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Product Cycle and Industrial Hollowing-out: The Case of the Electrical and Electronics Sector of Taiwan

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Abstract

This paper traces the route of Taiwan's industrial restructuring from 1980 to 1999, during which period Taiwan switched from a capital inflowing country to a capital-outflowing one. By establishing an empirical model based on the idea of Vernon's product cycle theory, we construct a quantitative measurement of product turnover and product upgrading. Tests are applied to the electrical and electronic industry to see whether its product turnover and product upgrading has significantly slowed down in the 1990s. If so, we may conclude that the industrial hollowing-out may have appeared. The empirical results show that product turnover and product upgrading do not significantly deteriorate in 1990s though the performances of the sub-industries within the EE industry are largely differentiated in 1990s compared with that in 1980s.

Keywords: Product cycle, Industrial restructuring, Product turnover, Product upgrading
JEL Classification: O14; L6

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Product Cycle and Industrial Hollowing-out

—The Case of Electrical and Electronics Industry of Taiwan

1. Introduction

Taiwan had been a capital-importing country receiving FDI from advanced countries. The inflow of FDI had complemented its shortage of capital and helped to promote the progress in technology. Its production pattern had maintained a close tie with the investing countries. It imported capital and intermediate goods from the investing countries, assembled and finished the production processes, and exported the final goods back to the investing countries. Such pattern had generated prosperity and trade surplus for Taiwan economy in 1970s and early 80s. During this period of time, the economic integration of Taiwan to global economy is constrained with import barriers and highly regulated foreign exchange and outward investment.

In 1985, the G5 ministers of finance met in Japan for solving trade disputes, especially that from the trade surplus of Japan against the US. In consequence, the Plaza Accord was signed for the joint efforts in reducing trade imbalances. Being caught in the crossfire, Taiwan was pressured to take actions to cut its trade surplus. Several measures were taken, including the removal of import barriers and deregulation of foreign exchange market. As the result, Taiwan became more exposed to the global economy. Facing immense competition from

foreign firms, Taiwanese firms had to take actions to adapt to the new situation. Its industrial restructuring has been undergoing ever since. On the other hand, further openness of trade, foreign exchange and outward investment provides more alternatives for the strategies of business development. Outward investment started to grow rapidly. In 1987, Taiwan's capital outflow outpaced its inflow and turned it into a capital-exporting country.

With the rapid increase of outward investment, the industrial structure adjustment also took place. The growth of Taiwan's traditional labor-intensive industries slowed down, and its share in the manufacturing sector reduced. At the same time, the capital- and tech-intensive IT industries quickly expanded. The adjustment deteriorated employment, causing unemployment rate to rise. The debates and concern for industrial hollowing-out has never ceased.

Whether or not the outward investment has caused industrial hollowing-out in Taiwan? The answers vary due to different empirical methodologies and test criteria. Some believe that outward investment did not cause hollowing-out but has relieved Taiwan economy from the disadvantage of scarcity in labor and land, and has helped industrial upgrading. (Chou and Wu 1990, Yu 1995) But some assert that outward investment has caused the unemployment rate to rise and domestic investment to slowdown. The hollowing-out effect has appeared. (Hsieh, 1999a)

This paper answers this question from the viewpoint of product cycle hypothesis

developed by Vernon (1966). The product cycle hypothesis explains the stages of product development and the change of production sites. It asserts that the innovation of a new product usually takes place in a high-tech and high-income states using skilled labor-intensive technology. By the exports to other high-income countries, the technology spills overseas and the production site of this new product starts to moves to these overseas markets through the foreign direct investment from the country of origin. When the technology becomes prevalent and product standardized, the demand for unskilled labor in the production process rises and the production site moves again to the developing countries to take advantage of their abundant, low-waged labor. Then, the country innovating the product gives up the production, turns from exporter to importer of the product, and refills its production line with the newly developed products. Thus, the production site of a particular product changes when it enters different stages of its life cycle. On the other hand, for a particular country, the product contents of its manufacturing sector should continue to change, by dropping out of the production of some old products and catching up to the markets of the higher-end or higher-tech new products. If an industry fails to enter new product markets while losing competitiveness of the old, lower-tech products, it may indicate that the hollowing-out has occurred.

This paper applies the view of identifying industrial hollowing-out above by constructing the product turnover index derived from a CES import demand function

modified from Feenstra et al. (1999). Tests are conducted for Taiwan's electrical and electronics exports in 1980s and 1990s, while the former period is featured with rapid increase of foreign direct investment and the latter with the high growth of outward investment. The two sets of results are compared to see whether there is a significant structural change and whether the hollowing-out takes shape in the later period.

The organization of the paper is as the following. Section 2 reviews the discussions of hollowing-out scenarios in the literature. Section 3 introduces the empirical model and data. In Section 4 the empirical results are presented and analyzed. Section 5 is conclusion.

2. Literature review

The discussion of industrial hollowing-out in the literature mainly focuses on the effect of outward investment on trade and unemployment. Singh (1977) asserts that an efficient manufacturing sector should be able to not only meet the needs of domestic consumption but also export to earn enough foreign exchange for imports. If there is constant trade deficit, it indicates that the manufacturing sector is not efficient, and it will result in the decline of output and employment. Singh named the scenario as the de-industrialization of an open economy. Four indicators are used by Singh to test whether the de-industrialization had appeared in UK. They are: 1) manufacturing output, 2) the share of manufacturing employment to total employment, 3) the share of manufacturing value-added to GDP, and 4)

the net exports of the manufacturing sector. He found that since 1973, the share of manufacturing employment and the share of manufacturing value-added had continued to decline; and the manufacturing sector had a constant trade deficit. He then concluded that de-industrialization had appeared. Singh attributed it as the consequence of outward investment.

Lipsey (1994) finds that the main purpose of US outward investment is to promote their market share in the foreign markets. His regression results show that outward investment firms did not decrease their domestic employment but increased the recruitment for R&D and management personnel. In the case study on US's IT industries, Kraemer et al. (1998) finds that the industries with decreasing returns to scale had moved to Asian countries. At the same time, the industries with increasing returns to scale, in particular, the computer software industries have tremendously expanded and increased employment. The outward investment did not cause the hollowing-out or decrease job opportunities.

Some economists test the hypothesis of product cycle in their empirical works. Hirsch (1972) traces the development of US electrical industry by comparing it with the features of each stage of product cycle. He found that the industry has started its outward investment in 1960s, mainly to Japan and Hong Kong, and imported the product back to the US, which is consistent with the hypothesis. Thomsen (1993) confirms that while investing outwardly, Japan's domestic industries continue to innovate new higher-value-added products, which is

also consistent with the hypothesis of product cycle.

3. Empirical model and data

Most of the empirical studies of the product cycle hypothesis are either tracing the movement of production sites among countries or examining the correlation between outward investment and domestic production. This paper tests the hypothesis from a different perspective. We argue that if an industry has a positive product turnover that it enters into new product markets more vigorously than it drops out of the production of the old products, it implies that the resources released from the production of old products are efficiently utilized and its technology continues in progress. We may reject the assertion of hollowing-out. In the following section, a product turnover index is derived from the CES import demand function modified from Feenstra et al. (1999) and the index measurement derived from Feenstra (1994). The index is computed for the electrical and electronics sector of Taiwan to see whether hollowing-effect has appeared.

3.1 Empirical model

A Taiwan's manufacturing industry exports N differentiated products. $I_t = \{1_t ... N_t\}$ is the set of the varieties of the industry's export at year t; and $x_t = (x_{1t}, x_{2t}, ... x_{Nt})$ is the vector of the quantity of each export variety. The total *service* provided by the exports can be

expressed with a CES function:

$$f(x_t, I_t) = \left(\sum_{i \in I_t} a_i x_{it}^{(\sigma-1)/\sigma} \right)^{\sigma/(\sigma-1)}, \quad a_i > 0, \tag{1}$$

where $\sigma > 1$ is the elasticity of substitution among export varieties. If the exports are consumer goods, $f(\cdot)$ represents the consumers' utility the exports create in the importing country. If the exports are intermediate goods, $f(\cdot)$ is the production services received by the firms of the importing country.

One of the advantages of the equation is that it points out that utility (or production services) comes from not only product quantity (*x*) but also varieties (*I*). In the case of consumption goods, more varieties to choose can better satisfy the consumers with different preferences and needs. In the case of intermediate and capital goods, more differentiated varieties can better serve the producers with different sizes and production patterns.[1]

Let $X_t = \sum_{i \in I_t} x_{it}$ be the total amount of the exports of this particular industry at year t. Then the average service A_t provided by one unit of exports can be expressed as

$$A_t = f(x_t, I_t) / X_t. \tag{2}$$

Dual to (1), $c(p_t, I_t)$ is the unit cost function, representing the cost of one unit *service*:

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

[1] The theoretical trade model of imperfect competition is first derived in Krugman (1980) and further developed in the literature such as Helpman and Krugman (1985). All have discussed the consumers' benefits from product varieties. It is not until Feenstra et al. (1999) that the empirical model is established so that the effect of product variety can be quantitatively measured by empirical data.

$p_{it} > 0$ is the export price of product variety *i* at year *t*. Since the total services $f(x_t, I_t)$ cannot be observed, the average services per unit export, A_t, cannot be directly measured from trade data. But the total export expenditure is equal to unit costs multiplied by total services $E_t = c(p_t, I_t) f(x_t, I_t)$. Then the ratio of A_t in turns of that in the previous year *t-1* can be computed as

$$\frac{A_t}{A_{t-1}} = \left(\frac{E_t / X_t}{E_{t-1} / X_{t-1}} \right) \Big/ \left(\frac{c(p_t, I_t)}{c(p_{t-1}, I_{t-1})} \right). \tag{4}$$

The numerator at the right hand side is the ratio of the unit value of exports between year *t* and *t-1*, and the denominator is the ratio of unit costs per service at year *t* and *t-1*. While unit value can be directly obtained from export/import statistics, the unit costs cannot be observed. However, the ratio can be measured by exact price index.

Suppose that x_t and x_{t-1} are the cost-minimized quantity with price p_t and p_{t-1}, and the set of the common goods $I \equiv (I_t \cap I_{t-1})$ is not empty, then the unit cost ratio can be computed as:[2]

$$c(p_t, I_t) / c(p_{t-1}, I_{t-1}) = P(p_t, p_{t-1}, x_t, x_{t-1}, I)(\lambda_t / \lambda_{t-1})^{1/(\sigma-1)}, \tag{5}$$

The first term at the right hand side of equation (5) is:

$$P(p_t, p_{t-1}, x_t, x_{t-1}, I) \equiv \prod_{i \in I} (p_{it} / p_{it-1})^{w_i(I)} \tag{5a}$$

$P(.)$ is the price index of the common goods *I*. The weights $w_i(I)$ are the logarithmic means

[2] The assumption of equation (5) is that there is no change of the elasticity of substitution σ at year t and t-1. Feenstra (1994) improves the traditional import/export price index by taking into account the change of product content and derives the modified price index with product turnover effect. Feenstra et al. (1999) adopts this modified import price index measurement and develops the product variety index, which is further

of the expenditure shares at year t and t-1.[3] The λ_t in the second term is the ratio of the export value of the common goods $i \in I$ divided by the total export sales for $i \in I_t$.

$$\lambda_t \equiv \sum_{i \in I} p_{it} x_{it} \Big/ \sum_{i \in I_t} p_{it} x_{it} \,. \tag{5b}$$

In other words, λ_t equals 1 minus the ratio of the export value from the new products (not previously exported before year t) divided by the total export sales; while λ_{t-1} equals 1 minus the ratio of the export value from the product varieties that are exported at year t-1 but not any more in the later years. If the sale share of the new varieties at year t is greater than that of the old product varieties at year t-1, then $\lambda_t < \lambda_{t-1}$. By plugging equation (5) into (4), we can get:

$$\frac{A_t}{A_{t-1}} = \left[\frac{(E_t / X_t)/(E_{t-1} / X_{t-1})}{P(p_t, p_{t-1}, x_t, x_{t-1}, I)} \right] \left(\frac{\lambda_{t-1}}{\lambda_t} \right)^{1/(\sigma-1)}$$

$$= (\text{product upgrading index}) \times (\text{product turnover index})^{1/(\sigma\text{-}1)} \tag{4'}$$

The relative services per unit export at year t (in terms of that at year t-1) are then

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modified to adapt to our analysis of product turnover.

[3] The price index is constructed by Sato (1976) and Vartia (1976). It first computes the expenditure shares $s_{it}(I) \equiv p_{it} x_{it} \big/ \sum_{i \in I} p_{it} x_{it}$,及$s_{i\,t\text{-}1}(I) \equiv p_{it-1} x_{it-1} \big/ \sum_{i \in I} p_{it-1} x_{it-1}$, which is then used in the formula of the weights:

$$w_i(I) \equiv \left(\frac{s_{it}(I) - s_{it-1}(I)}{\ln s_{it}(I) - \ln s_{it-1}(I)} \right) \Big/ \sum_{i \in I} \left(\frac{s_{it}(I) - s_{it-1}(I)}{\ln s_{it}(I) - s_{it-1}(I)} \right).$$

See Feenstra et al. (1999, p.83) for detail.

decomposed into two indexes, which can be interpreted as two different strategies of export expansion. One is to promote export value by improving product quality or upgrading to the higher-end products. The other is to actively explore the market of the new products.

The first term at the right hand side of (4') is the ratio of unit-value divided by price index. With the division, we remove the price change effect from the unit value change, which is left is the effect of the change of product structure. If the ratio is significantly greater than 1, it implies that the sale share from high-valued products is larger at year t than that at year t-1, or product structure upgrading. It is therefore named as product upgrading index.

The second term of (4') represents the relative ratio of new and old product turnover. If the index is significantly greater than 1, it is implied that this particular industry is more aggressively entering new products markets while dropping out from the markets of the old products. It indicates the vigorous metabolism of the industry. If the index is significantly less than 1, it shows that it is relatively slow in exploring the market of the new product while withdrawing from the market of the old products. The scenario may indicate the weakening of its competitiveness in the world market. If it continues to take place, it will be a signal of industrial hollowing-out.

In the following section, these indexes are measured for each industry to analyze the trend of product structure upgrading and competitiveness change in 1980s and 1990s.

3.2 Data description

The indexes above are constructed by using the data of the US's imports of Taiwanese products. The United States is the largest host countries for Taiwan's exports in the last two decades. More than one-third of Taiwan's exports are sold to the U.S. during 1980-1999. It is also the largest single-country market in the world with relatively high degree of openness and competition, at least for manufacturing products in general. The performance in this market shall be able to reflect its product competitiveness in the world market.[4] Its path of product upgrading and product turnover in this market may help us to understand the change of its status among its competitors and its dynamic industrial development.

The disaggregate U.S. import statistics, edited and published by The Center of International Data at UC Davis, is used to construct the indexes for the imports from Taiwan. We take the most detailed item of the tariff schedule (7-digit Tariff Schedule of the United States Annotated, TSUSA, 1980-1988; and 10-digit Harmonized Tariff Schedule, HTS, 1989-1999) as a product *variety* and construct the two indexes for each 4-digit Standard Industrial Classification (SIC) industry. In other words, the 4-digit SIC category is taken as

[4] The test can be applied to Taiwan's total industrial output or exports. The characteristic of industrial development might be better revealed than the case of using the U.S. importing data. But there is no industrial output data available as disaggregate in products as the database we use in this study. For the export data, Taiwan's tariff schedule was revised and expanded several times in 1990s to adapt to the rapid development of the new products, especially IT products. Without the concordance, it is impossible to apply the model for product variety analysis.

an ‘industry’ of equation (1), within which all product varieties are differentiate but substitutable. These 4-digit SIC industries are further aggregated to a single electrical and electronics sector to investigate its general performance.

To cope with the change of the tariff schedule system[5], we break the sample period into two parts, 1980-1988 and 1989-1999. The first period is to represent the stage of rapid increase of FDI and capital inflow, and the second period rapid growth of outward investment and net capital outflow. The year 1989 is also indicated as a policy change at which year the ban of Taiwanese outward investment toward China is lifted.

3.3 Hypothesis tests

The product upgrading and product turnover indexes are computed for each 4-digit industry at two consecutive years (t and t-1) to determine whether year t outperforms the previous year in product upgrading or has a positive product turnover. With these index numbers computed, we generate a panel of data across all 4-digit industries within the electrical and electronics category throughout the years of the sample period. A one-side t test is used to compare the relative performance over the sample periods. We calculated the mean of the indexes (in log) for each industry to see if the log index is greater or less than zero at 10% level of significance.

[5] Before 1988, Tariff Schedule of United States Annotated (TSUSA) system was applied by the US custom. But staring from 1989, it has switched to the Harmonized Tariff system.

Let z_{nt} be the log of the product upgrading index ($\ln\left[\frac{(E_t / X_t)/(E_{t-1} / X_{t-1})}{P(p_t, p_{t-1}, x_t, x_{t-1}, I)}\right]$) or product turnover index ($\ln\left(\frac{\lambda_{t-1}}{\lambda_t}\right)$) of industry *n* at year *t*. And μ_n denotes the mean value of industry *n* over the sample period and $\bar{z}_n$ is the sample mean:

$$z_{nt} = \mu_n + \varepsilon_{nt} \quad , \quad \varepsilon_{nt} \sim N(0, \sigma_n^2). \tag{6}$$

t can be one of the years over 1980-1988 or 1990-1999.

Then we test the hypotheses:

$H_0 : \mu_n \le 0$ versus $H_1 : \mu_n > 0$ and also

$H_0' : \mu_n \ge 0$ versus $H_1' : \mu_n < 0$. (7)

If $\bar{z}_n / S > t_{0.9}(\tau - 1)$, H_0 is rejected. If $\bar{z}_n / S < -t_{0.9}(\tau - 1)$, H_0' is rejected. If $\bar{z}_n / S$ falls in-between, then neither is rejected. S is the standard deviation and τ is the number of the years in the sample period.

For the product upgrading index, if *H0* is rejected, it implies that the product structure of the industry is significantly upgraded or the industry has moved its production to the higher-valued products. We denote it with B (better). If the other null hypothesis *H0'* is rejected, then the product structure is significantly deteriorated. We denote it with W (worse). If neither is rejected, then there is no significant change. We denote it with U (uncertain). The same is for the product turnover index that if the null hypothesis *H0* is rejected, the industry has a positive product turnover. It will be denoted with B.

We then test the performance of the indexes in the 2-digit SIC industries using the joint hypotheses for all the 4-digit SIC μ_n within this broader category ($n \in N$):

$$H_0 : \mu_n \le 0 \quad \text{all} \quad n \in N \qquad H_1 : \mu_n > 0 \quad \text{some} \quad n \in N \text{, and}$$

$$H_0' : \mu_n \ge 0 \quad \text{all} \quad n \in N \qquad H_0' : \mu_n < 0 \quad \text{some} \quad n \in N \tag{8}$$

Referring to Feenstra et al. (1999), a Likelihood ratio (LR) ratio is constructed to test the hypothesis of (8). The test is applied in two different ways. First, we set the LR ratio of H_0 as:

$$L = \prod_{n \in N} \left[\frac{\sum_t \left(z_{nt} - \bar{z}_n \right)^2}{\min_{\mu_n \le 0} \sum_t \left(z_{nt} - \mu_n \right)^2} \right]^{\tau/2} , \tag{9}$$

τ is the number of the years for the sample period; $\bar{z}_n$ is the means of z_{nt}, $t \in T$. For large τ, the value of -2logL is asymptotically distributed as $x^2(q)$, with q the number of the 4-digit SIC industries *n* within the broader 2-digit SIC category *N*. If H_0 is rejected at the 10% level and H_0' is not rejected at the 10% level, we can conclude that the 2-digit industry has shown significant improvement in either product upgrading or product turnover, which we denote in Table 1 with 'B'. On the other hand, if H_0 is not rejected at the 10% level, and H_0' is rejected at the 10% level, then it is concluded that the industry is deteriorated in either product upgrading or product turnover, which will be denoted with 'W'. In the cases that both H_0 and H_0' cannot be rejected or both are rejected, we denoted it with U. In the LR test of (9), $\bar{z}_n$ is computed by averaging the index numbers throughout

the years of t, $t \in T$. The SSR in the numerator and adjusted SSR in the denominator are then computed for L. Therefore this test is based on the performance of each *industry* during the period T.

On the other hand, we apply the same LR test based on the performance of each *year* across all the 4-digit industries. For each year t, we compute $\overline{z_t}$ as the mean of z_{nt}, $n \in N$. If $\overline{z_t}$ is significantly greater than 0 in more years, the smaller the L is, there is a greater chance for H_0 to be rejected. The LR ratio for H_0 then can be presented as:

$$L = \prod_{t \in T} \left[\frac{\sum_n \left(z_{nt} - \bar{z}_t \right)^2}{\min_{\mu_t \le 0} \sum_n \left(z_{nt} - \mu_t \right)^2} \right]^{\tau/2} , \qquad (9')$$

The advantage of this test is as the following. At each year, there may be some 4-digit industries showing deterioration ($z_{nt} < 0$) and some improvement ($z_{nt} > 0$). It may indicate that each one of them is at different stage of product cycle, some are arising and prospering (at product upgrading or product turnover) and some are declining. If, at year t, the industries with positive performance dominate, we conclude that at that year the sector has an improvement. If in most of the years, the industries with positive performance dominate, even though the ones with positive performance vary every year, there is a greater chance for H_0 to be rejected. In this way, we can catch the trend of development which we may miss in the test of (9). During the sample period, each industry has its own pattern of going through different stages of product cycle or even fluctuating around the cycle. The test based on the

average performance of an industry throughout the years may generate a result of U when fluctuation occurs, while the test based on the average performance across industries in a particular year may help us to capture the momentum in another perspective.

4. Empirical results

The results of the above empirical tests provide useful information for us to identify the position of each industry at the product cycle. With the help of the two product indexes, we may recognize the development pattern of the industries. In this section, the results of *t* tests are first presented, followed by the *LR* tests.

The electrical and electronics sector contributed one-third of Taiwan's outward investment of the manufacturing sector. Its exports occupied a quarter of Taiwan's commodity exports. The product items can be covered by SIC 35 and 36 categories. We divide the 4-digit SIC industries in this range into intermediate goods and final goods according to the product classification conducted by Chen et al. (1991).

Table 1A presents the t test results for the industries producing intermediate goods and Table 1B for the ones producing final goods. A summary is provided in Table 1C. There are total 28 industries in the first period, including 7 intermediate goods industries and 21 final goods industries. The number of industries rises to 64 in the second period, including 12 intermediate goods industries and 52 final goods industries. It reflects the development of diversification of the sector. The 5 largest industries with highest exporting value are household audio and video equipment (SIC3651), semiconductors and related devices (3674), other household appliances (3639), other office machine (3579) and machine tools (3541) for the first period. The 5 largest industries in the second period are other computer peripheral equipment (3577), semiconductors and related devices (3674), electronic computers (3571),

household audio and video equipment (3651) and other electronic components (3679). Each of the five is marked by its ranking in Table 1A and 1B. These two sequences reflect the product evolution of Taiwan in the sector from household electronics in the early years to computer and IT products in the latter. The t test results are analyzed for each of the two sample periods below.

Table 1A　Results of t test for electronic and electric equipment sector
（intermediate goods）

SIC	Product upgrading		Product turnover	
	1980-1988	1989-1999	1980-1988	1989-1999
3519		B		W
3544	U	B	B	W
3562	B	W	W	W
3568	U	W	U	B
3599		U		W
3624		B		U
3625		B		U
3641	B	B	U	B
3644	U	W	B	B
3671	U	U	B	B
3672		U		W
3674	U（2）	B（2）	U（2）	B（2）
	B-2	B-6	B-3	B-5
	U-5	U-3	U-3	U-2
	W-0	W-3	W-1	W-5
# of industries	7	12	7	12

Note: B represents significant better-off, W significant worse-off, U no significant change.
The number in the parenthesis represents the ranking of the exporting value in the electronic and electrical equipment sector.

Table 1B Results of t test for electronic and electric equipment sector (final goods)

SIC	Product upgrading		Product turnover	
	1980-1988	1989-1999	1980-1988	1989-1999
3523		B		B
3531	U	U	U	W
3532		U		W
3537		B		B
3541	U (5)	B	U (5)	U
3542	U	B	U	W
3546		U		B
3548		B		B
3552	B	U	U	W
3554		W		W
3555		U		W
3556		U		W
3559	U	W	U	B
3561	B	W	B	B
3563		U		B
3565		W		W
3566	U	U	U	W
3569	U	U	B	W
3571		B (3)		B (3)
3572		U		B
3577		U (1)		U (1)
3578		B		W
3579	B (4)	U	W (4)	B
3585		U		U
3586		U		U
3589		B		U
3594		U		U
3596		U		U
3612	W	U	B	B
3613	B	B	W	B
3621	B	B	U	W
3629		B		B
3631	B	U	U	B
3634		B		W
3635		U		U
3639	U (3)	B	B (3)	W
3643		B		B
3648	B	W	U	B
3651	U (1)	W (4)	W (1)	B (4)
3652	B	B	U	W
3661		U		B
3663		U		B

Table 1B (cont.) Results of t test for electronic and electric equipment industry（final goods）

SIC	Product upgrading		Product turnover	
	1980-1988	1989-1999	1980-1988	1989-1999
3669		U		W
3675	W	W	W	W
3676		U		W
3677		W		B
3678	B	B	B	B
3679	U	U（5）	U	B（5）
3691		W		W
3694	B	U	U	U
3695		U		W
3699		B		W
	B-10 U-9 W-2	B-17 U-26 W-9	B-5 U-12 W-4	B-22 U-9 W-21
# of industries	21	52	21	52

Table 1C Results of t test for the electronic and electric equipment（overall）

industry	Product upgrading						Product turnover					
	1980-1988			1989-1999			1980-1988			1989-1999		
	W	U	B	W	U	B	W	U	B	W	U	B
Intermediate goods	0	5	2	3	3	6	1	3	3	5	2	5
Final goods	2	9	10	9	26	17	4	12	5	21	9	22
subtotal	2 (7%)	14 (50%)	12 (43%)	12 (19%)	29 (45%)	23 (36%)	5 (18%)	15 (54%)	8 (28%)	26 (41%)	11 (17%)	27 (42%)
# of industries	28			64			28			64		

4.1 The *t* test results for 1980s

In 1980s, the foreign direct investment to Taiwan reached US$10.5 billion. It is 5 folds of that of the previous decade and 11% of domestic investment. A quarter of it went to the electrical and electronics sector. The inflow of foreign capital stimulated the development of new technology and the production of new products, hence the improvement of productivity of the sector (Schive 1990).

In this period, as shown in Table 1C, there are 12 industries or 43% out of the total 28 industries revealed significant product upgrading, and 8 industries or 28% with significant positive product turnover. Among the 12 industries showing significant product upgrading, 10 industries produce final goods and 2 produce intermediate goods. As for the 8 industries showing significant positive product turnover, 5 of them produces final goods and 3 intermediate goods. There are two industries showing the merit on both product upgrading and product turnover. Hence, there are total 18 industries or 64% of the total industries having at least one advantage in product structure improvement or product turnover. The comparison between final goods and intermediate goods industries shows that the expansion of final goods exports comes from the improvement in product upgrading more than product turnover, while there is no such significant trend for intermediate good exports.

Among the three largest exporting industries in the sector, household audio and video equipment (3651) had no significant change in product upgrading and was worsened in product turnover. Semiconductors and related devices (3674) ranked the second. It was in its early development stage and had no significant change in either aspect. Other household appliances (3639) ranked the third and presented significant product turnover though not much change in product upgrading.

4.2 The *t* test results for 1990s

Taiwan's outward investment has grown rapidly since late 1980s and outpaced the

inward foreign investment in 1987. About a quarter of the outward investment is from the electrical and electronics firms, occupying the largest share among all manufacturing firms. The destinations are mainly China and Southeast Asian countries. The main purpose is to lower labor costs (Chen and Ku, 2000). With this motivation, the outward investment may imply the emigration of some labor-intensive industries, which had lost comparative advantages in the local markets. Whether the resources released from the emigration have been effectively utilized by the newly developed industries is the major concern of this study.

From Table 1C, we find that there are 23 or 36% industries showing significant improvement in product upgrading and 27 or 42% industries showing vigorous product turnover. Comparing with the previous period, the percentage of the industries showing advantages in product upgrading is lower but that in product turnover increases considerably. It may imply the more vigorous intra-industrial restructuring in this period. There are 10 industries showing advantages in both aspects, six of which are new industries.[6] Forty out of total 64 or 62.5% industries reveal advantages in at least one aspect, similar to 64% of the first sample period.

For the 28 industries inherited from the last sample period, 10 of them demonstrate significant product upgrading, and 12 significant product turnover. With 5 having advantages in both aspects, there are total 17 or 61% industries revealing continuous advancement in product development.

Among the 12 industries producing intermediate goods, there are 6 and 5 industries performing significantly well in product upgrading and product turnover respectively. Two industries show advantages in both aspects (semiconductor and related devices 3674 and electric lamps 3641). As for the 52 industries producing final goods, there are 17 and 22 industries revealing significant product upgrading and product turnover, with 8 of them doing

[6] These six industries started their exports to the U.S. after 1980 and therefore are not listed in the first sample period.

well in both aspects. Comparing to the scenario of 1980s that the export expansion of final goods mainly came from the product structure upgrading, the momentum of final goods export expansion in the 1990s was more from product turnover, while that of intermediate good exports did not show favor in either aspect.

As for the three largest exporting industries, other computer peripheral equipment (3577) was ranked the first but showed no significant advancement in either aspect. On the contrary, semiconductors and related devices (3674), ranked the second, presented strong advantages in both aspects. Comparing its performance in the previous period, it revealed vigorous promotion in product development. Electronic computers (3571), ranked the third, also showed significant progress in the two aspects. The first largest exporting industry of the previous period-household audio and video equipment (3651)-fell to the fourth. Its product structure was significant worsened (i.e., product sale moved toward lower-priced products), yet the product turnover was significantly improved. This scenario reveals a special type of industrial restructuring that on the one hand the low-price strategy was taken for the competition in the old, given product markets, on the other hand, the firms were actively exploring new product markets. With these double efforts, the industry could still remain some export competitiveness.

It is worth noting that the performance of the industries exhibits the tendency of turning to the two extremes in the second period. It is especially obvious for the product turnover index. As shown in Table 1C, there are more than a half of the industries (54%) having no significant change (U) in product turnover in the first period, with 28% better-off (B) and 18% worse-off (W). But in the second period, there are only 17% of the industries showing no significant change, with 42% of better-off and 41% worse-off, revealing greater discrepancy among industries.

Overall speaking, from the viewpoint of individual industries, the electrical and electronics sector of Taiwan continued to demonstrate industrial upgrading in 1990s. Even

though a large number of firms went to China and Southeast Asian countries to establish production sites and move out the labor-intensive, lower-tech production activities, it seemed that the vitality of the domestic production sector had not been diminished.

4.3 The *LR* test results

In this section, we present the results of LR tests according to the equation (9) and (9') in section 3.3. The results of equation (9) represent the performance of the electrical and electronics sector resulted from the overall performance of each individual industry throughout the sample period. The comparison between intermediate goods and final goods in both periods are also listed. As shown in Table 2A, all have no significant change. By contrasting them with the results of t tests, we may understand the causes of these outcomes.

From the t test result, we find that in 1980s, about a half of industries revealed no significant change in either product upgrading or product turnover, while in 1990s industries showed great discrepancy that some industries vigorously advanced, yet some others slowed down or declined. During the sample period, each industry went through different path of its product cycle. Some just started and struggled to compete in the world market, some became well-built and enjoyed rapid growth, some experienced turbulences and regained niches, and even some grew old and turn to diminish. It seems that not one single type dominates and thus causes the insignificant LR results.

Table 2A The results of LR test of equation (9)

industry	1980-1988		1989-1999	
	Product upgrading	Product turnover	Product upgrading	Product turnover
All	U	U	U	U
Intermediate goods	U	U	U	U
Final goods	U	U	U	U

Table 2B The results of LR test of equation (9')

industry	1980-1988		1989-1999	
	Product upgrading	Product turnover	Product upgrading	Product turnover
All	B	U	U	U
Intermediate goods	B	B	B	W
Final goods	B	W	B	U

The insignificance of the LR results above gives us not much clue for the development of the electrical and electronic sector. We then conduct the LR test from another perspective. By adopting equation (9') for LR test, we calculate the indexes for each industry in each year. The average of the indexes of all industries in each year is taken as mean, and the overall performance of the year is investigated. If in most of the years, the industries performing significantly well dominate, then we can get the result of B, though these industries may vary in different years. The results of this cross-section LR test are presented in Table 2B. They show that the performance of intermediate goods in product turnover surpassed that of final goods in 1980s, thought the situation turn around later on. The product turnover of the intermediate goods was worsened in 1990s. It may indicate the adjustment of Taiwan's position in the global production chain due to its outward investment as well as the rise of China. On the other hand, the product structure upgrading continued, indicating the promotion of quality of Taiwan's electrical and electronics exports.

5. Conclusion

This study provides a new method to test the hollowing-out scenario of the manufacturing sector. It extends the implication of the product cycle theory and asserts that the product contents of a country's manufacturing sector should continue to change. Facing the competition of the less-developed countries, it has to drop out of the markets of some old

products and catch up to the markets of the higher-end or higher-tech new products. If an industry fails to enter new product markets while losing competitiveness of the old products, it may be a signal that the hollowing-out has occurred.

In order to measure the product structure change and product turnover, the product upgrading index and product turnover index are derived from a CES import demand function and are constructed by using the data of US imports from Taiwan. The results show that Taiwan's electrical and electronics sector showed slightly deterioration product turnover in the 1990s compared to that of 1980s, though the advantage of product upgrading remained. It may indicate the change of position of Taiwan in the global production chain. At the same time, the quality of Taiwan's electrical and electronics exports continue to improve.

Reference

Blomstrom, M., Fors, G. and Lipsey, R. E. (1997), Foreign direct investment and employment: home country experience in the United States and Sweden, *Economic Journal*, 107, 1787-1797.

Bluestone, B. and Bennett, H. (1982), *The deindustrialization of America*, Basic Books, New York.

Chen, B.C., Chi, S. and Wu, C.G. (1991), *The research report of further classification of importing and exporting commodity structure*, research commissioned by the Ministry of Finance of Taiwan. (in Chinese)

Chen, Tain-Jy (1992), Determinants of Taiwan's direct foreign investment：The case of a newly industrializing country, *Journal of Development Economics*, 39, 397-407.

Chen, Tain-Jy and Ku, Ying-Hua (2000), The effect of foreign direct investment on firm growth：the case of Taiwan's manufactures, *Japan and the World Economy*, 12, 153-172.

Chou, Tien-Chen and Wu, Huelin (1990), Industrial Structure Change and Hollowing-out of Taiwan, *Industries of Free China*, vol.74, no.4, pp.11-25. (in Chinese)

Kraemer, Kenneth, L. and Dedrick, J. (1998), Globalization and increasing returns: implications for the U.S. Computer Industry, *Information Systems Research*, 9, 303-323.

Feenstra, R. C. (1994), New product varieties and the measurement of international prices, *American Economic Review* 84(1), 157-177.

Feenstra, R. C. and Rose, A. K. (2000), Putting things in order: Trade dynamics and product cycle, *The Review of Economics and Statistics*, 82,369-382.

Feenstra, R. C., Yang, T.-H., Hamilton, G. G. (1999), Business groups and product variety in trade：evidence from South Korea, Taiwan and Japan, *Journal of International Economics,* 48, 71-100.

Glickman, N., and Woodward, D. (1989), *The new competitors：how foreign investors are changing the US economy,* Basic Books, New York.

Helpman, E. and Krugman, P.R. (1985), *Market Structure and Foreign Trade*, MIT press.

Hirsch, Seev (1972), The United States electronics industry in international trade*, in* Louis T. Wells ed., *The product life cycle and international trade,* Harvard University, 39-52.

Hsieh, K.Y. (1999a), Investigating the hollowing-out effect of Taiwan's industrial moving-out, Taiwan Economy and Finance Monthly, vol.35, no.8, pp.40-65. (in Chinese)

Krugman, P.R. (1980), Scale Economies, Product Differentiation, and the Pattern of Trade, *American Economic Review*, 70, 950-959.

Ku, Yinhua (1998), Outward investment and industrial restructuring: the empirical study of Taiwan electric industry, *Taiwan Economic Review*, vol.26 no.4, pp.459-486. (in Chinese)

Lipsey, R.E. (1994), Outward direct investment and the US economy, National Bureau of

Economic Research Working Paper, No.4691.

Rowthorn, R.E., and Ramaswamy R. (1997), Deindustrialization: Causes and Implications, IMF Working Paper WP/97/42.

Sato, Kazuo (1976), The ideal log-change index number, *Review of Economics and Statistics*, 58, 2, 223-228.

Schive, Chi (1990) *The Foreign Factor*, Hoover Press.

Singh, Ajit (1977), UK industry and the world economy: a case of de-industrialization?, *Cambridge journal of economics*, 1, 113-116。

Tejima, Shigeki (2000), Japanese FDI, the implications of "hollowing out" on the technological development of host countries, *International Business Review*, 9, 555-570.

Thomsen, Stephen (1993), Japanese direct investment in the European Community ：The product cycle revisited, *World Economy*, 16(3), 301-315.

Vartia, Yrjo O. (1976), Ideal log-change index numbers, *Scandinavian Journal of Statistics*, 3, 3, 121-126.

Vernon, Raymond (1966), International investment and international trade in the product cycle, *The Quarterly Journal of Economics*,80 ,190-207.

Yu, Zonshen (1995), Testing Taiwan's Industrial Hollowing-out, *Industries of Free China*, vol.84, no.4, pp.1-11. (in Chinese)