Economic Growth and International Trade: The Case of Hong Kong

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Abstract

This paper estimates the major factors of growth of Hong Kong. Instead of determining the growth of total factor productivity only, this paper suggests a fairly new technique to measure the factors of growth directly. The growth factors that are found to be important for Hong Kong are physical capital accumulation, (negative) growth of unskilled workers, education, technology spillover (from foreign countries) through retained import of capital goods and inward direct investment, and learning by doing through import and domestic manufacturing production. The results have important policy implications.

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http://weber.u.washington.edu/~karyiu/.

1 Introduction

The recent development of the economic growth theory and the impressive growth of several East Asian economies in the previous decades have brought the attention of economics theorists and government planners to an old question: How can an economy grow and grow rapidly and persistently? This question has been challenging economists of every generation, and every answer suggested by any generation was deemed not satisfactory by later generations. The present generation is facing the same challenge and also feel the same about the answers suggested by previous generations. However, what make the difference between this generation and previous ones in searching for new answers to this old question are the development of the "new" growth theory and the experiences of these East Asian economies.

The "new" growth theory, which is sometimes labelled as the endogenous growth theory, has postulated several important factors of growth, and many attempts have been made to apply these factors to explain the growth of different economies at different times.[1] While the success of this theory on the empirical ground in explaining economic growth is mixed, one thing is clear: This theory has drawn economists' attention to several growth factors and shown how these factors can be modelled mathematically. At the same time, economists have also paid attention to the success stories of growth in some East Asian countries, the so called newly industrialized economies (NIEs). It is very rare in the history that an economy could grow with the tremendous rates the NIEs experienced, and for so long. The more amazing thing is that these economies are quite different in many aspects, and it is difficult to imagine why they are so successful in economic growth: They range from small ones like Hong Kong and Singapore to bigger ones like Taiwan and Korea; they range from extremely free economy like Hong Kong to fairly government regulated one like Korea; and they also range from economy like Hong Kong that experiences a shrinking manufacturing sector characterized by mainly light industries to one like Korea that depends vitally on heavy industries. Similarities between these economies can also be found: All are deeply influenced by Eastern culture and all depend extremely heavily

[1]There are too many important pieces of work to cite here. For a recent survey on endogenous growth and international trade, see Long and Wong (1997).

on foreign trade. The natural questions are, how could these economies grow so rapidly and for so long, and how may other economies learn from their experience?

Like so many other economics theories that have become controversial, the answers to why these economies grow so rapidly are far from unanimous. On the one side, Young (1992, 1994, and 1995) argue that the growth of these economies in the past decades is due mainly to factor accumulation while Kim and Lau (1994, 1996) estimate that the factor productivity growth rate of these economies in the previous decades was practically zero. On the other side, Färe and Grosskopf (1997), Dessus, Shea and Shi (1995), and Liang (1996) measure considerable growth in factor productivity in these economies. Furthermore, Van and Wan (1997) suggest a theory to argue that an Asian economy can grow with factor productivity improvement through learning by doing and physical capital accumulation. In their model, physical capital accumulation is the consequence, not the cause, of growth.

This paper focuses on one of these NIEs, Hong Kong, and tries to identify some of the factors that have contributed to the growth of the economy in the previous decades. Hong Kong is chosen as the case of study because we feel that it is not under any significant government interventions and regulations, and its economic structure is close in many ways to what the neoclassical theory describes. The purpose of this paper, however, is not to get into the controversy of zero versus positive (or small versus large) factor productivity growth; rather, it wants to suggest a fairly new technique to measure growth factors and to help us understand better the growth and trade experience of this economy.

The theoretical foundation of the approach used in this paper is based on the unified framework suggested in Long and Wong (1997). A general framework is constructed to incorporate several important factors of growth, and it reduces to several endogenous growth models suggested in the literature. The main feature of the econometric framework proposed here is that the factors of growth are included in the estimation. This allows us to better and more directly estimate the contributions of these factors of growth.

The present approach can be contrasted with the one that has been used in many papers. In the latter approach, factor productivity is measured as the residual in the estimation of a economy-wide production function, and then analysis is provided to explain how this residual may be due to factors such as education. In the present approach, we incorporate various factors of growth in the estimation directly.

Section 2 of this paper briefly describes the growth and trade experiences of Hong Kong. Section 3 presents the theoretical background of the estimation in this paper. Section 4 describes the econometric model, the choice of data, the estimation procedure and some preliminary results. The long-run factors of growth are examined in Section 5. Section 6 concludes.

2 Growth and Trade of Hong Kong

The main feature of Hong Kongs economic development during the past three decades or so is its tremendous rate of growth. Using the data from the Penn World Table (version 5.6) compiled by Summers and Heston, we present in Table 1 different measures of the growth of Hong Kong for the period of 1960-1992. For comparison purposes, the growth statistics of the United States are also included in the same table.

Between 1960 and 1992, Hong Kong's GDP at current market prices grew at an annual rate of more than 14 percent. When adjusted for population growth, the average annual growth rate of Hong Kong's per capita nominal GDP was nearly 12 percent. More accurate measures are those deflated for price changes, and the corresponding figures dropped down to 8.6 and 6.4 percent, respectively. These are still among the most impressive growth rates in the world. For comparison, we note that the growth rates of real GDP and real per capita GDP of the United States in the same period were 2.98 and 1.88 percent, respectively. A better measure of the growth of Hong Kong is the growth rate of its per worker GDP. Using this measure, Hong Kong's annual growth in this period dropped slightly down to 5.15 percent. This is still a very impressive growth performance, as we can note that the corresponding figure for the United States was 1.37 percent.

The growth of an economy can be partly explained in terms of the growth of its primary factors. For Hong Kong, physical capital and working population in approximately the same period have been growing rapidly, with annual growth rates of 5.32 and 2.66 percent, respectively. For comparison, we can note that the annual growth rates of physical capital and working population in the United States were 4.52 and 1.74 percent, respectively. However, Hong Kong still remains capital scarce as compared with the United States.

The rapid growth in the output of Hong Kong is accompanied by an equal or even more rapid expansion in manufactured exports. During the same period, the nominal value of Hong Kong's domestically produced exports grew at an average rate of 15.17 percent per annum and 9.47 percent in quantum terms.

One of the issues concerning growth that has been raised in the recent literature is how much the growth of factor productivity may have contributed to the growth of an economy. For the case of Hong Kong, we presented some of the estimates of the total factor productivity (TFP) of Hong Kong made by various people in Table 2. This is not an exhaustive survey, but we can get some ideas from these results.

While the results in different papers may not be compared directly since different periods of data and definitions of terms may have been used, the general impression one can get from these figures is that the TFP of Hong Kong has been growing fast, accounting for 2.1 to 2.5 percent of the growth of Hong Kong. Alternatively, the TFP has contributed to about 28 to 35 percent of the growth of Hong Kong. One exception is given in Kim and Lau (1994). Using one approach to estimating the aggregate production function of the economy, they found no technical progress in Hong Kong.

One common weakness of all these studies is that they do not determine the source of technical progress. As a result, they do not show where the TFP comes from, and the policy implications that one can draw from their studies are limited.

3 The Theoretical Background

We now present the theoretical framework that is used in this paper to estimate the factors of growth in Hong Kong. Suppose that the Hong Kong economy can be represented by a one-sector model in which a homogeneous good is produced.[2] There are a large number of competitive firms, employing capital and labor to produce the good. International trade and physical capital movement exist between Hong Kong and other countries. The economy is completely specialized, exporting the good it produces and importing other goods. This means that even though only one good is produced in the economy, the residents may consume more than one commodities.

[2]The assumption of one single sector producing a homogeneous product means that issues related to resource allocation between sectors, and horizontal and/or vertical innovation are not considered. Attempts have been made to extend one-sector models to multi-sectors. See Long and Wong (1997) for a recent survey.

The sectoral production function of the economy is represented by the following condition:

$$Y = AF(K, L), \tag{1}$$

where Y is the aggregate output, A is a technology index, K is the physical capital input, and L is the labor input measured in efficiency units. Unless confusion may arise, time subindice are dropped for simplicity. The labor input depends on two factors, the number of workers used, N, and the average human capital level of the workers, h, according to the following function:

$$L = g(h, N), \tag{2}$$

which is strictly increasing in both h and N. Substituting (2) into (1) gives

$$Y = AF(K, g(h, N)). \tag{3}$$

The formulation in (3) is quite general, indicating the following factors that could contribute to output: technology, physical capital, human capital, and number of workers.

Define $y \equiv Y/N$ as the per capita output (or output per worker). Condition (3) can be written as

$$y = AF(K, g(h, N))/\, N. \tag{4}$$

Denote the growth rate of a variable by a "hat;" for example, $\hat{y} \equiv d \log y/y$. Following the tradition, we represent the growth rate of the economy by the growth rate of the per capita output, that is, the growth of the conomy in any period is equal to $\widehat{y}$.

The popular approach to measuring the factors of growth in the literature to estimate the production function given in (3) directly.[3] Total factor productivity (TFP) growth, which is the recent focus of economists concerning the factors of growth, is then measured as the residual in the production function. In other words, TFP growth is something other than observed accumulation of primary inputs that contribute to the growth of an economy. After measuring the TFP, efforts are then made to determine the factors of TFP (for example, Sessus, Shea, and Shi, 1995).

[3]For example, Young (1992, 1994), Kim and Lau (1994, 1996) and Dessus, Shea and Shi (1995).

In this paper, we adopt a different approach to estimating TFP growth that is based on the unified model introduced in Long and Wong (1997). Differentiating both sides of (4) and rearranging the terms, the production function can be expressed as

$$\hat{y} = \widehat{A} + \epsilon_K \widehat{K} + \epsilon_L[\varphi_h \hat{h} + \varphi_N \widehat{N}] - \widehat{N}, \tag{5}$$

where ϵ_i is the elasticity of function $F(.,.)$ with respect to variable i, $i = K, L$, and φ_j is the elasticity of function $g(.,.)$ with respect to variable j. Define the ratio of capital to worker by $k \equiv K/N$. Rearranging the terms, condition (5) reduces to

$$\hat{y} = \widehat{A} + \epsilon_K \hat{k} - (1 - \epsilon_K - \epsilon_L \varphi_N)\widehat{N} + \epsilon_L \varphi_h \hat{h}. \tag{6}$$

The formulation in (6) highlights the factors of growth of an economy (the rate of growth of its per capita output). These growth factors are the growth of technology (in a Hicks' neutral sense), $\widehat{A}$, the growth of capital-worker ratio, $\hat{k}$, the growth of population (negative), $\widehat{N}$, and the growth of human capital, $\hat{h}$. To determine the factors of growth of this economy requires the estimation of the coefficients in equation (6).

The problem of a direct estimation of equation (6) is that some of the variables such as the technological index and human capital are not observable. In the present estimation, instead of measuring the technological index and amount of human capital, we try to determine the factors of $\widehat{A}$ and $\hat{h}$.[4]

Let us first focus on $\widehat{A}$ and present a brief survey of the factors of technology improvement.[5] Three major factors of technology improvement have been mentioned and analyzed: innovation, imitation, and technology transfer. Innovation is to improve the existing technology used by local firms for the purpose of (a) improving the productivitiy of factors of production (or a decrease in the cost of production); (b) increaasing the varieties of commodities used by firms or consumers — horizontal innovation; and (c) improving the quality of some existing commodities — vertical innovation. Innovation usually requires intentional research and development (R&D), that is, the use of resources.

[4]One approach is to estimate a time-series of human capital first, and then it is used in the direct estimation of a production function. For an example, see Pyo (1995).

[5]More details about some of the points presented below can be found in Wong (1995) and Long and Wong (1997).

Imitation and technology transfer are two more important and possibly cost-effective ways of improving technology for most developing countries. Both of them are dependent on the more advanced technologies in other countries. Imitation is the process of learning directly from the advanced technology in other countries. Resources are needed for imitation, and it is observed as research and development.[6] Technology transfer is more direct process than imitation of shifting technology in one country to another. There are four channels for technology transfer. The first one is spillovers, which is a less intentional and less direct way for local firms to learn from firms in other countries, and it exists through contacts with other firms. Contacts exist when a firm does business with other firms (foreign trade, for example), or cooperation with other firms (joint ventures, for example). Contagion effects refer to the possibility that the more contacts a firm has with other firms the easier it is to learn. Such contacts are usually reflected in the volume of trade and the number of joint ventures.[7] The second channel is technology licensing or purchase. This is the way through which a domestic firm can directly use the technology owned by other firms. The third channel of technology transfer is foreign direct investment, when a foreign firm with more advanced technology invests in the local economy. Local economy benefits not just from an increase in production but also from spillovers of technology to local firms. The fourth channel is international labor migration.[8] This is the case in which workers with more skills and experience (human capital) move to another country, bringing with them human capital. Spillovers may exist in the destination country.

Another unobservable variable is human capital. The advantage of the formulation in (6) is that instead of using the level of human capital, the growth rate of human capital is used, and it is more convenient to relate the latter to some other variables that can be measured.

In the literature, two sources of human capital accumulation have been emphasized. The first one is education (Uzawa, 1965; Lucas, 1988). It is postulated that education improves the skill level and knowledge of students, and

[6]Empirically, it may be difficult to distinguish between innovation and imitation, except in the case of the production of a fairly new product, the invention of a new production technology, or a new improvement in the quality of an existing product; in this case we can be sure that innovation exists.

[7]For an analysis of contagion effects of trade and foreign investment, see Findlay (1978).

[8]For an analysis of technology transfer through international labor migration, see Wong (1997).

through intergenerational spillovers, human capital accumulates over time. The increase in human capital allows the economy to grow. Another source of human capital accumulation is learning by doing (LBD) (Arrow, 1962; Lucas, 1988). It is argued that workers can gather experience and improve productivity through working. For an open economy, it is further argued that workers may get learning experience not only through its own work, but may also learn from workers in other countries through direct (through personal interactions, for example) and indirect (through the products and other media such as journals) contacts with them. In this respect, international trade, foreign direct investment and international labor migration are important sources of technology transfer.

4 Estimation of the Model

The rest of this paper focuses on estimating equation (6). As explained earlier, one difficulty of estimating it directly is that some of the variables are not observable. We now make use of the endogenous growth theory described above to link the unobservable variable in the equation to observable variables.

We first look at technological progress, $\widehat{A}$. Three channels through which A improves can be identified: innovation, imitation, and technology transfer. The first two requires intentional R&D activities and resources. In the case of Hong Kong, there are no economy-wide, industry-wide, or firm-wide R&D data in official publications. It is generally believed that R&D expenditures in Hong Kong are not significant.[9] Therefore we assume that innovation and imitation are not important in Hong Kong. We thus focus on technology transfer as the important channel through which technology in Hong Kong improves. As explained earlier, technology transfer can take place through spillovers, licensing, foreign direct investment, and international labor migration. Spillovers are not directly observed, and we try to relate it to some measure of the volume of trade. Licensing could be important, but unfortunately no reliable economy-wide data exist. Data on foreign direct investment are published by the government. International labor migration, according to Wong (1997), could be an important way of technology transfer if workers flow from source countries where the technologies are more advanced. For the case of Hong Kong, this refers to the workers (maining the returning

[9] For example, very few firms in Hong Kong have sizable research units.

migrants) coming from countries like the United States, Canada, and Australia. However, there are two main difficulties in trying to measure these effects: Returning migrants are getting more significant in the past five years, but the date series used in the estimation below ends at 1990; furthermore, the government does not publish a detailed break down of the data of the returning migrants. So we drop this factor in the following estimation.

As for the growth of human capital, $\widehat{h}$, we focus on education and learning by doing. For the effects of education on growth, we try different data to represent educaton: education expenditures, number of students, and so on. For learning by doing, we postulate that it comes from two sources: domestic production and foreign trade.

Equation (6) is estimated using annual data for the period 1971-1990. The Summers-Heston data are used to compute levels and growth rates of GDP per woker, capital per worker, and working population. Descriptions of the variables used in the following estimation are presented in the Appendix.

The technique we use is a form of error-correction specification. This error-correction specification (which can be obtained as a transformation of the traditional stock adjustment model) has two desirable features: (1) it avoids the problem of spurious relationship in the regression analysis; and (2) it captures both short-run and long-run relationships by including the changes in the variables and the lagged values of the variables on the right hand side. The equation is estimated in first difference form, with the lagged values of the explanatory variables and of the dependent variable on the right-hand side.

Prior to the specification and estimation of the error correction model, we pretest the variables in order to determine their stationarity property. The augmented Dickey-Fuller (ADF) test is used. The results are reported in Table 3.

The results indicate that all of the level series are nonstationary; while the difference series are stationary. Cointegration analysis is also performed by applying the two-step procedure of Engle and Granger (1987), and the results show that the output per worker, capital per worker, working population, education expenditure, and learning by doing are cointegrated.[10] This finding implies that an error-correction representation in the following form exists:

[10] Johansen's maximum likelihood procedure is more appropriate in testing cointegration in a multivariate case like ours. In fact, we have tried this procedure, but the resultant cointegrating vectors have variables taking on incorrect signs. This procedure is therefore not used in this paper.

$$\Delta y_t = \alpha e_{t-1} + \gamma \Delta \mathbf{x}_t + \sum_{j=1}^{m} \theta_j \Delta \mathbf{x}_{t-j} + \sum_{i=1}^{k} \delta_i \Delta y_{t-i} + \varepsilon_t, \tag{7}$$

where y_t is the output per worker ($RGDPN$), $\mathbf{x}_t$ is a vector which contains the following explanatory variables: the capital per worker (K/N), working population (N), government expenditure on education (EDU), and learning by doing (LBD).[11] The variable e_t are ordinary least squares residuals from the long-run equilibrium relation: $y_t = \boldsymbol{\beta}'\mathbf{x}_t + \xi_t$, and can be interpreted as the deviations of y_t from its long run path. The term ε_t is a white nose variable. The k higher-order autoregressive terms (Δy_{t-i}) are included to correct for serial correlation. Since the variables involved in equation (6) are expressed in growth rates, we may replace the variables y_t, $\mathbf{x}_t$, and their lagged values in equation (7) by their rates of growth, and write equation (7) in the following form:

$$\Delta \widehat{y}_t = \alpha e_{t-1} + \gamma \Delta \widehat{\mathbf{x}}_t + \sum_{j=1}^{m} \theta_j \Delta \widehat{\mathbf{x}}_{t-j} + \sum_{i=1}^{k} \delta_i \Delta \widehat{y}_{t-i} + \varepsilon_t, \tag{8}$$

where $\widehat{y}_t$ is the growth of output per worker ($gdpn$), and the vector $\widehat{\mathbf{x}}_t$ contains the growth rates of the explanatory variables in equation (7). The term e_t are the residuals from the long-run relationship: $\widehat{y}_t = \boldsymbol{\beta}'\widehat{\mathbf{x}}_t + \xi_t$. The parameters to be estimated are the scalars α, δ_i's and the conformable vectors θ and γ. All variables are in logarithms. Hence, the coefficients represent elasticities. All of these variables are expected to have positive impact on the growth of output per worker except the growth of the working population ($\widehat{N}$) whose effect is expected to be negative.

The error-correction equation (8) is estimated by a two-step procedure. First, we estimate the long-run relationship: $\widehat{y} = \boldsymbol{\beta}'\widehat{\mathbf{x}}_t + \xi_t$, in which the growth of output per worker ($gdpn$) is the dependent variable, and the growth of capital per worker ($\widehat{K/N}$), the growth of working population ($\widehat{N}$), the growth of education expenditure ($\widehat{EDU}$), and the growth of learning by doing ($\widehat{LBD}$) are the independent variables. The estimated values of $\boldsymbol{\beta}_i$, and their associated t values are reported in column 2 (denoted as LR1) of Table 4. The residuals from this regression are e_t.

[11] We have tried several ways of representing education and learning by doing that improve the growth of human capital in Hong Kong. The variables that give the best results are described in the appendix.

With the estimated residuals, we then estimate equation (8) by using the least squares method. The estimated error-correction model, denoted as EC1, is shown in column 2 of Table 5. In this equation, e_{t-1} is the estimated value of $\widehat{y}_{t-1} - \boldsymbol{\beta}'\widehat{\mathbf{x}}_{t-1}$, where the estimated $\boldsymbol{\beta}$ values are taken from Table 4. All coefficients for the explanatory variables have the right signs. With the exception of the lagged residual e_{t-1}, none of the coefficients is significant, suggesting the short-run effects of the growth of capital per worker $(\widehat{K/N})$, the growth of working population $(\widehat{N})$, and their lagged values are not significant. The F statistic is also insignificant. To deal with this problem, we drop the change in the growth of working population $(\Delta\widehat{N})$ and its lagged value $[(\Delta\widehat{N})_{-1}]$ from equation EC1, and reestimate the equation. The estimated model, denoted as EC2, is presented in column 3 of Table 5.

As can be seen from equation EC2, the lagged residuals e_{t-1} is now significnat at the 5 percent level. The coefficients of the change in the growth of capital per worker and its lagged value are still not significant, but the F statistic is significant at the 5 percent level. The estimated capital share in both equations is 0.21 which is far below the mean capital share of about 0.44 published by Hong Kong government.[12] It is also smaller than the estimates (ranging between 0.22 and 0.30) for Taiwan obtained by Dessus, Shea, and Shi (1995). The capital share is obviously under-estimated. In an attempt to solve this under-estimation problem, we add the growth of technology $(\widehat{A})$ to the vector $\widehat{\mathbf{x}}_t$, and use the growth of the foreign direct investment $(\widehat{FDI})$ as its proxy. Like other explanatory variables, the level FDI is found to be difference stationary using the ADF test (see Table 3). With the addition of this new variable, the cointegration relation still holds. We proceed to estimate the cointegration regression as well as the residuals from this equation. The estimated long-run relation, denoted as LR2, is reported in column 3 of Table 4.

The next step is to estimate the error-correction equation. The estimated error-correction equation, denoted by EC3 in Table 5, gives more satisfactory results. The capital share is estimated to be 0.34, which, though still outside the range of the official estimtes, is very close to that obtained for Taiwan. The equation fits the data quite well and there is no evidence of serial correlation. The coefficient values of the estimated residuals e_{t-1} and the change of

[12] Based on limited data sources, the Hong Kong Census and Statistics Department had published three annual estimates of percentage distribution of GDP at factor cost by factor income. The estimates are 42.9%, 40%, and 50.5% for 1970, 1975, and 1980, respectively. No up-to-date values are available due to the termination of the project after 1980.

the growth of capital per worker are found to be significant. The estimation results show that education, capital per woker, working population, learning by doing, and technology all have significant long-run effects on Hong Kong's output growth per worker.

5 Long-run Growth Factors

We now determine the factors on the long-run growth in Hong Kong. We use the estimated equation EC3. Long run here refers to the situation in which all variables such as the output per worker are growing at constant rates. This is often called the balanced growth path (BGP). In such a situation, all the first differences of the hatted variables are zero; for example, $\Delta\widehat{y} = \Delta(\widehat{K/N}) = 0$. As a result, the long run equation EC3 contains only the lagged residuals, e_{t-1}. In terms of the estimated variables in a BGP, it reduces to, after dropping the first-difference terms and rearranging the remaining terms,

$$0.78\widehat{y} = 0.78(0.01 + 0.34\widehat{K/N} - 0.46\widehat{N} + 0.42\widehat{EDU} + 0.09\widehat{LBD} + 0.02\widehat{FDI}). \tag{9}$$

Dividing both sides of equation (9) by 0.78, we have,

$$\widehat{y} = 0.34\widehat{K/N} - 0.46\widehat{N} + 0.42\widehat{EDU} + 0.09\widehat{LBD} + 0.02\widehat{FDI} + 0.01. \tag{10}$$

Note that equation (10) is exactly the estimated long-run cointegration equation LR2 shown in Table 4. The coefficient for each explanatory variable is the estimated long-run elasticity of the variable. For example, the estimated long-run education elasticity is 0.42, implying that an increase in education expenditure by 1 percent will, on average, lead to an increase of 0.42 percent in the growth of GDP per worker in the long run. Similarly, the estimated long-run elasticities with respect to the capital-worker ratio, the number of workers, learning by doing, and technology are 0.34, −0.46, 0.09, and 0.02, respectively. These numbers are also shown in the bottom of Table 5.

We now make use of these elasticities to estimate the effects on the long-run growth of the Hong Kong economy of the five explanatory variables: capital-worker ratio, workers, education, learning by doing, and technology. In the period from 1975 to 1990, the annual growth rate of the economy was

5.19 percent, while the average annual growth rates of the capital-worker ratio, the number of workers, education expenditure, learning by doing, and technology were 1.64, 3.15, 8.48, 17.57, and 12.93 percent, respectively. To determine the contributions of these five variables on the long-run growth of Hong Kong, we substitute the average growth rates of $\widehat{K/N}$, $\widehat{N}$, $\widehat{EDU}$, $\widehat{LBD}$, and $\widehat{FDI}$ into equation (10). It can be observed that the growth of capital-worker ratio has contributed to around 13.0 percent of the growth of Hong Kong in that period. The relative contributions of the number of workers, education, learning by doing, and technology to the economy's growth are estimated to be −32.14, 78.67, 32.14, and 6.42 percent, respectively.

The contribution of TFP to the growth of Hong Kong from 1975–1990 is summarized in Table 6. The last column of the table shows the contribution of each factor to the annual growth of the Hong Kong economy in that period, which is obtained by multiplying the long-run elasticity for each variable with the variable's annual growth rate. For example, EDU contributes to 3.56 percent of the growth of the Hong Kong. The contributions of LBD and FDI are 1.58 and 0.26 percent, respectively. The total contribution of these three factors is 5.4 percent. Our estimate of the TFP in this period is consistently and substantially higher than those reported in Table 2.

The contribution of EDU to the growth of Hong Kong economy is quite impressive. This is partly due to the fact that the expenditure on education has been rising rapidly, and partly due to its large long-run elasticity. Learning by doing and technological transfer via foreign direct investment are also important factors of growth. Note that in the present model, it is the growth of value added, imports, and foreign direct investment, not their levels, that contribute to growth.

A question often asked is, how has trade contributed to the growth of an economy? We try to make use of the present estimation to answer this question for the economy of Hong Kong. Let us consider a hypothetical case in which in the period from 1975 to 1990 both the volume of import and the level of foreign direct investment were frozen at their levels in 1975. We try to determine what the TFP might contribute to the growth of Hong Kong in the absence of trade effects.

First, we set the growth rate of FDI at zero percent. The learning by doing variable, LBD, depends on local manufacturing production and import. The observed annual growth rate of the manufacturing value-added in this period was 8.62 percent, while in this hypothetical case that of import was set to be zero percent. Using 8.62 percent as its annual growth rate, the contribution of LBD to growth drops down to 0.78 percent. The total contribution of TFP to growth becomes 4.34 percent, which represents a drop of 1.06 percent when no trade effects are assumed. The details are presented in Table 7.

6 Concluding Remarks

As we mentioned earlier in this paper, our present objective is to determine various factors of growth of Hong Kong. We have found that in addition to the endowment of primary factors such as physical capital and workers, government education expenditures, incoming foreign direct investment, domestic manufacturing production and import volume all contribute to the growth of Hong Kong. The part of the growth of the economy that is due to the latter four factors is usually collectively called the total factor productivity (TFP). Our estimate is that over the period of 1975 to 1990, the average contribution to growth of TFP is 5.4 percent per year. We all estimated that if there were no trade effects in this period, the average annual contribution to growth of TFP would be 4.34 percent, that is, a drop in the annual growth rate of Hong Kong by 1.06 percent.

Our estimation methodolgy is considerably different from what is usually used in the literature. Instead of estimating the residual in the production function that cannot be explained by changes in primary factors, we estimate directly different factors of growth. This approach allows us to find out more directly and explicitly what have contributed to the growth of the economy.

We believe that the existing residual-estimation methodolgy that has been used widely is subject to serious problems. If the model that we specify is right, then the approach of estimating residuals would create biasedness of the coefficients due to the misspecification error. Furthermore, since technical changes tend to induce capital accumulation, if they are not included in the production function to be estimated, the coefficient of capital per worker will tend to capture the average rate of technical change, overstating the elasticity of output with respect to capital input. In other words, this approach can easily underestimate the TFP. This could explain why the TFP that we estimated is higher than those figures obtained in some other papers.

One of the limitations of our approach is that the lack of quality data series on capital stock, learning by doing, and technology may have biased the estimates of our models. Moreover, since the ADF unit-root and cointegration tests require a substantial amount of data information which is not available in the present study, the power of the present tests may be limited.

Appendix

Variable Definitions and Data Sources

Variable	Description	Source and Construction
$RGDPN$	Real GDP per worker	Penn World Table (version 5.6) by Summers and Heston
$gdpn$	Growth of real GDP per worker	$gdpn = \Delta RGDPN$
K/N	Capital per worker	Penn World Table (version 5.6) by Summers and Heston
LBD	Learning by doing	$LBD = \log(VAM)_{t-1} + \log(M)_{t-1}$, where VAM is the value added of manufacturing sector, and M is real retained imports of capital goods.
EDU	Total government expenditure on education	*Hong Kong Annual Digest of Statistics*, 1981–1996 issues. Data were fiscal-year figures, and were transformed to calendar year base.
FDI	Foreign direct investment	*Overseas Investment in Hong Kong Manufacturing Industries,* various issues.
N	Working population (in 1000 persons)	Derived from K/N and $RGDPN$

Note: All variables are expressed in logarithms. All real variables are in 1985 international prices.

Table 1. Hong Kong's Growth Record

Variable	Hong Kong, %	United States %
Nominal GDP (1960-92)	14.05	7.95
Nominal GDP per capita(1960–92)	11.77	6.79
Real GDP (1960-92)	8.59	2.98
Real GDP per capita (1960-92)	6.42	1.88
Physical capital (K) (1965-90)	5.32	4.52
Working population (N)	2.66(1966–90)	1.74(1960–90)
Capital per worker (K/N)	2.59(1965–90)	2.71(1965–92)
GDP per worker ($GDPN$)	5.15(1965–90)	1.37(1960–90)

Table 2. Estimated TFP of Hong Kong

estimates	period	TFP growth	TFP's relative contribution
Young (1992)	1971–90	—	35%
Young (1994)	1970–85	2.5%	—
Young (1995)	1966–91	2.3%	—
Kim & Lau (1994)	1966–90	—	0%
Kim & Lau (1994)	1966–90	—	35%
Kim & Lau (1996)	1966–90	—	28.2%
Färe & Grosskopf (1997)	1975–90	2.1%	—

Table 3. ADF test statistics for individual series

Variables	lag order	level	lag order	first difference
$RGDPN$	2	−3.1434 (with trend)	2	−2.9317* (no trend)
K/N	0	−1.3324 (no trend)	0	−4.6362** (no trend)
N	0	−2.7084 (no trend)	0	−3.9734** (with trend)
EDU	0	−2.1679 (no trend)	0	−4.1829** (no trend)
LBD	0	−0.2596 (no trend)	0	−3.5921** (no trend)
FDI	0	−0.6755 (no trend)	0	−3.5289** (no trend)

The sample is from 1971 to 1990. Critical values are computed based on Table 1 of Mackinnon (1991). The symbols '*' and '**' indicate significant at the 10% and 5% level, respectively.

Table 4. The Long Run Regressions: $\widehat{y} = \boldsymbol{\beta}'\widehat{\mathbf{x}}_t + \xi_t$

Variables	**LR1**	**LR2**
Constant	0.02	0.01
	(0.66)	(0.26)
$\widehat{EDU}_{t-3}$	0.30	0.42*
	(1.30)	(1.94)
$\widehat{K/N}_t$	0.21	0.34
	(0.65)	(1.22)
$\widehat{N}_{t-3}$	−0.55	−0.46
	(−0.86)	(−0.85)
$\widehat{LBD}_t$	0.09	0.09
	(1.43)	(1.68)
$\widehat{FDI}_{t-3}$	–	0.02
	–	(0.27)

Note: '*' indicates significant at the 10% level.

Table 5. Estimated Error-Correction Equations

Dependent Variable: Change in the Growth of Output per worker ($\Delta gdpn$)

Variable	EC1	EC2	EC3
Lagged Levels:			
e_{t-1}	−0.89**	−0.87**	−0.78*
	(−2.02)	(−2.53)	(−1.83)
First Differences:			
$\Delta(\widehat{K/N})$	0.71	0.56	0.79**
	(1.09)	(1.57)	(3.12)
$\Delta(\widehat{K/N})_{t-1}$	0.32	0.32	0.24
	(0.87)	(0.90)	(1.02)
$\Delta\widehat{N}$	−0.52	—	—
	(−0.66)		
$\Delta(\widehat{N})_{t-1}$	−0.78	—	—
	(−0.69)		
$\Delta gdpn_{t-1}$	—	—	0.12
			(0.65)
$\Delta gdpn_{t-2}$	—	—	−0.57**
			(−3.33)
R-square	0.41	0.35	0.74
R-bar-square	0.22	0.26	0.64
$\widehat{\sigma}$	0.05	0.05	0.03
χ^2	0.09	0.02	0.77
F-statistic	F(4,12) = 2.12	F(2,14) = 3.86	F(4,10) = 7.21
Long-run elasticities			
EDU	0.30	0.30	0.42
K/N	0.21	0.21	0.34
N	−0.55	−0.55	−0.46
LBD	0.09	0.09	0.09
FDI	—	—	0.02

Note: Sample is from 1974–1990. Variables with a 'hat' denote growth. t-values are given in parentheses. $\widehat{\sigma}$ = standard error of regression, χ^2 = chi-square test (with 1 degree of freedom for serial correlation in the residuals. '*' and '**' indicate significant at the 10% and 5% levels, respectively.

Table 6. Contribution of TFP to Growth

Variable	**LR elasticity**	**Growth Rate**	**Contribution to Growth**
EDU	0.42	8.48%	3.56%
LBD	0.09	17.57%	1.58%
FDI	0.02	12.93%	0.26%
Total			5.40%

Table 7. Contribution of TFP to Growth with No Trade Effects

Variable	LR elasticity	Growth Rate	Contribution to Growth
EDU	0.42	8.48%	3.56%
LBD	0.09	8.62%	0.78%
FDI	0.02	0.00%	0.00%
Total			4.34%

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