735	2.3182	2.0413	1.2104	1.3865	1.0522	1.9471	1.0445	1.1778	1.7091	2.2401	2.0352	1.2665	0.6609
Singapore	0.8077	−0.6625	−0.2148	1.1523	0.1658	−0.9143	−0.1547	−1.1830	−0.1353	−1.3346	−1.1062	0.0839	0.0465	−0.4909	−0.2017	0.0894	−0.0219
Hong Kong	0.7713	−0.2220	0.6086	0.1708	0.4608	−0.0071	−0.0315	−0.3593	0.2320	−0.2630	0.4506	0.6570	0.2928	0.2245	−0.0505	0.3150	−0.0885
Thailand	5.2446	1.7970	2.4175	1.9276	1.0864	0.8632	0.1010	0.4309	0.5715	0.4524	0.4559	0.7439	0.9804	0.2534	0.6061	0.4758	0.1150
Vietnam	0.0000	0.0000	0.0000	0.0000	0.0000	3.3733	2.1700	2.1687	0.1253	1.1255	0.9563	0.3847	3.6027	1.8543	0.9487	1.0212	0.5952
Malaysia	3.6934	1.8139	1.5876	1.9424	0.8700	0.4286	0.5792	−0.4302	0.8437	0.4733	0.8627	2.6843	2.6135	0.3081	0.2398	1.2886	0.7494
Indonesia	5.6541	2.8245	4.9022	2.8598	1.3677	1.3788	0.4099	1.1994	0.2031	0.5371	0.7829	1.2549	0.3383	−0.2363	0.0373	1.7155	0.3430
Philippines	3.3725	−0.0575	1.3463	1.5682	1.2006	0.8745	0.2021	0.8456	0.9633	0.6839	0.1166	2.6891	0.9171	−0.1257	−1.6026	0.4272	0.5069
India	0.9641	0.1103	0.8061	0.9672	0.8687	0.6349	0.3055	0.4816	0.3254	0.0056	0.3227	0.3873	0.7307	0.2952	0.1947	0.7002	0.3921
Eastern Europe	1.2117	0.6024	1.4507	1.5489	0.8155	1.0672	0.3090	0.7752	0.2286	0.3159	1.0272	0.3580	0.2595	0.5336	0.5244	0.6008	0.0401
Mexico	0.6747	0.4053	0.3508	0.5514	0.7935	0.5388	0.4564	0.4541	0.4683	0.6138	0.3931	0.4302	−0.2602	0.0284	0.1091	−0.0110	−0.1420
Brazil	0.1640	−0.0382	0.6096	0.7363	0.3111	0.2752	0.0107	−0.0875	−0.0218	0.0035	0.1522	0.0854	0.4317	0.0406	−0.2207	0.2172	−0.6346
Other developed countries	0.1141	−0.0560	0.0042	0.0807	0.1948	0.1219	0.0003	−0.0120	0.0628	−0.1447	−0.1088	0.0226	0.0394	0.0295	−0.1487	0.0415	−0.1289
Other developing countries	0.3312	0.0425	0.2712	0.2696	0.2469	0.2423	0.1145	0.1261	0.0882	0.3835	0.2178	0.0610	0.0076	0.1167	−0.0556	0.0697	−0.0235

Source: *U.S. Imports of Merchandise.*

Note: *Figures in Table 1 are ratios using the total imports of U.S. as the denominator, but figures in Table 3 use U.S. imports from each country as the denominator, therefore figures for each year in Table 3 cannot be added to produce the figures in Table 1.*

Table 5. Cumulative net replacement of Taiwan's exports to the United States by other countries, 1990 and 2006

Item / Country	% of U.S. imports from Taiwan		% of U.S. imports from the replacing countries	
	(1) CW	(2) CT	(3) CW	(4) CT
Japan	−13.1418	−16.3307	−3.3756	−4.1774
Korea	−2.2880	−2.4831	−1.8757	−2.0516
China	71.2145	85.6538	9.2538	39.4221
Singapore	−2.1374	−2.2337	−4.8913	−4.0744
Hong Kong	0.7814	1.0478	4.0151	3.1616
Thailand	4.5550	6.0844	7.8365	18.5225
Vietnam	0.9523	1.0770	4.2722	18.3260
Malaysia	9.0736	11.0001	9.3422	20.5486
Indonesia	3.5866	4.7307	11.4668	25.5721
Philippines	2.7315	3.4557	10.8729	13.9280
India	1.8723	2.2503	3.2816	8.4920
Eastern Europe	1.1223	1.3200	3.9537	11.6687
Mexico	9.7228	11.9405	1.9254	5.8548
Brazil	0.2450	0.4659	0.3681	2.0346
Other developed countries	−1.7963	−0.5450	−0.1114	0.1127
Other developing countries	6.0817	7.6456	0.7517	2.5097

Source: *U.S. Imports of Merchandise.*

Note: *CW is defined in equation (11), CT is the simple sum of each year's net replacement ratio during 1990 and 2006.*

Under the same assumption and equation (12), the same net replacement represents 9.25 percent of China's total export to the United States in 2006. We may note that the cumulated replacement ratios (*CW*) here are probably an underestimation of the reality because the U.S. import markets of many products continued to grow after the replacement, and the denominators or the total exports of Taiwan and China were also growing. If we add the net replacement ratio of each year to represent the cumulated net replacement (*CT*), the net replacement will be 85.65 percent of Taiwan's exports to the United States and 39.42 percent of China's exports to the United States (Table 5). We may regard the range between CW and CT in Table 5 as the possible range of the actual impacts and benefits from the replacement.

We can see from Table 5 that 13.14 percent to 16.33 percent of Taiwan's exports to the United States in 2006 were taken from Japan between 1990–06. Japan is still the largest import source of new geese for Taiwan. Taiwan also took about 6 percent of total exports to the United States from Korea, Singapore, and other developed countries.

From Taiwan's point of view, Mexico and Malaysia are also major countries replacing Taiwan's exports. Both countries took away 9 to 11 percent of Taiwan's export to the United States. From the recipient countries' point of view, more than 10 percent of the exports from Indonesia and the Philippines to the United States are taken from Taiwan.

7. The impact of the replacement between China and other countries

We already know that China has been replacing all countries' exports except Vietnam. Using equation (11) or CW, Table 6 shows that China's exports taken from developed countries from 1990 to 2006 is more than 20 percent of China's total exports. Another 20 percent of China's total exports are taken from the four Asian NICs. China also took about 7.5 percent of its total exports to the United States from Southeast Asian developing countries.

From the viewpoint of other countries, the impacts from China's competition are formidable. Using CW as the indicator, 71.21 percent of Taiwan's exports were replaced. The net export value replaced by China in the past 17 years is 97.89 percent of Hong Kong's export to the United States in 2006; 44.02 percent, 29.48 percent, and 18.55 percent in the cases of Korea, Singapore, and Japan, respectively. Developing counties including Thailand, Indonesia, Philippines, and Malaysia also lost 20 to 50 percent of their exports to China.

However, other developed countries and other developing countries in Table 6 lost a lower proportion of their exports to China. Therefore, the impact of China's growth is stronger for China's neighbors than for remote countries.

Note that the tremendous impact of China's export replacement on other countries cannot be regarded as the "hurt" from China to other countries. China also increased its imports from other countries. Conversely, we can neither regard China's increasing imports or the increase of each countries' exports to China as China's "contribution" to other countries. At least we have to compare one country's exports replaced by China in the whole world and the increase in the exports of this country to China before we make any conclusions. Of course, this is beyond the scope of this paper because we analyze only the export replacement in the U.S. market rather than the world market. However, because Taiwan's export to China is now roughly 40 percent of Taiwan's total exports and China replaced 71 to 85 percent of Taiwan's exports to the United States, the possibility that Taiwan has benefited from China's growth is not high.

8. Structure of export replacement with Taiwan

So far, we have discussed only the replacement in total exports of each country to the United States, we have not discussed the characteristics of the exports replaced by other countries. However, the structure of replacement may have more policy

Table 6. Cumulative net replacement of other countries' exports to the United States by China

Item / Country	(1) CW (% of U.S. imports from other countries)	(2) CW (% of U.S. imports from China)
Taiwan	71.2145	9.2538
Japan	18.5532	9.3860
Korea	44.0231	6.9780
China	0.0000	0.0000
Singapore	29.4880	1.6744
Hong Kong	97.8970	2.4756
Thailand	26.3721	1.9919
Vietnam	−3.7519	−0.1087
Malaysia	19.9269	2.5149
Indonesia	31.1885	1.2676
Philippines	52.8066	1.7238
India	5.6385	0.4180
Eastern Europe	16.6131	0.6128
Mexico	10.9129	7.1610
Brazil	15.5904	1.3481
Other developed countries	5.2983	11.1063
Other developing countries	3.0938	3.2526

Source: *U.S. Imports of Merchandise.*

Note: *CW is defined in equation (11), CT is simple sum of each year's net replacement ratio during 1990 and 2006.*

implications because we can find from this kind of analysis whether the exports replaced by other countries are something that we have to give up or something we want to keep. The trend of structure change can also indicate any future threats we might encounter. The method used in this paper can be used in any subset of products to find the international replacement inside that set. Therefore, we can use the same method and the same raw data to analyze what happened in any specific industry or in any specific group of products. By comparing the results in different product groups, we can find the differences between them and the trend of structure changes.

In order to capture the structure difference and changes, this paper will not use the standard industry or commodity classification. A characteristic classification will be used here. Following the Heckscher-Ohlin theory, we can classify commodities according to different indicators of factor proportions in the production process of each commodity. Using those classifications, Chen (1994) found that among all his indicators of the factor proportions, the ratio of highly educated labor to total labor is the best indicator to distinguish the exports of developing and developed countries. The commodities were classified into highly, medium, and low human capital-intensive products. According to this indicator in Taiwan's production, the cutting lines were set in the way that the value-added from these three groups of commodities were equal in the base year. The share of the highly human capital–intensive products in the export of advanced countries tends to be much higher than develop-

ing countries. This share of middle-income countries was also rising more rapidly than other groups of products (Chen 1994; Chen, Schive, and Chu 1994).

Table 7 shows that Taiwan has cumulated net replacement by other countries during 1990 and 2006 as a proportion of Taiwan's export to the United States in the respective commodity group. We found that Taiwan replaced the highly human capital–intensive products of all high- or middle-income countries and Brazil. Taiwan also replaced the middle and low human capital–intensive products of Japan, but the net replacement ratios were lower than in the highly human capital–intensive products. Taiwan was replaced by other countries in all other cases. Generally speaking, net replacement ratios tend to be lower for highly human capital–intensive products and higher for low human capital–intensive products. This result is in accordance with the Heckscher-Ohlin hypothesis. We found 17.78 percent of Taiwan's highly human capital–intensive exports to the United States were taken from Japan during this period. Another 10.74 percent and 13.06 percent were taken from other developed countries and other NICs, respectively. However, Taiwan obtained only 10.59 percent and 2.14 percent of Taiwan's medium and low human capital–intensive exports to the United States from Japan. Developing countries must have replaced many kinds of exports from Japan directly.

Developing countries including Mexico tend to replace a higher proportion of Taiwan's middle and low human capital exports, with Malaysia as the only exception. Malaysia replaced 16.52 percent of Taiwan's highly human capital–intensive exports to the United States, but replaced only 1.13 percent and 6.32 percent of Taiwan's medium and low human capital–intensive exports to the United States. Consequently, the amount of Taiwan's highly human capital–intensive exports replaced by Malaysia is second to the amount replaced by China. Malaysia must be more successful in upgrading its industry than other developing countries.

China replaced 63.92 percent, 63.93 percent, and 97.31 percent of Taiwan's highly, medium, and low human capital–intensive exports to the United States. It is evident that China's exports are not only growing very fast, but also upgrading rapidly so that China can replace such a high proportion of Taiwan's highly human capital–intensive exports.

Table 8 shows the proportion of each country's exports to the United States taken from Taiwan. It shows that 8.04 percent of Japan's highly human capital–intensive exports were taken by Taiwan. Hong Kong, Korea, and Singapore lost 15.68 percent, 6.06 percent, and 7.19 percent, respectively, of their highly human capital–intensive

Table 7. Cumulative net replacement of Taiwan's exports to the United States by other countries (CW) (% of 2006 U.S. imports of the respective commodity group from Taiwan)

	Replacing country														
Human capital intensity	Japan	Korea	China	Singapore	Hong Kong	Thailand	Vietnam	Malaysia	Indonesia	Philippines	India	Eastern Europe	Mexico	Brazil	Other developed countries	Other developing countries
High	−17.7856	−6.8660	63.9244	−5.0368	−1.1631	2.2774	0.0497	16.5239	1.1342	2.8211	0.2477	0.8503	7.7880	−0.8263	−10.7476	3.2640
Medium	−10.5986	0.8567	63.9384	0.2453	1.9139	4.8362	0.4961	1.7776	3.5137	1.1495	2.2197	0.8726	9.1060	0.4100	1.5005	2.8437
Low	−2.1486	2.8766	97.3140	0.9411	2.2101	9.4269	5.0300	6.3253	10.3613	7.0140	5.5255	2.5895	17.5296	2.3440	4.6615	24.4055

Source: *U.S. Imports of Merchandise.*

Table 8. Cumulative net replacement of Taiwan's exports to the United States by other countries (CW) (% of U.S. 2006 imports of the respective commodity group from the replacing countries)

	Replacing country															
Human capital intensity	Japan	Korea	China	Singapore	Hong Kong	Thailand	Vietnam	Malaysia	Indonesia	Philippines	India	Eastern Europe	Mexico	Brazil	Other developed countries	Other developing countries
High	−8.0434	−7.1974	11.7149	−6.0604	−15.6899	5.0297	2.5710	9.7710	17.6229	11.0557	1.7862	4.1347	4.4025	−2.7836	−1.1823	2.2344
Medium	−1.7141	0.5288	7.8143	1.9291	11.2924	7.4632	2.4535	5.1403	11.0885	7.4540	2.7630	2.4793	1.0654	0.3873	0.0597	0.1892
Low	−1.2316	4.6481	7.9677	2.5121	2.8518	11.2780	5.1769	11.5739	7.3680	12.1529	4.4914	8.4964	3.2623	3.0300	0.3118	2.7394

Source: *U.S. Imports of Merchandise.*

exports to Taiwan in the U.S. market during this period. However, they simultaneously replaced Taiwan's medium and low human capital–intensive exports. Thailand, Malaysia, Indonesia, and the Philippines all took more than 10 percent of their exports to the United States from Taiwan in some commodity groups. However, Vietnam and India won a much lower proportion of their exports to the United States from Taiwan in almost all groups of commodities than other Asian developing countries. Because they have a higher relative replacement ratio with China than other countries, we may regard them as the latecomers receiving relatively more geese from developing countries than from higher-income countries, as assumed in the flying geese hypothesis.

9. Structure of export replacement with China

We already found China replacing significant proportions of Taiwan's highly and medium human capital–intensive exports in the U.S. market. It is interesting to discover what happened between China and other countries. Table 9 is similar to Table 2, but the exports are classified into three groups according to the human capital intensity. The denominators to calculate these ratios are the respective total import of the United States in these commodity groups. The highly human capital–intensive exports of Japan replaced by China in the U.S. market during 1990 and 2006 reached 5.05 percent of the total imports of highly human capital–intensive products by the United States. The net replacement ratio is 4.35 percent. Both ratios are higher than the respective ratio Taiwan replaced by China, which is 3.67 percent and 3.35 percent, respectively.

The net ratio of Korea's highly human capital–intensive exports to the United States replaced by China is 2.79 percent of U.S. total imports in this commodity group, only 27 percent lower than the net ratio Taiwan replaced by China. Hong Kong, Singapore, Malaysia, Mexico, and other developed countries all lost more than 1 percent of U.S. total imports of highly human capital–intensive products to China. We can see from Table 9 that China is replacing exports from all countries in all three groups of commodities except the highly and medium human capital–intensive products of Vietnam.

Despite that, China is replacing almost every kind of export of other countries; we can see from column (4) of Table 9 that the relative replacement ratio is smaller for the highly human capital–intensive product and bigger for the low human capital–intensive products as compared with the medium human capital–intensive products in most of the countries. In other words, China has been replacing many advanced products from other countries; China still has relatively stronger competitiveness in

Table 9. Other countries' exports to the United States replaced by China between 1990 and 2006 (% of U.S. total imports of the respective commodity group)

		Taiwan	Japan	Korea	Singapore	Hong Kong	Thailand	Vietnam	Malaysia	Indonesia	Philippines	India	Eastern Europe	Mexico	Brazil	Other developed countries	Other developing countries
(1) China's share replaced by other countries, % of U.S. total import	High	3.6719	5.0517	3.0656	1.4777	0.6863	0.6979	0.0079	1.8676	0.3302	1.0368	0.1104	0.2386	3.1509	0.4066	4.1495	0.7577
	Medium	2.2982	2.3581	1.5067	0.1891	0.6094	0.6193	0.0311	0.4412	0.4428	0.2093	0.1967	0.1695	1.8137	0.4042	2.9990	0.9798
	Low	3.7732	1.0974	2.7222	0.2640	2.5269	1.1513	0.1959	0.5476	0.9173	0.9754	0.6918	0.2902	2.2577	0.3751	5.2182	3.6359
(2) Other countries' share replaced by China, % of U.S. total import	High	0.3282	0.7291	0.2814	0.1776	0.0901	0.1793	0.0185	0.5650	0.0968	0.1340	0.0734	0.0856	0.7096	0.0685	1.1980	0.2756
	Medium	0.2430	0.4414	0.1897	0.0353	0.1157	0.2276	0.0627	0.1331	0.1388	0.0483	0.1214	0.0570	0.6418	0.0947	1.0430	0.5326
	Low	0.5442	0.3119	0.4409	0.0997	0.7023	0.4593	0.1945	0.1869	0.4415	0.3797	0.4930	0.1067	0.9197	0.1161	1.2405	2.1688
(3) Net replacement of other countries' export by China, % of U.S. total import	High	3.3540	4.3525	2.7915	1.3024	0.5967	0.5195	−0.0106	1.3095	0.2337	0.9039	0.0371	0.1532	2.4577	0.3383	2.9848	0.4833
	Medium	2.0599	1.9247	1.3194	0.1539	0.4942	0.3926	−0.0316	0.3085	0.3044	0.1611	0.0754	0.1125	1.1790	0.3099	1.9754	0.4495
	Low	3.2456	0.7879	2.2908	0.1645	1.8370	0.6951	0.0014	0.3613	0.4779	0.5978	0.1998	0.1837	1.3500	0.2592	4.0247	1.4989
(4) Relative replacement ratio	High	0.0894	0.1443	0.0918	0.1202	0.1312	0.2568	2.3417	0.3025	0.2930	0.1293	0.6644	0.3586	0.2252	0.1684	0.2887	0.3638
	Medium	0.1057	0.1872	0.1259	0.1866	0.1899	0.3674	2.0158	0.3017	0.3135	0.2307	0.6173	0.3363	0.3538	0.2342	0.3478	0.5436
	Low	0.1442	0.2842	0.1620	0.3775	0.2779	0.3989	0.9931	0.3414	0.4813	0.3893	0.7126	0.3678	0.4074	0.3096	0.2377	0.5965

Source: *U.S. Imports of Merchandise.*

the lower human capital–intensive products in comparison with almost all other countries. Many highly-valued geese are now flying directly from developed countries to China without stopping in middle-income countries, but China is still more attractive to the low-valued geese. China is absorbing almost every kind of opportunity.

The robust competitiveness of China would probably exert a strong impact on other countries. Table 10 shows the net replacement by China as a proportion of the export of each country to the United States in each commodity group. The proportions are rather high for most of the East Asian countries. Hong Kong's highly human capital–intensive exports to the United States replaced by China in the past 17 years reached 112.53 percent of Hong Kong's export to the United States in this commodity group. The ratios for medium and low human capital–intensive products are 90.13 percent and 76.40 percent, respectively.

Hong Kong's situation must be worse if all the Chinese products exported to the United States in the name of Hong Kong are deducted from the export of Hong Kong. In the case of Taiwan, the three net replacement ratios are 63.92 percent, 63.93 percent, and 97.31 percent. The situation seems a little bit better than the case of Hong Kong. However, these lower ratios in the case of Taiwan are due to the continuous growth of other exports from Taiwan so that the export values or denominators for the indicators of Taiwan are much higher than Hong Kong. The net replacement ratios for the highly and low human capital–intensive exports of Korea are close to those of Taiwan, but the ratio for Korea's medium human capital–intensive products is only 25.98 percent, which is much lower than the 63.93 percent for Taiwan. This is probably because Korea is more competitive than Taiwan in these middle level products. Another possible reason is that Taiwan moved more industries in this product group to China.

The net replacement ratios for Japan are much lower than Taiwan, Hong Kong, and Korea. However, the replacement by China is more concentrated in highly human capital–intensive products. One-third of Japanese exports to the United States in this product group have been replaced by China. In comparison, using the same ratio in Singapore and other developed countries, Japan has lost much more high-level products to China. Japan's investment in China is probably an important reason for this situation. The cumulated net replacement ratio of Singapore is much lower than Taiwan, but Singapore's cumulated net replacement ratio for medium human capital–intensive exports is higher than that of Korea.

China also replaced significant parts of the highly human capital–intensive export from developing countries: 66.41 percent for the Philippines, 62.84 percent for Indo-

Table 10. Cumulative net replacement of other countries' exports by China (CW) (% of 2006 U.S. imports of the respective commodity group from the replaced countries)

	Replacing country															
Human capital intensity	Taiwan	Japan	Korea	Singapore	Hong Kong	Thailand	Vietnam	Malaysia	Indonesia	Philippines	India	Eastern Europe	Mexico	Brazil	Other developed countries	Other developing countries
High	63.9244	33.5164	60.1977	26.0854	112.5364	22.6210	−14.7992	15.3971	62.8498	66.4100	4.2159	15.3517	28.2600	23.7590	6.3152	6.4889
Medium	63.9384	12.6889	25.9866	42.6533	90.1393	23.0444	−8.2971	36.4827	36.6900	36.2291	4.8356	13.4881	6.2246	11.7883	3.5448	1.3337
Low	97.3140	15.8080	98.6846	13.0663	76.4459	33.0246	0.9550	24.9490	14.1497	40.0713	6.9147	24.9854	11.4803	12.8427	10.6980	8.7809

Source: *U.S. Imports of Merchandise.*

nesia, 22.62 percent for Thailand, and 15.39 percent for Malaysia. Only Vietnam can replace China's export of highly human capital–intensive products. Because Vietnam is a latecomer in East Asian development, the capability of Vietnam to replace China's highly human capital–intensive products is probably coming from some foreign investors. Direct foreign investment is now guiding geese to fly in almost any direction.

The cumulated net replacement ratios as a proportion of China's exports in Table 11 indicate the importance of replacement to China's highly human capital–intensive export. Taiwan, Japan, Korea, and other developed countries all contributed more than 10 percent of China's export of highly human capital–intensive products to the United States.

In addition to the significant amount of highly human capital–intensive products replaced by China, there is also a likelihood that China would replace more in the future. Table 12 shows the trend of other countries' export replaced by China in the United States. The net replacement of Taiwan's highly human capital–intensive exports by China was only 0.81 percent of Taiwan's exports to the United States in this category in 1990. The ratio was below one or slightly above one before 1997. The ratio increased to 1.43 percent and 4.91 percent in 1998 and 1999. Then the ratio exceeded 10 percent in 2003 and reached 18.21 percent in 2004.

The net replacement ratio of Japan's highly human capital–intensive exports replaced by China in the U.S. market were negative before 1993. It was around 1 percent before 2000 and around 4 percent from 2002 to 2006. The same ratio for Korea was less than 1 percent on the average before 1999. It jumped to 5.45 percent in 2002 and reached 23.21 percent and 9.31 percent in 2005 and 2006. Similar trends can be seen in almost all other countries.

China is a large country with diversified resources and high technology. Therefore, it must try to produce highly valued products when its labor-intensive exports can no longer grow as fast as before. Consequently, China will probably replace more and more high-end products from advanced countries.

10. Conclusions

The data analysis in this paper revealed the huge impact of China's export growth on other countries, especially Taiwan. It also indicated that the replacement of other countries' exports by China was through upgrading of products. Advanced countries would soon face strong competition from China.

Table 11. Cumulative net replacement of other countries' exports by China (CW) (% of 2006 U.S. imports of the respective commodity group from China)

	Replacing country															
Human capital intensity	Taiwan	Japan	Korea	Singapore	Hong Kong	Thailand	Vietnam	Malaysia	Indonesia	Philippines	India	Eastern Europe	Mexico	Brazil	Other developed countries	Other developing countries
High	11.7149	13.5819	10.5239	3.9731	1.5289	1.8770	−0.0524	4.7718	0.7413	3.1055	0.1071	0.5786	9.1616	1.2926	10.5210	1.7371
Medium	7.8143	9.5887	5.1458	0.6628	1.8671	1.8250	−0.2050	1.5419	1.4209	0.6828	0.4748	0.5802	6.5019	1.5251	10.8837	2.4495
Low	7.9677	2.2580	5.0003	0.4008	4.8507	2.2601	0.0760	1.1164	1.6292	1.8935	0.6965	0.6235	5.0507	0.8134	13.0958	6.4051

Source: *U.S. Imports of Merchandise.*

Table 12. Net replacement of other countries' exports by China (CW) (% of U.S. imports of the respective commodity group from the replaced countries)

		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Taiwan	High	1.0304	0.7673	0.7345	0.7165	1.0483	1.2116	0.3372	0.7954	1.4462	4.9101	1.2947	1.4305	7.6818	16.7644	17.7189	9.9413	4.0915
	Medium	7.1391	5.6682	7.2323	7.9294	4.8452	4.3410	3.1903	3.8905	2.9084	3.7418	3.9102	5.0583	4.9088	5.0617	7.1881	6.0355	5.7250
	Low	3.0211	1.3511	4.3275	5.6414	4.2957	5.2807	4.0063	5.0722	2.9323	4.4123	3.6387	6.8181	6.5520	6.4548	5.5062	13.0877	4.1323
Japan	High	0.3619	0.4764	0.5997	0.6571	0.9953	1.7784	0.8546	0.3017	1.4901	1.4746	1.5751	2.9808	3.8173	4.7841	3.7338	4.4760	2.9424
	Medium	−0.0661	0.1518	0.3165	0.3359	0.8733	0.6319	0.6466	0.3655	0.5510	0.3703	1.1631	1.1858	2.1135	2.4301	1.7682	1.1716	1.7378
	Low	0.7327	0.4013	0.9831	−0.1874	0.9948	1.3765	1.1247	0.1411	0.6187	0.4640	0.7135	1.3469	2.0351	2.0076	2.0703	2.8822	1.8274
Korea	High	1.0040	1.8749	0.8862	0.6733	0.4058	0.7796	0.4637	1.1070	0.9204	0.0883	1.7979	1.4856	5.7618	6.2910	6.5803	22.9030	8.6574
	Medium	2.9107	6.1422	8.8097	8.0153	4.5942	2.7897	4.5152	2.3328	2.3602	0.8126	1.3463	1.5284	1.7828	2.8960	3.3640	4.1188	2.5515
	Low	3.9666	4.9096	7.4576	6.6888	7.1705	4.1847	5.8587	3.3897	−0.8811	−0.4173	1.3896	3.0159	3.1108	5.1930	2.7169	20.1751	5.6671
Singapore	High	0.4972	1.3045	0.7667	0.7221	0.4352	0.7445	0.2624	1.2739	1.7411	0.8665	2.1929	1.3967	2.7810	1.9319	3.8589	4.9592	2.4282
	Medium	0.6590	1.9426	3.5004	2.2801	1.3604	2.9136	4.2278	2.1984	4.6674	2.2400	2.6725	3.6708	3.7379	5.3016	4.1246	1.9183	8.2319
	Low	0.6961	0.4068	2.1840	1.7260	0.4915	1.4012	0.7625	1.4259	2.0388	−0.1273	−0.4956	2.9817	−0.0246	1.1805	1.7685	4.3709	−0.3115
Hong Kong	High	2.6851	4.1022	3.2649	3.1480	2.7804	1.5999	1.4082	1.8207	3.4070	3.9820	1.9648	2.7855	4.0319	6.8081	8.5047	13.0430	12.3609
	Medium	4.9570	5.6733	6.8997	6.2484	6.0821	4.9157	4.8684	2.8946	2.0568	5.1270	5.4331	8.3647	4.8481	5.6461	7.8823	9.0687	5.3532
	Low	3.3493	1.5641	3.9111	3.8292	0.0100	0.3595	3.4151	3.8273	−1.6109	1.6892	−0.2174	1.4235	8.0366	2.0661	3.0482	20.8087	7.1461
Thailand	High	0.0458	−0.8636	−0.1744	0.2318	0.9573	1.6978	0.3698	1.7340	1.2253	1.9745	0.7303	2.1295	1.8322	9.1121	3.7939	2.3753	5.8975
	Medium	0.7274	0.6463	1.8864	0.9282	0.4629	1.7835	3.6573	2.4031	3.6573	1.7504	1.7380	1.6320	4.5620	3.2033	1.4783	4.2135	2.3991
	Low	0.2653	1.5749	−0.3705	2.0902	0.4958	0.0539	2.0247	2.5902	−0.9028	0.6341	0.5586	1.3764	6.3145	6.4124	2.4970	10.2077	4.4301
Vietnam	High	0.0000	0.0000	0.0000	0.0000	0.0000	0.5412	−0.1483	−0.4944	1.6191	0.1216	35.9974	16.4698	−1.1216	0.1207	28.2983	−13.1408	−14.4430
	Medium	0.0000	0.0000	0.0000	0.0000	0.0000	−2.8646	−1.6493	−1.1489	−5.9943	1.2666	5.2993	−0.0494	−4.2874	−1.4250	−2.2702	−5.9833	−1.0646
	Low	0.0000	0.0000	0.0000	0.0000	0.0000	−0.4346	−0.2443	−0.1204	−0.6798	0.5397	−0.8903	0.0396	−5.6245	−2.8460	−1.4540	5.9040	0.3889
Malaysia	High	−0.2684	0.2324	−0.6200	0.3288	0.6560	0.4354	0.2871	1.9247	1.9584	0.4841	0.7556	0.9199	3.2196	2.4317	4.9224	0.7428	3.9196
	Medium	−0.9388	1.4938	0.9728	1.1837	1.1527	1.0955	1.7919	1.9882	2.2512	4.1788	1.4017	3.1417	5.7801	6.9773	5.0879	4.6054	4.3051
	Low	0.9275	−0.6532	0.8239	0.7332	0.7365	0.4894	1.6628	2.1562	1.3475	2.5023	1.7402	2.2845	2.8958	4.5118	1.5806	6.1217	2.3679

Table 12. (continued)

		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Indonesia	High	0.2506	−0.2244	1.2024	−0.8539	1.2656	3.2289	4.2588	7.0865	2.0654	2.7684	4.2527	1.9632	11.4222	7.8616	5.1934	−1.3410	8.0017
	Medium	2.9920	1.0705	0.2027	0.2776	1.9221	1.5200	2.0669	3.1012	7.2658	1.6845	4.7483	1.5801	3.7937	5.1957	4.1184	2.9587	4.6774
	Low	0.7725	0.6521	−0.4352	−0.3883	0.4557	0.1140	0.3276	0.5800	−0.5987	1.2230	0.0654	0.4183	4.5891	5.3249	3.0263	3.6445	1.2381
Philippines	High	0.2863	1.0357	0.1670	0.2483	1.5706	0.0730	0.0367	−0.0903	3.7865	2.4496	1.5928	1.9020	4.1128	14.7896	19.4196	2.5461	2.4278
	Medium	2.6431	3.6284	2.2956	1.0343	1.7601	2.6611	3.0076	1.6028	3.1548	4.0396	3.6359	2.8240	3.9041	3.1097	2.6949	3.4884	3.4946
	Low	0.4143	1.6194	1.6407	1.2746	0.0737	−1.0396	2.3856	2.7708	−0.7394	1.1839	0.4777	1.2167	8.5620	5.5701	4.3504	12.3148	3.3206
India	High	1.8832	−0.4767	1.3826	1.3590	1.2714	0.2206	1.3519	0.1021	1.7241	3.5107	−0.1069	0.7672	1.3256	0.3755	0.0064	0.3202	0.8457
	Medium	0.7032	0.3374	0.3672	−0.9021	0.1621	0.1105	−0.2149	0.2052	−0.1296	−0.0674	0.3943	1.1735	0.6207	1.3134	1.0295	1.3296	1.1832
	Low	0.5396	0.8961	0.2528	0.0117	−0.6094	1.1195	0.4742	0.1379	−1.4106	0.1024	−0.7634	0.8468	0.4941	1.8494	0.7981	3.5828	1.4057
Eastern Europe	High	0.9346	0.0669	0.1554	0.7253	−0.4782	6.2222	0.3567	−0.0266	0.4076	−1.3601	0.2126	3.7304	1.7959	2.3607	1.3372	3.0770	4.4972
	Medium	0.9642	2.8468	3.7099	1.0677	0.1802	1.8886	0.9375	0.7712	0.9765	0.0101	1.0856	1.6355	5.5891	1.4644	2.1373	2.4759	1.8896
	Low	0.8958	1.8940	−0.2399	−0.5554	0.9917	0.5001	0.2406	2.3377	1.2919	2.5623	1.4173	5.8888	3.8508	1.8188	2.5578	6.0918	6.0576
Mexico	High	0.4668	0.3593	0.5039	0.4641	0.0181	−0.3032	−0.2581	0.4367	−0.5466	0.5538	0.9438	0.1645	6.2962	8.4716	6.6925	4.5912	3.1098
	Medium	0.5018	0.2971	0.8135	0.1796	0.3911	0.1286	0.0023	0.1133	−0.0486	0.4896	1.0265	0.6960	1.4188	1.4299	1.0314	1.3886	0.9726
	Low	0.4289	−0.0700	0.0715	0.0216	−0.1054	−0.0632	−0.6629	−0.5110	−0.0593	0.5596	0.6194	1.4404	1.9221	1.8873	1.0681	3.4180	1.9880
Brazil	High	0.1922	0.0562	0.5939	1.3663	1.0315	1.1338	−0.0449	0.0653	0.3632	0.0873	0.0416	−0.0761	1.2119	2.2704	15.4051	1.8394	3.7193
	Medium	1.1528	0.9321	0.5077	0.2853	0.4597	2.5251	0.4882	1.3648	2.4828	0.1473	0.2917	1.4013	1.8867	1.1867	1.2979	2.3902	2.5635
	Low	0.8182	0.5459	0.9422	1.0524	0.0636	0.8894	1.3670	1.1473	1.7598	0.0309	0.1099	0.8132	−0.2751	1.4523	1.0211	3.1920	4.3672
Other developed countries	High	0.0570	0.1413	0.2445	0.3030	0.1124	0.2579	0.2666	0.3268	0.1682	0.2684	0.4494	0.2831	0.9694	0.9576	1.2815	1.1543	1.1392
	Medium	0.1128	0.2814	0.1382	0.0672	0.0696	0.0894	0.1234	0.2006	0.1518	0.1723	0.4080	0.3057	0.3806	0.3999	0.6312	0.6372	0.8080
	Low	0.1666	0.5293	0.9184	0.4385	0.0063	−0.0959	0.2994	0.4068	0.2512	0.4892	0.7752	0.6553	1.6289	1.1835	1.4477	2.2355	1.8814
Other developing countries	High	0.2166	0.0505	0.3093	0.3440	0.3981	0.8551	0.0631	0.2177	0.2809	0.3511	1.6694	0.9125	0.8821	0.4138	1.5236	1.0168	1.6833
	Medium	0.0438	0.0451	0.3096	0.0461	0.0536	0.0898	0.0420	0.2068	0.0631	0.1191	0.1822	0.0435	0.4316	0.2146	0.2647	0.2595	0.3494
	Low	0.0800	0.0491	−0.1696	−0.5926	−0.3315	−0.2784	0.2901	−0.1507	−0.3072	0.1233	−0.6275	−0.0955	1.2595	1.3828	0.7040	5.0382	2.0903

Source: *U.S. Imports of Merchandise.*

Because multinational companies and international investments are the key decision-makers in the determination of production sites in the world, the achievement of China in replacing other countries' exports is not equivalent to the power or capability of China. In many cases, China might just be offering cheap resources for use by multinational companies.

In addition, due to the division of labor in the global economy, export products of a country may use many inputs from other countries. Therefore, when a country replaced a one-dollar export of another country, the value-added it replaced might be only several cents. Therefore, we should not use the replacement data here directly to overstate the threat from China.

However, we should not use the contributions of multinational companies and the international fragmentation of production to undermine the threat from China, either. The experiences of Taiwan and Korea show that countries may try to produce the imported inputs of their exports soon after they obtained competitiveness in the exports. As a large country with huge domestic input demand and a less-free economy, China will certainly use its market size and political power to increase the domestic content of its exports. Many upstream industries of Taiwan were forced to move their production to China soon after their downstream customers moved to China. According to government surveys of Taiwan, Taiwanese companies in China imported 52.47 percent and 56.26 percent of their materials and parts respectively from Taiwan in 1995. These ratios dropped to 34.01 percent and 39.39 percent respectively in 2006.

Some of the patterns of replacement in the exports to the U.S. market analyzed here are similar to the flying geese hypothesis. Some of the patterns fit the Heckscher-Ohlin hypothesis. However, some of the patterns do not follow either hypothesis. In particular, China has been replacing almost every kind of export from many countries. It is possible to use the replacement data here in econometric models to analyze the reasons behind the replacement. This would be the task of future papers.

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