What Explains the Industrial Revolution in East Asia? Evidence From the Factor Markets

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This paper presents dual estimates of total factor productivity growth (TFPG) for East Asian countries. While the dual estimates of TFPG for Korea and Hong Kong are similar to the primal estimates, they exceed the primal estimates by 1 percent a year for Taiwan and by more than 2 percent for Singapore. The reason for the large discrepancy for Singapore is because the return to capital has remained constant, despite the high rate of capital accumulation indicated by Singapore's national accounts. This discrepancy is not explained by financial market controls, capital income taxes, risk premium changes, and public investment subsidies. (*JEL* O11, O16, O47, O53)

The industrial revolution in several East Asian countries over the last three decades is one of the most important economic events in the postwar era. Several recent growth accounting exercises have found that their extraordinary rate of output growth was due primarily to an equally impressive rate of factor accumulation, with little due to technological progress. In Korea for example, estimates based on data from the national accounts indicate that the capital-output ratio has increased at an average rate of 3.4 percent a year from 1966 to 1990 while the rate of total factor productivity growth (TFPG) has averaged only 1.7 percent a year. To take another example, the capital-output ratio in Singapore has increased at an average rate of 2.8 percent a year from 1966 to 1990 while the rate of TFPG has averaged 0.2 percent a year.[1] Since these studies suggest that factor accumulation has been the lead actor in East Asia's growth, many economists have reached the conclusion that the industrial revolution in East Asia can largely be explained as transition dynamics in a neoclassical growth framework.[2] More broadly, these studies reinforce the message that a minimalist neoclassical growth model, perhaps augmented with human capital, is sufficient to explain why some countries are rich and others are poor.

The central point of this paper is that if the capital-output ratio in these countries has increased by the extent implied by their national accounts, the return to capital should have fallen dramatically as capital accumulation encounters diminishing returns.[3] It is useful to think about this as an accounting identity. Specifically, by dividing the share of payments to capital in total income by the capital-output ratio, we can obtain the rental price of capital and, assuming that capital is paid its marginal product, the marginal product of capital implied by the national accounts. Since the share of payments to capital in Korea and Singapore has remained roughly constant, the marginal product of cap-

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[1] These numbers are from Alwyn Young (1995), but also see Young (1992), Jong-Il Kim and Lawrence J. Lau (1994), and Susan M. Collins and Barry P. Bosworth (1996) for similar estimates.

[2] See, for example, N. Gregory Mankiw (1995) and Paul Krugman (1994).

[3] Young (1992) made the same observation about Singapore.

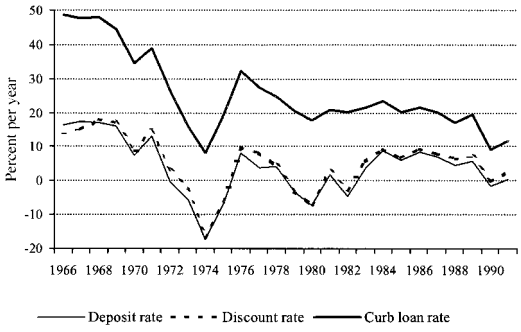

FIGURE 1. RETURN TO CAPITAL IN KOREA

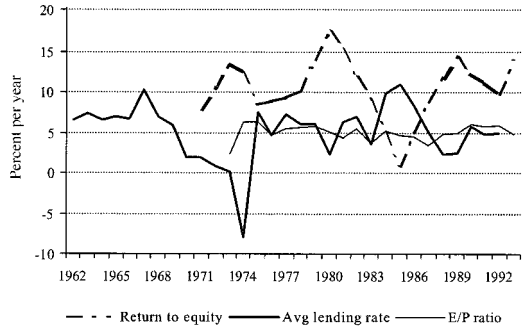

FIGURE 2. RETURN TO CAPITAL IN SINGAPORE

ital implied by Korea's and Singapore's national accounts must have *fallen* by 3.4 percent and 2.8 percent a year respectively, the same rate as the increase in the capital-output ratio.

In the case of Korea, there is overwhelming evidence that the marginal product of capital has in fact fallen by the extent implied by the national accounts. Figure 1 plots three alternative measures of the marginal product of capital in Korea. All three measures indicate that the marginal product of capital has fallen dramatically since the 1960's. In the case of Singapore, however, it is highly unlikely that the return to capital in Singapore has fallen by the magnitude indicated by the national accounts. First, with no restrictions on capital mobility in Singapore, private investors would not have been willing to continue investing in Singapore if their returns had fallen by such an extent, especially since the opportunity cost of these investments—world real interest rates—have more than doubled since the 1960's.[4] More importantly, the three market measures of real interest rates in Singapore presented in Figure 2 do not provide any evidence that the return to capital has fallen. This evidence suggests that while the data on investment expenditures in the Korean national accounts are reasonably accurate, Singapore's national accounts significantly overstate the amount of investment spending.

Of course, this simply reinforces what anybody who has ever worked with national accounts data knows: that the task of computing reliable national income statistics is an impossibly difficult one and that, even under the best circumstances, such statistics are riddled with large errors. As one solution to this problem, this paper presents price-based (dual) estimates of TFPG that do not rely on data from the national accounts. These price-based estimates of TFPG measure the outward shift of the *factor price frontier* as a share-weighted average of the growth rate of real factor prices. The basic idea is that any improvement in technology that causes an outward shift of the production possibilities frontier will also cause an outward shift of the factor price frontier. In a simple model with two factors, say capital and labor, the outward shift of the factor price frontier is simply a share-weighted average of the growth rate of real wages and the rental rate of capital. According to the dual growth accounting formula, if real wage growth is entirely due to capital accumulation, the return to capital must fall by the same magnitude as the rate of real wage growth.

These price-based estimates should be identical to the primal estimates as long as the factor price data are consistent with data from the national accounts.[5] For example, if we back out the rental rate from the national accounts by dividing the capital share by the capital-output ratio and use this estimate of the rental rate to measure the dual rate of TFPG, the resulting

[4] The estimates of world interest rates cited are GDP-weighted averages of real interest rates of the six major industrialized countries.

[5] See Zvi Griliches and Dale W. Jorgenson (1967) for an early exposition of the equivalence between the primal and dual growth accounting methodologies, and Matthew D. Shapiro (1987) for an application of the dual procedure.

estimate will be exactly the same as the primal estimate. However, we can use alternative measures of the rental rate to obtain estimates of TFPG that do not rely on data from the national accounts. Again, these estimates of TFPG will be identical to the primal estimates if the alternative estimates of the rental rate are consistent with the rental rate implied by the national accounts. In the case of Korea for example, the paper shows that the dual estimates of TFPG are very similar to the primal estimates since the alternative measures of the rental rate in Korea have fallen by roughly the same magnitude as that indicated by the national accounts. In contrast, the dual estimates of TFPG in Singapore are significantly higher than the primal estimates because the rental rate has remained roughly constant despite the sharp increase in the capital-output ratio indicated by the national accounts.

In an earlier companion paper (Hsieh, 1999), I presented a brief review of some of the ideas that are fully developed in the present paper. In addition, the estimates in the present paper make use of updated and more reliable data on factor prices in these countries and thus supersede those presented in my earlier paper.[6] This paper also presents several checks for the robustness of the results (which were not presented in my earlier paper), as well as detailed evidence to assess whether the return to capital in Singapore has fallen by the extent indicated by its national accounts. Finally, this paper provides a complete documentation of the data sources and a detailed explanation of how the factor prices used to compute the dual rates of TFPG are constructed from these sources.

The paper is organized as follows. Section I develops the methodology of the dual approach to growth accounting. Sections II and III implement this methodology using data on wages and returns to capital for the four East Asian countries. Sections IV and V assess whether changes in the risk premium, capital market controls, taxes on capital, implicit subsidies to private capital, or errors in Singapore's national accounts can explain why the rental rate in Singapore has not fallen despite the high rate of capital accumulation indicated by the national accounts. Section VI concludes.

I. The Dual Approach to Growth Accounting

This section derives the dual growth accounting procedure from the basic national income accounting identity that national output is equal to payments to the factors of production.[7] The dual growth accounting decomposition can also be derived from the properties of the cost function of any production function. The advantage of using the national income identity rather than the cost function approach is that the national income identity derivation makes it explicitly clear that the equivalence of the dual and primal procedures do not depend on any assumptions about the underlying technology or market structure.

Let us begin with the basic national income accounting identity that national output is equal to the payments to the factors of production, say capital and labor:

$$Y = rK + wL \tag{1}$$

where Y is aggregate output (or aggregate income), r is the real rental price of capital, w is the real wage, L is labor, and K is capital. Differentiating both sides of equation (1) with respect to time and dividing by Y, we get:

$$\hat{Y} = s_K(\hat{r} + \hat{K}) + s_L(\hat{w} + \hat{L}) \tag{2}$$

where $s_K \equiv rK/Y$ and $s_L \equiv wL/Y$ are the factor

[6] In addition to using more recent data to compute the rental price estimates, the two measures of real interest rates in Singapore are slightly different from that used in my earlier paper. Specifically, the return to equity from the Registry of Companies used in the earlier paper was only for the manufacturing sector, whereas the present paper uses the return to equity for the aggregate economy. In addition, the earnings-price ratio for Singapore used in the present paper is the E-P ratio for companies in Datastream's total market index for Singapore, which is a broader basket of companies than the Straits-Times index used in my earlier paper. Finally, the estimates of the rental price in this paper are computed from fitting a time trend to the rental price estimates, whereas the estimates in my earlier paper are simply averages of the annual growth rate of the rental price (calculated every year).

[7] I thank Susanto Basu and John Fernald for this derivation.

income shares.[8] By placing the terms involving the growth rates of factor quantities on the left-hand side of the equation, we get:

$$\hat{Y} - s_K\hat{K} - s_L\hat{L} = s_K\hat{r} + s_L\hat{w}. \tag{3}$$

The primal estimate of the Solow residual is the growth rate of output after subtracting the share-weighted growth in factor quantities:

$$SR_{primal} = \hat{Y} - s_K\hat{K} - s_L\hat{L}. \tag{4}$$

The dual measure of the Solow residual is the share-weighted growth in factor prices:

$$SR_{dual} = s_K\hat{r} + s_L\hat{w}. \tag{5}$$

It can be seen that SR_{primal} is the expression on the left side and SR_{dual} is the expression on the right side of equation (3). Hence, with only the condition that output equals factor incomes, we have the result that the primal and dual measures of the Solow residual are equal. No other assumptions are needed for this result: we do not need any assumptions about the form of the production function, bias of technological change, or relationship between factor prices and their social marginal products. We do not even need to assume that the data is correct. For example, if the capital stock data is wrong, the primal estimate of the Solow residual will clearly be a biased estimate of aggregate technological change. However, as long as the output and factor price data are consistently wrong, the dual measure of the Solow residual will be exactly equal to the primal measure and consequently, equally biased.

The two measures of the Solow residual can differ when national output exceeds the payments to capital and labor. Suppose, for example, that the national income accounting identity is given by $Y = rK + wL + \pi$.[9] When this is the case, the difference between the dual and primal estimates depends on how the capital share is measured. Typically, since we have better data on labor income, the capital share is measured as the residual of labor income. When π is positive, this estimate of the capital share is equal to the "true" capital share plus the profit share. When this biased estimate of the capital share is used to calculate the dual and primal estimates of the Solow residual, the primal estimates will exceed the dual estimates by $s_\pi(\hat{s}_\pi - \hat{s}_k)$ where $s_\pi \equiv \pi/Y$ and $s_K \equiv rK/Y$.[10] Therefore, as long as the data on factor prices are consistent with those from the national accounts, the two sets of TFPG estimates will be the same as long as the growth rate of the capital share is equal to that of the profit share. Since the sum of the capital share and the profit share in all the four East Asian countries has remained roughly constant since the 1960's, it is unlikely that the capital share and the profit share have changed by enough to result in a significant difference between the dual and primal estimates, particularly with a standard estimate of the profit share of roughly 5 to 10 percent of national income.[11] Therefore, any difference between the dual and primal estimates of TFPG is probably not due to imperfect competition or omitted factors of production, but rather due to inconsistencies between the data from the national accounts and the factor price data.

The dual procedure can be easily extended to allow for different types of labor and capital. To do this, I assume that the aggregate rental price of capital is itself a weighted average of the rental price of different types of capital:

$$\hat{r} = \sum_{i=1}^{n} s_{k_i}\hat{r}_i \tag{6}$$

[8] In this paper, a circumflex over a variable denotes the proportional growth rate.

[9] There are (at least) two possible interpretations of π. One interpretation is that firms have market power and π are their profits. An alternative interpretation is that π are the payments to the factors of production omitted from the growth accounting exercise.

[10] Taking the time derivative of both sides of this new national income accounting identity and dividing by Y yields $\hat{Y} = s_K(\hat{r} + \hat{K}) + s_L(\hat{w} + \hat{L}) + s_\pi\hat{\pi}$, where $s_L \equiv wL/Y$ is the labor share, $s_K \equiv rK/Y$ is the "true" capital share, and $s_\pi \equiv \pi/Y$ is the profit share. When we use $1 - wL/Y$ (instead of s_K) as the capital share for the dual and primal estimates, the relationship between the two estimates of the Solow residual is $SR_{primal} = SR_{dual} + s_\pi(\hat{s}_\pi - \hat{s}_K)$.

[11] Since the labor share has remained roughly constant in all four countries, the sum of the capital and profit share (which is one minus the labor share) must have remained unchanged as well.

where s_{k_i} is the share of payments and $\hat{r}_i$ is the growth rate of the rental price of type i capital. The aggregate wage is also a weighted average of the wage of different types of workers:

$$\hat{w} = \sum_{j=1}^{m} s_{L_j} \hat{w}_j \tag{7}$$

where s_{L_j} is the share of payments and $\hat{w}_j$ is the growth rate of wages of a worker of type j. These last two equations adjust for quality improvements in the aggregate capital and labor stocks by using the shares of payments to each factor input to weight the contribution of changes in the price of each factor input. For example, one possible explanation of higher real wages in East Asia is the improvements in labor quality, particularly due to rising educational levels. Equation (7) adjusts for this by measuring the wages of a *given* quality of labor across time for many different types of workers.[12] Although average real wages in East Asia have increased because the average worker is better educated, the growth rate of aggregate wages in equation (7) will be zero as long as the real wage of a worker with a given level of education does not change. The difference between the growth rate of average wages and the wage index in equation (7) can therefore be interpreted as the contribution of changes in labor quality. Similarly, although the aggregate rental price of capital may be affected by changes in the composition of the capital stock, the *quality-adjusted* aggregate rental price of capital [as computed in equation (6)] will not change as long as the rental price of each type of capital remains unchanged.

Finally, the dual framework for estimating TFPG assumes that producers are in a long-run equilibrium in which the quantities of factor inputs are at optimal levels. While this is a reasonable assumption in the long run, adjustment costs due to temporary shocks can drive a wedge between the rental rate and the marginal product of capital and thus bias the dual TFPG estimates in the short run. However, while adjustment costs are clearly important for short-run estimates of TFPG, they should not affect estimates of TFPG over the 20- to 30-year time period analyzed in this paper. Therefore, the estimates presented in this paper do not make any corrections for adjustment costs.

II. Measuring Factor Prices and Factor Shares

The dual rate of TFPG is calculated as a weighted average of the growth rate of different types of capital goods and wages of different types of workers, where the weights are the shares of payments to each factor.[13] Real wages of workers are differentiated by sex and by educational attainment (from four to six educational categories, depending on the country) computed from household surveys and the population censuses in the four countries. To compute the growth rate of real wages, I subtract the growth rate of the GDP deflator from the growth rate of nominal wages of each type of worker. The GDP deflator may be an inaccurate measure of the price of aggregate output, but the resulting bias in the growth rate of real wages in the dual calculation has the same effect on the growth rate of real output in the primal exercise.

Turning to the rental price of capital, I calculate the rental price of five categories of capital goods: residential buildings, nonresidential buildings, other construction, transport equipment, and machinery equipment. The rental price for capital good j is based on the standard Robert E. Hall-Jorgenson (1967) rental price formula:

$$\frac{r_j}{p} = \frac{p_j^k}{p} (i - \hat{p}_k + \delta_j) \tag{8}$$

where p_j^k/p is the relative price, $\hat{p}_k$ the inflation rate, and δ_j the depreciation rate of type j capital, and i is the nominal interest rate. This equation states that the rental rate of capital good j is equal to the product of its relative price and the real interest rate plus the depreciation

[12] This procedure, however, does not adjust for possible improvements in the *quality* of education.

[13] The Data Appendix provides additional details on the data sources.

rate.[14] When the relative price of capital is 1, equation (8) reduces to the familiar expression that the real rental price of capital is the real interest rate plus the depreciation rate.

To calculate the real rental price of each capital good j, I need estimates of the relative price of capital (p_j^k/p), the depreciation rate (δ_j), and the real interest rate ($i - \hat{p}_k$). The relative price of capital is measured as the ratio of the investment goods deflator of each capital good over the GDP deflator from the national accounts. The investment goods deflator may be inaccurate and result in misleading estimates of the real rental price of capital, but the same error will be reflected in the growth rate of the real capital stock in the primal exercise. Second, the depreciation rates of the five capital goods are taken from Charles R. Hulten and Frank C. Wykoff (1981).[15] The depreciation rate could also be incorrect, but the estimated growth rate of the rental price of capital will be unaffected as long as the gap between the depreciation rate and its true value does not change over time. When this is not the case, the resulting bias in the growth rate of the rental price will be exactly the same as the error in the growth rate of the real capital stock.

Third, I also need estimates of real interest rates to calculate the real rental price of capital. I use two methods to do this. One approach is to assume that all assets earn the same nominal return and subtract the rate of asset price inflation from this nominal rate. Another approach is to use a market-determined real rate of return such as the earnings-price (E-P) ratio.[16] I discuss each approach in turn.[17]

To estimate the real interest rate by subtracting the rate of asset price inflation from a nominal interest rate, I need the nominal returns of an asset whose returns are perfectly correlated with the returns of the country's capital stock. Since I do not have such an asset, I use the nominal returns of a number of different assets.[18] Although the returns on these assets are not perfectly correlated with those of a representative basket of the country's capital stock, as long as their betas and corresponding risk premium do not change over the 20–30-year time period analyzed in this paper, the *growth* rate of their nominal returns will equal the *growth* rate of nominal returns on a representative basket of the country's capital stock. In addition, I have several measures of nominal interest rates for each country, ranging from

[14] It is straightforward to adjust the Hall-Jorgenson rental price formula in equation (8) to incorporate the effects of taxes. Specifically, allowing for the effect of taxes, the rental price of type j capital is given by

$$\frac{r_j}{p} = \frac{p_j^k}{p}\,(i - \hat{p}_k + \delta_j)\left(\frac{1 - uz_j - k_j}{1 - u}\right) + b_j$$

where b_j is the effective rate of property taxes, u is the corporate income tax rate, z_j is the present value of depreciation deductions, and k_j is the effective rate of the investment tax credit. I do not have enough information on tax policies in these countries to calculate tax-adjusted rental prices. However, in Section IV, I use aggregate data on corporate income taxes in Singapore to assess the extent to which my estimates of the rental price of capital in Singapore are biased because I do not make an adjustment for taxes.

[15] The depreciation rates are 1.3 percent for residential buildings, 2.9 percent for nonresidential buildings, 2.1 percent for other construction, 18.2 percent for transportation equipment, and 13.8 percent for machinery equipment.

[16] Hall (1990) uses a similar procedure (he uses the dividend-price ratio as a real interest rate) to calculate the rental price of capital.

[17] See Michael Harper et al. (1989) for a comprehensive discussion of alternative methods for calculating the real interest rate. Although they present five different procedures for doing this, these five methods can be categorized as either an external rate of return specification or an internal rate of return specification. The procedure I use of calculating the real interest rate by subtracting expected inflation from a nominal rate is Harper et al.'s "external nominal rate of return" specification. I cannot adopt any of their "internal rate of return" specifications since I do not have a direct measure of the income accruing to each type of capital good (Harper et al. calculate an internal rate of return for each *sector*, not for each type of capital). However, since the E-P ratio and the return to equity is the internal rate of return of the firms covered by these measures, my alternative procedure of using the E-P ratio and the return to equity as the real rate of return of each capital good is a combination of an "internal rate of return" and an "external nominal rate of return" specification. Finally, it clearly does not make sense for me to use Harper et al.'s "constant external rate of return" specification since, by assumption, this procedure precludes me from using market data to measure the extent to which the return to capital has changed in the four East Asian countries.

[18] Specifically, I use the loan rate in informal financial markets, the one-year time deposit rate, the loan rate on secured loans, and the three-month treasury bill yield in Taiwan. For Hong Kong, I use the call money rate and the best lending rate of the Hong Kong and Shanghai Bank. For Korea, I use the curb market loan rate, the one-year time deposit rate, and the discount rate on commercial bills. In Singapore, I use the average lending rate of commercial banks.

lending rates of commercial banks to interest rates in informal financial markets, and can check the sensitivity of the dual estimates to these different measures. To calculate a real interest rate from these nominal interest rates, I assume perfect foresight and subtract the average *ex post* rate of asset price inflation from the nominal interest rate.[19]

I also estimate real interest rates by using market-determined real interest rates. As measures of the real interest rate, I use the E-P ratio of firms in the stock markets of Hong Kong and Singapore and direct estimates of the return on equity from the firm-level records in the Singapore Registry of Companies. The E-P ratio in Hong Kong and Singapore measure the return to capital of firms listed in the stock markets in these two economies, but these firms are clearly not a representative sample of firms in these economies. In contrast, the estimates of the return on equity in Singapore are compiled from annual reports filed by every incorporated business in Singapore, with the exception of partnerships and self-proprietorships, and thus provide a reasonably accurate measure of the aggregate return to capital in Singapore.

More generally, the E-P ratio is a good estimate of the real cost of capital when the companies are only able to invest in projects that yield the market rate of return. However, it will understate the real cost of capital if the firm is expected to make investments that yield returns above the market rate.[20] On the other hand, there are also firms whose investments are expected to yield returns that are below the market rate that should compensate for the firms that have extremely profitable investment opportunities.

Turning to the factor shares, the share of payments to different types of worker (again, differentiated by sex and education) is calculated as the product of the average wage and the number of workers in each category divided by total payments to labor.[21] To compute the shares of payments to each type of capital, I first estimate the stock of the five types of capital using the standard perpetual inventory method with geometric depreciation. The published investment series begins in 1951 for Taiwan, in 1953 for Korea, in 1960 for Singapore, and in 1961 for Hong Kong. I assume that the growth rate of investment before the beginning of the investment series is equal to its average growth rate in the first five years the data is available. The capital stock at the beginning of the period is thus computed as $K_i = I_i/(g_i + \delta_i)$ where I_i is quantity of investment at the beginning of the period, g_i is the growth rate of investment in the first five years, and δ_i is the depreciation rate. Given a long investment series and a positive rate of depreciation, the estimated capital stock is relatively insensitive to this assumption. I focus my analysis on the post-1966 period, so I have 6 to 16 years of investment data to establish the capital stock. To estimate the share of payments of each type of capital, I take the product of the nominal rental price of capital and the estimated capital stock and divide by the total payments to capital.

III. Dual Estimates of TFPG

This section presents the dual estimates of TFPG for the four East Asian countries. As a reminder to the reader, the dual rate of TFPG is calculated as a weighted average of the real rental price of five types of capital and real wages of workers differentiated by sex and education, where the weights are the shares of payments to each factor. As previously mentioned, in the cases in which the real interest rate is computed by subtracting the inflation rate from a nominal interest rate, the estimates presented in this section uses the *ex post* realized

[19] To check for sensitivity, I also estimate the *ex ante* expected rate of asset price inflation by regressing the realized rate of asset price inflation on lags of the inflation rate and other explanatory variables. The resulting estimates of TFPG using the *ex ante* expected real interest rates are very similar to those using *ex post* real rates and are therefore not presented in the paper (but are available upon request from the author).

[20] See Richard Brealey and Stewart Myers (1996, pp. 67–69). Using their terminology, the real interest rate is equal to the E-P ratio divided by (1 − present value of growth opportunities/*P*). If the present value of growth opportunities is positive, the real interest rate will exceed the E-P ratio. If earnings are fully paid out as dividends, then the real interest rate is given by $r = (E/P) + g$ where g is the expected growth rate of dividends (and earnings). In this case, r will exceed the E-P ratio when g is positive.

[21] I use Young's (1995) estimates of the aggregate share of capital and labor in total income.

TABLE 1—DUAL TOTAL FACTOR PRODUCTIVITY GROWTH

Real interest rate used	Labor share	Annual growth rate of: Rental price of capital	Wages	Dual TFP	Primal TFP
Korea					
Curb market loan rate (1966–1990)	0.703	−3.95	4.38	1.91	1.70
Deposit rate (1966–1990)	0.703	−3.41	4.38	2.07	1.70
Discount rate (1966–1990)	0.703	−4.91	4.38	1.62	1.70
Singapore (actual real interest rate)					
Return on equity (1971–1990)	0.511	−0.20	3.17	1.52	−0.69
Average lending rate (1968–1990)	0.511	1.64	2.67	2.16	−0.22
E-P ratio (1973–1990)	0.511	−0.50	3.63	1.61	−0.66
Singapore (constant real interest rate)					
(1971–1990)	0.511	0.34	3.17	1.78	−0.69
(1968–1990)	0.511	0.60	2.67	1.65	−0.22
(1972–1990)	0.511	0.08	3.63	1.89	−0.66
Hong Kong					
Prime lending rate (1966–1991)	0.628	−1.13	4.05	2.12	2.30
Call money rate (1966–1991)	0.628	−1.53	4.05	1.98	2.30
E-P ratio (1973–1991)	0.616	0.96	4.14	2.92	2.18
Taiwan					
Curb loan rate (1966–1990)	0.739	−0.36	5.26	3.79	2.60
One-year deposit rate (1966–1990)	0.739	−0.07	5.26	3.87	2.60
Secured loan rate (1966–1990)	0.739	−2.01	5.26	3.36	2.60
Three-month treasury bill rate (1975–1990)	0.746	−2.07	5.79	3.79	2.70

Notes: The return to equity and E-P ratio are used as real interest rates. All other measures of interest rates are used as nominal interest rates, from which the *ex post* inflation rate is subtracted to obtain the real interest rate, except the panel "Singapore (constant real interest rate)" which assumes that the sum of the real interest rate and the depreciation rate has remained constant. For all the estimates, the rate of dual TFPG is the weighted growth rate of quality-adjusted real wages and rental price of capital, where the weights are the factor shares. Primal TFPG and aggregate factor shares are calculated from Young (1995).

real interest rate. To calculate the growth rate of rental rate, I divide the point estimate of the time trend of the sum of the real interest rate and the depreciation rate by its average value and add this to the average growth rate of the relative price of capital. Since the point estimates of the time trend are relatively insensitive to different initial and end points, the dual estimates do not significantly change when different initial and terminal years are used for the analysis.

Table 1 presents the estimates of dual TFPG. The first panel presents the estimates for South Korea. As noted earlier, the dual TFPG estimates in South Korea are roughly the same as the primal estimates. Although real wages (in quality-adjusted units) grew at an annual rate of 4.4 percent from 1966 to 1990, the dual rate of TFPG is much lower due to the steep decline in the return to capital over this period (see Figure 1). Nominal interest rates have fallen steadily over this period. Without any appreciable decline in the rate of asset inflation, the fall in the nominal interest rates translates into a decrease in real interest rates. The fall in real interest rates was accompanied by a decline in the relative price of capital (averaging 1.4 percent a year from 1966 to 1990), which further decreases the real rental price of capital. Using the one-year time deposit rate as the nominal interest rate, the growth rate of TFP averages 2.1 percent a year from 1966 to 1990. Using the discount rate on commercial bills yields a slightly lower rate of TFPG (1.6 percent a year).

The main problem with using the one-year deposit rate and the discount rate on commercial bills as nominal interest rates is that these rates

were set by government fiat for a significant period of time. A solution is to use the interest rate in informal financial markets that were not regulated by the government to calculate the real return to capital. The interest rate in this unregulated market, the curb market loan rate, is always significantly higher than the other interest rates (see Figure 1), but the percentage decline in the real return to capital is roughly similar (−4 percent a year) to that obtained when using the deposit rate and the discount rate as the nominal interest rate. Therefore, the rate of TFPG (1.9 percent a year) is broadly similar to the two other dual estimates and the primal estimate of TFPG.

Turning to Singapore, the dual estimates of TFPG (shown in the second panel in Table 1) differ dramatically from existing primal estimates, due mainly to the fact that the rental rate of capital has not fallen. When the average lending rate is used to compute the real return to capital, the rental rate *increases* at an average rate of 1.6 percent a year from 1968 to 1990.[22] Over the same period, quality-adjusted real wages increased by 2.7 percent per year. Since the labor share is roughly 50 percent, this implies that the rate of dual TFPG averaged 2.2 percent a year from 1968 to 1990, which is 2.4 percentage points higher than the primal estimate. Another measure of the return to capital in Singapore is based on estimates of the return to equity from Singapore's Registry of Companies. As previously mentioned, this measure is compiled from annual reports filed by every incorporated business in Singapore with the Registry of Companies (with the exception of partnerships and self-proprietorships). Using the return to equity from this source as the real interest rate, the (quality-adjusted) real return to capital falls by an average of 0.2 percent a year from 1971 to 1990. The combination of an annual 0.2-percent decrease in the real rental price with an increase in (quality-adjusted) real wages by 3.2 percent a year from 1971 to 1990 yields an average rate of TFPG of 1.5 percent a year, which exceeds the dual estimate by 2.2 percentage points. Lastly, the rate of dual TFPG exceeds the primal estimates by roughly the same amount (2.3 percentage points) when the E-P ratio of firms in the stock market of Singapore is used as the real return to capital.

I should note that while the three estimates of the time trend of real interest rates in Korea are statistically significant, this is not the case for the three estimates of the time trend of the real interest rate in Singapore. Since the trend of real interest rates in Singapore is not statistically different from zero, an alternative approach is to assume that the sum of the real interest rate and the depreciation rate in Singapore has remained constant. With this assumption, the growth rate of the rental rate is simply the average growth rate of the relative price of capital. Using this as an estimate of the growth rate of the rental rate, we obtain a higher dual estimate of TFPG for one of the three estimates and a lower estimate for the remaining two estimates (see the third panel in Table 1). Nevertheless, all three alternative estimates of the dual rate of TFPG are still significantly higher than the primal estimates, and consistently exceed these estimates by about 2 percentage points a year.

Turning to the dual estimates of TFPG for Hong Kong, one can see that these estimates are virtually identical to the primal estimates (fourth panel in Table 1). Using the prime lending rate (from the Hong Kong and Shanghai Bank) as the nominal return to capital, the real rental price of capital fell by 1.3 percent a year from 1966 to 1991. After adjusting for labor quality, real wages increased by 4 percent a year. With a labor share of 0.63, the dual rate of

[22] The data on the average lending rate is first available in 1968 from the *Yearbook of Statistics Singapore*, which is why I begin my analysis in 1968 when using the average lending rate to calculate the rental price of capital. The return to capital computed from the average lending rate in Figure 2 combines the data from this source with comparable data on bank lending rates from Sheng-Yi Lee (1974) for the period prior to 1968 (additional details are provided in the Appendix). In addition, since the data on the average lending rate is not published after 1980, I add the average gap between the average lending rate and the prime lending rate in 1979 and 1980 (0.81 percentage points) to the prime lending rate as an estimate of the average lending rate after 1980. Since the average gap between the two lending rates in 1979 and 1980 is lower than that in previous years (average of 1.27 percentage points from 1968 to 1978), the increase in the rental rate would be lower if I had used the average gap from 1968 to 1980 to estimate the average lending rate after 1980. The point estimate from a regression of the gap between the average lending rate and the prime lending rate from 1968 to 1980 on a time trend indicates that this gap grew by 0.02 percentage points each year, but the trend is not significantly different from zero (the standard error is 0.03).

TABLE 2—COMPARISON OF GROWTH RATE OF REAL WAGES AND OUTPUT PER WORKER

Average annual growth rate of:	Taiwan (1966–1990)	Singapore (1972–1990)	Hong Kong (1966–1991)	Korea (1966–1990)
Output per worker	4.30	4.20	4.70	4.90
Real wages	5.62	4.18	4.77	5.12

Notes: Growth rates of output per worker and real wages are not adjusted for quality. Growth rate of output per worker calculated from Young (1995), and real wages from the sources described in the Appendix.

TFPG averages 2.1 percent a year. Turning to stock market indicators of the return to capital, the E-P ratio suggests that the rental price of capital increased at an average rate of almost 1 percent a year from 1973 to 1991. Since (quality-adjusted) real wages grew by 4.2 percent a year, the estimated rate of dual TFPG is 2.9 percent a year from 1973 to 1991 when the E-P ratio is used as a real interest rate.

The last panel in Table 1 presents the estimates of TFPG for Taiwan.[23] The average rate of dual TFPG from 1966 to 1990 is the highest of the four countries. The estimated rates of TFPG are relatively insensitive to the choice of nominal interest rates, ranging from a low of 3.4 percent a year (using the interest rate on secured loans) to 3.8 percent a year (using either the loan rate in informal financial markets or the treasury bill rate). Although the interest rate on secured loans and the one-year deposit rates were subject to government controls until the early 1980's, the lending rate in informal financial markets yields very similar estimates of TFPG (3.7 percent a year).

The dual estimates in Taiwan also exceed the primal estimates, albeit by less than in Singapore. In contrast to Singapore, the discrepancy between the dual and primal estimates of TFPG in Taiwan is not due to differences between the measures of the rental price of capital shown in Table 1 and that implied by national accounts. The four estimates of the rental price of capital shown in Table 1 suggest that the marginal product of capital fell from 1966 to 1990, which corroborates the data from the national accounts that indicate an increase in the capital-output ratio over the same time period. Instead, the gap between the two measures of TFPG is entirely due to an inconsistency between the growth rate of real wages computed from household surveys in Taiwan and that implied by the national accounts. Specifically, since the labor share in Taiwan has remained roughly constant, the growth rate of real wages implied by the national accounts is simply the growth rate of output per worker. Table 2 shows that the growth rate of real wages in Taiwan (computed from household surveys) exceeds the growth rate output per worker (computed from the national accounts) by 1.3 percent a year, which explains almost all the discrepancy between the dual and primal estimates of TFPG for Taiwan.[24]

The natural question is whether the household survey (the *Survey of Personal Income Distribution*) used for the estimates presented in Table 1 overstate the growth rate of real wages in Taiwan. An alternative source of data on wages by educational attainment in Taiwan is the *Survey of Manpower Utilization*, a household survey conducted annually since 1976. I used the *Survey of Personal Income Distribution* for the estimates presented in this paper since it provides more comprehensive and higher quality measures of income than the *Survey of Manpower Utilization*.[25] Nonetheless, the

[23] Young notes that Taiwan's national accounts incorporate a "quality adjustment" to output of public sector employees. The growth rate of TFP is therefore smaller once an adjustment is made to the measure of public sector output to conform to the standard (zero quality adjustment) measurement technique. To account for this in the dual procedure, I adjust the growth rate of the GDP deflator to remove the "quality adjustment" of public sector output. The growth rate of the adjusted GDP deflator is 0.5 percent higher than that of the unadjusted deflator.

[24] The figures presented in Table 2 are not adjusted for changes in labor quality and thus differ slightly from the figures presented in Table 1 (which do adjust for changes in labor quality).

[25] Specifically, the *Survey of Personal Income Distribution* provides data on income from secondary jobs as well as that from the person's primary job, and also provides data on annual income rather than monthly income.

growth rate of real wages from 1976 to 1990 from the *Survey of Manpower Utilization* is similar to estimates from the *Survey of Personal Income Distribution.*[26] The evidence from these two household surveys suggests that the discrepancy between the dual and primal estimates for Taiwan is probably due to an underestimate of real output growth by Taiwan's national accounts.

It's also worth mentioning that the growth rate of output per worker is virtually identical to the growth rate of real wages in Singapore, Hong Kong, and Korea (see Table 2). Since the labor share in these three economies has not changed, this indicates that any discrepancy between the primal and dual estimates for these countries is largely due to the inconsistency between market measures of the rental rate used in the dual analysis and the rental rate implied by the national accounts.[27]

Finally, I present two additional robustness checks. First, I remind the reader that the aggregate rental price of capital is computed as a weighted average of different types of capital goods, where the weights are the shares of payments to each type of capital. In turn, these shares are computed by estimating the quantity of each type of capital using a standard perpetual inventory approach and multiplying by its estimated rental price. An alternative to using these estimates of the capital shares to construct a quality-weighted rental price of capital is to simply calculate the rental price of capital as the real interest rate plus a constant depreciation rate. Appendix Table A1 presents the growth rate of the rental price of capital using this procedure (the "simple" rental price of capital) for one measure of the real interest rate for each country. As can be seen, the growth rate of the "simple" rental price is slightly lower than the "quality-adjusted" aggregate rental price of capital for three of the four rental rates presented in the table, but the gap is relatively small and therefore would not make much of a difference in the corresponding dual estimates of TFPG.

As another robustness check, I calculate the confidence intervals of the growth rates of the rental prices and dual estimates of TFPG as well as their point estimates. I remind the reader that the estimates of the growth rate of the return to capital presented in Table 1 are obtained from fitting a time trend to my estimates of the aggregate rental price of capital. However, especially when the real interest rate is computed from subtracting an expected rate of inflation from a nominal rate, it is clear that these estimates of the real interest rate are very volatile. Therefore, to assess the extent of and impact of this volatility on the dual rate of TFPG, Appendix Table A2 presents the 95-percent confidence interval of the growth rate of the rental price of capital and the corresponding ranges of the dual rate of TFPG for the four East Asian countries.[28] As can be seen from the ranges of the rental prices in Hong Kong and Singapore, market-determined real rates are typically less volatile than real interest rates obtained by subtracting an expected inflation rate from a nominal interest rate. Nonetheless, the results are still similar when one considers the confidence interval of the estimates rather than simply the point estimate of the dual rates of TFPG; the dual rate of TFPG are roughly similar to the primal estimates in Korea and Hong Kong, are slightly higher than the primal estimates for Taiwan, and are significantly higher than the primal estimates in Singapore.

IV. Has the Return to Capital in Singapore Fallen?

To recapitulate, the dual estimates for Korea are very similar to the primal estimates since the

[26] These estimates are not presented in the paper, but are available upon request.

[27] Young (1998) argues that the estimates of real wages used in this paper are problematic because they are derived from "different weighting procedures, combining data from different sources, covering different concepts of income in different years" (p. 42). However, these problems are also present in the national accounts. In addition, Table 2 shows that with the exception of Taiwan, the growth rate of output per worker from the national accounts is virtually identical to the growth rate of real wages computed from household surveys and population censuses in these countries. Therefore, if the growth rate of output per worker is used as an estimate of the growth rate of real wages to calculate the dual rate of TFPG, the resulting estimates will be very similar to those presented in this paper.

[28] I thank a referee for this suggestion.

market measures of the return to capital are consistent with the Korean national accounts—every estimate of the rental rate shows that marginal product of capital in Korea has fallen very sharply. Similarly, the market measures of the rental rate in Hong Kong and Taiwan are also broadly consistent with the national accounts. In contrast, while the Singaporean national accounts indicate that the marginal product of capital has fallen sharply, the three measures of the rental rate indicate no such trend.[29] The large gap between the dual and primal estimates of TFPG for Singapore is due to this inconsistency between the national accounts and the estimates of the rental rate.

This section considers four reasons for why the estimates of the rental rate of capital used in the dual estimates may not be good estimates of the marginal product of capital in Singapore. The two most serious potential problems with the dual estimates are that they do not incorporate changes in taxes associated with capital and that they do not account for implicit subsidies to private investment provided by public investment expenditures. Another potential problem is that there may have been a large risk premium in Singapore in the late 1960's and early 1970's that are not captured by the estimates of the rental rate. The last potential problem is that nominal lending rates in Singapore were regulated by a bank cartel until the 1970's. Therefore, the rental rate based on the nominal lending rate will be a biased estimate of the marginal product of capital. This section assesses these arguments and ultimately concludes that they do not explain the large discrepancy between the rental rates used in the dual analysis and the return to capital implied by the national accounts in Singapore.

A. *Taxes on Capital*

I first consider the argument that the dual measures of the return to capital are biased since they do not incorporate changes in taxes on capital income. Many observers have argued that due to a gradual fall in the corporate tax rate, increases in depreciation allowances, and a plethora of other tax incentives over the last two or three decades, the effective tax on capital in Singapore may have fallen since the 1960's.[30] However, while it is true that tax incentives have apparently become more generous over the last few decades, it is unclear whether most firms benefited from these incentives. Tax incentives for most foreign firms are negotiated individually with each firm by the Singaporean government (and details of each agreement are not released to the public). Therefore, while the *maximum* tax rate on capital has fallen over the last few decades, these rates are simply not relevant for many firms in Singapore. In other words, the critical question is whether the tax rate on *aggregate* capital has fallen over the last few decades.

One way to check whether the tax rate on aggregate capital has fallen is to look at aggregate data on the sources of tax revenues in Singapore. If taxes on capital have steadily fallen, then the share of revenues from capital taxation should also have fallen. Instead, the aggregate tax data indicates that the share of revenues from taxes on capital has increased. From 1966 to 1990, the share of corporate taxes in total tax revenues rose from 26 percent to 48 percent while the combined share of corporate and property taxes in total tax revenues increased from 58 percent to 64 percent (see Figure 3). As a fraction of GDP, the share of corporate taxes increased from 2 percent in 1966 to 5 percent by 1990. While the average property tax has fallen, the average corporate tax rate has more than doubled since the 1960's. This evidence is not conclusive since the marginal tax rate can differ from the average tax rate (e.g., if new investment is treated differ-

[29] Young (1998) points out that the publication *The Singapore Economy: New Direction* (1986, Chart 2-7) presents estimates of the return to capital supplied by Singapore's Department of Statistics that appear to indicate that the marginal product of capital has fallen since the early 1970's. However, these estimates of the return to capital are backed out of the national accounts; that is, they are obtained by dividing the payments to capital in national income by an estimate of the capital stock computed from data on investment expenditures from the national accounts. As previously discussed, since the national accounts indicate that the capital-output ratio has increased sharply, the return to capital implied by the national accounts must have fallen by the same amount.

[30] See for example, Young (1998) and John F. Ermisch and W. G. Huff (1999).

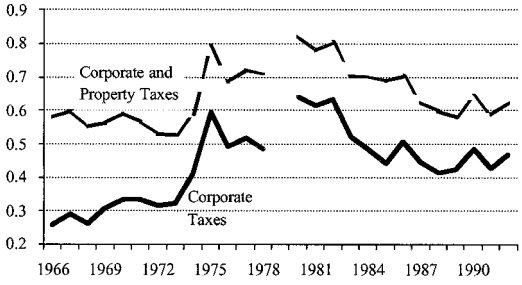

FIGURE 3. CAPITAL TAX REVENUES/TOTAL INCOME TAX

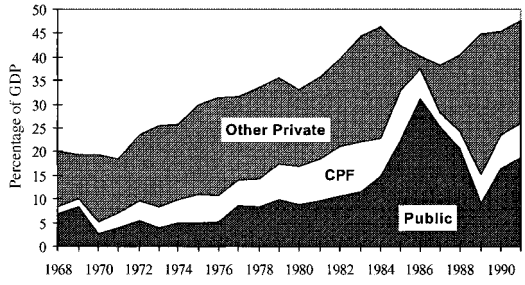

FIGURE 4. COMPOSITION OF NATIONAL SAVINGS IN SINGAPORE

ently from existing capital).[31] However, the fact that the average tax rate on aggregate capital has increased significantly since the late 1960's makes it more unlikely that the marginal tax rate on capital has fallen by enough to explain the discrepancy between the return to capital implied by the national accounts and the market-based measures of the return to capital.

B. *Stalinist Forced Investment*

While the tax rate on capital appears to have increased over the last few decades, private investment may have been implicitly subsidized by the large amount of public investment spending. According to this argument, the return to *private* investment may not have fallen thanks to these subsidies, but the return to aggregate capital has fallen due to a decline in the return to *public* capital. In support of this hypothesis, Young (1992) points to the large share of national savings under the control of the government. First, the government runs large budget surpluses, which increased from 3.6 percent of GDP in 1968 to about 20 percent of GDP by the 1980's (see Figure 4).[32] Second, in addition to its budget surpluses, the government also borrows extensively from the Central Provident Fund (CPF), which is required to hold the majority of its assets in the form of government securities.[33] The CPF has become one of the most important vehicles for private sector savings, accounting for 11 percent of GDP at its peak in 1985 (see Figure 4). The CPF, along with the government's budget surpluses, form a large pool of savings the government could have potentially used for public investment projects.

This section presents evidence to show that although the government controls a large share of national savings, these funds have largely been used to build up large holdings of foreign assets, and have not been channeled into public investment. In reviewing this evidence, it's useful to have the following accounting identity in mind:

$$(9)\quad S_{PUBLIC} + S_{PRIVATE} = I_{PUBLIC} + I_{PRIVATE} + CA_{PUBLIC} + CA_{PRIVATE}.$$

This is familiar savings-investment identity, except that savings, investment, and the current account are decomposed into their private and public components. This identity makes it clear that even if S_{PUBLIC} is large, it does not follow that I_{PUBLIC} must be large

[31] Specifically, the marginal tax rate on type j capital is given by

$$\frac{p_j^k}{p}(i - \hat{p}_k + \delta_j)\left(\frac{u(z_j - 1) + k_j}{1 - u}\right) + b_j$$

(the variables are defined in footnote 14). Therefore, if depreciation allowances, investment tax credits, or the corporate tax rate differ between new investment and assets which have already been invested, this can drive a wedge between marginal and average tax rates.

[32] These budget surpluses come from two sources. First, the central government runs large surpluses of current expenditures over current revenue. Second, a large number of off-budget government corporations and statutory boards also earn large profits.

[33] The CPF is Singapore's social security system. It is funded by payroll tax, currently at 40 percent of the employee's income divided evenly between the employee and the employer. Before they retire or leave the country, participants are allowed to use their fund balances to purchase housing or shares in certain government companies, but otherwise are not permitted to withdraw their balances.

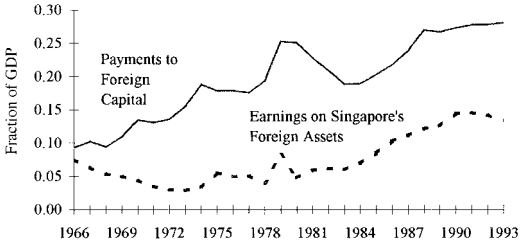

FIGURE 5. PAYMENTS TO FOREIGN CAPITAL IN SINGAPORE AND TO SINGAPORE'S FOREIGN ASSETS

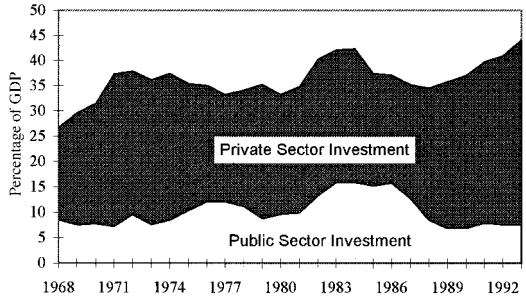

FIGURE 6. COMPOSITION OF INVESTMENT SPENDING IN SINGAPORE

because the government can invest the savings under its control in other types of assets. In fact, the Singaporean government has accumulated large holdings of foreign assets with these resources, and has not used them to finance public investment projects. The government does not provide the public with any information about its holdings of foreign assets, but we can obtain a rough estimate of the government's earnings from these assets from other data in the national accounts (Figure 5).[34] As can be seen, the earnings from these foreign assets are large, amounting to roughly 14 percent of GDP in 1990. A conservative estimate is that Singapore's public sector's foreign assets were worth 83 billion US dollars in 1991, roughly twice the size of Singapore's GDP that year.[35]

In sum, while S_{PUBLIC} is large in Singapore, CA_{PUBLIC} is large as well, and investment spending is primarily private investment, not public investment (see Figure 6). In turn, since $I_{PRIVATE}$ is much larger than $S_{PRIVATE}$, private investment has been financed by large inflows of foreign capital, largely in the form of direct foreign investment by multinationals. In the manufacturing sector, foreign investment accounted for an average 79 percent of total investment between 1972 and 1989.[36] As for aggregate investment, Singapore's published national accounts does not provide a breakdown between investment by foreigners and by Singaporean nationals. However, it does provide estimates of the share of income accruing to foreign nationals from which we can estimate the share of foreign capital in Singapore's capital stock. From 1980 to 1993, payments to foreigners (both labor and capital) averaged 29.1 percent of GDP (see Figure 5).[37] In 1980, payments to foreign labor accounted for one-sixth of total payments to foreigners.[38] Assum-

[34] Singapore's national accounts provides estimates of the so-called *indigenous* GNP and GDP, which roughly speaking, is the GNP and GDP corresponding to Singaporean nationals. Since foreigners play such a large role in Singapore's economy, indigenous GNP and GDP are significantly lower than GNP and GDP. The Singaporean government came up with these measures in the early 1970's to persuade the IMF to continue to classify Singapore as a developing country. The estimated earnings of the government from its foreign assets is calculated as the difference between indigenous GNP and indigenous GDP. Although this measure also includes the wage earnings of Singaporeans abroad and the earnings on foreign assets held by the private sector in Singapore, these are probably quite small, at least until the early 1990's when the private sector in Singapore started to invest abroad.

[35] This calculation uses the published estimates of the increase in public sector foreign assets before 1982. The *Yearbook of Statistics Singapore* stopped publishing a series on the increase in the public sector's foreign assets in 1982. Therefore, after 1982, I assume that the annual accumulation of foreign assets is the sum of the operating surplus of the consolidated public sector (central government and statutory boards) and the increase in domestic debt. To arrive at the US$ 83 billion estimate, I also assume that Singapore held no foreign assets in 1966 and that after 1966, the rate of return on Singapore's foreign assets was the average return on long-term government bonds in the six largest industrialized countries. These last two assumptions are rather conservative and thus impart a downward bias to the estimated stock of foreign assets.

[36] This data is compiled by the *Report on the Census of Industrial Production.*

[37] The income accruing to foreign nationals is the difference between GDP and so-called "indigenous" GDP.

[38] The estimate of wage income of foreigners takes the estimate of total wage payments to foreigners from the 1980 census and scales the resulting estimate to account for self-employed workers.

ing that the share of payments to labor in total payments to foreigners remained constant, payments to foreign capital accounted for an average 24.1 percent of GDP from 1980 to 1993, which is roughly one-half of total payments to capital and 70 percent of payments to private capital.[39]

Since private investors, particularly foreign investors, own the largest share of Singapore's capital stock, the subsidies required to prevent a fall in the return to private investors are simply enormous if the data on Singapore's stock of private capital is to be believed. A simple way to assess the magnitude of the required subsidies is to ask the following question: if we believe that the return to private capital in Singapore has remained unchanged since the 1960's and that the figures on private investment provided by Singapore's national accounts are accurate, what would the share of payments to private capital had to have been by 1990? A simple back-of-the-envelope calculation indicates that if the return to private capital has remained constant since 1968, the payments to private capital would have reached 90 percent of GDP by 1990.[40] Since the share of *total* payments to capital (including public capital) has remained roughly constant at 50 percent of GDP, the necessary subsidy to private capital would exceed *total* payments to capital by 40 percent of GDP in 1990. In sum, even if the entire public capital stock were used to subsidize private capital, there would still not be enough to pay the required subsidies.

C. *Changes in the Risk Premium*

I next consider the possibility that there was a large risk premium in Singapore in the late 1960's and early 1970's that has subsequently fallen. A simple way to gauge the importance of possible changes in the risk premium is to use a measure of the return to capital that already incorporates a risk premium. In fact, one of the measures I use to estimate the marginal product of capital in Singapore is based on the data on the return to equity from the Singapore Registry of Companies. This registry compiles data from *every* incorporated business in Singapore, including government-owned enterprises and subsidiaries of foreign companies. If there was a large risk premium in Singapore, this should appear in this measure of the return to capital. While it is true that the return to equity yields a negative growth rate of the rental rate, the rate of dual TFPG calculated from this estimate still exceed the primal estimate by 2.2 percentage points a year (see Figure 2 and Table 1). In addition, as previously mentioned, the negative trend is not statistically significant. Since the trend of the rental rate calculated from the return to equity is not significantly different from that of the two other measures of the rental rate, this suggests that the risk premium in Singapore has not changed significantly since the early 1970's.

Another way to measure the risk premium in Singapore is to look at the interest rate paid on US-dollar denominated bonds issued by the Singaporean government in the early 1970's. Although this interest rate provides a measure of the sovereign risk premium in Singapore and not the private risk premium, it can give us an idea of the magnitude of the private risk premium in Singapore since the two measures are typically highly correlated in developing countries. The Singaporean government tapped international financial markets for the first time on

[39] This calculation assumes that total payments to capital account for 50 percent of GDP, and payments to private capital account for 34 percent of GDP.

[40] The hypothetical private capital share in 1990 is calculated as $\alpha_{K,1990} = r_{1968}K_{PRIVATE,1990}/Y_{1990}$ where $K_{PRIVATE,1990}$ is the private capital stock in 1990 (computed from the national accounts), Y_{1990} is aggregate income, and r_{1968} is the return to capital in 1968. In turn, since

$$r_{1968} = \frac{\alpha_{K,1968}}{K_{PRIVATE,1968}/Y_{1968}}$$

the hypothetical private capital share in 1990 can be expressed as

$$\alpha_{K,1990} = \alpha_{K,1968}\left(\frac{K_{PRIVATE,1990}/Y_{1990}}{K_{PRIVATE,1968}/Y_{1968}}\right).$$

With an initial share of private capital (in 1968) of one-third and

$$\frac{K_{PRIVATE,1990}/Y_{1990}}{K_{PRIVATE,1968}/Y_{1968}} = 2.7$$

this yields a hypothetical share of payments to private capital in 1990 of 90 percent ($\frac{1}{3} \times 2.7 = 0.9$).

December 1971 by issuing bonds with a face value of 10 million US$ with a 10-year maturity at a 8.5-percent interest rate. In October 1972, the government issued US-dollar denominated bonds again, this time with a face value of 20 million US$ and a 15-year maturity at a 7.75-percent interest rate. The interest rate paid by the Singaporean government on its first two issues of US-dollar denominated bonds exceeded the interest rate on U.S. Treasury bonds of comparable maturity by an average of 195 basis points. In the late 1980's, Singapore's long-term sovereign foreign currency debt was rated Aa3 by Moody's and AA+ by Standard and Poors, which implies a sovereign risk premium of 100–110 basis points.[41] An 85–95-basis points drop in the sovereign risk premium over two decades implies that the average annual growth rate of the rental price of capital is 0.21–0.23 percent lower than what the estimates in this paper indicate.[42] In turn, with a capital share of 50 percent, this implies that the estimates of dual TFPG presented in this paper are upwardly biased by 0.11–0.12 percent a year, which is relatively small.

D. *Financial Market Controls*

One of the measures I use to estimate the trend in the real interest rate is the average lending rate of commercial banks in Singapore. A potential problem with the average lending rate is that these rates were regulated by a bank cartel until the cartel was disbanded in the early 1970's.[43] According to this argument, lending rates were kept below their equilibrium levels in the late 1960's by ceilings on lending rates. However, after these controls were lifted in the 1970's, lending rates rose to their equilibrium levels. Therefore, the end of the bank cartel in the 1970's could have masked the fall in the marginal product of capital. In support of this argument, Young (1998) shows that the gap between the lending rate (primarily for housing loans) of finance companies, which were not subject to the cartel's regulations, and the average lending rate of commercial banks narrowed in the 1970's. However, the narrowing of this gap was probably due to the housing loan subsidies provided by the Post Office Savings Board (POSB) in the 1970's. Tan (1978 p. 174) states that the POSB established a subsidiary in 1974 specifically to "extend housing loans to depositors at interest rates lower than the prevailing market rates." Thanks to these subsidies, the POSB's share of the housing loan market increased from 5.4 percent in 1975 to over 27 percent in 1986, largely at the expense of the finance companies.[44]

Furthermore, this argument is only valid if the cartel kept lending rates *below* their equilibrium levels. The truth of the matter is that while the bank cartel set ceilings on deposit rates, it set *floors* on lending rates. The cartel set *minimum* lending rates for different types of transactions but the banks were allowed to charge higher rates.[45] After all, the cartel's objective was to increase the gap between lending and deposit rates and thus maximize the profits of its members. If the bank cartel's minimum lending rates prevented banks from offering lower rates to some of their customers, the *average* lending rate in the late 1960's would have been *higher* than their market-clearing rates. After the cartel was dismantled in the 1970's, the average lending rate should have fallen to its equilibrium level. Therefore, if the cartel's controls on lending rates had any effect, the estimated rental rate of capital based on the

[41] This calculation is based on the average gap in 1987 and 1988 between the yields of long-term bonds rated AA+ and Aa3 and that of U.S. Treasury bills of similar maturity. The information on maturity and yields of the bonds issued by the Singaporean government in the early 1970's is from Chwee Huat Tan (1978), the ratings on Singapore's sovereign long-term debt in the late 1980's are from Bloomberg's database, and the yields on corporate bonds and U.S. Treasury bills are from various issues of *An Analytical Record of Yields and Yield Spreads* by Salomon Brothers.

[42] If the average rental rate of capital is 20 percent (assuming a real interest rate of 8 percent and a depreciation rate of 12 percent), an 0.85–0.95-basis point drop in the rental rate is equivalent to a 4.25–4.75-percent fall. Over 20 years, this translates into an average decline of 0.21 to 0.23 percent per year.

[43] This cartel (the Association of Banks in Malaysia and Singapore) was finally dissolved in 1975. See Chapter 8 in Lee (1974) for additional details on the cartel's interest rate regulations.

[44] See Dudley Luckett et al. (1994, p. 67).

[45] According to data collected by Lee (1974), the average lending rate for most small and medium-sized firms in Singapore was 2.8 percent higher than the minimum loan rate in 1966 (p. 168).

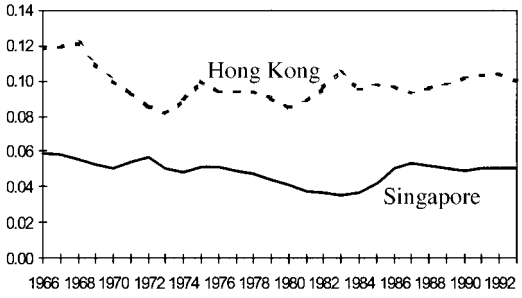

FIGURE 7. PRIVATE CONSUMPTION EXPENDITURES ON HOUSING/GDP

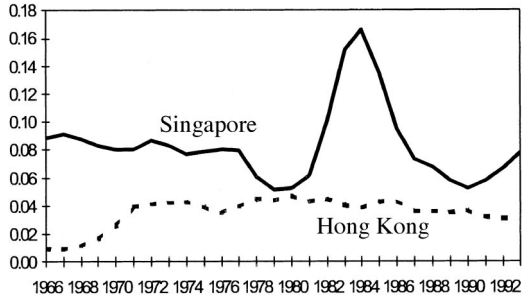

FIGURE 8. RESIDENTIAL HOUSING INVESTMENT/GDP

average lending rate would *overstate*, not understate, the fall in the marginal product of capital. Finally, it's worth remembering that the other two measures of the return to capital (earnings-price ratio and the return to equity) that are unaffected by the banking cartel yield results that are broadly similar to that obtained from the average lending rate of commercial banks.

V. Errors in the National Accounts

What we are left with then are two sets of estimates of TFPG for Singapore that are difficult to reconcile. While one can raise objections to any individual estimate of dual TFPG presented in this paper, it is difficult to see how all three estimates of the rental rate in Singapore could have remained constant over the last few decades if in fact the marginal product of capital has fallen sharply. If the capital-output ratio has increased in Singapore by the extent implied by its national accounts, why hasn't the rental rate fallen as it has in Korea? The natural explanation for this discrepancy is that Singapore's national accounts have overstated the amount of investment spending. In fact, Goh-Keng Swee, one of the founders of modern Singapore and the main architect of its economic policies, has suggested that investment expenditures in Singapore are overstated.[46]

The more general point is that there are idiosyncrasies in how every government compiles their national accounts that make cross-country comparisons problematic. As an example of this, consider the way the statistical authorities in Singapore estimate the rental value of owner-occupied housing.[47] The Singaporean statistical authorities assume that the rental price of owner-occupied housing is the rental price of public rental housing. However, the rental rates of public rental housing are highly subsidized. Since over 90 percent of Singapore's population live in owner-occupied housing, this has a significant effect on the national accounts. For comparison, while private consumption expenditures on housing in Singapore account for roughly 5 percent of GDP, they account for 10 to 11 percent of GDP in Hong Kong (see Figure 7). In Hong Kong, official estimates of the value of residential housing do not depend as much on estimates of imputed rent because only 45 percent of Hong Kong's population live in owner-occupied housing.

While official statistics indicate that the rental value of residential housing in Singapore is much lower than in Hong Kong, they also indicate that Singapore has invested significantly more resources (8 to 10 percent of GDP) into housing than Hong Kong (about 4 percent of GDP) (see Figure 8). This translates into large differences in the average quality of housing between Hong Kong and Singapore. As late as 1987, a Hong Kong government report estimates that 38 percent of Hong Kong's population live in inadequate housing.[48] Public

[46] See Swee and Linda Low (1996).

[47] I am grateful to Soon Teck-Wong, the Director of the National Accounts Section of Singapore's Department of Statistics, for bringing the treatment of imputed rent in Singapore to my attention.

[48] Inadequate housing is defined as "temporary structures," "overcrowding by tenants sharing housing units in

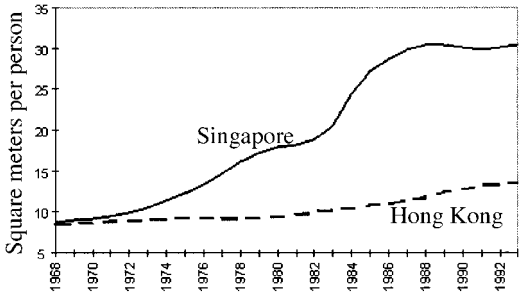

FIGURE 9. RESIDENTIAL HOUSING SPACE PER PERSON

housing in Singapore is much better than in Hong Kong. In 1980, public housing in Hong Kong provided between 2.2 to 5.7 square meters per person, while public housing in Singapore provided between 7.7 to 50 square meters per occupant.[49] Taking both public and private housing into account, residential housing space per person was approximately the same in both countries in 1968, but the gap between the two cities widened subsequently. By 1980, Singapore's housing stock per person was roughly double that of Hong Kong and three times that of Hong Kong by 1990 (see Figure 9).[50]

One way to assess the importance of the treatment of owner-occupied housing in Singapore is to look at the difference between the rate of TFPG in the aggregate economy and in the manufacturing sector in which the undervaluation of residential housing is not an issue. From 1970 to 1990, the average rate of (primal) TFPG was 0.84 percent a year in the manufacturing sector and −0.7 percent a year for the aggregate economy.[51] The difference between the rate of TFPG in the manufacturing sector and the aggregate economy is rather large, and may be due to other factors in addition to the undervaluation of residential housing. Nonetheless, the treatment of owner-occupied housing in Singapore is illustrative of the potential pitfalls one faces when using national accounts data. Since the task of learning the intricacies of national income accounting for every country is prohibitively time consuming, the dual approach provides a way to bring alternative data to bear to check the consistency of data from a country's national accounts. At a minimum, the large discrepancy between the dual and primal estimates of TFPG in Singapore suggests that we should be very cautious about the data from the Singaporean national accounts and the growth accounting exercises that rely on this data.

VI. Conclusion

This paper has shown how the dual exercise can be a useful complement to standard primal growth accounting exercises. Given the enormous difficulties faced in constructing reliable national account and capital stock data, the dual approach has the additional advantage of using data on prices instead of quantities. The advantage of using the dual is that factor prices, primarily wages and interest rates, are observed as an equilibrium outcome in a marketplace. In contrast, a number of tenuous assumptions and estimates have to be made in order to construct the data on quantities of output and capital needed for a primal growth accounting exercise.

In the case of Korea, the dual TFPG estimates are remarkably similar to the primal estimates. Where the dual and primal estimates differ, and dramatically so, is for Singapore. In Singapore, standard estimates of primal TFPG suggest that there has been no technological progress over the last 30 years, and all of the increase in standards of living has been due to factor accumulation, primarily capital accumulation. If this story is correct, then the return to capital should have fallen dramatically. Yet, the evidence suggests that the return to capital has increased in

private housing," and "public housing with structural problems, due for redevelopment." See Table 2.4, p. 16 in M. Castells et al. (1990).

[49] This estimate is from Aline Wong and Stephen Yeh (1985, p. 502). 2.2 square meters is about the area of a coffin.

[50] The stock of residential housing is calculated by a standard perpetual inventory approach from annual estimates of the total area of completed residential housing. See the Appendix for further details.

[51] The TFP growth rates for the manufacturing sector for the 1980's are from Fat-Chyi Wong and Wee-Beng Gan (1994) and Yuan Tsao (1985) for the 1970's. The estimates for the aggregate economy are from Young (1995). Young's estimates of TFPG for the manufacturing sector are lower than the estimates from Tsao (1985) and Wong and Gan (1994). However, Young's estimates are apparently based on aggregate data for the manufacturing sector, whereas the estimates by Tsao and Wong and Gan are based on two-digit industry-level data.

Singapore. The dual estimates of TFPG uses this evidence, along with data showing an increase in real wages over the last 30 years, to obtain estimates of TFPG which suggest that technological progress has played as important a role in Singapore's growth as that in the other East Asian countries.

Appendix: Data Sources

Hong Kong:

Estimates of Gross Domestic Product (1996) provide data on GDP deflators, rental value of residential housing, and nominal and constant investment in capital goods starting in 1961. Data on wages by sex and education for 1981, 1986, and 1991 are the author's tabulations from the 1-percent sample of the Hong Kong Censuses of 1981 and 1991 and the Hong Kong By-Census of 1986. The 1976 wage data is from the published tables in the publication *Hong Kong By-Census 1976, Basic Tables* (Table 17, p. 41). The published tables of the 1966 Hong Kong By-Census (*Report of the By-Census 1966*, Table 215, pp. 199–201) provide data on the number of people by sex and education in three income ranges (below 400, 400–600, above 600 Hong Kong dollars per month). I estimated average wage by sex and education by assuming that the average wage for each income range was 200, 500, and 750 respectively.

The best lending rate of the Hong Kong and Shanghai Bank after 1971 and the money market rate after 1982 are unpublished data provided by the Hong Kong Census and Statistics Department (⟨http://www.wws.princeton.edu/~chsieh/hkblr.pdf⟩). For previous years, the money market rate are compiled from various issues of the publication *Hong Kong Monthly Digest of Statistics* (1977 to 1981 from p. 64 in the March 1983 issue, 1973 to 1976 from p. 37 in the January 1977 issue, 1969 to 1972 from p. 44 in the January 1973 issue, and 1966 to 1968 from p. 44 in the January 1970 issue). The data for the best lending rate for 1966 and 1967 is from *Hong Kong Statistics, 1947–1967* (p. 153) and from 1968–1970 from the July 1972 issue of the *Hong Kong Monthly Digest of Statistics* (p. 44). The dividend yield and the earnings-price ratio of stocks included in the Hang Seng index were provided by the Hang Seng Bank (http://www.wws.princeton.edu/~chsieh/hangseng.pdf).

The quantity of residential housing is calculated by a standard perpetual inventory approach from the annual estimates of the area of completed residential housing (from the annual issues of the *Hong Kong Annual Digest of Statistics*). To initialize the series, I take the estimated total area of residential housing from the 1971 Census. I also make the following adjustments to the annual estimates of new residential housing. First, the area of new housing does not include the area of kitchens, bathrooms, and hallways. To make the figures for Hong Kong comparable to that of Singapore (which does include the space occupied by kitchens, bathrooms, and hallways), I add 50 percent to the area of new residential housing in Hong Kong. Second, the figures for the area of new residential housing in Hong Kong does not include certain types of public housing, namely the resettlement estates, housing authority buildings, and the home-ownership scheme. It does however include the area of new public housing provided under the private sector participation scheme, middle-income housing program, and the housing society. To estimate the area provided by new public housing not included in the published figures, I calculate the cost per square meter of private housing (excluding the developer's profit) and assume that the cost of a given square meter of public housing is one-third that of private housing. I multiply this cost per square meter by the expenditures on public housing investment from the national accounts to estimate the area provided by new public housing. This adjustment roughly doubles the estimated area of new residential housing each year.

Korea:

Wages by sex and education for 1969–1991 are compiled from several issues of the *Report on the Occupational Wage Survey* (pp. 468–469 in the 1969 issue, p. 537 in the 1971 issue, pp. 410–411 in the 1972 issue, pp. 314–315 in the 1973 issue, pp. 628–629 in the 1974 issue, pp. 522–523 in the 1976 issue, pp. 746–747 in the 1977 issue, pp. 740–741 in the 1978 issue, pp. 620–621 in the 1979 issue, p. 219 in the 1981 issue, p. 265 in the 1984–1989 issues, p.

269 in the 1990 issue, and p. 255 in the 1991 issue). Prior to 1969, a survey by the Bank of Korea in 1967 (*Report on the Occupational Wage Survey*, Table 2, pp. 50–51) provides data on wages by sex and education in the manufacturing and mining industries. Data on wages include special payments and monthly equivalent of annual bonuses. Real and nominal expenditures on investment goods, as well as the GDP deflator, are calculated from the annual issues of the *Korea Statistical Yearbook*. The interest rate on secured loans and the one-year time deposit rate are from the annual issues of the *Economic Statistics Yearbook* (data from 1962–1969 are from Tables 244 and 247, pp. 368 and 371 in the 1970 issue of the *Economic Statistics Yearbook*, data from 1970–1976 are from Tables 179 and 181, pp. 312 and 314 in the 1977 issue, data from 1977 to 1982 are from Tables 20 and 22, pp. 330 and 332 in the 1983 issue, and data from 1983 to 1993 are from Tables 22 and 23, pp. 383 and 384 in the 1994 issue). Lastly, the curb market loan rate is from Collins and Won-Am Park (1989, p. 353) and Sung-Tae Ro (1994, p. 171).

Singapore:

The earliest source of wage data by sex and education is from the 1966 Sample Household Survey. The official publications from this survey (*Singapore Sample Household Survey, 1966*) does not have any data on income by worker characteristics, but V. V. Bhanoji Rao and M. K. Ramakrishnan (1980) obtained previously unpublished data on the number of workers by sex and education in different income ranges from the 1966 Sample Household Survey. I use the tables presented in their book to obtain estimates of average wages (Tables B13 and B14, p. 104). Since their tables only presents the number of workers in each income range, I assume that wages in the top two income groups follow a Pareto distribution and average wage in the other groups is simply the midpoint between the lower and upper wage brackets. The next survey was undertaken in 1972 (*Report on the Household Expenditure Survey 1972/1973*) from which the 1972 estimates of wages are obtained (Table 7, p. 6). The Labour Force Survey was first conducted in 1973 and has been conducted annually ever since then (with the exception of 1980 and 1990). All subsequent estimates on wages by sex and education (except 1980 and 1990) are from the annual issues of the *Report on the Labour Force Survey*. Specifically, the data from the 1973 issue of the *Report on the Labour Force Survey* are from Table 18, 1974 from Tables 54–55, 1975 from Tables 54–55, 1976 from Tables 54–55, 1977 from Tables 54–55, 1978 from Tables 54–55, 1979 from Tables 54–55, 1981 from Tables 32–33, 1982 from Tables 42–43, 1983 from Tables 45–46, 1984 from Tables 45–46, 1985 from Tables 38–39, 1986 from Tables 39–40, 1987 from Table 37, 1988 from Table 39, and 1989 from Table 36. The data in 1980 and 1990 are from the publications of the Population Censuses conducted in these two years (Table 11, p. 46 in *Census of Population, 1980, Singapore, Volume 4: Economic Characteristics* and Table 41, p. 143–144 in *Singapore Census of Population, 1990: Economic Characteristics*). The annual Labour Force Surveys only provide data on the number of workers by sex and education in different income groups. To estimate average wages, I again assume that wages in the two top income brackets follow a Pareto distribution and that the average wage in the other income groups is the midpoint of the lower and upper wage brackets.

The return to equity from Singapore's Registry of Companies were provided by Singapore's Department of Statistics (⟨http://www.wws.princeton.edu/~chsieh/sroe.xls⟩). Singapore's Department of Statistics published this data from 1980 to 1989 in a 1992 working paper (*Efficiency of Singapore Companies: A Study of Returns to Asset Ratios*). The average lending rate from 1968 to 1980 and the prime lending rate from 1968 to 1990 are from the *Yearbook of Statistics Singapore*. Specifically, the average lending rate and the prime lending rate from 1968 to 1977 are from the 1977/1978 issue of the *Yearbook of Statistics* (Table 11.8, p. 156), from 1978 to 1981 from the 1983/1984 issue (Table 11.14, p. 190), and from 1982 to 1990 from the 1992 issue (Table 12.13, p. 232). The average lending rate prior to 1968 used to compute the return to capital shown in Figure 2 is the loan rate of commercial banks from Lee (1974 Table 8.2, p. 170). The E-P ratio is from Datastream (series TOTMKSG; ⟨http://www.wws.princeton.edu/~chsieh/datastream.xls⟩).

The GDP deflator is calculated from the *Economic and Social Statistics Singapore, 1960–1982* and annual issues of the *Yearbook of Statistics Singapore.* Nominal and real investment spending as well as the breakdown between private and public investment spending, residential housing investment, and private consumption expenditures on utilities and housing are from the annual issues of the *Economic Survey of Singapore* and *Singapore National Accounts 1987.* The annual issues of the *Yearbook of Statistics Singapore* from 1967 to 1972 provides figures of private consumption expenditures on housing. However, later issues only provide an aggregate estimate of private consumption on housing and utilities. To obtain estimates of the residential value of housing after 1972, I assume that the share of rental value of housing in total expenditures on housing and utilities after 1972 is the same as the average share (slightly above two-thirds) from 1967 to 1972. The housing stock is estimated by a perpetual inventory approach with annual estimates of the area of new residential housing from the *Yearbook of Statistics Singapore.* To initialize the series, I assume that the growth rate of new residential housing before 1963 (the first year the investment series is available) is the same as the growth rate from 1964 to 1969.

The data on income tax revenues are from the *Annual Reports* of the Inland Revenue Board. Current and operational surpluses of the central government and statutory boards from 1967 to 1973 are from Low (1985) and from the annual issues of the *Economic Survey of Singapore* for subsequent years. After 1988, the annual issues of the *Economic Survey of Singapore* do not break down expenditures of the statutory boards into current and investment expenditures. I assume that the share of investment spending in total expenditures by the statutory boards from 1989 to 1991 is the same as the average from 1984 to 1988. In addition, the published estimates of the central government's current expenditures do not include debt service payments after 1985. For the figures presented in this paper, I therefore add debt service payments to the published figures of current expenditures by the central government. Lastly, capital receipts are excluded from the estimated revenues of the central government after 1987 and of the statutory boards after 1986. However, I cannot adjust for this since I am unable to obtain estimates of capital receipts. Annual net increases in the CPF balances and the public sector's domestic debt are from *Economic and Social Statistics of Singapore 1960–1982* and the annual issues of the *Yearbook of Statistics Singapore.*

Taiwan:

The *Report on the Survey of Personal Income Distribution* contains data on household income by educational attainment. This survey has been conducted since 1964, but published tables on household income by educational attainment of the head of household are only available since 1972. The estimates of wages by education from 1972–1976 and from 1988–1990 are from the published tables of the *Report on the Survey of Personal Income Distribution* (Table 29, pp. 452–455 in the 1972 issue, Table 29, pp. 452–455 in the 1973 issue, Table 29, pp. 604–607 in the 1974 issue, Table 30, pp. 150–151 in the 1975 issue, Table 10, pp. 176–179 in the 1976 issue, Table 116, pp. 346–347 in the 1988 issue, Table 96, pp. 294–295 in the 1989 issue, and Table 90, pp. 312–313 in the 1990 issue) and from 1977 to 1987 from annual issues of the *Statistical Abstract of the Republic of China* (Supp. Table 25, pp. 358–360 in 1977, Supp. Table 25, pp. 480–483 in 1978, Supp. Table 25, pp. 526–529 in 1979, Supp. Table 25, pp. 534–537 in 1980, Supp. Table 25, pp. 514–517 in 1981, Supp. Table 26, pp. 276–279 in 1982, Supp. Table 26, pp. 152–155 in 1983, Supp. Table 28, pp. 146–149 in 1984, and Supp. Table 28, pp. 148–151 in 1987). John C. H. Fei et al. (1979) went back to the original tabulation sheets of the 1966 survey and estimated wages by sex and education (Table 4.27, pp. 222–223 in Fei et al.). The data from the 1966 survey is not fully comparable to the data presented after 1972 since the 1966 survey presents data on wage income of each worker, and not on household income. The only data on wage income for each worker by sex and education prior to the mid-1970's is from a survey conducted in 1972 by the Ministry of Education (Keith Gannicott, 1972 pp. 63 and 81). Therefore, the estimates of the growth rate of real wages from 1966 to 1972 are from the 1966 household survey and from the 1972 survey by the Ministry of Education.

The publication *National Income in Taiwan*

Area of the Republic of China provides data on capital formation in current and constant prices. The GDP deflator is also obtained from the same source. Lastly, the interest rate on loans in informal markets is a simple average of interest rates on postdated checks in Taipei, Kaohsiung, and Taichung. This data, as well as the three-month treasury bond yield, the interest rate on short-term secured loans, and the one-year time deposit rate, are from Tables 23 and 24 of the monthly issues of the *Financial Statistics Monthly* of the Central Bank of China from 1966 to 1991.

TABLE A1—COMPARISON OF GROWTH RATE OF "QUALITY-ADJUSTED" RENTAL PRICE OF CAPITAL AND "SIMPLE" MEASURE OF RENTAL PRICE OF CAPITAL

	"Quality-adjusted" rental price	"Simple" rental price
Korea (curb market loan rate)	−3.95	−4.68
Singapore (return to equity)	−0.20	0.04
Taiwan (curb loan rate)	−0.36	−0.24
Hong Kong (E-P ratio)	0.96	1.20

Notes: The "quality-adjusted" rental price of capital is the weighted average of the rental price of five capital goods, where the weights are the factor shares of each type of capital. The "simple" rental price is calculated as the real interest rate plus a constant depreciation rate (8 percent).

TABLE A2—RANGE OF DUAL TOTAL FACTOR PRODUCTIVITY GROWTH

		Annual growth rate of:			
Country and real interest rate used	Labor share	Rental price of capital (ranges)[a]	Wages	Dual TFP (ranges)[a]	Primal TFP
Singapore					
Return on equity (1971–1990)	0.511	−0.99 to 0.58	3.17	1.14 to 3.14	−0.69
Average lending rate (1968–1990)	0.511	0.69 to 2.60	2.67	1.70 to 2.67	−0.22
E-P ratio (1973–1990)	0.511	−0.92 to −0.09	3.63	1.40 to 3.63	−0.66
Taiwan					
Informal loan rate (1966–1990)	0.739	−1.00 to 0.29	5.26	3.63 to 3.96	2.10
Deposit rate (1966–1990)	0.739	−1.82 to 1.69	5.26	3.41 to 4.33	2.10
Secured loan rate (1966–1990)	0.739	−3.50 to −0.52	5.26	2.97 to 3.75	2.10
Treasury bill rate (1975–1990)	0.746	−0.64 to 1.28	5.24	3.21 to 4.38	2.06
Hong Kong					
Best lending rate (1966–1991)	0.628	−2.20 to −0.05	4.04	1.73 to 2.53	2.30
Call money rate (1966–1991)	0.628	−2.60 to −0.45	4.04	1.58 to 2.38	2.30
E-P ratio (1973–1991)	0.616	−0.64 to 1.28	4.18	2.79 to 3.04	2.18
Korea					
Curb market loan rate (1966–1990)	0.703	−5.90 to −2.01	4.38	1.33 to 2.48	1.70
Deposit rate (1966–1990)	0.703	−5.13 to −1.68	4.38	1.56 to 2.58	1.70
Discount rate (1966–1990)	0.703	−5.55 to −4.28	4.38	1.43 to 1.81	1.70

Note: See text and notes of Table 1 for additional details.
[a] 95-percent confidence interval.

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