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# Productivity versus Endowments

## A Study of Singapore's Sectoral Growth, 1974–92

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Productivity and factor endowments both play an important role in growth in Singapore's manufacturing industries. But productivity is more important as a source of growth in the electronics industry, while factor endowments make a larger contribution in other industries.

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## Summary findings

Productivity and the Rybczynski effects of factor endowments have been highlighted as the two main reasons behind the growth of newly industrializing economies in East Asia. However, empirical studies at the aggregate level do not find support for these claims.

Focusing on Singapore's manufacturing industries, Kee estimates the contributions of productivity and factor endowments to sectoral growth. The results show that both are important. But productivity is more important as a source of growth in the electronics industry, while factor endowments make a larger contribution in other industries.

This paper—a product of Trade, Development Research Group—is part of a larger effort in the group to study the relationship between trade, productivity, and economic growth. Copies of the paper are available free from the World Bank, 1818 H Street NW, Washington, DC 20433. Please contact Lili Tabada, room MC3-333, telephone 202-473-6896, fax 202-522-1159, email address ltabada@worldbank.org. Policy Research Working Papers are also posted on the Web at http://econ.worldbank.org. The author may be contacted at hlkee@worldbank.org. November 2001. (35 pages)

# Productivity versus Endowments: A Study of Singapore's Sectoral Growth, 1974-92

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# 1 Introduction

The renewed interest in growth theory since the second half of the 1980s has stirred a huge volume of theoretical and empirical research on economic growth. As a result, being the fastest growing economies for the past three decades, the economic "miracles" of the four East Asian Newly Industrializing Economies (NIEs) have drawn a lot of attention.[1] However, the reasons for their extraordinary growth rates are still far from being settled.

There are two main theories that attempt to explain the growth of the East Asian NIEs. Both schools center around the growth effects of international trade, but differ in the channel by which trade influences growth. The first school originated from the new growth theory[2] emphasizes the role of productivity growth. One of the papers in this school, Lucas (1988) introduces the effect of trade on productivity growth through a learning-by-doing mechanism. He advocates 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) also 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 trade.

However, the controversial findings of Young (1992, 1995) appear to cast doubt on the productivity growth hypothesis of this school. Using growth accounting techniques, Young shows that there is in fact no sign of productivity growth in Singapore. The average annual growth rate of primal total factor productivity (TFP) of Singapore is almost zero for the period 1974 to 1992. The growth rates of primal TFP of the other three economies are also far from impressive. Based on Young's finding, Krugman (1994) claims that the growth of the East Asian NIEs is purely input driven, and is comparable to the miraculous growth experience of the Soviet Union in the

[1] The East Asian NIEs consist of Singapore, Hong Kong, Taiwan (China), and the Republic of Korea. Their average annual growth rates of GDP for the past three decades are around 8 percent.

[2] The new growth theory is also known as the endogenous growth theory.

1950s – an economic legacy that was not sustainable due to the inherent nature of diminishing returns of capital accumulation.

The recognition of this input driven growth pattern gave rise to the second school led by Findlay (1996) and Ventura (1997). 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 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 non-capital intensive industries. Diminishing returns to factor accumulation do not set in due to factor price equalization of international trade. Thus for this school, the East Asian miracle is driven by the rapid growth of factor endowments under the influence of international trade.

Empirical research at this area has been mainly focusing on the aggregate statistics of these economies, which overlooks the sectoral relocation of resources within the economy. Even in a recent work, when the dual approach is used to challenge Young's primal approach, Hsieh (1999) finds no evidence of diminishing returns to capital investment in Singapore. In order to capture the growth effect of international trade through the Rybczynski effects of factor accumulation, *sectoral* study in a general equilibrium setting is essential, which so far has been rare in the literature.

Using industry level data of Singapore's manufacturing sector, this paper sets out to test the two theories directly by comparing the relative contributions of productivity and factor accumulation to the growth of the industries in this sector. The methodology of this paper closely follows Harrigan (1997) with a twist in the empirical specification, which adopts a general equilibrium framework based on a translog revenue function.[3]

The estimation results show that for the electronics industry in the Singapore manufacturing sector, the growth effect of productivity clearly dominates that of factor accumulation. In contrast,

[3] Harrigan uses the translog revenue function to study the relationship between the patterns of international trade, factor endowments and productivity differences of the OECD countries.

factor accumulation plays a much bigger role for the rest of the industries in the sector, with the exception of the primary products industry. For the primary products industry, productivity and factor endowments are found to be equally important.

Thus, the results of this paper suggest that while the Rybczynski effects of factor accumulation are more relevant for the non-electronics industries, the new growth theory is supported by the electronics industry. In addition, given that nearly 60 percent of the value added of the manufacturing sector is generated in the electronics industry and the primary products industry, we can conclude that for the manufacturing sector as a whole, the role of productivity is at least as important as that of factor endowments.

This paper is organized as follows. A theoretical model utilizing a translog revenue function is developed in Section 2. Section 3 presents the data used and is followed by a description of the empirical strategy in Section 4. The regression results are shown in Section 5. Section 6 presents a direct comparison between the growth contribution of productivity and factor endowments, and Section 7 concludes this paper.

# 2 Theoretical Model

## 2.1 A General Equilibrium Set Up

Consider a neoclassical small open economy with fixed aggregate factor supplies, constant returns to scale production technology, and perfectly competitive good and factor markets.

Let $R_t$ be the total value added, or the GDP, of the economy in period $t$. There are $M$ factors and $N$ industries in this economy, with each industry producing only one good.[4] The general equilibrium of this economy is obtained by maximizing the total value added subject to all the production and resources constraints:

$$\begin{aligned} \max \quad R_t &= \mathbf{p}_t \mathbf{y}_t \\ s.t. \quad y_{nt} &= A_{nt} f_n(\mathbf{v}_{nt}), \quad n = 1, ..., N \end{aligned}$$

[4] To be precise, each industry produces one composite good.

$$\sum_{n=1}^{N} \mathbf{v}_{nt} = \mathbf{v}_t, \quad \mathbf{v}_t \in \mathbf{R}^M, \tag{1}$$

where $\mathbf{p}_t$ and $\mathbf{y}_t$ are the value added price and output vectors,[5] $A_{nt}$ is the Hicks neutral technology level of industry $n$, and $\mathbf{v}_t$ is the endowment vector of the economy.

The above program is equivalent to

$$\begin{aligned} \max \quad R_t &= \sum_{n=1}^{N} (p_{nt} A_{nt})\, \tilde{y}_{nt} \\ s.t. \quad \tilde{y}_{nt} &= f_n(\mathbf{v}_{nt}) \\ \sum_{n=1}^{N} \mathbf{v}_{nt} &= \mathbf{v}_t, \end{aligned} \tag{2}$$

which shows that productivity and prices enter the program multiplicatively.[6]

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 will result in the optimal value function

$$R_t^* = R^* (\mathbf{p}_t \mathbf{A}_t, \mathbf{v}_t), \tag{3}$$

where $*$ denotes the optimum, and $\mathbf{A}_t = diag\{A_{1t}, A_{2t}, ..., A_{Nt}\}$ is a $N \times N$ diagonal matrix that defines the level of Hicks neutral technology of the economy. The second order sufficient conditions also imply that $R^*$ is convex in $\mathbf{p}_t$, and $\mathbf{A}_t$.

By the envelope theorem, the output of industry $n$ is equal to the partial derivative of $R^*$ with respect to the price of $n$:

$$y_{nt}^* = \frac{\partial R^* (\mathbf{p}_t \mathbf{A}_t, \mathbf{v}_t)}{\partial p_{nt}} \tag{4}$$

$$\Rightarrow \quad y_{nt}^* = y_n^* (\mathbf{p}_t \mathbf{A}_t, \mathbf{v}_t), \quad \forall n = 1, ..., N. \tag{5}$$

Thus the output of industry $n$ depends on the value added prices and productivity of all industries. It also depends on the total factor endowments in the economy.[7]

[5] Throughout this paper, the term "output" refers to the real value added of the industry.

[6] This multiplicative property of productivity and prices is highlighted by Harrigan (1997), who suggests that empirically we can model productivity in a similar way as we model prices.

[7] Please notice that since we focus on the total value added of the economy, intermediate inputs and materials

If we multiply both sides of Equation (4) by $\frac{p_{nt}}{R_t^*}$, we will have an expression that defines the share of industry $n$ in total value added $R^*$,

$$
\begin{aligned}
s_{nt}^* &\equiv \frac{p_{nt}y_{nt}^*}{R_t^*} = \frac{\partial R_t^*}{\partial p_{nt}}\frac{p_{nt}}{R_t^*} \Rightarrow && (6)\\
s_{nt}^* &= \frac{\partial \ln R^*\left(\mathbf{p}_t\mathbf{A}_t, \mathbf{v}_t\right)}{\partial \ln p_{nt}} = s_n^*\left(\mathbf{p}_t\mathbf{A}_t, \mathbf{v}_t\right), \quad \forall n = 1, ..., N. && (7)
\end{aligned}
$$

In other words, the share of industry $n$ in total value added equals the elasticity of total value added with respect to the price of $n$. In addition, given the multiplicative nature of prices and productivity, for every industry $n$, the elasticities of total value added with respect to $p_{nt}$ and $A_{nt}$ equalize:

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

In other words, the share of industry $n$ also equals the elasticity of total value added with respect to productivity of $n$.

Hence in a general equilibrium framework, the share of industry $n$ in total value added of an economy depends not only on its own value added price and own technology, but also depends on the prices of all other goods, their technology and the total endowments of the economy.

With a similar method, we can also show that the share of factor $m$ in total value added equals the elasticity of total value added with respect to the quantity of $m$ :[8]

$$
s_{mt}^* = \frac{\partial \ln R_t^*}{\partial \ln v_{mt}}. \tag{8}
$$

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.

do not enter the output function explicitly. However, intermediate inputs and materials would still affect output indirectly via their influence on the value added prices. In other words, the value added price of a good reflects not only its market price, it also reflects the prices of intermediate inputs and materials.

[8] By the zero profit condition, or the national income identity, total value added equals total cost of primary factors at the optimum, $R_t^* = C_t^* = \mathbf{w}_t\mathbf{v}_t$. Thus, the share of factor $m$ in total value added is

$$
s_{mt}^* \equiv \frac{w_{mt}v_{mt}}{R_t^*} = \frac{w_{mt}v_{mt}}{C_t^*} \Rightarrow s_{mt}^* = \frac{\partial C_t^*}{\partial v_{mt}}\frac{v_{mt}}{C_t^*} = \frac{\partial R_t^*}{\partial v_{mt}}\frac{v_{mt}}{R_t^*} = \frac{\partial \ln R_t^*}{\partial \ln v_{mt}}, \ \forall m.
$$

Specifically, for every industry $n$ and $k$, $y^*_{nt}$ equals $\frac{s^*_{nt} R^*_t}{p_{nt}}$, and $s^*_{nt}$ equals $\frac{\partial \ln R^*(\mathbf{p}_t \mathbf{A}_t, \mathbf{v}_t)}{\partial \ln A_{nt}}$. Given the shares of $n$ and $k$, the elasticity of $n$'s output with respect to the productivity of $k$ , $\varepsilon^A_{nkt}$, is a *linear* function of the partial effect, $\frac{\partial s^*_{nt}}{\partial \ln A_{kt}}$:

$$\begin{aligned} \varepsilon^A_{nkt} &\equiv \frac{\partial \ln y^*_{nt}}{\partial \ln A_{kt}} \\ &= \frac{1}{s^*_{nt}} \frac{\partial s^*_{nt}}{\partial \ln A_{kt}} + s^*_{kt}, \quad \forall n, k = 1, ..., N. \end{aligned} \tag{9}$$

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

$$\begin{aligned} \varepsilon^f_{nmt} &\equiv \frac{\partial \ln y^*_{nt}}{\partial \ln v_{mt}} \\ &= \frac{1}{s^*_{nt}} \frac{\partial s^*_{nt}}{\partial \ln v_{mt}} + s^*_{mt}, \quad \forall n = 1, ..., N, \ \forall m = 1, ..., M. \end{aligned} \tag{10}$$

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

Thus, our empirical strategy would be first to estimate the partial effects of productivity and factor endowments on the output shares, namely $\frac{\partial s^*_{nt}}{\partial \ln A_{kt}}$ and $\frac{\partial s^*_{nt}}{\partial \ln v_{mt}}$. Subsequently, we will construct the elasticities using the corresponding estimated partial effects and shares, as according to Equations (9) and (10). Finally, for every industry $n$, we can then measure its portion of growth that is due to the growth of productivity in industry $k$, or the growth of factor $m$, as the product of the corresponding elasticity and growth rate:

$$\pi_{nkt} = \varepsilon^A_{nkt} \hat{A}_{kt}, \quad \forall n, k = 1, ..., N, \text{ and} \tag{11}$$

$$\pi_{nmt} = \varepsilon^f_{nmt} \hat{v}_{mt}, \quad \forall n = 1, ..., N, \ \forall m = 1, ..., M. \tag{12}$$

The convexity of $R^*$ in prices, which requires that all the own price elasticities be non-negative, can serve as a specification test of the model. The elasticity of the output of industry $n$ with respect to the price of industry $k$ is

$$\varepsilon^p_{nkt} \equiv \frac{\partial \ln y^*_{nt}}{\partial \ln p_{kt}}$$

$$= \begin{cases} \frac{1}{s^*_{nt}} \frac{\partial s^*_{nt}}{\partial \ln p_{kt}} + s^*_{kt} - 1, & \forall n = k, \quad n, k = 1, ..., N \\ \frac{1}{s^*_{nt}} \frac{\partial s^*_{nt}}{\partial \ln p_{kt}} + s^*_{kt}, & \forall n \neq k, \quad n, k = 1, ..., N \end{cases} \tag{13}$$

Moreover, the multiplicative property of productivity and prices in $s^*(\mathbf{p}_t\mathbf{A}_t, \mathbf{v}_t)$ implies that $\frac{\partial s^*_{nt}}{\partial \ln p_{kt}} = \frac{\partial s^*_{nt}}{\partial \ln A_{kt}}$. Hence, for every pair of industries $n$ and $k$, the cross price elasticity equals the cross productivity elasticity, while the own price elasticity equals the own productivity elasticity *minus one*. In other words, to make sure that all the own price elasticities are non-negative, all the own productivity elasticities have to be not less than one:

$$\varepsilon^A_{nnt} \geq 1, \quad \forall n. \tag{14}$$

This property can be best represented by Figure 1, which shows that a 10 percent increase in the productivity of industry $X$ will result in a more than 10 percent increase in the output of $X$, given the relative price of $X$ remains the same.

## 2.2 The Translog Revenue Function

To implement the model empirically, let us assume that $R^*$ is a translog function of productivity, value added prices and factor endowments, with productivity and value added prices of goods entering multiplicatively.

$$\begin{aligned} \ln R^*(\mathbf{p}_t\mathbf{A}_t, \mathbf{v}_t) &= a_{00} + \sum_{n=1}^{N} a_{0n} \ln(A_{nt}p_{nt}) + \frac{1}{2}\sum_{n=1}^{N}\sum_{k=1}^{N} a_{nk} \ln(A_{nt}p_{nt}) \ln(A_{kt}p_{kt}) \\ &+ \sum_{m=1}^{M} b_{0m} \ln v_{mt} + \frac{1}{2}\sum_{m=1}^{M}\sum_{l=1}^{M} b_{ml} \ln v_{mt} \ln v_{lt} \\ &+ \sum_{n=1}^{N}\sum_{m=1}^{M} c_{nm} \ln(A_{nt}p_{nt}) \ln v_{mt} \end{aligned} \tag{15}$$

This translog revenue function approach follows Harrigan (1997), which originated from the GNP function developed by Kohli (1991). Kohli's GNP function depends on prices of goods, the factor endowments of the economy as well a time index, $t$. The inclusion of time index into the GNP function is due to the assumption that technology or productivity level shifts over time. In other words, productivity does not enter the GNP function explicitly. Recognizing the multiplicative property of productivity and prices in theory, Harrigan (1997) explicitly introduced productivity into the translog GNP function, as shown in Equation (15) in order to study the effects of productivity and endowments differences on the trade patterns of the OECD countries.[9]

Without lost of generality, let $R^*$ be symmetric such that

$$\begin{aligned} a_{nk} &= a_{kn}, \quad \forall n, k = 1, ..., N, \\ b_{ml} &= b_{lm}, \quad \forall m, l = 1, ..., M. \end{aligned} \tag{16}$$

In addition, to ensure that $R^*$ is homogenous in degree one with respect to $\mathbf{p}_t\mathbf{A}_t$ and $\mathbf{v}_t$, we impose the following restrictions:

$$\begin{aligned} \sum_{n=1}^{N} a_{0n} &= 1, \ \sum_{k=1}^{N} a_{nk} = 0, \ \sum_{m=1}^{M} c_{nm} = 0, \quad \forall n = 1, ..., N, \\ \sum_{m=1}^{M} b_{0m} &= 1, \ \sum_{l=1}^{M} b_{ml} = 0, \ \sum_{n=1}^{N} c_{nm} = 0, \quad \forall m = 1, ..., M. \end{aligned} \tag{17}$$

Thus, the share of industry $n$ in total value added can be derived as the elasticity of $R^*$ with respect to $p_{nt}$ based on Equations (15), (16), and (17):

$$s_n^* (\mathbf{p}_t\mathbf{A}_t, \mathbf{v}_t) = a_{0n} + \sum_{k=1}^{N} a_{nk} \ln (A_{kt}p_{kt}) + \sum_{m=1}^{M} c_{nm} \ln v_{mt}, \quad \forall n = 1, ..., N, \tag{18}$$

with $a_{nk}$ and $c_{nm}$ representing the partial effects of productivity and factor endowments on output shares, $\frac{\partial s_{nt}^*}{\partial \ln A_{kt}}$ and $\frac{\partial s_{nt}^*}{\partial \ln v_{mt}}$, respectively.

In other words, for every industry $n$, $k$, and factor $m$, we can estimate the partial effects, $a_{nk}$ and $c_{nm}$, by regressing output share of $n$ on the levels of productivity, price indices, and factor endowments, as according to Equation (18).

Equation (18) involves the levels of productivity and price indices, which are known to be highly nonstationary according to Keller and Pedroni (1999). This causes the ordinary least squares estimates of $a_{nk}$ and $c_{nm}$ to be inefficient. Nevertheless, given that the partial effects,

[9] Subsequent work on production characteristics of US firms by Feenstra, Hanson and Swenson [1998] also employs a similar framework.

$a_{nk}$, and $c_{nm}$, are invariant over time, we can get around the nonstationarity problem by taking the first difference of Equation (18).[10]

Equation (19) presents the first difference of Equation (18) with the variable $\hat{x}_t$ denotes the growth rate of $x$.[11] It shows that for every industry $n$, $k$ and factor $m$, the change in share of industry $n$, $ds_n^*$, depends on the growth rates of productivity, $\hat{A}_{kt}$, value added prices, $\hat{p}_{kt}$, and factor endowments, $\hat{v}_{mt}$,

$$ds_n^*\left(\mathbf{p}_t\mathbf{A}_t, \mathbf{v}_t\right) = \sum_{k=1}^{N} a_{nk}\left(\hat{A}_{kt} + \hat{p}_{kt}\right) + \sum_{m=1}^{M} c_{nm}\hat{v}_{mt}, \quad \forall n = 1, ..., N. \tag{19}$$

Good measurements of the growth rate of productivity and value added price are quite difficult to obtain. Nevertheless, given that only the *sum* of the two growth rates, $\hat{A}_{kt} + \hat{p}_{kt}$, matters in Equation (19), we can avoid the potential measurement errors by utilizing the dual definition of total factor productivity (TFP),

$$\hat{A}_{kt} \equiv \overline{\hat{w}}_{kt} - \hat{p}_{kt}, \tag{20}$$

where $\overline{\hat{w}}_{kt} = \sum_{m=1}^{M} \theta_{mkt}\hat{w}_{mkt}$ denotes the weighted average of the growth rates of input prices, $w_m$. Here the cost shares of input in total value added, $\theta_m$, is used as the weights to construct $\overline{\hat{w}}_{kt}$. We can therefore rewrite Equation (19) as

$$ds_n^*\left(\mathbf{p}_t\mathbf{A}_t, \mathbf{v}_t\right) = \sum_{k=1}^{N} a_{nk}\overline{\hat{w}}_{kt} + \sum_{m=1}^{M} c_{nm}\hat{v}_{mt}, \quad \forall n = 1, ..., N. \tag{21}$$

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 (21) will form the basis of our estimation for $a_{nk}$ and $c_{nm}$, $\forall n, k, m$.

Finally, for every industry $n$, $k$, and factor $m$, the estimated productivity elasticity and the

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[10] To justify the first difference, Dickey-Fuller unit root tests have been performed on the levels of productivity, price index, and output share of each industry. The results indicate that for most of the series, the unit root hypothesis cannot be rejected at the 95% confidence level. On the other hand, the nonstationarity problem is less severe when the unit root test is applied to the first difference of the series. The detailed results on the tests are available upon request.

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

factor elasticity are respectively

$$\varepsilon^A_{nkt} = \frac{a_{nk}}{s^*_{nt}} + s^*_{kt}, \quad \text{and} \tag{22}$$

$$\varepsilon^f_{nmt} = \frac{c_{nm}}{s^*_{nt}} + s^*_{mt}. \tag{23}$$

# 3 Data

The data set focuses on Singapore's manufacturing sector, which consists of a panel of 7 industries for a period of 19 years, from 1974 to 1992.[12] Table 1 presents a description of the data set. All the data is published in the *Report of the Census of Industrial Production, Singapore* and the *Yearbook of Statistics of Singapore.*

There are two types of factor endowments: capital and labor. Capital inputs consist of land and buildings, and machinery capital.[13] Each type of capital is individually constructed by the standard perpetual inventory method with a different depreciation rate, as listed in Table 1. Labor inputs consist of workers, which represents the unskilled labor, and other employees, which represents the skilled labor.[14]

For each industry, the market price of each type of labor is measured as the respective type's unit cost of labor.[15] On the other hand, the market price of each type of capital is captured by the corresponding rental price of capital. It is constructed according to the internal nominal rate of return specification model developed by Jorgenson, Gollop and Fraumeni (1987). For a detailed

[12] According to the Yearbook of Statistics of Singapore, the share of foreign net investment commitments in the manufacturing sector was 84 percent in 1980. In 1992, the number decreased slightly to 80 percent. Thus it is appropriate to conclude that while most of the capital investment in the manufacturing sector is of foreign origin and there was not much of the reallocation of capital input between manufacturing sector and other sectors of the economy. On the other hand, the share of the Singapore's labor force working in the manufacturing sector was 30 percent in 1980. It dropped only slightly to 27 percent in 1992. This again demonstrates that there was limited reallocation of factors between the manufacturing and the non-manufacturing sectors. This justifies us focusing only on the manufacturing sector and the reallocation of factors between the industries within the manufacturing sector.

[13] Machinery capital includes machinery equipment, transport equipment, and office equipment.

[14] According the literature, the eduction level attained is a better measure for the skill level of a worker. However since there is no detailed published data on the education level of the labor force of Singapore, the skill level of a worker is thus classified according to their occupations in this paper.

[15] Some complications arise due to the reclassification of data for the later years, please refer to the appendix for the details.

description of the construction of the rental prices, please refer to the appendix.

The growth of the productivity of the industries obtained using Equation (20) is known as the growth rate of dual TFP. Under the assumptions of constant returns to scale and perfect competition, growth rate of dual TFP equals to the actual productivity growth:

$$\widehat{TFP}_{nt}^{dual} \equiv \hat{\overline{w}}_{nt} - \hat{p}_{nt} = \hat{A}_{nt}. \tag{24}$$

Table 2 presents a summary of the data set. According to Table 2, for the period 1974 to 1992, the average annual growth rate of value added of the industries varies between -1.5 percent and 16.1 percent. Thus there is a wide range of growth patterns in the manufacturing sector.

The largest industry in the manufacturing sector is the electronics industry. It produces nearly 50 percent of the total value added of the sector. In contrast, with a value added share of less than 2 percent, the rubber & wood industry is the smallest industry in the sector.

Data on the change in value added share of the industries shows that three of the seven industries have become relatively larger. Overall, the average annual change in the shares of the industries ranges from -0.4 percent to 0.9 percent.

The fastest growing industry in the sector is the electronics industry. It also has the highest average annual growth rate of productivity. Thus, if productivity is important in explaining output growth, as hypothesized by the new growth theory, we would expect to find some evidence in this industry.[16]

On the other hand, the average annual growth rate for prices in this industry is -1.9 percent, which means that the own price of goods produced in this industry have been declining. Intuition tells us that if own price has any effect on output growth, the effect would at best be modest in this industry.

The bottom half of Table 2 presents data on the endowments of the Singapore manufacturing sector. It is clear that both capital inputs and labor inputs are growing for the sector, and

[16] Note that the electronics industry is also the largest exporting industry in Singapore. If we expect trade to have an effect on growth, it should be the most evident in this industry.

since capital inputs as a whole grows nearly twice as fast as labor inputs, we will expect capital endowments to play a bigger role in explaining the sectoral growth patterns.

# 4 Empirical Strategy

In order to estimate the growth contributions of productivity and factor endowments of Singapore's manufacturing sector, the empirical model that consists of 7 equations, as described in Equation (21), will be fitted. Moreover, given that, for each equation, the dependent variable is the change in share of output of one of the seven industries in the sector, the error terms of the regressions will be correlated across equations by construction. Hence the proper way to implement the empirical model will be to estimate it as a system of equations using seemingly unrelated regressions.

Specifically, the following model will be fitted:

$$\begin{aligned} ds_{nt} &= a_n + \beta_n \hat{P}^M_{nt} + \sum_{k=1}^{7} a_{nk}\overline{\hat{w}}_{kt} + \sum_{m=1}^{4} c_{nm}\hat{v}_{mt} + u_{nt}, \quad \forall n = 1, ..., 7 && (25) \\ a_{nk} &= a_{kn}, \ \sum_{k=1}^{7} a_{nk} = 0, \ \sum_{m=1}^{4} c_{nm} = 0, \ \sum_{n=1}^{7} c_{nm} = 0, \quad \forall n, k, m. && (26) \end{aligned}$$

Equation (25) shows the seven equations to be estimated, and Equation (26) presents the thirty five restrictions. For each equation, the dependent variable is the change in share of output, with $u_n$ being the industry specific error term.

Independent variables for each equation include the weighted averages of the growth rates of input prices of all the seven industries, and the growth rates of the endowments of the four factors. These variables are derived directly from the theoretical model. Besides these variables, an industry specific effect, $a_n$, is introduced into each equation to control for the unobserved variation of the error terms that is specific to the industry.[17] In addition, in order to test the hypothesis that the effects of value added prices on output embrace the effects of intermediate inputs and materials, the growth rate of industry specific import prices, $\hat{P}^M_n$, is also introduced

[17] An example on the industry fixed effect would be the industry specific tax policy. For a detailed exposition of the theoretical model with the inclusion of the industry fixed effect, $a_n$, please refer to the Appendix.

into each equation.[18]

We will first estimate all the seven unrestricted equations presented in Equation (25) individually using OLS regressions. All the cross-equation restrictions in Equation (26) will then be tested. The results of the tests will form the basis of the estimation when the seven equations are fitted as a system of equations using seemingly unrelated regression.

Finally, since all the dependent variables add up to zero,

$$\sum_{k=1}^{N} ds_{nt} = 0, \quad \forall t = 1, ..., T,$$

the system of equations is singular. When dealing with a singular system of equations, the standard treatment in the literature is to exclude one of the equations from the system. Barten (1969) shows that the likelihood function of the system is completely irrelevant to which equation is dropped. Thus, we shall follow the standard treatment to drop one of the equations from Equation (25), and employ the maximum likelihood estimation, or equivalently the iterative seemingly unrelated regression, to fit the system.

# 5 Results

## 5.1 The Ordinary Least Squares Regressions

The results of the unrestricted OLS estimations are shown in Table 3. There are a total of seven columns in the table, each column 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 thirteen explanatory variables for each regression. These explanatory variables are categorized into two groups. The first consists of the weighted averages of the growth rates of input prices of the various industries, and the second includes the growth rates of the four factors and import prices. The industry fixed effects are presented as the constant terms in the table.

[18] Kohli (1991) shows that imports could be an important input of production for the GNP function. However, since we only focus on the value added of the industries in the theoretical model, import prices are not explicitly included earlier. Nevertheless, given that imports are parts of the intermediate inputs of production, any changes in import prices would still affect output through the changes of value added prices. In other words, movements of value added prices embrace the movements of import prices.

As shown in bold in Table 3, all of the estimated own productivity partial effects, $a_{nn}$, are positive. The 35 restrictions listed in Equation (26) are tested, and only the following 6 restrictions are rejected at the 95% confidence level:

$$a_{27} = a_{72}; \; a_{57} = a_{75}, \; \sum_{m=1}^{4} c_{5m} = 0, \; \sum_{k=1}^{7} a_{1k} = 0, \; \sum_{k=1}^{7} a_{2k} = 0, \; \sum_{k=1}^{7} a_{5k} = 0.$$

In other words, the symmetry property of the value added function is violated between the rubber & wood industry and the miscellaneous manufactures industry. It also fails to hold between the primary products industry and the miscellaneous manufactures industry. The constant returns to scale assumption is rejected by the primary products industry, while the homogeneity assumption of prices is rejected by the food industry, the rubber & wood industry, and the primary products industry.

Table 3 also shows that the growth rate of own import price is only significant in the food industry. Thus for the vast majority of the manufacturing sector, the hypothesis that imports do not enter the value added function cannot be rejected.

## 5.2 The Iterative Seemingly Unrelated Regressions

When the equations are estimated as a system using iterative SUR, those restrictions that were rejected in the previous OLS regressions are dropped. In addition, since the food industry is the only industry that has a significant estimate on the partial effect of import price , it is chosen to be dropped from the system to avoid singularity. The result of the estimation is presented in Table 4.

The set up of Table 4 is similar to that of Table 3, with the only difference being the exclusion of the growth rate of import price as an explanatory variable. All the partial effects of own productivity, which are shown in bold in Table 4, are positive and significant. This satisfies the theoretical restriction of the model that the partial effect of own productivity cannot be negative. Moreover, majority of the partial effects of cross productivity are also significant, which indicate the existence of the spillover effects of productivity across industries.[19]

The effects of factor endowments on the changes in shares of the industries are mixed. Skilled labor has a positive and significant effect on the growth of the primary products industry, while unskilled labor significantly contributes to the rubber & wood industry. Land and buildings are important in explaining the growth of the chemicals industry and the miscellaneous manufactures industry, while machinery capital is vital for the petroleum industry.

Before we move on to convert the estimated partial effects of productivity and factors into the corresponding elasticities, a close comparison can be drawn against Harrigan (1997).[20] First, unlike Harrigan (1997), all of the own productivity partial effects are estimated to be significantly positive in Table 4. This makes the regression results of this paper more conformable with the theory.

In addition, Harrigan finds that while highly educated workers and non-residential construction are associated with lower output shares, producer durables and moderately educated workers are associated with larger output shares. If we take highly educated workers as skilled labor, non-residential construction as land and buildings, producer durables as machinery capital, and moderately educated workers as unskilled labor, then the regression results shown in Table 4 actually present an interesting contrast. In our case, there is no factor that is only associated with either higher or lower output shares. We find positive and significant effects of the growth of skilled labor in the share of primary products industry. It also has positive effects on the share of the electronics industry and the miscellaneous manufactures industry even though the estimates are not significant. On the other hand, positive significant effects of land and buildings are found

[19] It may be concerned that non-negative own price elasticity is a necessary but not sufficient condition for the maximization program. Sufficient condition would requires the Hessian matrix to be negative definite. However, given that all the point estimates of the regression result are subject to individual standard errors, checking the property of the Hessian matrix using point estimates may not be too informative. Same problem applies to the attempt to generate the eigen values of the Hessian matrix from the estimated coefficients. In other words, the theoretical sufficient condition may not be empirically applicable.

[20] In order to study the effects of productivity and factor endowments on the trade pattern of the OECD countries, Harrigan estimated a system of equations similar to Equation (18). In other words, our current model is the first difference version of Harrigan (1997).

in the chemicals industry and the miscellaneous manufactures industry which again did not show up in Harrigan (1997).

## 5.3 The Estimated Growth Effects and Contributions

Since we are interested in the effects of productivity and factor endowments on the output of industries, we need to transform the estimated partial effects from Table 4 into the corresponding elasticities as according to Equations (22) and (23).

### 5.3.1 Productivity

Table 5 shows the estimated productivity elasticities of the six industries. 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.[21]

As shown in bold in Table 5, all of the estimated own productivity elasticities are positive and significant. The range of the estimated own productivity elasticities is between 0.9 and 1.3. In addition, none of the estimated own productivity elasticities is statistically significantly less than unity. In other words, for each of the six industries in the manufacturing sector, a 1 percent increase in the own productivity will induce at least 1 percent increase in the output of the industry. Given that own price elasticity equals own productivity elasticity minus one, the regression result satisfies the specification of the theoretical model that the own price elasticities should not be negative.[22]

All the figures in Table 5 that are not in bold are the cross productivity elasticities. Nearly half of the cross productivity elasticities are significant, which suggest the existence of the interindustry spillover effects of productivity growth. Note that, the estimated cross productivity elasticities are always less than the own productivity elasticities, which makes intuitive sense.

[21] For example, a 1 percent increase in productivity in the food industry causes the output of the rubber & wood industry to decrease by 0.35 percent. It also leads to a 0.02 percent increase in the output of the petroleum industry.

[22] Please refer to Equation (14).

Table 6 details the effects of productivity growth on output growth of the industries. With the exception of the last row, each cell shows the percentage change in output of the industry in the column solely due to the actual productivity growth of the industry in the row. As it is specified in Equation (11), the value of each cell equals to the value of the corresponding cell in Table 5 multiplied by the average annual growth rate of productivity of the industry in the row. The total changes in output of each industry due to the productivity growth of all the industries are presented in the last row, which sums up all the *statistically significant* effects in each column.

Overall productivity growth has significant and positive growth effects in the industries. Industry that benefits the most from the productivity growth in the industry is the electronics industry. The 5 percent average annual productivity growth in the industry causes its output to growth by 4.6 percent annually. In contrast, the industry that benefits the least from its own productivity growth is the petroleum industry. Its output only increases by 0.4 percent due to its productivity growth.

While the largest positive spillover effect of productivity is found between the miscellaneous manufactures industry and the primary products industry, the largest negative spillover effect is found between the miscellaneous manufactures industry and the rubber & wood industry. Productivity growth in the miscellaneous manufactures industry causes output of the primary products industry to increase by 2.6 percent annually. It also causes the output of the rubber & wood industry to decrease by 4 percent annually.

As shown in the last row of Table 6, when all the significant interindustry spillover effects on productivity are taken into consideration, the electronics industry remains the industry that benefits the most from the overall productivity growth of the sector. In contrast, the strong adverse spillover effect from the miscellaneous manufactures industry to the rubber & wood industry causes the total effect of productivity growth in the latter to be slightly negative. Overall productivity growth of the sector is also important in the primary products industry and the miscellaneous manufactures industry.

### 5.3.2 Factor Endowments

Table 7 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 factor endowments in an economy. Similar to Table 5, 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.

First let us look at the labor inputs. Output of the primary products industry, and the miscellaneous manufactures industry are responsive to the growth of skilled labor of the manufacturing sector. The estimated skilled labor elasticities of both industries are positive and significant. On the other hand, growth of the unskilled labor significantly benefits the rubber & wood industry, and significant hurts the primary products industry. Thus, by the definition of the Rybczynski elasticity, we can conclude that the primary products industry and the miscellaneous manufactures industry are relatively skilled labor intensive, while the rubber & wood industry is relatively unskilled labor intensive. This result seems reasonable given the nature of goods produced in the industries.

For the case of capital inputs, industries that respond positively to the growth of land and buildings are the chemicals industry, the electronics industry, and the miscellaneous manufactures industry. In other words, these industries use land and buildings intensively in their production. On the other hand, machinery capital has significant and positive impact on the petroleum industry and the electronics industry. Thus machinery capital is the intensive factor for these industries.

The estimated effects of factor endowments on output growth of the industries are presented in Table 8. Similar to Table 6, the value of each cell is constructed as shown in Equation (12). It shows the percentage change in output of the industry in the column solely due to the actual growth of the factor in the row. The total significant effects on output of each industry due to the growth of all factors are again presented in the last row.

Focusing only on the statistically significant estimates, it is apparent that the effects of factor endowments are generally greater than that of productivity for all the industries with the sole exception of the electronics industry. As shown in the last row, the total of the significant effects range from 3.5 percent in the primary products industry to 15.1 percent in the petroleum industry.

The growth of skilled labor on average increases the output of the primary products industry by nearly 5.8 percent annually. It also rises the output of the miscellaneous manufactures industry by 2.7 percent. On the other hand, the growth of unskilled labor on average increases the output of the rubber & wood industry by 4.7 percent, while it decreases the output of the primary products industry by 2.3 percent.

Relative to labor input, capital input generally plays a bigger role in the growth of the sector. The growth of land and buildings increases the output of the chemicals industry by 8.7 percent. It also rises the output of the miscellaneous manufactures industry and the electronics industry by 6.1 percent and 1.5 percent respectively. Similarly, machinery capital increases the output of the petroleum industry and the electronics industry by 15.1 percent and 2.2 percent respectively.

# 6 The Growth Decomposition

Table 9 presents the contributions of productivity and factor endowments on output growth of the manufacturing sector. In order to stay focused, we break down the contribution of productivity on output growth into the contribution of the own productivity and the cross productivity. Similarly, factor endowments are categorized into labor input and capital input. Labor input consists of skilled and unskilled labor, while capital input consists of land and buildings, and machinery capital.[23]

The value of each cell is the sum of the *statistically significant* contributions of the variable in the row on the output of the industry in the column.[24] In addition, beside productivity and factor endowments, the contributions of prices and industry fixed effects are also included in the table

[23] A detailed version of this table is included in the Appendix.

[24] The inclusion of those contributions which are not statistically significant into the calculation of total contribution does not change the qualitative result of the table. Please refer to the appendix for details.

for completeness.[25] For each industry, the contribution of productivity is constructed as ratio of the estimated effect of productivity from Table 6 to the total estimated effects of productivity, factor endowments, prices, and the fixed effect. The contributions of factor endowment, prices, and fixed effect are also constructed in a similar way.[26] In other words, the contributions of productivity, factor endowments, prices, and the fixed effect are normalized such that the sum of the contributions equals to 100 percent.

When we compare the contributions of productivity and factor endowments at a disaggregated level, labor input is found to be most important for the growth of the rubber and wood industry, and the primary products industry. Together these two industries produce 15 percent of the value added of the sector. On the other hand, capital input plays the largest role in the petroleum industry, the chemicals industry, and the miscellaneous manufactures industry. These industries account for 33 percent of the total value added. Finally, own productivity growth is the most prominent source of growth for the electronics industry which produces 46 percent of the value added of the sector. The effects of prices and fixed effects on all industries are negligible.

When focusing on the total contributions of productivity and factor endowments, Table 9 shows the contribution of factor endowments are generally greater than that of productivity, with the exception in the electronics industry. For the electronics industry, the contribution of productivity is greater than that of factor endowment by nearly 23 percent. With a large contribution from cross productivity, the role of productivity is also considerable high in the primary products industry. The contribution of productivity in this industry is only 8 percent smaller than that of factor endowments.

Finally, what can we conclude regarding the relative importance of productivity and factor

[25] As mentioned in the theoretical model, given the multiplicative property of productivity and prices in the value added function, $R^*(\mathbf{p}_t\mathbf{A}_t, \mathbf{v}_t)$, prices have a similar growth effect on output as productivity. However, since the growth rates of prices are small in the manufacturing sector, as shown in Table 2, the actual impact of prices on output growth is expected to be very modest. This is why we did not discuss about the growth effect of prices in the earlier section. For a detailed exposition on the growth effect of prices, please refer to the appendix.

[26] Please refer to the appendix for the details on the construction on the growth effect of the industry fixed effect.

endowments in the manufacturing sector as a whole ? As shown in Figure 2, the above industry evidence suggests that 46 percent of the value added of the manufacturing sector derives from an industry that relies most heavily on productivity as the source of growth. In contrast, approximately 35 percent of the total value added of the sector is originated from industries that are driven by the growth of factor endowments. The result also shows for 13 percent of the total value added of the sector, the role of productivity and factor endowments are almost equally important.[27]

# 7 Conclusion

What contributes most to the remarkable growth of Singapore's manufacturing sector? Productivity growth or factor accumulation? At an industry level, regression results indicate that productivity and factor endowments are both important in explaining the growth of the sector, from 1974 to 1992.

The role of productivity is most prominent in the electronics industry, which is also the largest and fastest growing industry in the sector. Productivity is almost as important as factor endowments in the primary products industry. As for the rest of the sector, the role of factor endowments is clearly dominant.

Thus this paper suggests that, for the period of 1974 to 1992, the Rybczynski effects of factor accumulation, as advocated by Ventura (1997) and Findlay (1996), play a more relevant role in explaining the growth of the non-electronics part of the sector. In contrast, the growth of the electronics industry is best explained by the productivity driven hypothesis of the new growth theory, as advocated by Lucas (1988, 1993). Finally, given the strong growth prospect of the electronics industry, productivity growth could play a even more important role in the Singapore's manufacturing sector in the future.

[27] The shares only add up to 96 percent because food industry in dropped from the regression.

# A Appendix

## A.1 Translog Revenue Function with Fixed Effects

To introduce fixed effects into the model, let consider the following specification:

$$\begin{aligned}\ln R^*(\mathbf{p}_t\mathbf{A}_t, \mathbf{v}_t) &= a_{00} + \sum_{n=1}^{N}(a_{0n} + a_n t)\ln(A_{nt}p_{nt}) + \frac{1}{2}\sum_{n=1}^{N}\sum_{k=1}^{N} a_{nk}\ln(A_{nt}p_{nt})\ln(A_{kt}p_{kt}) \\ &+ \sum_{m=1}^{M} b_{0m}\ln v_{mt} + \frac{1}{2}\sum_{m=1}^{M}\sum_{l=1}^{M} b_{ml}\ln v_{mt}\ln v_{lt} \\ &+ \sum_{n=1}^{N}\sum_{m=1}^{M} c_{nm}\ln(A_{nt}p_{nt})\ln v_{mt} \qquad (A.27)\end{aligned}$$

Equation (27) is identical to our original translog revenue function, Equation (15), except that $a_n t$ is added to the first summation of the function. Differentiate Equation (27) with respect to $\ln p_{nt}$ gives us the share equation:

$$s_n^*(\mathbf{p}_t\mathbf{A}_t, \mathbf{v}_t) = a_{0n} + a_n t + \sum_{k=1}^{N} a_{nk}\ln(A_{kt}p_{kt}) + \sum_{m=1}^{M} c_{nm}\ln v_{mt}, \quad \forall n = 1, ..., N. \qquad (A.28)$$

By first difference $s_n^*(\mathbf{p}_t\mathbf{A}_t, \mathbf{v}_t)$ and substituting the dual definition of TFP, we arrive at the following equation,

$$ds_{nt} = a_n + \sum_{k=1}^{7} a_{nk}\overline{\hat{w}}_{kt} + \sum_{m=1}^{4} c_{nm}\hat{v}_{mt} + u_{nt}, \ \forall n. \qquad (A.29)$$

which shows that the change in share of each industry depends on an industry fixed effect, $a_n$. Notice that an fixed effect in the change in share equation is equivalent to a trend effect in the share equation. The effect of fixed effect on output growth of industry $n$, is the growth of output that results from the change in time trend, $t$ :

$$\begin{aligned}\frac{\partial \ln y_{nt}^*}{\partial t} &= \frac{1}{s_{nt}^*}\frac{\partial s_{nt}}{\partial t} + \frac{\partial \ln R_t^*}{\partial t} \\ &= \frac{a_n}{s_{nt}^*} + \sum_{n=1}^{N} a_n \ln(A_{nt}p_{nt}) \qquad (A.30)\end{aligned}$$

Thus, with the appropriate normalization such that the average annual *levels* of productivity and prices of the industries are unity, the average annual growth rate of output in industry $n$ that is specific to the industry is

$$\frac{\partial \ln y_{nt}^*}{\partial t} = \frac{a_n}{s_n^*}, \quad \forall n. \qquad (A.31)$$

## A.2 Detailed Growth Decomposition

Table 10 is the detailed version of Table 9, which breaks down productivity, prices and factor endowments into smaller categories. Notice that the total contributions (figures in bold) in this table is not directly comparable to that of Table 9 as the latter only shows the statistically significant contributions.

## A.3 Rental Price of Capital

Assume that rate of return of capital, $\rho$, is the same for all assets, and $q_m$ is the price of investment good $m$, then rental price of capital good type $m$ in year $t$, $r_{mt}$, is

$$\begin{aligned} r_{mt} &= \frac{1 - u \cdot z_{mt}}{(1-u)(1-\tau_m)} \left[ q_{mt-1}\rho_t + \delta_m q_{mt} - (q_{mt} - q_{mt-1}) \right], \qquad \text{(A.32)} \\ \tau_m &= 0, \text{ for } m \neq \text{ land and buildings} \end{aligned}$$

where $u$ is the corporate income tax rate, $z$ is the present value of depreciation allowances for capital (for tax purposes), and $\tau_m$ is the property tax rate and is only applicable to land and buildings. Thus rental price of capital good $m$, consists of the returns to capital investment, $q_{mt-1}\rho_t$, plus the depreciation of capital, $\delta_m q_{mt}$, less the possible capital asset appreciation, $q_{mt} - q_{mt-1}$, and adjusted for the taxes.

The sum of the payments of each type of capital good, $r_{mt}K_{mt}$, equals value added less the payment to other input:

$$\sum_{m=1}^{M} r_{mt}K_{mt} = p_t y_t - w_t L_t \qquad \text{(A.33)}$$

Nominal rate of returns to capital, $\rho_t$, can be solved by substituting Equation (32) into Equation (33) , for all capital goods. To get $r_{mt}$, substitute the generated $\rho_t$ back to Equation (32).

## A.4 Data on Skilled and Unskilled Workers

The Report on the Census of Industrial Production (CIP) of Singapore publishes annual data on most of the variables needed in this study. However, since 1991, CIP of Singapore stop publishing detailed data on the breakdown of the employment structure of the industries. Only the total number of workers and the total remunerations are available. In order to maintain the size of the sample in this paper, data on workmen, other employees, and their respective wage bills need to be constructed.

First, the shares of workmen and other employees in total workers are calculated for period prior to 1991. A simple time series plot shows that the share of workmen has been declining while the share of other employee has been rising. Thus, as a conservative measure, for 1991 and 1992, I assume that the *growth rates* of the two shares stay at the 1990 level. Using the fixed growth rates, I constructed the corresponding shares of workmen and other employee in total workers in 1991 and 1992. A similar method is also applied to the construction of the corresponding of wage bills of the two types of workers.

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Table 1: Data Description

*Years:* 1974-1992

*Product classification system:* There are 7 industries which briefly correspond to the nine categories of the one-digit SITC (Rev.3). The categories, and their three-digit SIC constituent parts are listed below.

| Industry | Description | SITC | SIC | Description |
|---|---|---|---|---|
| **Ind. 1** | **Food** | 0 | 311/312 | Food |
| | | 1 | 313 | Beverage |
| | | 4 | 314 | Tobacco Products |
| **Ind. 2** | **Rubber & Wood** | 2 | 331 | Wood |
| | | | 355 | Rubber |
| **Ind. 3** | **Petroleum** | 3 | 353/354 | Petroleum |
| **Ind. 4** | **Chemicals** | 5 | 351 | Chemicals |
| | | | 352 | Paints & Pharmaceuticals |
| **Ind. 5** | **Primary Products** | 6 | 321 | Textiles |
| | | | 323 | Leather |
| | | | 341 | Paper |
| | | | 356 | Rubber Products |
| | | | 361/362 | Pottery & Glass |
| | | | 363 | Bricks, Tiles, and Clay |
| | | | 364 | Cement |
| | | | 365 | Concrete |
| | | | 369 | Non-Metallic Mineral |
| | | | 371 | Iron & Steel |
| | | | 372 | Non-Ferrous Metal |
| | | | 381 | Fabricated Metal |
| **Ind. 6** | **Electronics** | 7 | 382 | Machinery |
| | | | 383 | Electrical |
| | | | 384 | Electronic |
| | | | 385 | Transport Equipment |
| **Ind. 7** | **Miscellaneous Manufactures** | 8 | 322 | Wearing Apparel |
| | | | 324 | Footwear |
| | | | 332 | Furniture |
| | | | 342 | Printing & Publishing |
| | | | 357 | Plastic Products |
| | | | 386 | Instrumental Equipment |
| | | | 390 | Other Manufacturing |

*Share of each industry in total value added of manufacturing sector*

Source: Report of the Census of Industrial Production, Singapore (CIP)

*Prices of good: Singapore manufactured products price index*

Source: Yearbook of Statistics, Singapore

*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: CIP

*Factor endowments of manufacturing sector*

**Capital** Two types of capital input, generated by the perpentual inventory method:

1. Land and building, depreciation rate is 0.0361.
2. Machinery Capital: i) Machinery Equipment, depreciation rate is 0.1048.
   ii) Transport equipment, depreciation rate is 0.2935.
   iii) Office equipment, depreciation rate is 0.2729.

**Labor** Two types of labor input:

1. Workers, this refers to persons employed directly in the process of production.
2. Other employees, includes working directors, managers, supervisors, engineers, technicians, and clerical staff.

Source: CIP

Table 2: Data in a Glance, 1974 - 1992

| Variables | Years | All | Food | Rubber & Wood | Petroleum | Chemicals | Primary Products | Electronics | Miscellaneous Manufactures |
|---|---|---|---|---|---|---|---|---|---|
| Growth rate of output | 1975 | -6.4279 | -2.3624 | -2.8749 | -40.1142 | 13.9405 | 6.8579 | 14.1900 | 19.0940 |
| | 1992 | 13.0743 | 4.1541 | 7.3156 | 2.7736 | 1.2536 | 12.8418 | 15.8022 | 8.5858 |
| | **mean** | **10.7210** | **7.0722** | **-1.4918** | **3.1165** | **13.8727** | **9.4302** | **16.1355** | **10.8208** |
| Share of value added | 1975 | 100 | 7.0824 | 2.4430 | 17.7349 | 5.3430 | 14.6039 | 40.5911 | 12.2018 |
| | 1992 | 100 | 4.3733 | 0.3209 | 7.0254 | 9.3366 | 12.0677 | 53.8703 | 13.0053 |
| | **mean** | **100** | **5.6170** | **1.6510** | **12.4458** | **7.6192** | **13.2308** | **46.1436** | **13.2926** |
| Change in value added share | 1975 | 0 | 0.4301 | -0.3751 | -6.7709 | 0.6861 | -0.1960 | 3.7762 | 2.4496 |
| | 1992 | 0 | 0.0328 | -0.0296 | -1.6005 | -1.1009 | 0.3300 | 2.1653 | 0.2030 |
| | **mean** | **0** | **-0.1804** | **-0.2782** | **-0.3808** | **0.2024** | **-0.3036** | **0.9173** | **0.0233** |
| Growth rate of price of goods | 1975 | 3.0529 | 2.3417 | -13.5820 | 4.4017 | -5.4456 | -6.4005 | -8.6643 | 2.3717 |
| | 1992 | -7.0381 | 0.5696 | -10.2140 | -17.2613 | -8.7011 | -4.1414 | -5.6369 | -2.8838 |
| | **mean** | **0.1370** | **1.4804** | **0.3940** | **0.8004** | **1.6731** | **1.1893** | **-1.9211** | **1.8056** |
| Growth rate of productivity* | 1975 | -13.5900 | -6.6125 | 7.8259 | -36.3972 | 2.8993 | -3.6083 | 4.7604 | 0.3299 |
| | 1992 | 8.0000 | -2.7550 | 11.5253 | -2.2404 | -9.7166 | 8.6015 | 10.1351 | 5.0511 |
| | **mean** | **3.7700** | **0.2510** | **3.2130** | **0.4322** | **2.3935** | **1.8564** | **4.9854** | **3.5765** |

| Factor Endowments | | Skilled Labor** | Unskilled Labor** | Land & Building | Machinery Capital*** | Machinery Equipment | Transport Equipment | Office Equipment |
|---|---|---|---|---|---|---|---|---|
| Growth rates | 1975 | 0.7093 | -9.5296 | 15.2818 | 5.8056 | 5.7261 | 4.9535 | 9.6532 |
| | 1992 | 3.7816 | -1.0756 | 5.6359 | 8.4065 | 7.5986 | 8.2988 | 21.4859 |
| | **mean** | **4.9275** | **2.5903** | **8.6840** | **8.8582** | **8.7074** | **7.0689** | **13.5766** |
| Share in value added | 1975 | 14.3932 | 20.2161 | 30.2780 | 35.1140 | 32.9967 | 1.1755 | 0.9413 |
| | 1992 | 16.4942 | 17.1537 | 24.7725 | 41.5565 | 38.1369 | 1.0553 | 2.3643 |
| | **mean** | **14.3094** | **18.3434** | **26.7979** | **40.4978** | **37.8519** | **1.2583** | **1.3875** |

Notes: All values are in percentage terms. Mean values are the annual averages for the period 1974-1992.

*productivity is measured as the dual total factor productivity.

**There is no published data on Skilled Labor and Unskilled Labor for 1991 and 1992. For these years, the growth rates and the shares are constructed according to the descriptions in appendix.

***Machinery Capital consists of Machinery, Transport, and Office Equipment.

Table 3: Dependent Variables – Changes in Shares

Estimation method: OLS - unrestricted regression

Total system observations: 108

| | Independent Variables: | Eq (1) Food | Eq(2) Rubber & Wood | Eq(3) Petroleum | Eq(4) Chemicals | Eq(5) Primary Products | Eq(6) Electronics | Eq(7) Misc. |
|---|---|---|---|---|---|---|---|---|
| Weighted Average of the Growth Rates of Input Prices in: | Food | **0.0442***** | -0.0069 | 0.0338 | -0.018 | -0.0115 | 0.0016 | -0.0374*** |
| | | (0.0025) | (0.0049) | (0.0334) | (0.0153) | (0.0072) | (0.0361) | (0.011) |
| | Rubber & Wood | -0.0044*** | **0.0213***** | -0.0437* | 0.0045 | 0.0093** | 0.0052 | 0.0017 |
| | | (0.0013) | (0.003) | (0.0233) | (0.0083) | (0.0042) | (0.0213) | (0.0064) |
| | Petroleum | -0.0065*** | -0.0039 | **0.0818***** | 0.013 | -0.0294*** | -0.0357* | -0.0257*** |
| | | (0.0012) | (0.0025) | (0.017) | (0.0111) | (0.0041) | (0.0188) | (0.0086) |
| | Chemicals | -0.0091*** | -0.006* | -0.044 | **0.0816***** | 0.0092* | -0.0461 | -0.0063 |
| | | (0.0015) | (0.0032) | (0.0273) | (0.0147) | (0.0053) | (0.0338) | (0.0096) |
| | Primary Products | -0.004 | -0.0021 | -0.0042 | 0.0109 | **0.1106***** | -0.1379*** | 0.0041 |
| | | (0.0028) | (0.0062) | (0.0419) | (0.0211) | (0.0092) | (0.0532) | (0.0149) |
| | Electronics | -0.0178*** | -0.0006 | -0.0443 | -0.018 | -0.0393*** | **0.1887***** | -0.0441*** |
| | | (0.0029) | (0.006) | (0.04) | (0.0173) | (0.0088) | (0.0473) | (0.0138) |
| | Miscellaneous Manufactures | -0.0193*** | -0.0273** | 0.0829 | -0.034 | -0.1112*** | 0.0124 | **0.0246** |
| | | (0.0064) | (0.0128) | (0.1121) | (0.0404) | (0.0214) | (0.1106) | (0.0443) |
| Growth Rate of: | Skilled Labor | -0.0039 | -0.0191 | -0.2228 | -0.0204 | 0.0155 | 0.1903 | 0.0512 |
| | | (0.0109) | (0.0193) | (0.1411) | (0.0763) | (0.0306) | (0.1578) | (0.0489) |
| | Unskilled Labor | -0.0035 | 0.0314* | 0.1305 | -0.0772 | 0.0318 | -0.033 | 0.0061 |
| | | (0.0084) | (0.0168) | (0.123) | (0.0735) | (0.0265) | (0.1578) | (0.0544) |
| | Land & Building | 0.0203*** | -0.0008 | -0.0918 | 0.0502 | 0.1171*** | -0.1644* | 0.0826*** |
| | | (0.0067) | (0.0139) | (0.0945) | (0.0405) | (0.0202) | (0.0999) | (0.0321) |
| | Machinery Capital | -0.0173*** | -0.0151* | 0.1488*** | -0.0375 | 0.0413*** | -0.0582 | -0.0365 |
| | | (0.0045) | (0.0079) | (0.0545) | (0.0302) | (0.0118) | (0.062) | (0.0252) |
| | Own Import Price | -0.0079** | 0.0007 | -0.0019 | -0.0261 | -0.0181 | 0.0908 | 0.0821 |
| | | (0.004) | (0.0039) | (0.014) | (0.0316) | (0.0232) | (0.107) | (0.0556) |
| | Constant | 0.0004 | 0.0013 | -0.0085 | 0.0036 | -0.013*** | 0.0185** | -0.0049* |
| | | (0.0005) | (0.001) | (0.0081) | (0.003) | (0.0015) | (0.0073) | (0.0026) |
| | Sample size | 18 | 18 | 18 | 18 | 18 | 18 | 18 |
| | R-squared | 0.9861 | 0.9375 | 0.8956 | 0.8937 | 0.9599 | 0.8326 | 0.9015 |

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: Dependent Variables – Changes in Shares

Estimation method: MLE - iterative restricted seemingly unrelated regression

Total system observations: 108

| | Independent Variables: | Eq (1) Rubber & Wood | Eq(2) Petroleum | Eq(3) Chemicals | Eq(4) Primary Products | Eq(5) Electronics | Eq(5) Misc. |
|---|---|---|---|---|---|---|---|
| **Weighted Average of the Growth Rates of Input Prices in:** | Food | -0.0067** | -0.0042 | -0.0037 | 0.0072 | -0.003 | -0.0235*** |
| | | (0.0033) | (0.0028) | (0.0029) | (0.0087) | (0.0052) | (0.0057) |
| | Rubber & Wood | **0.0219***** | -0.0052*** | -0.0054** | 0.001 | -0.0027 | -0.0106*** |
| | | (0.0018) | (0.0019) | (0.0024) | (0.0039) | (0.0038) | (0.0035) |
| | Petroleum | -0.0052*** | **0.0949***** | -0.0084 | -0.03*** | -0.0288** | -0.0183*** |
| | | (0.0019) | (0.0125) | (0.006) | (0.0093) | (0.0123) | (0.005) |
| | Chemicals | -0.0054** | -0.0084 | **0.0633***** | -0.0011 | -0.0358*** | -0.0088* |
| | | (0.0024) | (0.006) | (0.0088) | (0.0093) | (0.0114) | (0.0046) |
| | Primary Products | 0.001 | -0.03*** | -0.0011 | **0.1118***** | -0.0921*** | 0.0145* |
| | | (0.0039) | (0.0093) | (0.0093) | (0.0199) | (0.0161) | (0.0076) |
| | Electronics | -0.0027 | -0.0288** | -0.0358*** | -0.0921*** | **0.2167***** | -0.0543*** |
| | | (0.0038) | (0.0123) | (0.0114) | (0.0161) | (0.021) | (0.0077) |
| | Miscellaneous Manufactures | -0.0207*** | -0.0183*** | -0.0088* | 0.0771*** | -0.0543*** | **0.1011***** |
| | | (0.0061) | (0.005) | (0.0046) | (0.0123) | (0.0077) | (0.0128) |
| **Growth Rate of:** | Skilled Labor | -0.0144 | -0.1492 | -0.0836 | 0.1361* | 0.0986 | 0.0528 |
| | | (0.0171) | (0.1235) | (0.0569) | (0.0751) | (0.1248) | (0.0436) |
| | Unskilled Labor | 0.027** | 0.0777 | 0.0222 | -0.1403** | 0.0168 | -0.0359 |
| | | (0.011) | (0.0696) | (0.0339) | (0.0444) | (0.072) | (0.0259) |
| | Land & Building | 0.0002 | -0.0908* | 0.0559** | -0.0389 | -0.0421 | 0.057*** |
| | | (0.0071) | (0.0503) | (0.0223) | (0.0304) | (0.0499) | (0.019) |
| | Machinery Capital | -0.0128* | 0.1623*** | 0.0054 | -0.0064 | -0.0733 | -0.0739*** |
| | | (0.0066) | (0.0526) | (0.0231) | (0.0306) | (0.0523) | (0.0182) |
| | Constant | 0.0005 | -0.0086*** | 0.0002 | -0.0051*** | 0.0154*** | -0.0011 |
| | | (0.0005) | (0.0026) | (0.0012) | (0.0018) | (0.0027) | (0.0009) |
| | Sample size | 18 | 18 | 18 | 18 | 18 | 18 |
| | R-squared | 0.9317 | 0.8555 | 0.8464 | 0.5968 | 0.7978 | 0.8568 |

Note: All figures in bold are the own partial effects of productivity. Standard errors are in parentheses.

Food Industry is dropped out of the system to avoid singularity.

*, **, and *** indicate significance at 90%, 95%, and 99% confidence levels respectively.

Table 5: The productivity elasticity

| 1% change in productivity in: | Effect in terms of percentage change in output in: Rubber & Wood | Petroleum | Chemicals | Primary Products | Electronics | Miscellaneous Manufactures |
|---|---|---|---|---|---|---|
| Food | -0.3483* | 0.0223 | 0.0079 | 0.1107* | 0.0498** | -0.1207*** |
| | (0.2015) | (0.0223) | (0.0386) | (0.0655) | (0.0195) | (0.0427) |
| Rubber & Wood | **1.3425*****  | -0.0253* | -0.055* | 0.0243 | 0.0107 | -0.0634** |
| | (0.1112) | (0.0154) | (0.0318) | (0.0291) | (0.0094) | (0.0266) |
| Petroleum | -0.1904* | **0.8873***** | 0.0145 | -0.1025 | 0.0621** | -0.0134 |
| | (0.1164) | (0.1004) | (0.0784) | (0.0706) | (0.0279) | (0.0377) |
| Chemicals | -0.2538* | 0.0089 | **0.9066***** | 0.0677 | -0.0015 | 0.0101 |
| | (0.1468) | (0.048) | (0.1157) | (0.0704) | (0.0263) | (0.0349) |
| Primary Products | 0.1947 | -0.109 | 0.1175 | **0.9773***** | -0.0673** | 0.2416*** |
| | (0.2335) | (0.075) | (0.1222) | (0.1506) | (0.0301) | (0.0572) |
| Electronics | 0.2986 | 0.2301** | -0.0091 | -0.2347* | **0.9311***** | 0.0526 |
| | (0.23) | (0.0989) | (0.1502) | (0.1217) | (0.0455) | (0.0581) |
| Miscellaneous Manufactures | -1.1236*** | -0.0143 | 0.0176 | 0.7158*** | 0.0152 | **0.8932***** |
| | (0.3717) | (0.0403) | (0.0608) | (0.0929) | (0.0198) | (0.0962) |

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 (from Table IV) to the share of industry n.
*, **, and *** indicate significance at 90%, 95%, and 99% confidence levels respectively.

Figure 1: The Effect of a 10 Percent Increase in Productivity of Industry X

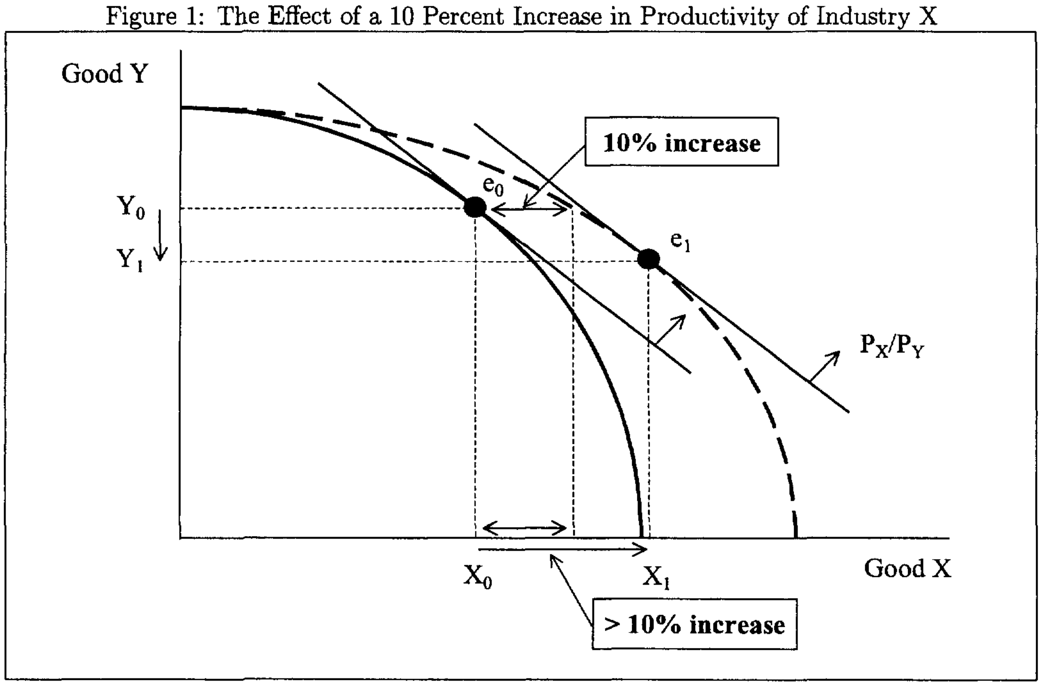


Table 6: The effects of productivity on output growth

| Change in productivity in: | Rubber & Wood | Petroleum | Chemicals | Primary Products | Electronics | Miscellaneous Manufactures |
|---|---|---|---|---|---|---|
| | **Effect in terms of percentage change in output in:** | | | | | |
| Food | -0.0874* | 0.0056 | 0.002 | 0.0278* | 0.0125** | -0.0303*** |
| | (0.0506) | (0.0056) | (0.0097) | (0.0165) | (0.0049) | (0.0107) |
| Rubber & Wood | **4.3133*****| -0.0812* | -0.1767* | 0.0781 | 0.0343 | -0.2036** |
| | (0.3574) | (0.0496) | (0.1022) | (0.0936) | (0.0301) | (0.0356) |
| Petroleum | -0.0823* | **0.3835***** | 0.0063 | -0.0443 | 0.0268** | -0.0058 |
| | (0.0503) | (0.0434) | (0.0339) | (0.0305) | (0.0121) | (0.0163) |
| Chemicals | -0.6076* | 0.0212 | **2.17**** | 0.1619 | -0.0036 | 0.0241 |
| | (0.3513) | (0.1149) | (0.277) | (0.1684) | (0.0629) | (0.0834) |
| Primary Products | 0.3615 | -0.2023 | 0.2181 | **1.8142***** | -0.1249** | 0.4485*** |
| | (0.4335) | (0.1392) | (0.2268) | (0.2796) | (0.0559) | (0.1062) |
| Electronics | 1.4884 | 1.1473** | -0.0452 | -1.1699* | **4.6419***** | 0.2623 |
| | (1.1468) | (0.493) | (0.7488) | (0.6066) | (0.227) | (0.2894) |
| Miscellaneous Manufactures | -4.0186*** | -0.0512 | 0.0629 | 2.5599*** | 0.0542 | **3.1945***** |
| | (1.3294) | (0.1442) | (0.2175) | (0.3324) | (0.0707) | (0.3441) |
| **Total Effect** | **-0.4826** | **1.4516** | **1.9933** | **3.2320** | **4.5563** | **3.4091** |

Note: Standard errors are in parentheses. Total effect refers to the sum of all significant estimates in each column. The effect of productivity growth in industry k on output in industry n equals the productivity elasticity of industry n with respect to industry k multiplied by the average annual productivity growth of industry k.
*, **, and *** indicate significance at 90%, 95%, and 99% confidence levels respectively.

Table 7: The factor elasticity

| 1% change in: | Rubber & Wood | Petroleum | Chemicals | Primary Products | Electronics | Miscellaneous Manufactures |
|---|---|---|---|---|---|---|
| | **Effect in terms of percentage change in output in:** | | | | | |
| Skilled Labor | -0.7314 | -1.0554 | -0.9542 | 1.1718** | 0.3569 | 0.5406* |
| | (1.0344) | (0.992) | (0.7473) | (0.5673) | (0.2705) | (0.328) |
| Unskilled Labor | 1.8199*** | 0.8076 | 0.4753 | -0.8767*** | 0.2198 | -0.0868 |
| | (0.6686) | (0.5592) | (0.4451) | (0.3352) | (0.156) | (0.1946) |
| Land & Building | 0.283 | -0.4617 | 1.002*** | -0.0258 | 0.1768* | 0.6969*** |
| | (0.4307) | (0.4043) | (0.2922) | (0.2296) | (0.1081) | (0.1429) |
| Machinery Capital | -0.372 | 1.7089*** | 0.4763 | 0.3566 | 0.2461** | -0.1513 |
| | (0.4026) | (0.4224) | (0.303) | (0.2316) | (0.1133) | (0.1368) |

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 (from Table IV) and the share of industry n.
*, **, and *** indicate significance at 90%, 95%, and 99% confidence levels respectively.

Table 8: The effects of factor endowments on output growth

| | | Effect in terms of percentage change in output in: | | | | | |
|---|---|---|---|---|---|---|---|
| | | Rubber & Wood | Petroleum | Chemicals | Primary Products | Electronics | Miscellaneous Manufactures |
| Change in: | Skilled Labor | -3.6041<br>(5.0969) | -5.2004<br>(4.888) | -4.7018<br>(3.6823) | 5.7742**<br>(2.7955) | 1.7585<br>(1.3327) | 2.664*<br>(1.6162) |
| | Unskilled Labor | 4.7141***<br>(1.732) | 2.092<br>(1.4486) | 1.2313<br>(1.153) | -2.2709***<br>(0.8683) | 0.5692<br>(0.4041) | -0.2248<br>(0.5042) |
| | Land & Building | 2.458<br>(3.7399) | -4.009<br>(3.5109) | 8.7015***<br>(2.5376) | -0.2245<br>(1.9939) | 1.535*<br>(0.939) | 6.0523***<br>(1.2413) |
| | Machinery Equipment | -3.2955<br>(3.566) | 15.1375***<br>(3.742) | 4.2194<br>(2.684) | 3.1591<br>(2.0518) | 2.18**<br>(1.0038) | -1.3404<br>(1.2114) |
| | **Total Effect** | **4.7141** | **15.1375** | **8.7015** | **3.5033** | **3.7150** | **8.7163** |

Note: Standard errors are in parentheses. Total effect refers to the sum of all significant estimates in each column. The effect of factor m growth on output in industry n equals the factor elasticity of industry n with respect to factor m multiplied by the average annual growth of factor m.
*, **, and *** indicate significance at 90%, 95%, and 99% confidence levels respectively.

Table 9: The contributions of productivity and factor endowments on output growth

| | Rubber & Wood | Petroleum | Chemicals | Primary Products | Electronics | Miscellaneous Manufactures |
|---|---|---|---|---|---|---|
| **Productivity** | **-38.77** | **15.80** | **18.68** | **70.22** | **39.12** | **27.92** |
| Own Productivity | 346.48 | 4.17 | 20.33 | 39.42 | 39.85 | 26.16 |
| Cross Productivity | -385.24 | 11.63 | -1.66 | 30.80 | -0.73 | 1.76 |
| **Factor Endowments** | **378.67** | **164.76** | **81.53** | **76.12** | **31.90** | **71.39** |
| Labor Input | 378.67 | - | - | 76.12 | - | 21.82 |
| Capital Input | - | 164.76 | 81.53 | - | 31.90 | 49.57 |
| **Prices of Goods** | **-239.91** | **-4.92** | **-0.20** | **37.87** | **0.37** | **0.69** |
| **Fixed Effect** | **-** | **-75.64** | **-** | **-84.21** | **28.61** | **-** |
| TOTAL | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |

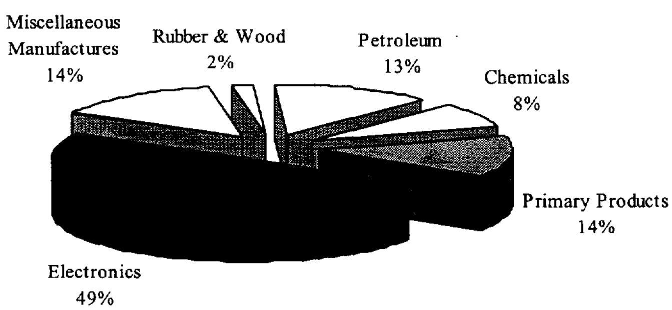
Note: All values are in percentage terms. The value of each cell refers to the total significant contributions of the variable in the row on the output of the industry in the column, and are normalized such that all the figures in bold add up to 100. Please refer to the text for the construction of the values. For a detailed version of this table please refer to the Appendix.
"-" refers to value is not statistically significant.

Table 10: The detailed contributions of productivity and factor endowments on output growth

| | Rubber & Wood | Petroleum | Chemicals | Primary Products | Electronics | Miscellaneous Manufactures |
|---|---|---|---|---|---|---|
| **Total** | | | | | | |
| **Productivity** | **94.3377** | **74.4029** | **18.6658** | **43.3309** | **32.6354** | **37.6455** |
| Food | -6.0327 | 0.3407* | 0.0165 | 0.3514** | 0.0879*** | -0.3092*** |
| | (3.3912) | (0.1799) | (0.0699) | (0.1745) | (0.0303) | (0.0991) |
| Rubber & Wood | 297.593*** | -4.9379*** | -1.4744** | 0.9868 | 0.2413 | -2.0771*** |
| | (23.9573) | (1.5923) | (0.7367) | (0.9927) | (0.1864) | (0.7906) |
| Petroleum | -5.6781* | 23.3297*** | 0.0523 | -0.5602* | 0.1886** | -0.0591 |
| | (3.3731) | (1.3925) | (0.2442) | (0.3233) | (0.0747) | (0.1507) |
| Chemicals | -41.919* | 1.2926 | 18.104*** | 2.0472 | -0.0252 | 0.2463 |
| | (23.5506) | (3.6852) | (1.9969) | (1.7856) | (0.3897) | (0.7711) |
| Primary Products | 24.9385 | -12.3109*** | 1.8197 | 22.9339*** | -0.8783** | 4.5762*** |
| | (29.0554) | (4.4676) | (1.6348) | (2.9652) | (0.3465) | (0.9814) |
| Electronics | 102.6941 | 69.8048*** | -0.3774 | -14.7885** | 32.6399*** | 2.6758 |
| | (76.8691) | (15.8195) | (5.3977) | (6.4327) | (1.4071) | (2.6748) |
| Miscellaneous Manufactures | -277.2583*** | -3.1161 | 0.5251 | 32.3603*** | 0.3811 | 32.5926*** |
| | (89.109) | (4.6261) | (1.5679) | (3.5249) | (0.4382) | (3.1797) |
| **Total Factor** | | | | | | |
| **Endowments** | **18.7979** | **487.9476** | **78.8428** | **81.3833** | **42.4897** | **72.9605** |
| Skilled Labor | -248.6645 | -316.398** | -39.2265 | 72.9926** | 12.3648 | 27.1798* |
| | (341.6495) | (156.8401) | (26.5437) | (29.6443) | (8.2594) | (14.9357) |
| Unskilled Labor | 325.2456*** | 127.2797*** | 10.2724 | -28.7063*** | 4.0026 | -2.2934 |
| | (116.0986) | (46.4809) | (8.3112) | (9.2079) | (2.5044) | (4.6593) |
| Land & Building | 169.5857 | -243.9113** | 72.595*** | -2.8377 | 10.7934* | 61.7498*** |
| | (250.6922) | (112.6533) | (18.2924) | (21.1438) | (5.8197) | (11.471) |
| Machinery Capital | -227.3689 | 920.9772*** | 35.2019* | 39.9346* | 15.3289** | -13.6757 |
| | (239.0331) | (120.0698) | (19.3474) | (21.7583) | (6.221) | (11.1949) |
| **Total** | | | | | | |
| **Price** | **-229.652** | **-39.5419** | **0.2861** | **24.2813** | **1.4398** | **-2.0823** |
| Food | -35.5756* | 2.0094* | 0.0972 | 2.0721** | 0.5181*** | -1.8236*** |
| | (19.9984) | (1.0609) | (0.4121) | (1.0288) | (0.1785) | (0.5847) |
| Rubber & Wood | 9.3107*** | -0.6056*** | -0.1808** | 0.121 | 0.0296 | -0.2547*** |
| | (2.9382) | (0.1953) | (0.0903) | (0.1217) | (0.0229) | (0.097) |
| Petroleum | -10.5159* | -5.4901** | 0.0968 | -1.0374* | 0.3493** | -0.1095 |
| | (6.247) | (2.579) | (0.4522) | (0.5988) | (0.1383) | (0.2792) |
| Chemicals | -29.3014* | 0.9035 | -1.3034 | 1.431 | -0.0176 | 0.1722 |
| | (16.4619) | (2.576) | (1.3959) | (1.2482) | (0.2724) | (0.539) |
| Primary Products | 15.9775 | -7.8873*** | 1.1658 | -0.3412 | -0.5627** | 2.9319*** |
| | (18.6151) | (2.8623) | (1.0474) | (1.8998) | (0.222) | (0.6288) |
| Electronics | -39.5723 | -26.8987*** | 0.1454 | 5.6986** | 0.9307* | -1.0311 |
| | (29.6209) | (6.0959) | (2.08) | (2.4788) | (0.5422) | (1.0307) |
| Miscellaneous Manufactures | -139.975*** | -1.5732 | 0.2651 | 16.3372*** | 0.1924 | -1.9675 |
| | (44.987) | (2.3355) | (0.7915) | (1.7796) | (0.2212) | (1.6053) |
| **Fixed Effect** | **2.1652** | **-4.2281*** ** | **0.0221** | **-0.49*** ** | **0.2344*** ** | **-0.0852** |
| **TOTAL** | 1 | 1 | 1 | 1 | 1 | 1 |

Note: All values are in percentage terms. The value of each cell refers to the total contributions of the variable in the row on the output of the industry in the column, and are normalized such that all the figures in bold add up to 100. Please refer to the text for the construction of the values.

Figure 2: The Contributions of Productivity and Factor Endowments




Notes: The size of pie represent the share of each industry in the total value added of the manufacturing sector.
Industry that is mainly factor endowments driven
Industry that is mainly productivity driven
Industry that is driven equally by factor endowments and productivity

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