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Productivity or Endowments? Sectoral Evidence for Hong Kong's Aggregate Growth[1]

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Abstract

This paper provides sectoral evidence that sheds new light on the current debate regarding the sources of growth of the East Asian miracle. We test both the productivity-driven and endowment-driven hypotheses using Hong Kong's sectoral data. The results show that most of the growth of the services sector is driven by the rapidly-accumulating capital endowments, and not by productivity growth. In addition, productivity growth in the manufacturing sector is also unimpressive. The manufacturing sector is revealed to be more labor intensive and it's growth is hindered by the reallocation of resources into the services sector as a result of the growth of capital endowments and imports. Overall, sectoral evidence supports the endowment-driven hypothesis.

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Keywords: East Asia miracle; Endowments; Productivity; Rybczynski elasticity

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Nontechnical Summary

This paper provides sectoral evidence that sheds new light on the current debate between Alwyn Young and Chang-Tai Hsieh regarding the sources of growth of the East Asian miracle. Using a standard growth accounting technique, Young (1992, 1995) finds little sign of TFP growth at the aggregate level of the four East Asian newly industrialized economies. This leads to his conclusion that the East Asian miracle is purely endowment-driven. His results have since be accepted as the mainstream belief among economists and policy markers, and are supported by other authors. On the other hand, citing the non-diminishing factor market returns as evidences of higher productivity growth in these economies, Hsieh (1999, 2002) is successful in challenging Young's findings and resurrecting the productivity-driven hypothesis. All of these papers however use only aggregate macro-level data of these economies. We test both the productivity-driven and endowment-driven hypotheses using Hong Kong's sectoral data. The results show that most of the growth of the services sector is driven by the rapidly-accumulating capital endowments, and not by productivity growth. In addition, productivity growth in the manufacturing sector is also unimpressive. The manufacturing sector is revealed to be more labor intensive and it's growth is hindered by the reallocation of resources into the services sector as a result of the growth of capital endowments and imports. Overall, sectoral evidence supports the endowment-driven hypothesis for Hong Kong's aggregate growth.

1. Introduction

The history-defying growth of the four East Asian newly industrialized economies (NIEs) in the past three decades has fascinated economists and policy makers around the world. After more than a decade of extensive research based on the aggregate statistics of the economies, the literature has offered two hypotheses regarding the "economic miracle": the productivity-driven and the endowments-driven hypotheses. To date, there is still an ongoing debate regarding which of the two is the more important source of growth of these economies. The goal of this paper is to provide consistent sectoral evidence that may substantiate or invalidate these aggregate findings, and to shed new light on the debate.

The productivity-driven hypothesis originated from the new growth theory, which emphasizes the role of productivity growth. Lucas (1988) introduces the effect of trade on productivity growth through a learning-by-doing mechanism. He proposes that the growth of the East Asian NIEs is a result of productivity growth, which in turn is due to the production experience accumulated in the export markets. Subsequent papers by Young (1991) and Lucas (1993) explore the growth effects of trade in a similar way. Thus, this school postulates that the growth of the four East Asian NIEs is a result of productivity growth that is associated with export growth.

To provide a theory of sustainable long-run growth that is consistent with the empirical findings, Findlay (1996) and Ventura (1997) formalize the endowment-driven hypothesis. Ventura shows that in a general equilibrium setting, a small open economy can sustain high growth through the Rybczynski effects of factor accumulation. Given that factor prices are equalized through the free trading of goods, when an economy experiences growth in a factor, say capital, the capital-intensive industries in the economy will grow at the expense of the noncapital-intensive industries. Reallocation of resources across sectors makes it possible to defy diminishing returns to factor accumulation as long as the economy is not completely specialized. Thus, for this school, the East Asian miracle is driven by the rapid growth of factor endowments sustained by international trade,

and it can continue as long as the economies remain small and open.

In terms of empirical evidence, there is overwhelming support for the endowment-driven hypothesis. Using aggregate (primal) growth accounting techniques to infer the growth of primal total factor productivity (TFP), Young (1992, 1995) shows that most of the gross domestic product (GDP) growth of the NIEs could be explained by their aggregate capital accumulation, such that there is little sign of productivity growth in these economies. Young's results are supported by many papers, including Kim and Lau (1994), Krugman (1994), Collins and Bosworth (1996), and Kohli (1997).

It is only recently that the productivity-driven hypothesis has been resurrected by Hsieh (1999, 2002). Hsieh derives the implied (dual) productivity growth of the four East Asian NIEs based on the market factor returns in these economies. He shows that the dual TFP growth is in general higher than the primal TFP growth by 1 to 2 percentage points in these economies, depending on the various measures of rate of returns to capital investment. The difference is especially large for Singapore, which may have inflated aggregate capital investment data in its national accounts and caused a smaller primal TFP growth. Hsieh attributes the discrepancy between the primal and dual TFP growth rates to data issues. So far, this is the only piece of evidence that supports the productivity-driven story.

The central idea of this paper is simple: If the contribution of productivity is indeed large at the aggregate level, then we should find high productivity growth in the industries in the economy. Conversely, if industry data show that most of the industry growth could be explained by the growth of the aggregate endowments, then it would be consistent with an endowment-driven growth hypothesis at the aggregate level.

To give some structure to the idea, we use a translog production-based GDP function approach similar to Kohli (1991, 1997) and Harrigan (1997). We show that the contribution of an aggregate endowment in GDP is correlated to the industry Rybczynski elasticity, which measures the percentage change of each industry output due to 1 percent increase in that aggregate endowment. On

the other hand, the aggregate contribution of productivity is correlated to industry productivity growth. In both cases, the degree of correlation depends on the output share of the industry in GDP.

We study the manufacturing and services industries of Hong Kong, which together cover more than 99 percent of the economy, from 1984 to 1997.[3] During that period, the GDP of Hong Kong jumped fivefold, and the aggregate capital stock more than doubled.[4] At the same time, output share of manufacturing in GDP dropped from 60 to 18 percent, share of import in GDP increased by nearly 40 percent. The services sector, the remaining majority of the economy, was growing at an average rate of 17 percent annually. A finding of a large and positive Rybczynski elasticity of the services sector with respect to capital and a low productivity growth in the manufacturing sector would be sufficient to reject the productivity-driven hypothesis in favor of the endowment-driven hypothesis at the aggregate level.[5]

The results of our empirical analysis show that the services sector is indeed the more capital-intensive sector, which benefited tremendously from the rapidly-growing capital endowment of the economy. The estimated Rybczynski elasticity shows that for every 1 percent increase in the capital endowment, output of the services sector increases by more than 2.4 percent. Given that the average annual growth rate of capital endowment is nearly 8 percent, it fully explains all of the output growth of the services sector in the sample period. Thus, even though the regression results indicate that productivity elasticity of the services sector is positive and significant, given such a large endowment effect, the role of productivity in the services sector is negligible. On the one hand, productivity growth in the manufacturing sector is also found to be minimum – an average

[3] There are insignificant amounts of agriculture and fishing activities in Hong Kong.
[4] The labor force of Hong Kong increased by only 20 percent during that period.
[5] Given that the services' share is growing when the aggregate capital endowment is increasing, a positive Rybczynski elasticity of capital in the services sector would be consistent with the endowment-driven story at the aggregate level. However, a positive Rybczynski elasticity of capital in the growing sector is not sufficient to lead to an aggregate finding of endowment-driven growth, unless there is no sign of any industries' productivity growth in the economy. To put it differently, if the Rybczynski elasticity of the services sector with respect to capital is not only positive, it is large enough that most of the growth of the services sector is explained by the growing endowment and leaves little sign of productivity growth, then to support the productivity-driven hypothesis at the aggregate level it would be necessary for the manufacturing sector to have high productivity growth.

of 0.6 percent annually. The manufacturing sector is revealed to be more labor intensive. Its output growth is predominantly hindered by the reallocation of production factors into the services sector as a result of the growth of the aggregate capital endowments and imports.[6]

Combining a large and positive Rybczynski elasticity of the services sector with respect to the growing capital endowment with a lackluster productivity growth in the manufacturing sector, this paper concludes that there is sufficient sectoral evidence to reject the productivity-driven hypothesis in favor of the endowment-driven hypothesis at the aggregate level in Hong Kong. The results are robust to the possible endogeneity of industry productivity and the aggregate capital endowment.

This paper is organized as follows. A production-based GDP function that includes imports is derived in Section 2. Empirical specification utilizing a translog function is developed in Section 3. The relationships between aggregate growth accounting and sectoral elasticities are presented in Section 4. The data set used for the empirical analysis is shown in Section 5. The estimations and results are discussed in Section 6. Robustness checks of the estimation are provided in Section 7. The conclusion is presented in Section 8.

2. Theoretical Model: A General Equilibrium Setting

Consider a neoclassical small open economy with fixed aggregate factor supplies, constant returns to scale production technology, and perfectly competitive goods and factor markets. This economy has two main sectors, manufacturing and services; together there are N industries. Each industry n produces only one good (y_n) from primary factors $(\mathbf{v}_n)$ and intermediate materials (Z_n). Intermediate materials are sourced both domestically and from overseas. There are I kinds of primary factor in the economy. In each period t the production of each industry n is subjected to a Hicks-neutral productivity progress, A_{nt}. The GDP of the economy is equal to the total output of the industry minus the value of imports, $p_{Mt}M_t$. Given aggregate primary factor endowments $(\mathbf{v})$, the productivity level, and import and export prices, the general equilibrium of this small open

[6] In other words, the manufacturing sector is revealed to be more labor intensive, so it is hurt by the negative Rybczynski effect as the economy becomes more capital abundant.

economy is obtained by reallocating resources to maximize its GDP, subject to all the production and resources constraints:

$$\begin{aligned} \max \quad GDP_t &= \sum_{n=1}^{N+1} (p_{nt} A_{nt}) \tilde{y}_{nt} \\ s.t. \quad \tilde{y}_{nt} &= f_n (\mathbf{v}_{nt}, Z_{nt}), \quad n = 1, ..., N \\ \tilde{y}_{N+1t} &= -M_t \\ \sum_{n=1}^{N} \mathbf{v}_{nt} &= \mathbf{v}_t, \ \mathbf{v}_t \in \mathbf{R}^I, \end{aligned} \tag{1}$$

where for simplicity of presentation, we treat the *negative* of import demand as the $(N+1)$th output supply of the economy and let $y_{N+1} = -A_{N+1} M_t$, with $A_{N+1t} \equiv 1$.

The assumption of constant returns to scale in production functions ensures that the second order sufficient conditions for maximization hold. Hence the solution to the first order conditions imply that GDP is a function of the prices of domestic output and imports, the sectoral productivity, and the aggregate endowments:

$$\begin{aligned} GDP_t^* &= GDP^* (\mathbf{p}_t \mathbf{A}_t, \mathbf{v}_t) \\ \mathbf{p}_t &\in \mathbf{R}_+^{N+1} \\ \mathbf{A}_t &= diag \{A_{1t}, A_{2t}, ..., A_{Nt}, 1\} \in \mathbf{R}^{N+1} \times \mathbf{R}^{N+1} \\ \mathbf{v}_t &\in \mathbf{R}^I, \end{aligned} \tag{2}$$

where $*$ denotes the optimum. $\mathbf{A}_t$ is a diagonal matrix that defines the level of productivity of the economy, and $\mathbf{p}_t$ is the price vector of the economy.[7] The second order sufficient conditions also imply that GDP^* is convex in $\mathbf{p}_t$, and $\mathbf{A}_t$.[8]

[7] The GDP function presented in Equation (2) incorporates two GDP function models developed in Kohli (1991, 1997) and Harrigan (1997). Kohli (1991) shows that the import price is important in explaining the expenditure-based GDP function, and we can derive import demand from the GDP function. Harrigan (1997) introduces productivity into the production-based GDP function by recognizing the multiplicative nature of prices and productivity in the revenue function. This enables him to model productivity empirically, in a similar way as prices. Thus the current GDP model includes the possible terms of trade effect or import competition faced by domestic industries, as well as possible efficiency gain due to the relocation of the aggregate resources as a response to sectoral productivity shocks.

[8] Notice that with the assumption of a small open economy, $\mathbf{p}_t$ is exogenous and is fixed in the world market. In the context of a large economy, $\mathbf{p}_t$ would depend on domestic output and would not enter the GDP function.

By the envelope theorem, the output supply of industry equals the gradient of GDP^* with respect to own price, and import demand equals the negative of the gradient:

$$y_{nt}^* = \frac{\partial GDP^*(\mathbf{p}_t\mathbf{A}_t, \mathbf{v}_t)}{\partial p_{nt}} = y_n^*(\mathbf{p}_t\mathbf{A}_t, \mathbf{v}_t), \quad \forall n = 1, ..., N, \tag{3}$$

$$M_t^* = -y_{N+1t}^*(\mathbf{p}_t\mathbf{A}_t, \mathbf{v}_t) = -\frac{\partial GDP^*(\mathbf{p}_t\mathbf{A}_t, \mathbf{v}_t)}{\partial p_{Mt}}. \tag{4}$$

Define the share of the output of industry n in GDP as $s_{nt} = \frac{p_{nt}y_{nt}}{GDP_t}$, then by construction, the sum of all the industry's shares will be greater than 1, and the share of imports will be negative. By Equation (3) it can be shown that the share of output of industry n in GDP is the elasticity of GDP^* with respect to its price:

$$s_{nt}^* = \frac{\partial \ln GDP^*(\mathbf{p}_t\mathbf{A}_t, \mathbf{v}_t)}{\partial \ln p_{nt}} = s_n^*(\mathbf{p}_t\mathbf{A}_t, \mathbf{v}_t), \quad \forall n = 1, ..., N+1. \tag{5}$$

$$s_{nt}^* \geq 0, \quad \forall n = 1, ..., N, \; s_{N+1t}^* \leq 0, \; \sum_{n=1}^{N+1} s_n^* = 1.$$

In addition, given the multiplicative nature of prices and productivity, for every industry n, the elasticities of GDP with respect to p_{nt} and A_{nt} equalize:

$$\frac{\partial \ln GDP^*(\mathbf{p}_t\mathbf{A}_t, \mathbf{v}_t)}{\partial \ln p_{nt}} = \frac{\partial \ln GDP^*(\mathbf{p}_t\mathbf{A}_t, \mathbf{v}_t)}{\partial \ln A_{nt}}.$$

In other words, the share of industry n also equals the elasticity of GDP with respect to productivity of n.

Hence in this general equilibrium framework, the share of industry n in GDP depends not only on its own price and productivity, but also on the prices of all other goods, their productivity, and the aggregate endowments of the economy.

With a similar method, we can also show that the share of factor i in total value added equals the elasticity of total value added with respect to the quantity of i :

$$s_{it}^* = \frac{\partial \ln GDP_t^*}{\partial \ln v_{it}}. \tag{6}$$

Our ultimate objective is to estimate the contributions of productivity and factor endowments to output growth of the industries. One method would be to estimate the elasticities of output

with respect to productivity and factor endowments, and use the estimated elasticities to construct the corresponding contributions.

Specifically, for every industry n and m, $y^*_{nt} = \frac{s^*_{nt} GDP^*}{p_{nt}}$, and $s^*_{nt} = \frac{\partial \ln GDP^*(\mathbf{p}_t \mathbf{A}_t, \mathbf{v}_t)}{\partial \ln A_{nt}}$. Given the shares of n and m, the elasticity of n's output with respect to the productivity of m, ε^A_{nmt}, is a *linear* function of the partial effect, $\frac{\partial s^*_{nt}}{\partial \ln A_{mt}}$:

$$\varepsilon^A_{nmt} \equiv \frac{\partial \ln y^*_{nt}}{\partial \ln A_{mt}} = \frac{1}{s^*_{nt}} \frac{\partial s^*_{nt}}{\partial \ln A_{mt}} + s^*_{mt}, \quad \forall n, m = 1, ..., N+1. \tag{7}$$

Similarly, for every industry n and factor i, the factor elasticity of n with respect to i, ε^f_{nit}, is also *linear* in the partial effect $\frac{\partial s^*_{nt}}{\partial \ln v_{it}}$:

$$\varepsilon^f_{nit} \equiv \frac{\partial \ln y^*_{nt}}{\partial \ln v_{it}} = \frac{1}{s^*_{nt}} \frac{\partial s^*_{nt}}{\partial \ln v_{it}} + s^*_{it}, \quad \forall n = 1, ..., N+1, \ \forall i = 1, ..., I. \tag{8}$$

The factor elasticity is known as the Rybczynski elasticity in the literature.

Finally, it can be shown that own price elasticity of each industry equals its own productivity elasticity minus 1, while cross price elasticity of each industry equals its corresponding cross productivity elasticity:

$$\varepsilon^p_{nmt} \equiv \frac{\partial \ln y^*_{nt}}{\partial \ln p_{mt}} = \begin{cases} \varepsilon^A_{nmt} - 1, \forall n = m \\ \varepsilon^A_{nmt}, \forall n \neq m \end{cases}. \tag{9}$$

Thus, our empirical strategy would be first to estimate the partial effects of productivity and factor endowments on the output shares, namely $\frac{\partial s^*_{nt}}{\partial \ln A_{mt}}$ and $\frac{\partial s^*_{nt}}{\partial \ln v_{it}}$. Subsequently, we will construct the elasticities using the corresponding estimated partial effects and shares, according to Equations (7) and (8). Finally, for every industry n, output growth is decomposed as follows:

$$\hat{y}^*_{nt} = \sum_{m=1}^{N+1} \varepsilon^A_{nmt} \hat{A}_{mt} + \sum_{m=1}^{N+1} \varepsilon^p_{nmt} \hat{p}_{mt} + \sum_{i=1}^{I} \varepsilon^f_{nit} \hat{v}_{it}.$$

3. Empirical Specification

To implement the model empirically, let us assume that $GDP^*(\mathbf{p}_t \mathbf{A}_t, \mathbf{v}_t)$ is a translog function of productivity, prices, and factor endowments, with productivity and prices of goods entering

multiplicatively. Let n and m be the indices for industries and i and j be the indices for factors:

$$\begin{aligned}
\ln GDP^*\left(\mathbf{p}_t\mathbf{A}_t,\mathbf{v}_t\right) &= a_{00}+\sum_{n=1}^{N+1}a_{0n}\ln\left(A_{nt}p_{nt}\right)+\frac{1}{2}\sum_{n=1}^{N+1}\sum_{m=1}^{N+1}a_{nm}\ln\left(A_{nt}p_{nt}\right)\ln\left(A_{mt}p_{mt}\right)\\
&\quad+\sum_{i=1}^{I}b_{0i}\ln v_{it}+\frac{1}{2}\sum_{i=1}^{I}\sum_{j=1}^{I}b_{ij}\ln v_{it}\ln v_{jt} \qquad (10)\\
&\quad+\sum_{n=1}^{N+1}\sum_{i=1}^{I}c_{ni}\ln\left(A_{nt}p_{nt}\right)\ln v_{it}, \qquad (11)
\end{aligned}$$

with the usual symmetry and homogeneity restrictions:

$$\begin{aligned}
a_{nm} &= a_{mn},\ b_{ij}=b_{ji},\quad \forall n,m=1,...,N+1,\quad \forall i,j=1,...,I,\\
\sum_{n=1}^{N+1}a_{0n} &= 1,\ \sum_{m=1}^{N+1}a_{nm}=0,\ \sum_{i=1}^{I}c_{ni}=0,\quad \forall n=1,...,N+1,\\
\sum_{i=1}^{I}b_{0i} &= 1,\ \sum_{j=1}^{I}b_{ij}=0,\ \sum_{n=1}^{N+1}c_{ni}=0,\quad \forall i=1,...,I. \qquad (12)
\end{aligned}$$

Thus, the share of industry n in total value added can be derived as the elasticity of GDP^* with respect to p_{nt} based on Equation (10) and the above restrictions:

$$s_n^*\left(\mathbf{p}_t\mathbf{A}_t,\mathbf{v}_t\right)=a_{0n}+\sum_{m=1}^{N+1}a_{nm}\ln\left(A_{mt}p_{mt}\right)+\ \sum_{i=1}^{I}c_{ni}\ln v_{it},\quad \forall n=1,...,N+1, \qquad (13)$$

with a_{nm} and c_{ni} representing the partial effects of productivity and factor endowments on output shares, $\frac{\partial s_{nt}^*}{\partial \ln A_{mt}}$ and $\frac{\partial s_{nt}^*}{\partial \ln v_{it}}$, respectively. In other words, for every industry n, m, and factor i, we can estimate the partial effects, a_{nm} and c_{ni}, by regressing output share of n on the levels of productivity, price indices, and factor endowments, as shown in Equation (13).

However, two obvious problems are associated with the estimation of Equation (13) . The first problem is the non-stationarity of the level of productivity and prices, which causes the ordinary least squares (OLS) estimates to be inefficient, as shown in Keller and Pedroni (1999). The second problem is the lack of randomness of the model: With full information on the economy, Equation (13) presents a complete model with no error term. Nevertheless, given that neither reliable data on productivity nor prices of the services sector are easily available or constructible, empirically it

is impossible to have a full set of productivity and prices for all the industries in both the manufacturing and services sectors to implement Equation (13). By excluding prices and productivity of the services sector from Equation (13), we introduce randomness to the model. On the other hand, given that the partial effects, a_{nm}, and c_{ni}, are invariant over time, we can get around the non-stationarity problem by taking the first difference of Equation (13).

Specifically, let the industry index for the services sector be $n = 1$. In order to capture the highly non-stationary property of the level of productivity and price, we assume the log level of the product of the productivity and the price of the service sectors follows a random walk with drift:

$$\begin{aligned} \ln A_{1t} p_{1t} &= \delta + \gamma t + \zeta_t \\ \zeta_t &= \zeta_{t-1} + u_t,\ u_t \sim \mathcal{N}(0, \sigma_\varepsilon). \end{aligned}$$

Then by separating the services sector from the first summation of Equation (13), we have:

$$s_n^*(\mathbf{p}_t \mathbf{A}_t, \mathbf{v}_t) = a_{0n} + a_{n1}(\delta + \gamma t + \zeta_t) + \sum_{m=2}^{N+1} a_{nm} \ln(A_{mt} p_{mt}) + \sum_{i=1}^{I} c_{ni} \ln v_{it}, \quad \forall n = 1, ..., N+1, \tag{14}$$

with its first difference as

$$\begin{aligned} ds_n^*(\mathbf{p}_t \mathbf{A}_t, \mathbf{v}_t) &= a_{n1}(\gamma + u_t) + \sum_{m=2}^{N+1} a_{nm}\left(\hat{A}_{mt} + \hat{p}_{mt}\right) + \sum_{i=1}^{I} c_{ni} \hat{v}_{it}, \\ &= a_n + \sum_{m=2}^{N+1} a_{nm}\left(\hat{A}_{mt} + \hat{p}_{mt}\right) + \sum_{i=1}^{I} c_{ni} \hat{v}_{it} + u_{nt} \quad \forall n = 1, ..., N+1, \end{aligned} \tag{15}$$

where $a_n = a_{n1}\gamma$, $u_{nt} = a_{n1} u_t$, and the variable $\hat{x}_t$ denotes the growth rate of x.[9] Equation (15) shows that for every industry n, m, and factor i, the change in share of industry n, ds_n^*, depends on the growth rates of productivity, $\hat{A}_{mt}$, output prices, $\hat{p}_{mt}$, and factor endowments, $\hat{v}_{it}$, as well as an industry fixed effect, a_n.

Equation (15) can be further simplified by utilizing the dual definition of TFP,

$$\hat{A}_{mt} \equiv \overline{\hat{w}}_{mt} - \hat{p}_{mt}, \tag{16}$$

[9] Specifically, $\hat{x}_t \equiv \ln x_t - \ln x_{t-1}$.

where $\overline{\hat{w}}_{mt}$ denotes the weighted average of the growth rates of input prices.[10] We can therefore rewrite Equation (15) as

$$ds_n^*(\mathbf{p}_t\mathbf{A}_t, \mathbf{v}_t) = a_n + \sum_{m=1}^{N+1} a_{nm}\overline{\hat{w}}_{mt} + \sum_{i=1}^{I} c_{ni}\hat{v}_{it} + u_{nt}, \quad \forall n = 1, ..., N+1. \tag{18}$$

Thus the change in share of industry n depends on the weighted averages of the growth rates of input prices of all industries and the growth rates of factor endowments. Equation (18) will form the basis of our estimation for a_{nm} and c_{ni}, $\forall n, m, i$.

For every industry n, m, and factor i, the estimated productivity elasticity and the factor elasticity are respectively

$$\varepsilon_{nmt}^A = \frac{a_{nm}}{s_{nt}^*} + s_{mt}^*, \quad \text{and} \tag{19}$$

$$\varepsilon_{nit}^f = \frac{c_{ni}}{s_{nt}^*} + s_{it}^*. \tag{20}$$

4. Multisector Aggregate Growth Accounting

Equations (19) and (20) allow us to reinterpret the traditional aggregate growth accounting as the output share weighted average of the sectoral productivity and Rybczynski elasticities:

$$\sum_{n=1}^{N+1} s_{nt}^*\varepsilon_{nmt}^A = s_{mt}^*, \quad \sum_{n=1}^{N+1} s_{nt}^*\varepsilon_{nit}^f = s_{it}^*. \tag{21}$$

In other words, the aggregate factor share equals the average Rybczynski elasticity of the economy, and the industry share equals the average productivity (price) elasticity.

[10] For example, if there are only four kinds of inputs, namely labor (L), capital (K), domestic materials (D), and imported materials (M), with input prices equal to w, r, p^D, and p^M respectively, then

$$\begin{aligned}
\overline{\hat{w}}_{nt} &= \bar{\theta}_{nt}^L\hat{w}_{nt} + \bar{\theta}_{nt}^K\hat{r}_{nt} + \bar{\theta}_{nt}^D\hat{p}_{nt}^D + \bar{\theta}_{nt}^M\hat{p}_{nt}^M \qquad (17)\\
\bar{\theta}_{nt}^L &= 0.5 * \left(\frac{w_{nt}L_{nt}}{p_{nt}y_{nt}} + \frac{w_{nt-1}L_{nt-1}}{p_{nt-1}y_{nt-1}}\right)\\
\bar{\theta}_{nt}^K &= 0.5 * \left(\frac{r_{nt}K_{nt}}{p_{nt}y_{nt}} + \frac{r_{nt-1}K_{nt-1}}{p_{nt-1}y_{nt-1}}\right)\\
\bar{\theta}_{nt}^D &= 0.5 * \left(\frac{p_{nt}^D D_{nt}}{p_{nt}y_{nt}} + \frac{p_{nt-1}^D D_{nt-1}}{p_{nt-1}y_{nt-1}}\right)\\
\bar{\theta}_{nt}^M &= 0.5 * \left(\frac{p_{nt}^M M_{nt}}{p_{nt}y_{nt}} + \frac{p_{nt-1}^M M_{nt-1}}{p_{nt-1}y_{nt-1}}\right)\\
1 &= \bar{\theta}_{nt}^L + \bar{\theta}_{nt}^K + \bar{\theta}_{nt}^D + \bar{\theta}_{nt}^M.
\end{aligned}$$

For the case of import, $\overline{\hat{w}}_{kt} = \hat{p}_{kt}$ since A_{kt} is assumed to be 1.

It could be shown that under such a specification, the growth rate of GDP consists of the following terms:

$$\widehat{GDP}^{*}\left(\mathbf{p}_t\mathbf{A}_t, \mathbf{v}_t\right) = \sum_{n=1}^{N+1} s_{nt}^{*}\hat{p}_{nt} + \sum_{n=1}^{N+1} s_{nt}^{*}\hat{A}_{nt} + \sum_{i=1}^{I} s_{it}^{*}\hat{v}_{it}, \tag{22}$$

where the first summation captures both the domestic price effect and the terms of trade effect a la Kohli (1997). Utilizing the average elasticity interpretation of industry and factor shares, we conclude that the growth rate of GDP depends on the growth rates of industry prices, industry productivity, and aggregate factor endowments. The contribution of these determinants depends on the average productivity and Rybczynski elasticities across all sectors.

Finally, according to this interpretation, the endowment-driven hypothesis is correct if the majority sector of the economy has a large positive Rybczynski elasticity with respect to the fast-growing endowment and has little productivity growth. Similarly, the productivity-driven hypothesis is correct if the majority sector has large productivity growth and has small or negative Rybczynski elasticity with respect to the fast-growing endowment.

5. Data

We aggregate the 26 industries in Hong Kong's manufacturing sector into five major manufacturing industries. Together with imports and the services sector, there are a total of seven aggregate industries. On the other hand, we only consider two types of primary aggregate factors, namely labor and capital. Both labor and capital are homogeneous inputs.

Table 1 presents the concordance of the five major manufacturing industries to their Hong Kong Standard Industrial Classifications. From 1976 to 1997, there were two classification regimes, with the break taking place in 1990. Due to data reporting problems, the food, beverage, tobacco, and petroleum and coal products industries (SIC 311/312, 313, 314, and 353/354) are excluded from the sample. Data sources and the constructions of the variables are in the appendix.

Table 2 presents some summary statistics of the variables used in the regressions. It is clear from the growth in real output and output share in GDP that the manufacturing sector as a whole

has been shrinking. Among the manufacturing industries, two of the largest industries in 1985, textiles/machinery and electronics, each dropped from more than 20 percent of GDP in 1976 to less than 7 percent in 1997. The rate of decline is rapid by any measure. On the other hand, the aggregate factor endowments of the economy have been increasing. The growth rate of capital is on average nearly 8 percent a year, while the growth rate of labor is 1.6 percent.

Evidence of import competition is clearly demonstrated by the growth rate of imports and the change in the import share in GDP. While the value of manufacturing imported materials is dropping due to the decline in manufacturing output, the imports as a whole is certainly getting larger. In other words, we expect to see a lot of negative effects on the manufacturing industries coming from imports.

Finally, the growth rate of productivity of the manufacturing sector shows sign of declining. This is also true at an industry level for machinery and electronics and for miscellaneous manufactures.

6. Estimations and Results

Equation (23) shows a system of seven equations, and Equation (24) presents the 21 restrictions. For each equation, the dependent variable is the change in share of output in GDP, with u_n being the industry-specific error term. Notice that we are not imposing restrictions on the homogeneity in prices in the system, as we do not have a complete set of prices.

$$ds_{nt} = a_n + \sum_{m=2}^{7} a_{nm}\overline{\hat{w}}_{mt} + \sum_{i=1}^{2} c_{ni}\hat{v}_{it} + u_{nt}, \quad \forall n = 1, ..., 7 \tag{23}$$

$$a_{nm} = a_{mn}, \ \sum_{m=1}^{2} c_{ni} = 0, \quad \forall n, m, i. \tag{24}$$

Right-hand side variables for each equation include the weighted averages of the growth rates of input prices of all the five industries plus import price, and the growth rates of the two aggregate factor endowments. Given that the dependent variable is the change in share of output of one of the seven industries in the sector for each equation, the error terms of the equations will be correlated by construction. Hence the proper way to implement the empirical model will be to estimate it

as a system of six equations using iterative seemingly unrelated regressions.[11] Given that the estimates are neutral to the dropping equation, without further complication, we choose to drop the services sector out of our system and will recover its coefficients via symmetry and homogeneity restrictions.

Table 3 presents the regression results of the system. Each of the six columns in the table represents the regression result of one industry. The dependent variable of each regression is the change in share of the industry in the column, and there are nine explanatory variables for each regression. These explanatory variables are categorized into three groups. The first group consists of the weighted averages of the growth rates of input prices of the various industries as well as the growth rate of import prices. The second group of explanatory variables includes the growth rates of the two aggregate factors. The third group is the industry fixed effects.

At first glance, most of the partial effects of productivity are estimated with precision, while all of the partial effects of factor endowments are not significant. Moreover, all of the partial effects of own price on output are positive and significant, and most of the partial effects of import price on output of the industries are negative and significant. This finding is in line with the theoretical restriction of the model.[12]

Table 4 shows the estimated productivity elasticities of the five manufacturing industries, the services sector, and imports. Elasticities for the services sector are obtained by imposing the symmetry and homogeneity restrictions. Each cell shows the percentage change in output of the industry in the column due to a 1 percent change in productivity of the industry in the row.[13]

As shown in bold in Table 4, all of the estimated own productivity elasticities are positive and significant. The range of the estimated own productivity elasticities is between 1.2 and 5.4. In addition, all manufacturing industries have estimated own productivity elasticities that are signifi-

[11] This is equivalent to estimating a system using maximum likelihood estimators. See Barten (1969) for details.

[12] To satisfy convexity of GDP function, all the output supply of the industries should be positively related to own price and negatively related to import price, where import is taken as the intermediate input. Thus it is necessary that all the partial effects on own price be positive and partial effects on import price be negative.

[13] For example, a 1 percent increase in productivity in the textile industry causes the output of the chemicals industry to decrease by 1.33 percent. It also leads to a 1.89 percent increase in the output of the machinery and electronics industry.

cantly greater than 1. In other words, for each of the five industries in the manufacturing sector, a 1 percent increase in own productivity will induce more than 1 percent increase in the output of the industry. The productivity elasticity of the services sector is positive but not significantly different from 1. Given that own price elasticity equals own productivity elasticity minus 1, the regression result satisfies the specification of the theoretical model that the own price elasticities should be nonnegative, as shown in Table 5.

Interestingly enough, imports react positively to productivity growth in the industry, even though the estimated elasticities are less than unity. Thus, when there is technological progress in the manufacturing sector, we would expect to see an increase in import demand. On the other hand, as shown in Table 5 that all of the import price elasticities of the manufacturing industries are negative and significant. For the manufacturing industries, a 1 percent increase in import prices decreases industry output from 3.7 percent to 6.5 percent. For example, from 1984 to 1997, import prices increased by more than 20 percent, and as a result, output dropped by 130 percent in the miscellaneous manufactures industry. Thus the rising imports in the sample period have produced some huge negative effects on the output of the manufacturing industries.

Table 6 presents the estimated factor elasticities. These elasticities are also known as the Rybczynski elasticities, which measure growth of output due to the growth of the aggregate factor endowments in an economy. Each cell shows the percentage change in output of the industry in the column due to a 1 percent growth of the factor in the row.

According to Table 6, the estimated Rybczynski elasticity with respect to aggregate capital of the services sector is positive and statistically significant. In other words, the services sector is revealed to be capital intensive. For every 1 percent increase in the aggregate capital endowments, output of the services sector increases by 2.4 percent. Given that, from 1984 to 1997, the average annual growth rate of Hong Kong's aggregate capital endowments is nearly 8 percent, this would cause the output of the services sector to increase by more than 18 percent annually. Thus, accumulation of capital endowments alone can explain all of the services sector's growth, leaving no

room for productivity growth in the sector.

On the other hand, most of the manufacturing industries are revealed to be labor intensive, with positive Rybczynski elasticities with respect to aggregate labor endowment and negative Rybczynski elasticities with respect to capital endowment. However, with the exception of the miscellaneous manufactures industry, the elasticities are not precisely estimated. One possibility is that given that most of the manufacturing industries have a concurrent decline in output over the sample period, these elasticities are likely to be highly correlated, which make it difficult to estimate each individual elasticity precisely. Nevertheless, given the strong positive Rybczynski elasticity with respect to aggregate capital of the services sector, it is safe to infer that overall the manufacturing sector is revealed to be labor intensive.

A labor intensive manufacturing sector would have benefitted from the increase in the aggregate labor endowment. However, given that the average growth rate of the aggregate labor endowment is only 1.6 percent annually, it helps little in offsetting the negative effect of the faster cumulating aggregate capital on the manufacturing industries. Resources are moving into the services sector from the manufacturing sector as a result of the changes in the mix of aggregate endowments which push the economy to be more capital abundance.

Overall, the estimated productivity, prices and factor elasticities suggest that the growth of the capital intensive services sector is mainly driven by the growth of the aggregate capital endowment, while the growth of the labor intensive manufacturing sector is mainly hindered by the reallocation of resources into the services sector as a result of the growth of the aggregate capital endowment and the rising imports.

We also perform some specification tests on the regression results. All of the industries satisfy the homogeneity hypothesis, which implies that the constant returns to scale assumption is not rejected by the data. On the other hand, none of the industries satisfies the symmetry hypothesis.[14]

However, it is not unusual for such regularity conditions to fail in this type of model, and it

[14]Detailed results on the specification tests are available upon request.

is necessary to impose such restrictions for the estimation to conform to the model. Failure in symmetry restriction could be due to the fact that the sizes of the industries are quite different, ranging from 2 percent of GDP to 112 percent of GDP (including import). Harrigan (1997) has similar findings in the system of equations of the OECD countries.

7. Robustness Checks

7.1 Endogeneity of TFP

There are at least two reasons why the sectoral growth rates of TFP and the contemporary regression errors could be correlated and cause the estimates to be biased. The first has to do with the measurement of TFP, and the second reason is due to econometric issues associating with the fixity of some inputs. Both of these issues will overestimate the industry productivity growth, leading to underestimation of the productivity elasticities.

Specifically, the value of total industry output is used to construct the share of industry in GDP and its changes. On the other hand, by invoking the dual definition of TFP, according to Equation (16) , we use data on total cost to construct the growth rate of industry TFP. With the assumption of perfect competition, value of total output equals total cost. Hence we may have mechanically introduced a spurious correlation between the dependent variable and the growth rates of industry productivity.

In addition, if there is fixity of some inputs in the short run, then a sectoral-specific shock will affect the sector's share in GDP and the measured sectoral TFP concurrently. This is similar to the classical econometric problem of estimating a production function.

We use the lagged growth rate of the industry TFP as an instrumental variable to get around the potential endogeneity issue of the current-period industry TFP growth. As a results, we use the full information maximum likelihood estimation to fit the above system of equations. While the point estimates of the regression are slightly different, they do not significantly alter the industry productivity and Rybczynski elasticities. Correcting for endogeneity of productivity raises the

services sector productivity elasticity from 1.17 to 1.18. We maintain the earlier results that growing capital endowment is the main driving force behind the growth of the services sector, while the manufacturing industries are hurt by the reallocation of resources into the services sector due to capital accumulation and import competition.[15]

7.2 Endogeneity of the Aggregate Capital Endowment

Hong Kong is one of the world's most open economies, not just in terms of movement of goods and services but also in terms of movement of capital, both inward and outward. As such, the aggregate capital stock of the economy could be a result of investors' response to the different rate of returns across countries, as well as across industries. Specifically, a growing sector of a booming economy provides investors with a higher expected rate of return in the future and further attracts investment and causes the aggregate capital endowment to grow. This situation would lead to an overestimation of the Rybczynski elasticity of the growing industry.

While the standard H-O model and Rybczynski theorem call for aggregate capital endowment to be exogenous, with the free trade of goods and services, returns to factors are nevertheless equalized across countries and sectors. Thus, we could use interest rates as an instrument of the aggregate capital stock, which would capture the exogenous movement of capital due to changes in interest rates that are not related to specific industries. A full information maximum likelihood estimation, with the best lending rate of Hong Kong used as the instrument for the aggregate capital endowment is performed. Once again, while the point estimates are slightly different from those in Table 3, they do not change the industry productivity and Rybczynski elasticities significantly. Correcting for the endogeneity of the aggregate capital endowment reduces the Rybczynski elasticity of the services sector with respect to capital from 2.42 to 2.38. We maintain that the growth of the services sector is predominantly due to the growth of the aggregate capital endowment.[16]

[15] Detailed regression results are available upon request.
[16] Detailed regression results are available upon request.

8. Concluding Remarks

This paper sets out to find sectoral evidence that may substantiate the existing aggregate findings in the literature regarding the relative importance of productivity and endowments in the growth of Hong Kong.

Under a general equilibrium framework of a production-based GDP function approach, this paper links the contributions of aggregate productivity and endowments to industry-level productivity and Rybczynski elasticities. Given the drastic cumulation of aggregate capital stock, a finding of a large Rybczynski elasticity of the majority sectors with respect to capital would be consistent with the endowment-driven hypothesis. On the other hand, if most of the growth of the majority sectors could be explained by factors other than productivity, then it would be inconsistent with the aggregate productivity driven hypothesis.

The results of an iterative seemingly unrelated regression indicate that most of the growth of the services sector is driven by the rapidly-accumulating capital endowments, and not by productivity growth. In addition, productivity growth in the manufacturing sector is also unimpressive. The manufacturing sector is revealed to be more labor intensive and it's growth is hindered by the reallocation of its production factors into the services sector as a result of the growth of capital endowments and imports. Overall, sectoral evidence supports the endowment-driven hypothesis. The results are robust to the corrections of endogeneity of industry productivity and aggregate capital endowment.

In terms of relevancy to the trade literature, this paper is the first to estimate the sectoral Rybczynski elasticities and relate them to the aggregate growth of a small open economy. In terms of relevancy to the growth literature, the sectoral evidence of this paper substantiates those existing endowment-driven findings which so far have been mainly focused on the aggregate statistics.

A Appendix

A1 Data Sources

Most of the industry-level raw data are from the *Survey of Industrial Production* published by the Census and Statistics Department of Hong Kong from 1976 to 1997. Earlier year data are supplemented by *Hong Kong Annual Digest of Statistics,* published by the same source. Data from these sources include value of gross output ($p_{nt}y_{nt}$), value of materials purchased $\left(p_{nt}^{D}D_{nt} + p_{nt}^{M}M_{nt}\right)$, number of persons engaged (L_{nt}), compensation of employees ($w_{nt}L_{nt}$), gross addition to fixed assets $\left(\text{value of investment: } p_t^I I_{nt}\right)$.

Hong Kong Annual Digest of Statistics also provides data necessary for the construction of the aggregate factor endowments, which include labor force (L_t) and gross domestic fixed capital formation (value of aggregate investment: $p_t^I I_t$).

Finally, the Census and Statistics Department of Hong Kong collected detailed Hong Kong trade data at a commodity level from 1984 to 1998.[17] This data set provides us with information on the value and quantity of import and export by commodities, year, and country of origin/consignment. Given the highly disaggregate nature of the data, it is possible to construct unit value of import and export by industry. Because trade statistics begin in 1984 and the industry data end in 1997, this determined the time dimension of this paper.

A2 Capital Stock and Factor Shares

Both industry and aggregate real investments are inferred by deflating the value of investment by the appropriate GDP deflator of gross domestic fixed capital formation. Capital input is then compiled using the perpetual inventory method from real investment,

$$K_{nt} = K_{nt-1} * (1 - \delta) + I_{nt}, \tag{25}$$

[17] The data are purchased by the Pacific Rim Business and Development program at the University of California at Davis, and are only available for students and faculty of UC-Davis.

with the assumption that we correctly specify some base year level of capital stock, K_{n0}. Fortunately, the 1976 *Survey of Industrial Production* publishes the book value of all assets by industry. Taking 1976 as our base year, we compile industry-level capital stock by Equation (25), at a fixed depreciation rate of 10 percent. Log difference of industry capital stock gives us the growth rate of industry capital input.

There are no published data for the aggregate capital stock in the base year. However, aggregate investment series is available since 1972. We take 1972 as the base year to compile aggregate capital stock. Given the high growth rate of aggregate investment, any underestimation at the beginning of the series would not be significant for the later years, when we want to construct the growth rate of aggregate capital stock, as we need only the growth rates of aggregate capital after 1984 for regression purposes.

There are no published data on the shares of labor and capital in GDP of Hong Kong. Labor share in GDP is constructed as a weighted average of industry's labor shares, with the share of each industry in GDP as the weight, and capital share in GDP is constructed as 1 minus the labor share:

$$\frac{w_t L_t}{GDP_t} = \frac{\sum_{n=1}^{N} w_{nt} L_{nt}}{GDP_t} = \sum_{n=1}^{N} \frac{VA_{nt}}{GDP_t} \frac{w_{nt} L_{nt}}{VA_{nt}}. \tag{26}$$

Industries included in the construction of aggregate labor share are manufacturing, wholesale and retail trades, restaurants and hotels, transport and related services, storage, communication, financing and business services sectors, banking and insurance industries. All these industries together account for more than 80 percent of the economy.

A3 Export and Import Prices

Export prices are constructed using Tornqvist price index from the unit value of export commodities:

$$dp_{nt} = \sum_{i_n=1}^{I_{nt}} \bar{\theta}_{i_n t} \left(\ln \frac{p_{nt}^{i_n} Q_{nt}^{i_n}}{Q_{nt}^{i_n}} - \ln \frac{p_{nt-1}^{i_n} Q_{nt-1}^{i_n}}{Q_{nt-1}^{i_n}} \right), \ \forall n, t, \tag{27}$$

where $i_n = 1, ..., I_{nt}$ is the group of common export commodities between year t and $t-1$ in industry n, and $\bar{\theta}_{i_n t}$ is the average share of commodity i_n in the the total value of export of

industry n between year t and $t-1$.[18]

$$\bar{\theta}_{i_n t} = 0.5 * \left(\frac{p_{nt}^{i_n} Q_{nt}^{i_n}}{\sum_{i_n=1}^{I_{nt}} p_{nt}^{i_n} Q_{nt}^{i_n}} + \frac{p_{nt-1}^{i_n} Q_{nt-1}^{i_n}}{\sum_{i_n=1}^{I_{nt}} p_{nt-1}^{i_n} Q_{nt-1}^{i_n}} \right), \ \forall i_n, t. \tag{28}$$

Thus for every year and industry, we need to first identify the group of common export commodities between last and current year, then construct the share of each commodity in the group of common commodities for each of the two years, and take the average of the shares to obtain $\bar{\theta}_{i_n t}$. Average share, $\bar{\theta}_{i_n t}$, is the weight used to construct the change in export price of industry n from the change in log unit value of the commodities. In short, the change in industry price equals the weighted average of the change in log unit value of the commodities in the industry. Import prices are constructed in the same way.

There are three different commodity classifications used from 1984 to 1997. Commodities were classified under 6 digits SITC revision 2 for 1984-1991, 6 digits SITC revision 3 for 1992-1993, and 8 digits HS for 1994-1998. We first tried to match up the commodities under different classifications by the appropriate concordances. However, the generated price indices presented big swings in 1992 and 1994, which showed that the matching process was not successful. As such, in order to minimize the noise in the data, changes in price of the industry for these two years were interpolated from the rest of the years. Finally, with the help of a SITC to SIC concordance, all the commodities are aggregated using the Equation (27) to construct industry-level export price indices.[19]

A4 Domestic versus Imported Materials

To infer the values of domestic and imported materials from the value of total materials purchased, we need to refer to the input-output tables of Hong Kong, which detail the composition of imported and domestic materials by industry over time. Unfortunately, there is no frequent publication of Hong Kong input-output tables other than those compiled by GTAP in 1995.[20]

[18] Commodities imported from different countries, or exporting to different countries, are considered as different commodities.

[19] Concordances used in this paper can be found on the following web site maintained by Jon Haveman: http://www.eiit.org/Trade.html.

[20] GTAP stands for the Global Trade Analysis Project, which was established in 1992 by Thomas Hertel at Purdue University. It has a rich global database, which includes individual country input-output tables that account for intersectoral linkages.

There are two ways we can make use of the information provided from the input-output table of Hong Kong in 1995. The first is to assume that purchase shares of industry in total imported materials stay constant. In other words, if in 1995, the textile industry purchased 35 percent of the imported chemical products, then we assume that textile industry demands 35 percent of the imported chemical products for all the years. Thus the change in the total import of chemical products equals the changes of chemical products materials in all industries, regardless of the intensity of the materials in production.

Alternatively, we assume that within each industry, the expenditure shares of various imported materials in total imported materials stay constant. In other words, total imported materials of each industry can be thought of as a Cobb Douglas function of the different types of imported materials. Thus, if in 1995 the expenditure share of chemical materials in the total imported materials of textiles was 13 percent, then we assume that the share of chemical materials in total imported materials of textile industry stays at 13 percent for all years. In this way, an increase in the imports of chemicals products will have a different impact on different industries, and the size of the impact depends on the intensity of chemical materials of the industries. The same method applies to domestic materials.[21]

We use the expenditure shares to construct the growth rates of total domestic materials, with the assumption that growth rate of each type of domestic materials equals the growth rate of total domestic sales of the industry in which the materials are originated.[22] Growth rate of the share of domestic materials in total materials is calculated as the difference between the growth rates of total domestic materials $\left(\widehat{p_{nt}^{D} D_{nt}}\right)$ and total materials $\left(\widehat{p_{nt}^{Z} Z_{nt}}\right)$. Share of domestic materials in total materials is constructed by compiling change in share of domestic materials, and the share of imported materials in total materials is 1 minus the share of domestic materials: $\theta_{nt}^{D} \equiv \frac{p_{nt}^{D} D_{nt}}{p_{nt}^{z} Z_{nt}} \Longrightarrow \hat{\theta}_{nt}^{D} = \widehat{p_{nt}^{D} D_{nt}} - \widehat{p_{nt}^{Z} Z_{nt}}$, and $\theta_{nt}^{D} = \theta_{t-1}^{D} \exp\left(\hat{\theta}_{nt}^{D}\right)$.

[21]Detailed data on the expenditure shares are available upon request.
[22]Domestic sales of industry n is the difference between total output and exports.

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Table 1: Data Description

Years: 1981-1998

Product classification system: There are a total of 5 industries, briefly follows the nine categories of the two-digit level of the Hong Kong Standard Industrial Classification (HSIC). The categories, and their three-digit HSIC constituent parts, are listed below.

Industry	HSIC(81-89)	Description	HSIC(90-96)	Description
Textiles	320/322	Wearing Apparel	320/322	Wearing Apparel
	323	Leather Products	323	Leather Products
	324	Footwear	324	Footwear
	325-329	Textiles	325-329	Textiles
Paper &	341	Paper Products	341	Paper Products
Printing	342	Printing & Publishing	342	Printing & Publishing
Chemicals	351/352	Chemical Products	351/352	Chemical Products
	355	Rubber Products	355	Rubber Products
	356	Plastic Products	356	Plastic Products
	361-369	Non-Metallic Mineral	361-369	Non-Metallic Mineral
Machinery &	371/372	Basic Metal	371/372	Basic Metal
Electronics	380/381	Fabricated Metal	380/381	Fabricated Metal
	382	Machinery	382	Office Machinery
	383	Electrical, Electronic Products	383	Radio, TV & Communication Equipment
	384	Electrical, Electronic Parts	384	Electronic Parts
	385	Scientific Instruments	385	Electrical Appliances
			386/387	Machinery
			388	Transport Equipment
	389	Transport Equipment	389	Scientific Instruments
Miscellaneous	331	Wood Products	331	Wood Products
Manufacture	332	Furniture	332	Furniture
	390/391	Other Manufacturing	390/391	Other Manufacturing

Share of each industry in total output of manufacturing sector

Source: Survey of the Census of Industrial Production, Hong Kong (SIP)

Prices of goods

Measured by Tornqvist unit value of exports, 1984-1998

Source: Census and Statistical Department, Hong Kong Special Administrative Region

Growth rate of productivity

Measured by the growth rate of dual TFP, which equals to the weighted average of the growth rates of input prices minus the growth rate of output price. Source: SIP

Capital

Generated by compiling real investment using the perpetual inventory method with a depreciation rate of 10%

Source: SIP

Labor

Number of Workers

Source: SIP

note: * HSIC 353/354 (Petroleum and Coal Products) is not included due to the lack of data for the first half of our sample.

Table 2: Data at a Glance

Variables	Years	Manufacturing*	Textiles	Paper & Printing	Chemicals**	Machinery & Electronics	Miscellaneous Manufactures
Growth rate of	1985	-6.0682	-4.2574	-3.6711	-9.9102	-7.0832	-5.9565
real output	1997	-6.6898	-7.0543	10.2951	0.9745	-10.2835	-15.2646
	mean	**-1.6259**	**-2.8623**	**8.2323**	**-1.5203**	**-3.4195**	**-5.9101**
Output share in	1985	63.3975	26.0510	3.6012	8.0945	23.1072	2.5435
GDP	1997	18.3703	5.7102	3.0152	1.8082	6.9176	0.9191
	mean	**46.6110**	**17.7564**	**3.5614**	**5.1490**	**18.0762**	**2.0681**
Change in	1985	-9.4480	-3.0853	-0.3068	-1.1359	-4.3124	-0.6076
output share	1997	-3.3320	-0.9576	-0.0969	-0.2837	-1.8875	-0.1064
	mean	**-4.1904**	**-1.8020**	**-0.0687**	**-0.5709**	**-1.5771**	**-0.1717**
Growth rate of	1985	-5.1498	-5.0099	-0.9816	-4.3604	-7.0656	0.7698
labor input	1997	-12.9138	-20.0259	-3.3155	-2.4379	-13.0069	-10.6848
	mean	**-9.6201**	**-11.8160**	**0.1375**	**-12.4491**	**-9.5455**	**-6.7535**
Growth rate of	1985	1.0403	-1.4933	5.7958	4.2795	1.5403	2.4435
capital input	1997	0.0670	-7.1892	5.1020	1.0617	3.2378	-4.0387
	mean	**1.9914**	**-2.1438**	**8.9152**	**0.6080**	**3.7834**	**2.6861**
Growth rate of	1985	-0.0183	-0.1383	1.2950	-0.0416	-2.6897	1.2950
domestic materials	1997	-0.6184	1.0808	-2.4948	-3.5613	-3.5156	-2.4948
	mean	**-4.1495**	**-10.4167**	**5.3958**	**1.3159**	**0.7093**	**5.3958**
Growth rate of	1985	-2.4893	-4.1282	-1.7080	-4.1119	-1.0342	-1.7080
imported materials	1997	-3.3262	0.0494	-5.1927	-3.8111	-5.8325	-5.1927
	mean	**-0.3556**	**0.7460**	**5.6183**	**-2.9746**	**-2.4599**	**-2.1475**
Growth rate of	1985	-1.2056	-0.3177	2.1132	3.3962	-3.4111	-8.8478
output price	1997	0.1052	1.6337	-3.3732	-5.4577	-3.7528	14.3940
	mean	**3.8458**	**3.1427**	**2.5895**	**1.8035**	**5.6426**	**9.2487**
Growth rate of	1985	0.6145	-0.9625	0.4368	-5.3264	2.8227	8.4632
productivity***	1997	-0.8846	0.4558	6.5895	4.6663	-1.7500	-17.1295
	mean	**0.5967**	**1.3408**	**2.4033**	**2.1025**	**-1.1075**	**-5.9419**

Aggregate Endowments		Labor	Capital	Imports
Growth	1985	0.7911	7.1454	3.5405
rates	1997	3.8738	9.4722	5.0481
	mean	**1.6173**	**7.8511**	**15.2178**
Share in	1985	45.8083	54.1917	86.8899
GDP	1997	42.8246	57.1754	122.4305
	mean	**42.2041**	**57.7959**	**111.9986**

Notes: All values are in percentage terms. Mean values are the annual averages for the period 1984-1997.

*SIC 311/312, 313, 314 (Food, Beverage and Tobacco Products) are excluded.

** SIC 353/354 (Petroleum and Coal Products) is excluded from the data due to the lack of data prior to 1988.

***productivity is measured as the dual total factor productivity.

Table 3: Dependent Variables: Change in share of output in GDP

Estimation method: Restricted Iterative Seemingly Unrelated Regression (MLE)

Total number of restrictions: 21

Total system observations: 78

	Independent Variables:	Eq(1) Textiles	Eq(2) Paper & Printing	Eq(3) Chemicals	Eq(4) Machinery & Electronics	Eq(5) Miscellaneous Manufacture	Eq(6) Imports
Weighted Average of the Growth Rates of Input Prices in:	Textile	**0.3612*** **	0.0232	-0.0776**	0.3093***	0.0464***	0.6967**
		(0.0975)	(0.0211)	(0.0327)	(0.0969)	(0.018)	(0.3102)
	Paper & Printing	0.0232	**0.1133*** **	-0.0647***	0.1145***	-0.037***	0.0927
		(0.0211)	(0.0163)	(0.022)	(0.0251)	(0.013)	(0.0588)
	Chemicals	-0.0776**	-0.0647***	**0.2741*** **	0.0183	0.0157	0.2517**
		(0.0327)	(0.022)	(0.0329)	(0.0383)	(0.0176)	(0.102)
	Machinery & Electronics	0.3093***	0.1145***	0.0183	**0.5196*** **	0.0062	0.8368**
		(0.0969)	(0.0251)	(0.0383)	(0.1283)	(0.0238)	(0.3759)
	Miscellaneous Manufactures	0.0464***	-0.037***	0.0157	0.0062	**0.0705*** **	0.1123**
		(0.018)	(0.013)	(0.0176)	(0.0238)	(0.0169)	(0.0486)
	Imports	-0.6967**	-0.0927	-0.2517**	-0.8368**	-0.1123**	**-1.1299**
		(0.3102)	(0.0588)	(0.102)	(0.3759)	(0.0486)	(1.465)
Growth Rates of:	Capital	-0.264	-0.0344	0.076	-0.3376	-0.0815	2.4095
		(0.3812)	(0.0743)	(0.1229)	(0.426)	(0.052)	(1.794)
	Labor	0.264	0.0344	-0.076	0.3376	0.0815	-2.4095
		(0.3812)	(0.0743)	(0.1229)	(0.426)	(0.052)	(1.794)
	Industry Fixed Effect	-0.0198	-0.0051	-0.0116	-0.0248	0.0018	-0.1935*
		(0.0223)	(0.0042)	(0.0071)	(0.0251)	(0.0029)	(0.1096)

Note: All figures in bold are the own partial effects of productivity. Standard errors are in parentheses.
*, **, and *** indicate significance at 90%, 95%, and 99% confidence levels respectively.

Table 4: The Elasticity of Output with respect to Productivity

		Effect in terms of percentage change in output in:						
		Textiles	Paper & Printing	Chemicals	Machinery & Electronics	Miscellaneous Manufactures	Service	Imports
1% increase in productivity in:	Textiles	**2.2116*** **	0.8293	-1.3294**	1.8884***	2.4221***	0.1982**	0.7996***
		(0.549)	(0.5927)	(0.6349)	(0.536)	(0.8689)	(0.0975)	(0.277)
	Paper & Printing	0.1663	**3.2178*** **	-1.221***	0.6688***	-1.7544***	0.0014	0.1184**
		(0.1189)	(0.4568)	(0.4263)	(0.139)	(0.6305)	(0.0194)	(0.0525)
	Chemicals	-0.3855**	-1.7653***	**5.3741*** **	0.1529	0.8093	0.1034***	0.2762***
		(0.1841)	(0.6163)	(0.639)	(0.2119)	(0.852)	(0.033)	(0.0911)
	Machinery & Electronics	1.9224***	3.3944***	0.5367	**3.055*** **	0.4828	0.1015	0.9279***
		(0.5456)	(0.7053)	(0.744)	(0.7098)	(1.1484)	(0.1143)	(0.3356)
	Miscellaneous Manufactures	0.2821***	-1.0188***	0.3251	0.0552	**3.4294*** **	0.027*	0.1209***
		(0.1012)	(0.3661)	(0.3422)	(0.1314)	(0.8152)	(0.0151)	(0.0433)
	Service	1.8465**	0.0664	3.322***	0.9289	2.1599*	**1.1682*** **	0.8858
		(0.9084)	(0.9019)	(1.0605)	(1.0454)	(1.2094)	(0.4357)	(0.7957)

Note: Figures in bold are the own productivity elasticities. Standard errors are in parentheses.
The productivity elasticity of industry n with respect to industry k equals the share of industry k plus the ratio of the corresponding estimated cross partial effect to the share of industry n.
*, **, and *** indicate significance at 90%, 95%, and 99% confidence levels respectively.

Table 5: The Elasticity of Output with respect to Prices

		Effect in terms of percentage change in output in:						
		Textiles	Paper & Printing	Chemicals	Machinery & Electronics	Miscellaneous Manufactures	Service	Imports
1% increase in price in:	Textiles	**1.2116** **	0.8293	-1.3294**	1.8884***	2.4221***	0.1982**	0.7996***
		(0.549)	(0.5927)	(0.6349)	(0.536)	(0.8689)	(0.0975)	(0.277)
	Paper & Printing	0.1663	**2.2178*** **	-1.221***	0.6688***	-1.7544***	0.0014	0.1184**
		(0.1189)	(0.4568)	(0.4263)	(0.139)	(0.6305)	(0.0194)	(0.0525)
	Chemicals	-0.3855**	-1.7653***	**4.3741*** **	0.1529	0.8093	0.1034***	0.2762***
		(0.1841)	(0.6163)	(0.639)	(0.2119)	(0.852)	(0.033)	(0.0911)
	Machinery & Electronics	1.9224***	3.3944***	0.5367	**2.055*** **	0.4828	0.1015	0.9279***
		(0.5456)	(0.7053)	(0.744)	(0.7098)	(1.1484)	(0.1143)	(0.3356)
	Miscellaneous Manufactures	0.2821***	-1.0188***	0.3251	0.0552	**2.4294*** **	0.027*	0.1209***
		(0.1012)	(0.3661)	(0.3422)	(0.1314)	(0.8152)	(0.0151)	(0.0433)
	Service	1.8465**	0.0664	3.322***	0.9289	2.1599*	**0.1682**	0.8858
		(0.9084)	(0.9019)	(1.0605)	(1.0454)	(1.2094)	(0.4357)	(0.7957)
	Imports	-5.0435***	-3.7239**	-6.0075***	-5.7492***	-6.5491***	-0.5999	**-3.1288** **
		(1.747)	(1.6522)	(1.981)	(2.0795)	(2.3476)	(0.5389)	(1.3081)

Note: Bold face figures are own price elasticities. Standard errors are in parentheses.
All the cross price elasticities equal to the corresponding cross productivity elasticities, while the own price elasticities equals to own productivity elasticities minus one.
*, **, and *** indicate significance at 90%, 95%, and 99% confidence levels respectively.

Table 6: The Elasticity of Output with respect to Factors

		Effect in terms of percentage change in output in:						
		Textiles	Paper & Printing	Chemicals	Machinery & Electronics	Miscellaneous Manufactures	Service	Imports
1% change in:	Labor Endowment	1.9087	1.3877	-1.0537	2.2895	4.3631*	-1.4227	-1.7293
		(2.1468)	(2.0863)	(2.3869)	(2.3567)	(2.5158)	(0.9128)	(1.6018)
	Capital Endowment	-0.9087	-0.3877	2.0537	-1.2895	-3.3631	2.4227***	2.7293*
		(2.1468)	(2.0863)	(2.3869)	(2.3567)	(2.5158)	(0.9128)	(1.6018)

Note: Standard errors are in parentheses. The factor elasticity of industry n with respect to factor m equals the share of factor m plus the ratio of the corresponding estimated partial effect and the share of industry n.
*, **, and *** indicate significance at 90%, 95%, and 99% confidence levels respectively.