NBER WORKING PAPER SERIES

ALTERNATIVE ESTIMATES OF PRODUCTIVITY GROWTH IN THE NIC'S: A COMMENT ON THE FINDINGS OF CHANG-TAI HSIEH

Alwyn Young

Working Paper 6657
http://www.nber.org/papers/w6657

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
July 1998

Alternative Estimates of Productivity Growth
in the NICs: A Comment on the Findings
of Chang-Tai Hsieh
Alwyn Young
NBER Working Paper No. 6657
July 1998

ABSTRACT

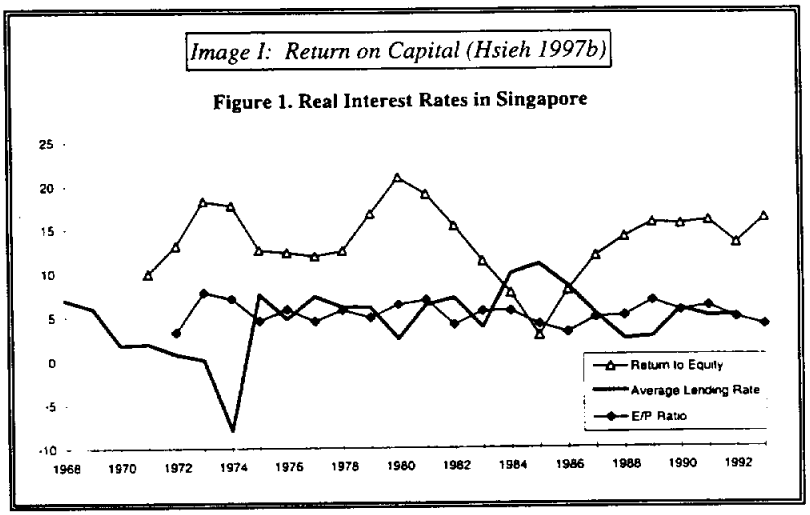
Dual estimates of productivity growth by Chang-Tai Hsieh have raised questions about the accuracy of the East Asian national accounts, suggesting that productivity growth in the NICs, particularly Singapore, may have been substantially higher than previously estimated. This paper shows that once one corrects for computational and methodological errors, dual estimates, using Hsieh's own data, are not that far removed from the results implied by primal sources. Further, Hsieh's criticisms of the accuracy of the national accounts capital formation figures are shown to be invalid. Finally, other data exist which support the picture of declining real rentals painted by the national accounts capital formation figures.

Alwyn Young
Graduate School of Business
University of Chicago
1101 East 58th Street
Chicago, IL 60637
and NBER
a-young2@uchicago.edu

I. Introduction

In a recent paper, Hsieh (1997b) uses data on wages and capital returns to compute dual estimates of productivity growth in the East Asian NICs. Hsieh's results indicate that productivity growth in some of the NICs, particularly Singapore, may have been substantially higher than previously estimated, using primal techniques, by Tsao (1982) and myself (1995). Hsieh argues that the primal estimates imply a substantial decline in the return to capital in the Singaporean economy, but he finds no evidence of this. His three measures of "real interest rates" in Singapore, reproduced in Image I below,[1] indicate no secular decline, whatsoever, in the return to capital. Using these data, he estimates that the real rental in Singapore has risen through time, producing, in the extreme, estimates of total factor productivity growth of 2.6% per annum.

Image I: Return on Capital (Hsieh 1997b)

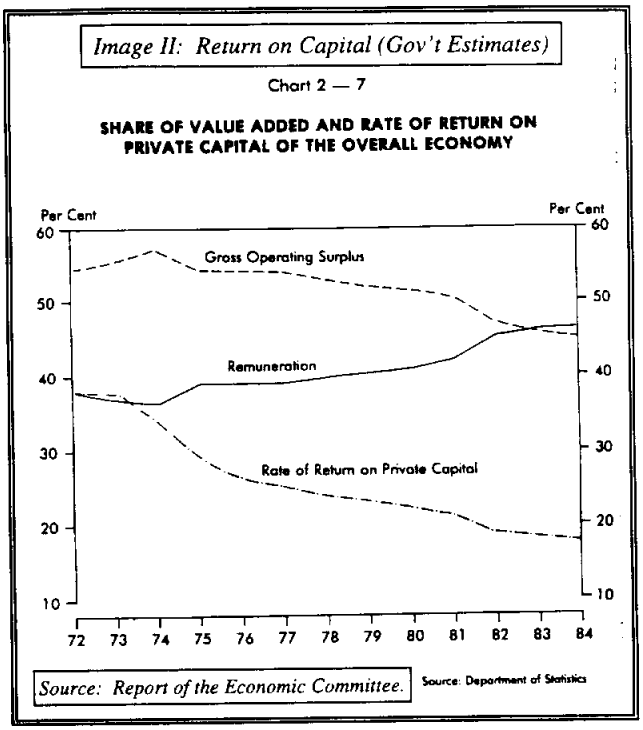


In Image II below I reproduce Chart 2-7 of the Report of the Economic Committee, "The Singapore Economy: New Directions." In 1985, after two decades of uninterrupted rapid growth, the GDP of the Singaporean economy fell 1.6%. Chaired by none other than Brigadier-General (Res) Lee Hsien Loong, the Economic Committee was charged with the task of reviewing the progress of the Singaporean economy and identifying new directions for its future growth. In his letter accepting the report of the Committee, the Minister for Trade and Industry (Tony Tan) noted that it would be transmitted to the Cabinet for consideration and that his Ministry would "prepare a simplified version of the Economic Committee's Report which can be used in community centres, schools and work places." No student of the Singaporean economy is unaware of the importance of the 1985 recession, and the impact the Economic

[1]In this paper I use scanned images of parts of other documents to present data which are crucial to my argument. My annotations of these images are in italics. All growth rates reported in the paper are logarithmic. Unless otherwise noted all aggregate data on Singapore (GDP growth, deflators, etc.) come from Singapore System of National Accounts 1995 and, for more recent years, from the annual editions of the Yearbook of Statistics, and are in the base prices of 1990.

Committee's recommendations had on Singapore's tax, accounting and other conventions. For now, however, I simply direct the reader's attention to the "Rate of Return on Private Capital" (defined as the operating surplus over gross fixed assets), furnished to the Committee by Singapore's Department of Statistics. This series might usefully be compared with Hsieh's measure of the Return on Equity (Image I), which is based on data given to him by the very same Department of Statistics. Although Hsieh's Return on Equity falls during the early 1980s, this appears to be a temporary blip in a series of constant returns to capital. In contrast, in Image II the fall in the Return on Private Capital during the early 1980s is clearly part of a long term secular decline in the return to that factor.

Image II: Return on Capital (Gov't Estimates)



A comment on an empirical study which so starkly contradicts one's own work would, typically, be expected to focus on problems with the indices selected by the author and the existence of alternative series which confirm one's results. It is indeed my opinion that there are problems with the representativeness and accuracy of Hsieh's series. Further, it is not hard to find data which support the picture of declining capital productivity painted by the Singaporean national accounts. None of this is the focus of this comment. A detailed discussion of the ins and outs of Singaporean data, of the complex institutional, accounting and statistical arrangements of that economy, will do little to enlighten the average reader who, with no direct knowledge of her own, would ultimately find herself unable to evaluate the inconsistent opinions of different experts. Consequently, in this comment I will focus on elements that someone who has read my work, read Hsieh's papers, and is familiar with the methodology of growth accounting and the basic precepts underlying the construction of LDC data, but who otherwise knows little about Singapore, will be able to evaluate. I will introduce information about the

Singaporean economy, but only to develop and round out arguments which are, otherwise, "visible to the naked eye."

I begin, in Section II, by showing that the growth of labour input, not capital, is the key element behind my finding that productivity growth in the NICs has not been unusually high. One can eliminate all of the capital deepening from my results, and still find low productivity growth in the Singaporean economy, particularly since 1980. Hsieh's estimates of high productivity growth stem from the fact that his estimates indicate that the real rental has not only not fallen (as implied by the national accounts), or even remained constant, but, rather, has *risen* through time.

In Section III I examine Hsieh's methodology. First, I show that Hsieh's cost of capital calculations ignore the impact of changes in the tax code and that when these are taken into account real rentals in Singapore decline by one to two percent per annum, even when the return on capital is constant. Second, I show that there are systematic problems with Hsieh's computational procedure, i.e. that his method generates negative rentals (in levels, not growth rates), that his series are extraordinarily volatile, and that, relative to his data, his reported results overstate the growth of the real rental. I show that once one takes these problems into account, Hsieh's own data series generate negative rental growth which closely approximates that implied by the national accounts. Put differently, Hsieh's estimates of positive real rental growth are a function of computational error, a failure to take into account the tax code in computing the cost of capital, and the fact that his endpoints are peak years in otherwise highly volatile series.

In Section IV I evaluate the arguments that Hsieh uses to reconcile his estimates of rising real rentals with the negative rental growth implied by the rapid capital formation of the national accounts. First, as I explain, the argument that investors overreport investment expenditures in Singapore is not relevant, since the national accounts of Singapore, like those of most LDCs, do not make use of reported investment expenditures. Second, the argument that second hand capital goods sales lead to an overstatement of investment expenditure implies that there should be large discrepancies between the production and expenditure sides of the Singaporean national accounts, discrepancies which, in actuality, do not exist. Third, Singapore's sectoral surveys, like those of most countries, report both capital formation and capital sales. Consequently, in computing our primal estimates of productivity growth in manufacturing, both Tsao and I

adjusted for second hand capital sales. Overall, the sectoral surveys of the Singaporean economy indicate no significant positive trend in capital goods sales. Fourth, the argument that accelerated depreciation leads to a drastic overstatement of the growth of the capital stock repeats an argument I examined in 1992. I once again show that adjustments along these lines do little to improve Singapore's productivity growth and, furthermore, result in an equally rapid fall in the real return to capital. Finally, I show that the argument that monopoly markups explain the difference between primal and dual estimates of productivity growth in the Singaporean economy contains some notational confusion which, when clarified, invalidates the argument. Given that no compelling argument can be given as to why the national accounts would mistakenly indicate negative rental growth (when the reality is supposed to be one of positive rental growth), given that that there are methodological and computational problems with Hsieh's estimates which, when corrected, generate negative rental growth, and given that there exist other series corroborating the national accounts (or implying even more negative rental growth), I see little reason to question the accuracy of the picture painted by Singapore's capital formation statistics.

The paper concludes, in Section V, with some observations on the difficulty of constructing productivity estimates and the ambitiousness of Hsieh's project. So as not to shy away from the data, I also provide two appendices that discuss the specifics of Singaporean sources. First, as an illustration of the types of problems that arise in Hsieh's selection of Singaporean data, I discuss, in detail, one of his measures of real returns, that on bank lending rates. Second, I show that the data in the censuses and surveys of different economic sectors provide independent evidence in support of the Singaporean national accounts. A short companion paper (Young 1998) discusses the theoretical objections to my growth accounting estimates raised by Nelson & Pack (1995), Rodrik (1997) and Hsieh (1997a), showing that their methods generate positive Paasche estimates of productivity growth at the expense of massively negative Laspeyres estimates.

II. Labour, not Capital

Hsieh's paper helps perpetuate the popular misconception that the accumulation of physical capital is the crucial element underlying my finding that productivity growth in the NICs has not been unusually high.[2] As I emphasized in Young 1995, Young 1994, and even as early as Young 1992 (p. 62), the growth of labour input plays an equal, if not much more important, role. Moving from the growth of GDP per capita to the growth of non-agricultural GDP per effective worker hour (Table I), knocks 1.6% off of the growth of output per capita in Hong Kong, almost 3% off of the growth of output per capita in South Korea and Taiwan, and a full 3.8% off of the growth of output per capita in Singapore. If one knew the share of labour in these economies, a "naive" estimate of productivity growth, i.e. one assuming no deepening of factors, might be that share times the growth of output per capita. This prior would imply sustained total factor productivity growth ranging from a low of 3.5% per annum in Singapore to a high of 5.0% in Taiwan. Comparing these numbers with my 1995 estimates, one sees that "labour deepening", i.e. the rise in participation rates, transfer of labour out of agriculture, and increase in the human capital of the workforce, accounts for at least two-thirds of the difference in all of the economies except Singapore, where it still accounts for 59% of my results.[3]

The long run averages in Table I obscure important time trends, particularly in the case of Singapore. Table II reproduces my period by period results for that economy. As the reader can see, while output per weighted worker (i.e. adjusting for sex, age, education and hours of work) grew 9.7% per annum between 1966 and 1970, this growth had slowed to 3.0% per annum by the 1970s, and a mere 0.3% per annum during the 1980s. While the growth of the capital stock has

---

[2]See, for example, Rodrik 1995 (p. 60). I should, however, differentiate between accounting and causality. One could increase the contribution of capital accumulation (and policies that favour it) by arguing, for example, that the investment booms raised the value of market labour, thereby raising female participation, lowering birth rates, and encouraging investment in market oriented human capital. The magnitude of the impact, of course, depends upon one's assessment of the elasticities of these behavioral patterns with respect to the market wage.

[3]Total factor productivity growth equals the weighted average of the growth of output per unit of labour input and output per unit of capital input. For the naive estimate, this equals $\theta_L(\hat{Q}-\hat{P})+\theta_K(\hat{Q}-\hat{K})$, and I assume that the growth of the capital-output ratio is zero. In my estimates, total factor productivity growth equals $\theta_L(\hat{Q}_{NA}-\hat{L}_{NA})+\theta_K(\hat{Q}_{NA}-\hat{K}_{NA})$, where I use the notation NA to remind the reader that for Korea and Taiwan my measure covers the non-agricultural sector alone. I take the difference between the θ_L weighted terms as the contribution of labour deepening and the difference between the θ_K weighted terms as the contribution of capital deepening, both relative to the naive prior. Table I follows Table XV in Young 1995, which provides a fuller accounting.

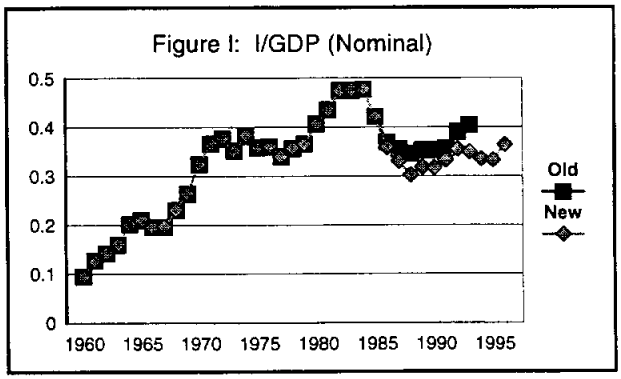
Table I: Sources of East Asian Productivity Growth (1966-1990)				
	Hong Kong	Singapore	South Korea	Taiwan
Growth of:				
GDP/Population	5.7	6.8	6.8	6.7
Non-ag. GDP/Effective worker	4.1	3.0	3.9	4.0
Non-ag. GDP/Effective capital	-0.7	-2.8	-3.4	-3.4
Labour share (avg.)	0.628	0.509	0.703	0.743
Naive Estimate of TFP growth	3.6	3.5	4.8	5.0
Young (1995)	2.3	0.2	1.7	2.1
Of difference:				
Contribution of labour deepening	79%	59%	66%	70%
Contribution of capital deepening	21%	41%	34%	30%
Source: Young 1995. Hong Kong refers to 1966-1991.				

Table II: Total Factor Productivity Growth: Singapore							
	Annual growth of:						
Time period	Output	Raw capital	Weighted capital	Raw labour	Weighted labour	TFP	Labour share (avg.)
Young (1995)							
66-70	13.0	11.9	13.4	5.4	3.3	4.6	0.503
70-80	8.8	12.2	14.0	5.0	5.8	-0.9	0.517
80-90	6.9	9.1	8.4	3.6	6.6	-0.5	0.506
66-90	8.7	10.8	11.5	4.5	5.7	0.2	0.509
Updated (preliminary)							
66-70	13.1	12.5	13.3	5.4	3.3	4.8	0.503
70-80	8.5	12.3	14.0	5.0	5.8	-1.2	0.517
80-90	7.1	8.9	7.9	3.6	6.6	-0.2	0.515
90-95	8.3	7.2	7.9	2.0	7.9	0.4	0.499
66-95	8.6	10.3	10.7	4.1	6.1	0.3	0.508

slowed, the growth of human capital has accelerated over time. Weighted labour input grew 2.1% slower than raw labour in the late 1960s, but 0.8% faster in the 1970s and 3.0% faster in the 1980s. In Table II I update my estimates using the results of the 1995 by-census[4] and recent revisions of the national accounts. An unprecedented revision of the Singaporean national

[4]Actually, the General Household Survey 1995, which functioned as a by-census.

accounts in the mid-1990s lowered the investment to GDP ratio, which had peaked at 48% in 1984, back to a level not seen since 1970 (Figure I).[5] Estimates of capital goods price inflation were also revised slightly upwards, as was the nominal level and real growth of GDP. Nevertheless, total factor productivity growth during the first half of the decade averaged a mere 0.4% per annum, a consequence of the extraordinary growth of labour input.[6] Although the raw labour force grew only 2.0% per annum, the effective labour force grew a full 5.9% faster (Table II).[7]



---

[5]In the Figure, the "Old" series is drawn from Singapore National Accounts 1987 and the Yearbook of Statistics up to 1993, while the "New" series represents the data of the Singapore System of National Accounts 1995 and the 1996 Yearbook of Statistics.

[6]Absent the national accounts revisions, total factor productivity growth during the first three years of the decade would have been -.9% lower per annum. I should note that besides the revisions of the national accounts my updated estimates include new information from the input-output tables and revisions of earlier census estimates of labour force characteristics. Furthermore, I have modified my measures of output and raw capital growth to be the tornqvist weighted sum of the growth of the components of output (by industry, excluding import duties) and the capital stock. The weights are the current value shares of each component of output or the capital stock in the total value. As the national accounts of LDCs are rebased again and again, one's measure of the growth of output and of the raw capital stock (e.g. $\Sigma P_{Bi}K_i$) becomes sensitive to the choice of base year. However, when LDCs rebase their national accounts they chain-link (i.e. preserve) the growth of the components of output or capital formation, so measuring growth as a tornqvist weighted sum of component growth eliminates the dependence on the base year. Relative to the national accounts measure of GDP growth, my new measure raises the growth of output in Singapore by 1.2% over the 29 year period. The growth of the raw capital stock is also increased, but this measure is not used in the final TFP estimates. The growth of the weighted capital stock remains a tornqvist weighted sum of the growth of the components, where the weights are the *income* shares (rather than value shares), as explained in Young 1995 (p. 656). I should note that these estimates are preliminary, as I am working to make use of other labour force and income data from the mid-1990s, improve my procedure for weighting capital and, finally, evaluate evidence which suggests that I may have substantially overestimated TFP growth in the late 1960s.

[7]The difference is driven by the rapid aging of the labour force and a steep rise in its educational attainment. For example, according to the 1990 Census (release 4, table 41) the average incomes from work of eight educational categories (no formal education, incomplete primary, completed primary, incomplete secondary, secondary, upper secondary, polytechnic & university) were 875, 954, 909, 1071, 1420, 1825, 2251 & 4148 (S$), respectively. The share of the working population in each educational category was .066, .121, .150, .197, .285, .080, .041 & .060, respectively. The corresponding working population shares in 1995 (General Household Survey 1995, release 1, table 38) were .039, .074, .133, .115, .304, .121, .080 & .134. Using these data to compute factor shares, the reader should arrive at a rough estimate of a 4.1% per annum adjustment for education alone. My estimates differ from this number because I adjust for age, sex, education and hours of work and, in addition, as explained in

Hsieh argues that, given the historic "openness" of Singapore's capital market, the capital-output ratio in Singapore could not have risen during the past 30 years, as this would imply a decline in the return to capital. Readers familiar with my papers would immediately recognize the time path of productivity growth implied by Hsieh's proposition. One could simply take my estimates and remove the contribution of capital deepening, assuming that the weighted capital-output ratio remained constant, as I do in Table III. While this raises the average productivity growth of the economy by 1.0%, its impact is principally felt in the early periods. Thus, under these assumptions, Singapore's productivity growth rate falls monotonically, from an extraordinary 4.9% in the late 1960s, to a moderate 1.4% in the 1970s, and an almost imperceptible 0.2% in the 1980s and early 1990s, as the growth of the output per effective worker has become negligible.[8] Preliminary

Table III: Singaporean Growth Rates (assuming no Capital Deepening)

	Output	Labour	TFP
66-70	0.131	0.033	0.049
70-80	0.085	0.058	0.014
80-90	0.071	0.066	0.002
90-95	0.083	0.079	0.002
66-95	0.086	0.061	0.013

Young 1995, I estimate the full distribution of workers by income, industry, occupation, class of worker, education, sex and age, which allows me to separately determine the educational wage profile of employees alone (which I then use as an implicit wage for the self-employed, employers and unpaid family workers, thereby purging capital returns from the weighting).

I should note that the rise in educational attainment is primarily driven by immigration. Prior to the 1990 Census Singaporean sources openly reported data on the legal/residential status of the working population. However, as I was informed in 1993, following the 1990 Census such information was deemed, by cabinet decision, to be an official state secret and Singaporean publications since that date have studiously avoided providing information on the characteristics of the non-resident population. Given this, I was surprised to find The Economist (Jan. 17, 1998, p. 35) reporting that non-residents accounted for 12% of the working population in 1992 and 25% by 1998. For my part, I have found it possible to estimate the number and, more importantly, detailed characteristics of the non-resident population by combining tabulations from official statistical publications. Notwithstanding the colourful anecdotes on Filipino housekeepers provided by the Economist, the official data actually indicate that a substantial part of the non-resident population is extraordinarily well educated, accounting, by 1995, for a huge proportion of the university degrees in the economy. The immigration of skilled foreign workers is supported by the Singaporean government. For example, in 1990 the Economic Development Board introduced a scheme allowing firms "hiring skilled workers from abroad to recover about 50% of the costs of relocating such workers and their families to Singapore." (MAS, Annual Report 1990/91, p. 72.)

Given the great premia, relative to their Singaporean counterparts, tertiary educated foreign workers command, an adjustment for residential/citizenship characteristics has significant implications for the estimated growth of the effective labour force and for one's understanding of the evolution of the structure of Singaporean wages during the past two decades. Nevertheless, pending clarification as to whether or not these data constitute an official secret, I do not pursue this topic at this time.

[8]Similarly, the growth of weighted real wages since 1980, as indicated by the principal series on worker incomes in the Singaporean economy, has been close to zero. This is discussed further in the Conclusion.

data up through late 1997 indicate that performance in the second half of the 1990s will probably be considerably worse, whether or not one measures capital deepening, as GDP growth rates have fallen while crude employment growth has accelerated (reaching 4.6% in 1997).[9] One can choose to believe that the rapid growth of output per worker in earlier years was driven by a rise in the capital-output ratio, or one can choose not to. In terms of one's assessment of the productivity growth of the Singaporean economy and its long term health, it, ultimately, matters not.

[9]Based upon data drawn off of the Department of Statistics' website.

III. Methodology

(A) Taxation

For his dual analysis, Hsieh needs estimates of the growth of the real rental by asset category (r_j/P_Q). He arrives at these by using estimates of real interest rates (computed on asset inflation) and of the relative price of capital goods to output:

$$(1)\ \frac{r_j}{P_Q} = \frac{P_{Kj}}{P_Q}\left(i - \hat{P}_{Kj} + \delta_j\right)$$

One can more readily appreciate the logic of this equation if one inverts it to derive an expression for the nominal return on capital:

$$(2)\ i = \frac{r_j}{P_{Kj}} + \hat{P}_{Kj} - \delta_j$$

The nominal return on capital equals the gross rental ratio (r/P_K) plus capital goods appreciation, minus depreciation. From a practical standpoint, when discussing the return to capital one should take into consideration taxes. Thus, following Jorgenson et al (1987), one could use a formula of the form:

$$(3)\ i = \left(\frac{(r_j - tP_{Bj})(1-\tau)}{P_{Kj}(1-\tau D - C)}\right) + \hat{P}_{Kj} - \delta_j$$

where τ is the corporate income tax rate, t the property tax rate, P_B the property tax basis, D the net present value of the depreciation allowances associated with a dollar's investment, and C the investment tax credit (if any). Inverting this equation, one arrives at the following expression for the real rental:

$$(4)\ \frac{r_j}{P_Q} = \frac{P_{Kj}}{P_Q}\left(i - \hat{P}_{Kj} + \delta_j\right)\frac{(1-\tau D - C)}{(1-\tau)} + \frac{t * P_{Bj}}{P_Q}$$

In February 1986 the Economic Committee, having been informed by the Singaporean Department of Statistics that the return on private capital was in secular decline (Image II earlier), recommended a reduction of corporate and property taxes, an increase in depreciation allowances, and a movement toward indirect taxation. On February 26 1986, the Deputy Prime Minister announced that the corporate tax rate would be reduced from the long standing 40% to 33%. In March 1989 a further reduction to 32% was announced, followed by announcements of a reduction to 31% (March 1990), then 30% (February 1992), and then 27% (March 1993). As of year of assessment 1997 the tax rate was again reduced, to 26%. To sustain revenue, a Goods and Services Tax was implemented on 1 April 1994, falling on virtually all domestically

consumed goods and services, but not on exports, imports used for export production or registered intercompany transactions. In Singapore property taxes are levied on the implicit rental value of property[10] and stood at 36% in 1968. Following the recommendation of the preliminary report of the Economic Committee (released in July 1985), a one and a half year property tax rebate of .3 of the, by then, standard rate of 23% was introduced. This rebate was then increased to .5 and, subsequently, extended to June 1990. By 1996, the property tax rate was standardized at 12%. Regarding capital allowances, in the early 1960s the initial capital allowance for machinery and equipment was 20%, with straight-line depreciation thereafter at rates of 5-20% per annum. By 1990, all companies were allowed accelerated depreciation of machinery & equipment over 3 years (33 1/3% p.a.), with 100% allowances (i.e. immediate write off) given for computers, robots, and automation equipment in offices or factories. In addition, companies could claim an investment allowance of up to 50% on approved projects, such allowance not interfering with the regular or accelerated depreciation charges associated with the same expenditure. These changes would do much to offset the impact of a declining gross rental ratio on the after tax return to capital in Singapore.[11]

---

[10]That is, the gross rental, "the amount at which the property could reasonably expect to be rented from year to year with the landlord paying the expenses of maintenance, insurance and taxes." The gross rental is arrived at by comparison with comparable rental properties or, when unavailable, by imputing an implicit rate of return to the cost of building. For owner-managed hotel and restaurant premises the implicit rental is taken as 15% and 5%, respectively, of annual gross receipts. (Price Waterhouse 1984, p. 146, Price Waterhouse 1990, p. 154). Historically, concessionary rates have been granted to rural areas and owner-occupied residences.

[11]The preceeding examples barely scratch the surface of the extraordinary range of tax incentives and preferential capital and input costs (given to targetted companies) that have been introduced and expanded over the years. These include Pioneer status, the expansion incentive, the international consultancy services incentive, the preferential tax rates on offshore banking activities, the EDB's capital assistance scheme, the EDB's equity participation scheme, the product development assistance scheme, the research and development assistance scheme, the software development assistance scheme, the initiatives in new technology scheme, the skills development fund, and on and on and on and on.

I should note that accelerated depreciation, for manufacturing firms alone, was introduced as early as 1965. At that time, however, manufacturing accounted for less than 15% of GDP. Accelerated depreciation was not extended to other sectors of the economy until year of assessment 1985.

The facts in the text above come from: Monetary Authority of Singapore, Annual Report, 1985/86 (pp. 44-45), 1988/89 (p. 52), 1989/90 (p. 53), 1991/92 (p. 84), 1992/93 (p. 6); Singapore 1995, pp. 128-129; Lim 1988, pp. 46-49 & 107; Report of the Economic Committee, pp. 49, 53, 89-93; Price Waterhouse 1968, p. 53; Price Waterhouse 1975, p. 47; Price Waterhouse 1984, pp. 23-24, 146; Price Waterhouse 1990, pp. 27-28, 169-170; Price Waterhouse 1996, pp. 130, 167, 183; Peat, Marwick, Mitchell & Co 1984, p. 97; SGV-Goh Tan 1978, p. 45; Hong 1978, pp. 26, 35-36, 47-54; Fordham 1988, pp. 202-203, 372-379; and Ernst & Whinney 1987, pp. 8 & 15.

To see how consideration of the tax code might influence the computation of the real rental, one can work out a partial example or two. For instance, for machinery & equipment, assuming a .15 to .20 nominal discount rate and *ignoring all other incentives*, between the early 1960s and the early 1990s the value of $(1-\tau D)/(1-\tau)$ in equation (4) goes from about .75/.6=1.25 to about .73/.73=1, a fall of 25% or about .8% per annum for thirty years. For properties, if the implicit rental value equals market value, then, ignoring rising depreciation allowances and all other incentives, and assuming that the real interest rate plus depreciation equals a constant value of .2, owners of property would have seen the value of $[(i-\hat{P}_K+\delta)/(1-\tau)]+t$ go from (.2/.6) + .36 = .69 to (.2/.73) + .12 = .39, i.e. a fall of 56%, or almost 2% per annum for thirty years. In other words, even if one assumes that the real return to capital is constant, a proper cost of capital computation, following the methodology used by Jorgenson and others, would indicate that capital rentals in Singapore have been falling 1 to 2 percent per annum.[12]

Hsieh argues that:

> ...The advantage of using the dual is that factor prices, primarily wages and interest rates, are observed as an equilibrium outcome in a market place. 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. (1997b, p. 37).

---

[12]These calculations are by no means extreme. First, they do not take into account the preferential incentives, such as the extra investment allowance or profit tax holidays, which have been introduced or expanded since the early 1960s. For example, for the part of the economy enjoying tax holidays, one can substitute a terminal value of 0 for τ in the computations above. This leaves unchanged the growth of the rental for machinery, but lowers the terminal value of $[(i-\hat{P}_K+\delta)/(1-\tau)]+t$ to .32, implying an annual decline of about -2.6% p.a. for 30 years.

Second, one should take into account the impact of taxes on both the value of income and the cost of capital (i in the above). Hsieh's measures of interest rates based upon the return to equity and the earnings-price ratio are after tax costs of capital and, hence, do not need be modified. For the lending rate of banks, however, one should substitute $i(1-\tau)$ for i in the equations above, reflecting the fact that interest paid in the production of business income is tax deductible in Singapore. This means that, for a constant i, the value of $i(1-\tau)-\hat{P}_K+\delta$ rises as the tax rate falls. Surprisingly, this works in favour of lowering the overall growth of the real rental. The prime rate was about 8% in 1968 and 7% in 1990 (the initial and terminal points of Hsieh's analysis). Multiplying these values by the tax rate, one gets initial and final values of $i(1-\tau)$ of about .05. For machinery & equipment, any movement in the small (in magnitude) value of $i(1-\tau)$ is of negligible importance when summed with the low inflation rates and high depreciation rates (14% and 18%, respectively) of these asset types. For structures, asset inflation is substantial and the depreciation rates small (on the order of a few percent per annum). Consequently, when one introduces taxes one drives the value of $i(1-\tau)-\hat{P}_K+\delta$ to zero. In this case, the growth of the real rental is increasingly determined by the change in t, which went from .36 to .12, i.e. fell 3.7% p.a. for 30 years.

In cost of capital computations, real rentals are not observed, but must be estimated. In this, choosing not to consider taxes is an important assumption. Hsieh states:

> ...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. In contrast, the growth rate of the real capital stock [in primal estimates] will be severely biased if the depreciation rate is incorrect, even if the gap between the available estimates of the depreciation rate and its true value remains unchanged. (1997b, p. 11).

If one examines equations (1) and (4) one sees that if one is backing out estimates of the change in the real rental from data on real interest rates, the estimated level of the depreciation rate will have a first order effect on one's analysis. The relationship between the real return to capital and the real rental is a complex one, and the assumptions one makes in the analysis, and how one chooses to deal with issues such as taxation and depreciation, are by no means of trivial importance.[13]

---

[13]I should also clarify a slight confusion concerning the real return and the real rental. As Hsieh explains (1997b, pp. 1-2):

> ...in the case of Singapore, the capital-output ratio computed from the national accounts has increased at an average rate of 3.7 percent a year from 1968 to 1990...Since the share of payments to capital has remained roughly constant over the same period, the return to capital implied by Singapore's national accounts must have *fallen* at an average rate of 3.7 percent a year -- the same rate as the increase in the capital-output ratio...it is highly unlikely that the return to capital in Singapore has fallen by the magnitude implied by the national accounts...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...

Thus, Hsieh is equating the real rental (the marginal product of capital) with the real return to capital (which determines investment decisions).

First, let me state that the 3.7% figure is Hsieh's number, not mine (which is 2.6%, weighted, for the period 1966-1990). Second, if the reader takes the identity $\theta_K = rK/P_Q Q$ and differentiates she will see that, for a constant capital share, the growth of the real rental is inversely related to the growth of the capital-output ratio. The real rental (r/P_Q), however, is only part of the real return to capital (see equations (2) and (3)).

Third, it is easy to change one's measure of the growth of the effective capital stock without influencing, in any way, one's measure of the real return to capital. To see this, take equation (2) and multiply both sides of the equation by $P_{Ki}K_i$, sum across all i, and, under the assumption that all assets earn the same nominal rate of return, divide appropriately to arrive at:

$$i = \left(\frac{\Sigma r_i K_i}{\Sigma P_{Ki} K_i}\right) + \left(\frac{\Sigma \dot{P}_i K_i}{\Sigma P_{Ki} K_i}\right) - \left(\frac{\Sigma \delta_i P_{Ki} K_i}{\Sigma P_{Ki} K_i}\right)$$

This equation is the equivalent of equation (2), but for differentiated capital goods. Now, say I compute the capital stock by components and estimate the growth of the unweighted capital-output ratio to be 2% p.a. Someone else, using the exact same data, weights the capital stock components by their income shares and finds the growth of the capital-output ratio to be 3% p.a. The change in the real return, in both calculations, is the same. Weighting the capital stock changes the index of capital growth, but it does not change the amount of capital around, its rentals, capital gains, or depreciation. There is no simple

(B) Negative Rentals and Volatility

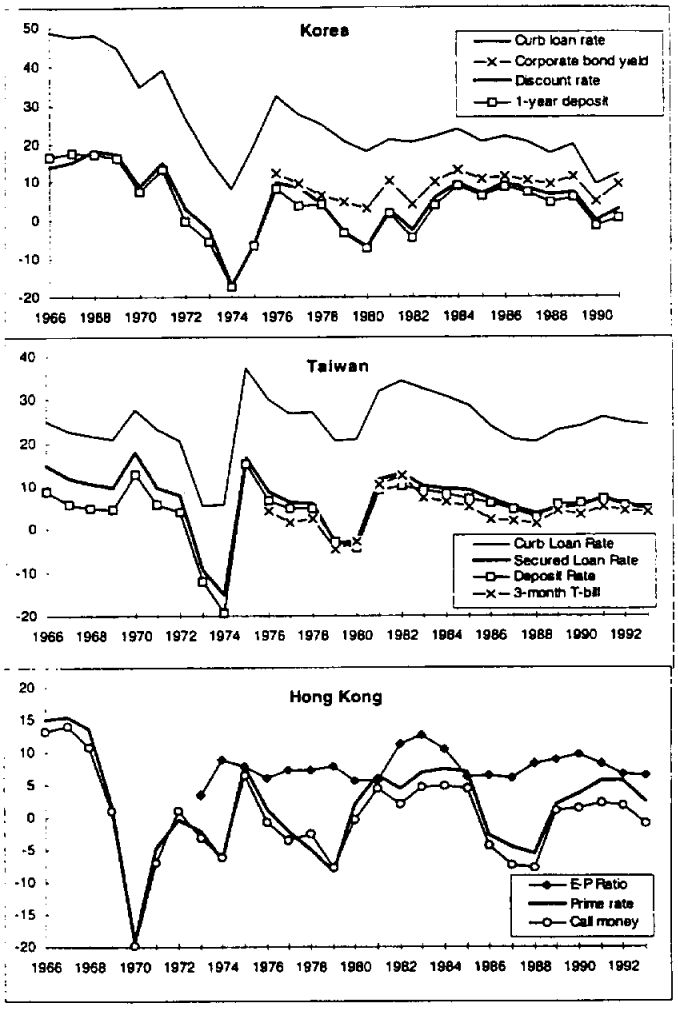
If the reader will return to Image I at the beginning of this paper, she will see that Hsieh's measure of the real average lending rate in Singapore falls below zero in a number of years. In Image III below I reproduce Hsieh's Figure 2, which reports real interest rates for Korea, Taiwan and Hong Kong. As the reader can see, in many years the rates are negative. As noted earlier, Hsieh estimates real rentals using the following formula (see 1997b, p. 13):

$$(5)\quad \frac{r_j}{P_Q} = \frac{P_{Kj}}{P_Q}\left(i - \hat{P}_{Kj} + \delta_j\right)$$

For assets with low depreciation rates, a negative real return will imply *negative* rentals. Furthermore, even when the average real return is positive, in any year in which a particular asset category has rapid inflation, if the nominal interest rate is not sufficiently high the rental of that asset will be negative.[14] All of Hsieh's estimates revolve

Image III: Return on Capital (Hsieh 1997b)

Figure 2. Real Interest Rates in Korea, Taiwan, and Hong Kong.



Notes: In Hong Kong, the E/P ratio is used as a real interest rate. For all other cases, the real interest rate is the nominal interest rate minus the ex-post rate of asset price inflation. See text for further details.

---

one-for-one relationship between estimates of the growth of the capital-output ratio and implied changes in the real return to capital.

[14]This comes from the fact that Hsieh assumes that all assets earn the same nominal rate of return. One might wonder if this problem arises in my estimates when I compute capital rentals so as to weight asset types (e.g. Young 1995, p. 656). It could, but in practice is not a problem because rather than take a nominal interest rate as datum, I adjust a fictitious nominal interest rate until payments to asset types exhaust all capital income. For all of my estimates, the nominal interest rates are high enough to ensure that all asset types earn substantially positive rentals (this helps when one is trying to exhaust capital income). Nevertheless, I have been bothered by this weighting procedure for some time, because it implies that assets which experience rapid inflation in a particular year immediately earn comparatively

around average capital rental growth rates spanning the years 19xx (the first of his series) to 1990, i.e. he does not report growth rates period by period. As the reader can see from Image III, had Hsieh ended his analysis of Hong Kong or Taiwan just one or two years earlier, his growth rates would be undefined. Interestingly, in the case of some of the South Korean measures, the rates appear to be negative, or very nearly so, even in the endpoint year of Hsieh's analysis. In these cases it is possible that Hsieh, in computing the weighted growth of capital rentals, was unable to avoid taking the logarithm of a negative number.

Regarding his estimates for Taiwan, Hsieh explains:

> Turning to the rental price of capital, nominal interest rates typically fall from 1966 to 1990. Since asset price inflation rates have not fallen, this translates into a decline in real interest rates. This is accompanied by a decline in the relative price of capital (by 1.3 percent a year from 1966 to 1990), which results in a decline in the real rental price of capital. (1997b, p. 17)

In Table IV I reproduce Hsieh's estimates of the change in the real rental price of capital in Taiwan. As the reader can see, the real rental, in the case of the first two measures, falls less than one half of a percent per annum. According to Hsieh, the relative price of capital falls by 1.3 percent per annum. The real interest rate (plus a constant depreciation) falls as well. And the sum of the two effects, as in equation (5), is about -0.5 percent per annum. In a similar vein, for Singapore, using the "average lending rate" of commercial banks, Hsieh finds that the real rental rises half a percent or more per annum between 1968 and 1990 (Table IV). If one takes a straightedge to Hsieh's series for the real average lending rate (Image I earlier), one finds that the average lending rate fell between 1968 and 1990. When added to the depreciation rate, this produces a negative number, to which one adds the growth of the relative price of capital. Unfortunately, between 1968 and 1990 the relative GFCF to GDP deflator in Singapore rose only 0.21 percent per annum. These

Table IV: Annual Growth of Real Rentals (Hsieh)		
Taiwan, using:	Unweighted	Weighted
Loan rate in informal markets (1966-90)	-0.43	-0.75
One year deposit rate (1966-90)	-0.45	-0.77
Secured loan rate (1966-90)	-1.46	-1.73
3 month treasury bill rate (1973-90)	-1.34	-1.52
Singapore, using:		
Average lending rate (1968-90)	0.75	0.52
Return on equity (1971-90)	2.09	1.94
S: Hsieh 1997b, Tables 2 and 3.		

low (albeit positive) rentals. My estimates are less influenced by this issue than Hsieh's, since I am *weighting* my primary data (capital stock growth rates), while he is *computing* his primary data (real rentals). Using a measure of ex ante expected inflation alleviates this problem, but does eliminate it, particularly in the dual, where, in years with low nominal interest rates, negative rentals may still appear.

calculations are rough and imprecise, as they do not take into account the fact that Hsieh is computing a differentiated capital stock (not a homogenous aggregate). Nevertheless, they suggest, to a reader, that there are problems with Hsieh's computational procedure.

Rather than spend time eyeballing Hsieh's graphs and speculating on the approximation error involved in adding aggregate growth rates, one can cut to the chase by using some of Hsieh's sources and estimating the growth of real rentals in Singapore. For this purpose, the lending rate of commercial banks is ideal. The annual issues of the Yearbook of Statistics (Hsieh's stated source) provide historical data on the prime (or minimum lending) rate. As these data are never revised, there is no question about which version Hsieh might have used.[15] Furthermore, the Yearbook of Statistics, which also contains information on capital formation and GDP, is available in research libraries throughout the United States, so that, with little effort, readers of this paper will be able to perform the requisite calculations independently. I copy, to the letter, Hsieh's stated methodology to construct capital stocks and capital rentals by asset type.[16] I use both the most recent (revised) versions of the national accounts, and, just in case Hsieh did not have the new numbers, the last edition of the "old" accounts.

[15]Nevertheless, it is true that there is still some question as to which data Hsieh used. Hsieh (1997b) states on p. 12 and 15, as well as in his Figure I, that he used the "average lending rate" of commercial banks, while on p. 2 and in his data appendix (p. 41) he states that he used the "prime rate." In his Table 2 (p. 16) he states, in one sentence, that he used the average lending rate and, in the following sentence, that he used the prime rate. Unfortunately, in Singaporean data the two interest rates are not the same (see the Image in Appendix I). However, the average lending rate is only reported for the period 1968-1980, while the prime rate is reported from 1968 on. As Hsieh's analysis covers 1968-1990, I use the prime rate in the computations above. Since the average lending rate lies above the prime rate, if I started my analysis with the average lending rate, and then continued on with the prime (after 1980), the growth of real rentals reported in Table V would be more negative.

[16]Hsieh explains, 1997b p. 11, that to calculate the relative price of capital he takes the ratio of the investment goods deflator by asset type to the GDP deflator from the national accounts. He states (p. 12) that he uses the ex-post rate of asset inflation to construct his estimates of the rental price. On p. 11 he provides the depreciation rates used in his analysis. On p. 14 he says he follows my procedure for computing the initial capital stock by assuming that the capital stock at the beginning of the period is given by $K_i = I_i/(\delta_i + g_i)$, where g_i is the growth rate of investment in the first five years of the series. He uses the perpetual inventory method thereafter (p. 14). He computes the share of payments to each type of capital by taking the product of the rental price times the estimated capital stock and dividing by the total payments to capital (p. 14). His weighted index of real rental growth is the tornqvist income-share weighted sum of the individual real rentals (p. 8). He is less clear about what his unweighted measure of the real rental is, but I assume that he takes the sum across asset types of the products of the individual real rentals times the capital stocks, divided by the total value of the capital stock (a measure analogous to the aggregate real wage).

It is instructive to review what, in practice, all of this means. Let B be the base year. The real rental in each year is given by:

Table V: Growth of Real Rental in Singapore (annual %)				
		Old Accounts 19xx-1990	New Accounts 19xx-1990	New Accounts 19xx-1995
Prime Rate (beginning 1968)	Unweighted	0.1	0.1	-0.4
	Weighted	-0.6	-0.6	-1.3
Return on Equity (beginning 1971)	Unweighted	1.6	1.6	0.6
	Weighted	1.5	1.7	0.4
Note: The "Old" accounts end in 1993.				

Table V above shows the results of my computations. Whether one uses the "new" or the "old" national accounts, one finds that between 1968 and 1990 the weighted real rental grew -0.6% per annum, i.e. 1.1% less than Hsieh's estimates (Table IV above). I should note that, in both cases, the real rentals are negative in many years. Nevertheless, by computing the growth between 1968 and 1990, I am able to skip the negative numbers of the intervening years. Otherwise, if one tries to compute year by year, the growth of the real rental is undefined. A spreadsheet detailing my computational procedure, and providing all of the necessary data, is available at my website at the University of Chicago.[17] In addition, as noted above, the reader

---

$$\frac{P^T_{Kj}/P^B_{Kj}}{P^T_Q/P^B_Q} * (i_T - \ln(P^{T+1}_{Kj}/P^T_{Kj}) + \delta_j)$$

or, in other words, the measured real rental is actually the desired real rental (equation 1) multiplied by the ratio of the base year price of output to the base year price of capital good j. With chain-linked deflators, the growth of this measure will not be influenced by the choice of base year. The income of each capital good j is the estimated real rental times the constant price value of each capital good ($P^B_{Kj}K_j$) or, in other words, the true value of capital income times the base year price of output. Since the income share of each capital good is arrived at by dividing its capital income by the sum of capital income across all capital goods, it is apparent that that the base year price of output will cancel out and the value share will not be influenced by the choice of base year. With the income shares and individual rental growth rates unaffected by the choice of base year, it follows that the growth of the weighted rental will be independent of the choice of base year.

Turning to the unweighted measure one could, logically, simply multiply the individual real rentals by the corresponding real capital stocks, sum across all capital goods, and then divide by the aggregate real value of the capital stock:

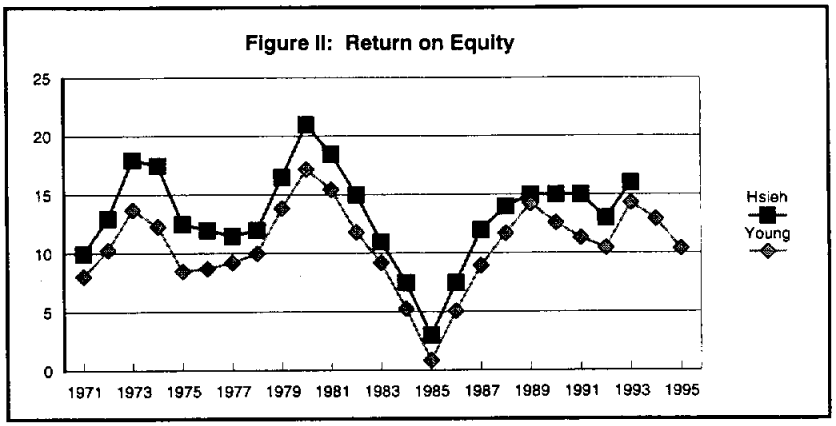
$$\frac{\Sigma \frac{r_j}{P_Q} K_j}{\Sigma K_j}$$

The problem is that one never measures K_j, one measures $P^B_{Kj}K_j$. Summing across capital goods, one finds that the growth rate of the aggregate capital stock measured in this manner varies with the choice of base year (if the relative price of different capital goods changes). Consequently, the growth of the unweighted real rental varies with the choice of the base year. In the discussion above, which compares my results to Hsieh's, I focus on the weighted rental, where Hsieh's equations are explicit, and where the results are not influenced by the choice of base year.

[17] gsbwww.uchicago.edu/fac/alwyn.young.

can check all of the computations independently, using the widely available Yearbook of Statistics.

Hsieh's other measures of rental growth are more difficult to confirm, as they use rare data and a less explicit methodology. Hsieh's highest estimate of real rental growth is derived using unpublished data on the return on equity provided by the Singaporean Department of Statistics. I asked the Department for the same data, which I graph, along with Hsieh's numbers, in Figure II. Surprisingly, the information provided by Department of Statistics does not agree with the numbers reported by Hsieh.[18] Nevertheless, I went ahead and used these data to compute the growth of real rentals between 1971 and 1990.[19]



[18]The Department of Statistics defines the return on equity as "net earnings" (specifically, the "net profits available for distribution to shareholders after deducting taxes and adjusting for extraordinary losses or gains of companies") divided by "the average of the stock of equity capital invested in the current year and the preceeding year." (Foreign Equity Investment in Singapore, 1990-1992 and personal communication with the Department). Just in case, I tried recomputing the series by dividing by just the current year's equity, or just the past year's equity. I also computed the return on equity, separately, for foreign and local investors (using average, current and past equity in the denominator). I also tried computing the series using profits and losses before taxes and extraordinary items (again, trying both average, current and past equity). None of these series matches Hsieh's data. Since Hsieh states that he uses the return to equity measure as the measure of real returns (1997b, pp. 12-13), deflation, or the choice of deflator, is not the issue here.

I should note that parts of this data set have been published in a number of sources. Nevertheless, I purchased the return on equity data, as well as the underlying components used in its calculation, so as to be able to confirm that the unpublished data disseminated by the Department of Statistics agreed with the publicly available information. Using Foreign Equity Investment in Singapore, 1990-1992, I was able to confirm that, at least for the period 1986-1992, the return on equity data provided to me by the Department of Statistics agreed with the information in public sources.

[19]Hsieh states (1997b, pp. 12-13) that he uses the return on equity as the measure of the real interest rate. However, his formula (equation 5) requires a nominal rate, from which one subtracts, individually, asset inflation by category. To compute the nominal rate, I add aggregate asset inflation to the return on equity. I compute aggregate asset inflation as the weighted average of asset inflation rates, where the weights are the shares of each asset type in the nominal value of the capital stock. This measure does not agree with, and should not agree with, the growth of the aggregate GFCF deflator. If asset types have different depreciation rates, the share of each asset type in the capital stock will differ from its share in the flows of current investment (which determine the implicit GFCF deflator).

The numbers I derive, i.e. 1.5% or 1.7% per annum (Table V), lie slightly below the numbers reported by Hsieh (Table IV).[20]

If the reader will reexamine Images I and III above, she will notice that Hsieh's estimates of the real return to capital are extraordinarily volatile. In its extreme form, this volatility is associated with negative rentals (where the growth rates are undefined), but even when the rentals are positive, the results are dramatically influenced by the years of the comparison. To illustrate this, in Table V I extend the analysis using the Singaporean prime rate and the return on equity to 1995. For the prime rate, the growth of real rentals is now found to have averaged -1.3 percent per annum. If one adds the approximate negative one to two percent growth in real rentals implied by changes in the tax code, one arrives at an estimate of a falling rental for the 1968-1995 period which is, in fact, *in excess* of the -2.1% implied by the national accounts (see Table II earlier). For the return on equity, the real rental now rises only 0.4, which, when combined with the tax code, should yield an estimate of around minus one percent growth in the real rental. If the reader will examine Figure II, she will see that Hsieh's estimate of an extraordinary 1.9% per annum growth in the real rental between 1971 and 1990, derived using this series, stems from taking a highly volatile series and starting at a low and ending near a high. If the initial and final points are each moved forward two years, my calculations show that the growth of the real rental during 1973-1992 averages -0.8% per annum (new accounts).

One approach to handling volatility, of course, is to take a time trend. In this regard, it is interesting to note that none of Hsieh's series on real returns in Singapore appears to have a

---

[20]I would report calculations using Hsieh's measure of the earning-price ratio in Singapore, but I have been unable to find his sources. On p. 16 Hsieh states (three times) that he uses the earnings price ratio of the Straits-Times index. In his appendix (p. 41) Hsieh states that this is taken from the "Singapore Stock Exchange Handbook," which is also listed as a source in his bibliography. I checked Worldcat, Rlin and the library catalogs of major research universities, and could not find any publication by the name of the Singapore Stock Exchange Handbook. When queried, the Stock Exchange of Singapore denied ever having published any such Handbook (they publish an annual *Companies* Handbook, but this does not contain earnings/price ratios, and reports only the annual high and low price). The Straits-Times, when I approached them, insisted that they do not compute a price earnings ratio for the companies in their index. Finally, in the annual issues of the Singapore Stock Exchange *Fact Book* I found a price-earnings ratio that covers the exact same time period as Hsieh's data. Hsieh, however, could not possibly have used this source. The price-earnings ratio in the Fact Book is not for the companies in the Straits-Times Price Index. Furthermore, the coverage of the annual price-earnings ratio published in the Fact Book changes through time. In early years it covers the entire exchange, later it covers industrial companies only, and then Singapore incorporated companies only. Hsieh could not have constructed a consistent series using these data.

statistically significant time trend. Consequently, one could take as a benchmark the proposition that the real return to capital in Singapore has been constant. If one then takes it as given that the real rental has been constant as well, and uses Hsieh's estimate of a growth of quality adjusted real wages of 3% and a labour share of one-half, one finds productivity growth of about one and a half percent per annum. This is similar to the primal estimates without capital deepening that I presented earlier in Table III, where, as I noted, most of the productivity growth occurs prior to 1980. A proper cost of capital computation, taking into account the tax code, finds, however, that even with a constant real return to capital, the real rental should have declined one to two percent per annum. This then brings the estimate of average total factor productivity growth down below one percent per annum, which is only slightly above the primal estimate of 0.3% (Table II).

IV. Reconciling the Dual and Primal Estimates

If one takes the identity $\theta_K = rK/P_Q Q$ and differentiates, one sees that:

(6) $\hat{r} - \hat{P}_Q = \hat{\theta}_K + (\hat{Q} - \hat{K})$

As this equation shows, once one arrives at an estimate of substantially positive real rental growth, one must believe that either the capital share has risen or the capital-output ratio has fallen.[21] Hsieh accepts and uses my estimates of a constant capital share in the Singaporean economy. Consequently, it becomes necessary for him to explain how the national accounts could mistakenly indicate that the capital-output ratio has risen 2.6% per annum (1966-1990) when, according to his estimates of real rentals, it has been falling anywhere from .2% to 1.9% per annum. As Hsieh explains:

> "...Goh Keng-Swee, one of the founders of modern Singapore and the main architect of its economic policies, suggests that the private sector overstates its capital inputs in order to take advantage of certain tax breaks. Another possibility for why the capital stock is overestimated is that there have been significant exports of second-hand capital goods from Singapore. According to the Singaporean statistical authorities, these transactions have been recorded in Singapore's national accounts as exports without a corresponding debit in the investment expenditure account. Lastly, it is likely that depreciation rates in Singapore have been much higher than in other countries, due primarily to the high rate of structural transformation of the economy." (Hsieh, p. 29).

Hsieh also argues that markups bias primal and dual estimates and uses an estimate of the markup to reconcile the two procedures and estimate true productivity growth. I will deal with each of these arguments in turn.

(A) Exaggeration of investment expenditures

The reporting of investment expenditures by the private sector has virtually no relevance to the estimation of capital formation in most LDCs. To understand why this is so, the reader might use introspection to consider how one would go about estimating gross fixed capital formation, particularly in a "data poor" country. If one were to rely on reported expenditures, one would have to survey every sector of the economy, making sure, in each case, that one

---

[21] I write equation (6) as if for a single, homogeneous, capital good, but the same relation holds with differentiated capital goods. Specifically, $\theta_K = \Sigma\, r_j K_j / P_Q Q$ and, differentiating:

$$\Sigma\left(\frac{\theta_{Kj}}{\theta_K}\right)(\hat{r}_j - \hat{P}_Q) = \hat{\theta}_K + \left(\hat{Q} - \Sigma\left(\frac{\theta_{Kj}}{\theta_K}\right)\hat{K}_j\right)$$

The growth of the weighted real rental equals the growth of the aggregate share of capital plus the growth of output per unit of weighted capital.

managed to cover all firms, including small firms. Alternatively, one could focus on the much more concentrated *sources* of capital equipment. Export and import data are one of the first areas to be be monitored by LDC statistical agencies, either for revenue reasons or because, in the case of the more open trading economies, they provide the life blood of the economy. Net retained imports of machinery and equipment, added to the estimated domestic output of machinery & transport equipment (manufacturing is typically one of the first sectors to be surveyed intensively), can yield an estimate of capital formation in machinery & equipment. For buildings and structures, building permits (i.e. standard bureaucratic regulations) provide an early record of construction activity, which can then be further developed with a survey of construction firms and architects. In sum, the standard data collected by the bureaucratic and tax apparatus of the government, combined with a concentrated survey of construction and some sectors of manufactures, provide a first cut at capital formation. Over time, surveys of other sectors of the economy (e.g. FIRE, wholesale & retail trade, etc.) can be developed. At this point, the national accounts typically begin to report data on aggregate capital formation *and* capital formation by sector.

Singapore National Accounts 1987 (p. 14) explains that capital formation in machinery in that economy is estimated as follows:

> ...Data on retained imports and retained production of capital goods are initially derived from external trade statistics and the Census of Industrial Production. These are adjusted to remove intermediate consumption by industries and final consumption by households...

Regarding transport equipment:

> ...Capital formation...is estimated from external trade statistics, production data and registration figures of these items. Capital expenditure on ships and aircraft is derived from the c.i.f. value of their retained imports or retained production at ex-factory prices...For road vehicles such as cars, taxis, lorries and buses, capital expenditure is estimated from registration data supplied by the Registrar of Vehicles while their respective prices are collected from retailers...

Regarding construction:

> ...The estimates cover certified payments for work done by architects, developers, civil and structural engineering firms, statutory boards, government departments, shipyards, and oil-refineries...

Similar explanations are published in *Singapore National Accounts 1960-1973*. Other than the *Census of Industrial Production*, occasional surveys of sectors of the economy did not begin until

the late 1960s and early 1970s, and did not become annual until the late 1980s. The Singaporean national accounts have never published estimates of capital formation by sector. Like most developing economies, Singapore bases its estimates of capital formation on the concentrated sources of *supply* of capital goods, rather than on the diffuse sources of *demand.*

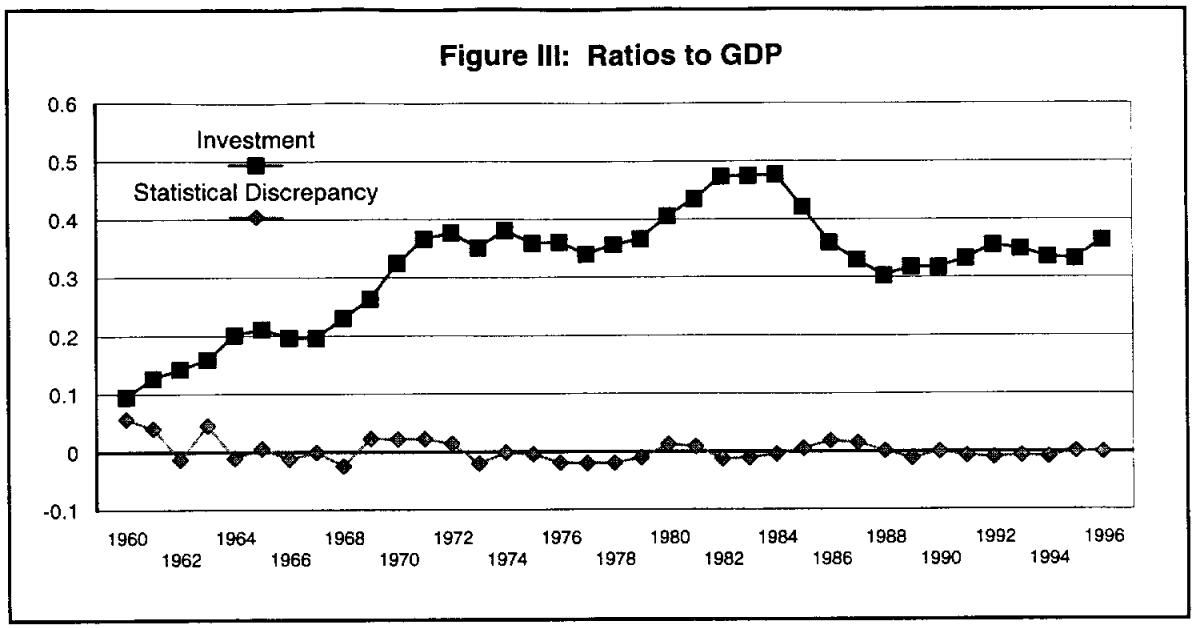
(B) Sales of Second-hand Capital Goods

I shall deal with Hsieh's argument that primal estimates overstate the growth of the Singaporean capital stock because they neglect exports of second-hand capital goods in two parts, focusing first on its aggregate implications and then on the evidence found in sectoral surveys.

Aggregate Implications

The national income accounts must balance, i.e. the measurement of output by the expenditure approach must equal the measurement of output by the income approach, as well as the measurement of output by the production approach. Further, output equals "the value of goods and services *produced* within a given time period." Consequently, investment expenditure does not typically include a debit for sales of capital goods. According to Hsieh, Singapore's statistics are no different in this respect (see the quotation above). If large overseas capital goods sales are, however, included in exports, and if these are to explain the extraordinary differences between Hsieh's dual estimates and those derived from primal sources, then the value of output as measured by the expenditure approach in the Singaporean accounts should exceed the value of output as measured by the production or income approaches. Furthermore, if this argument is to lower the growth rate of the capital stock, it is necessary that this discrepancy increase through time (i.e. the investment figures must be increasingly overstated).

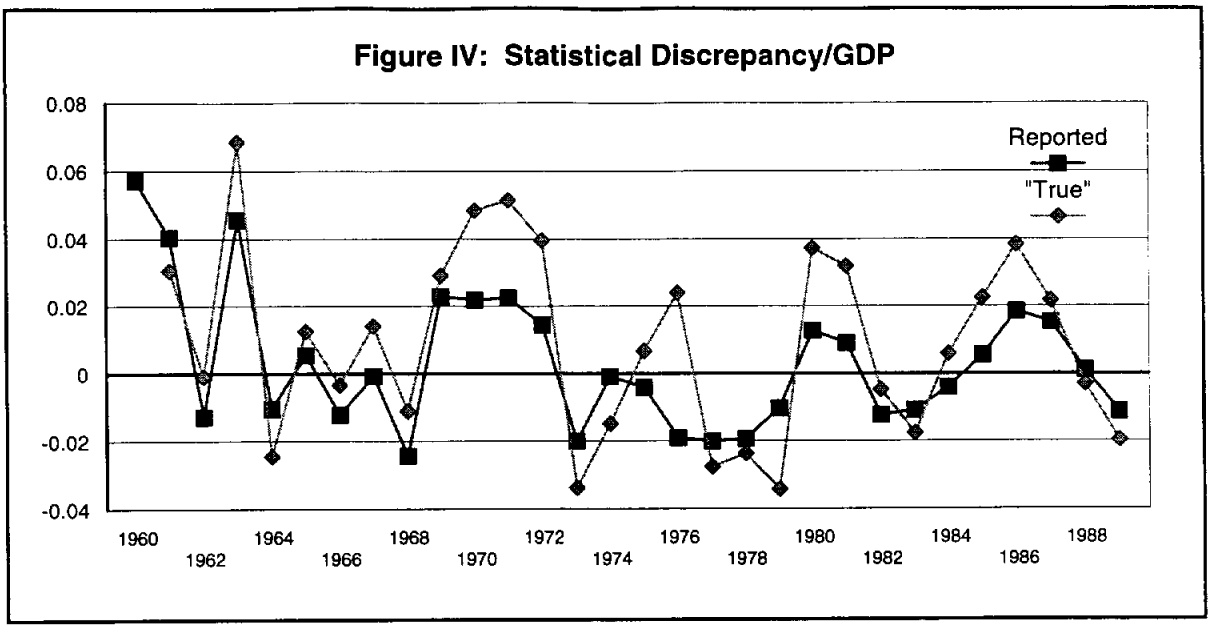
Figure III below graphs the "statistical discrepancy" added to the Singaporean expenditure accounts to reconcile them with the production accounts as a percentage of production output. If Hsieh is right, and the investment figures are overstated, then the value of this discrepancy should be negative, and increasingly so. The discrepancy was large in 1960-1961, suggesting that investment could have been *understated.* Beyond those two years, however, it shows no particular sign or trend. Relative to the volume of investment, the discrepancy is trivial.



Our story would end here were it not for the fact that the "statistical discrepancy" frequently does not reflect the true margin of error in the national accounts. Many countries adopt (but do not advertise) the practice of adjusting their reported "changes in stocks" so as to slim down the published statistical discrepancy. In 1992 the Singaporean statistical authorities graciously provided me with their unpublished numbers, i.e. their true estimates of inventory changes. Using these data, I reconstruct the "true" statistical discrepancy as a percent of production output (Figure IV).[22] The true discrepancy is substantially larger than the reported discrepancy in many years, reaching values of 4% as late as the 1980s. It is rarely, however,

[22]In estimating changes in stocks for the national accounts (even at current prices), one must remove stock appreciation during the year. Singapore National Accounts 1995 explains how one should handle such issues (if one were actually doing so). I follow their equations, using the period T to T+1 increase in the manufacturing and wholesale & retail trade GDP deflators to remove the effect of stock appreciation in those sectors in period T. My measure of the "true" discrepancy is not always larger in absolute value than the reported discrepancy. This might be due to the choice of deflator or due to other adjustments the Singaporeans are making.

I should emphasize that the Singaporeans are, by no means, the worst on this issue. There are countries which report detailed changes of stocks figures, by sector, by type of good (raw materials, finished goods, etc), and in current and constant prices, all of which, based upon conversations with officials, appear to be the purest fantasy (for this reason, I did not include inventories in my measures of capital in my 1995 paper). It is actually a tribute to the accuracy of Singaporean statistics how closely the expenditure accounts, making use of the true stock data taken from the surveys of manufacturing and wholesale & retail trade, match the production accounts.



substantially negative. Although it shows a small, statistically insignificant, negative time trend (-.06 of one percent p.a.), relative to the investment figures, it remains trivially small.

Before moving away from the consideration of aggregate relations, the reader might want to consider the implication of the passage quoted earlier above, where the Singaporeans state that they, like most LDCs, measure capital formation in machinery and equipment by taking domestic production and adding retained imports. If the Singaporeans measure second hand capital goods sales in their export statistics, as Hsieh states they do, and as most likely is the case, then these capital sales are automatically, *by construction*, subtracted from the estimates of domestic capital formation.[23]

Sectoral Surveys

Readers of Tsao's work and mine will know that we computed productivity growth in Singaporean manufacturing using data from the *Census of Industrial Production* (recall, the Singaporean national accounts do not contain information on capital formation by sector). The

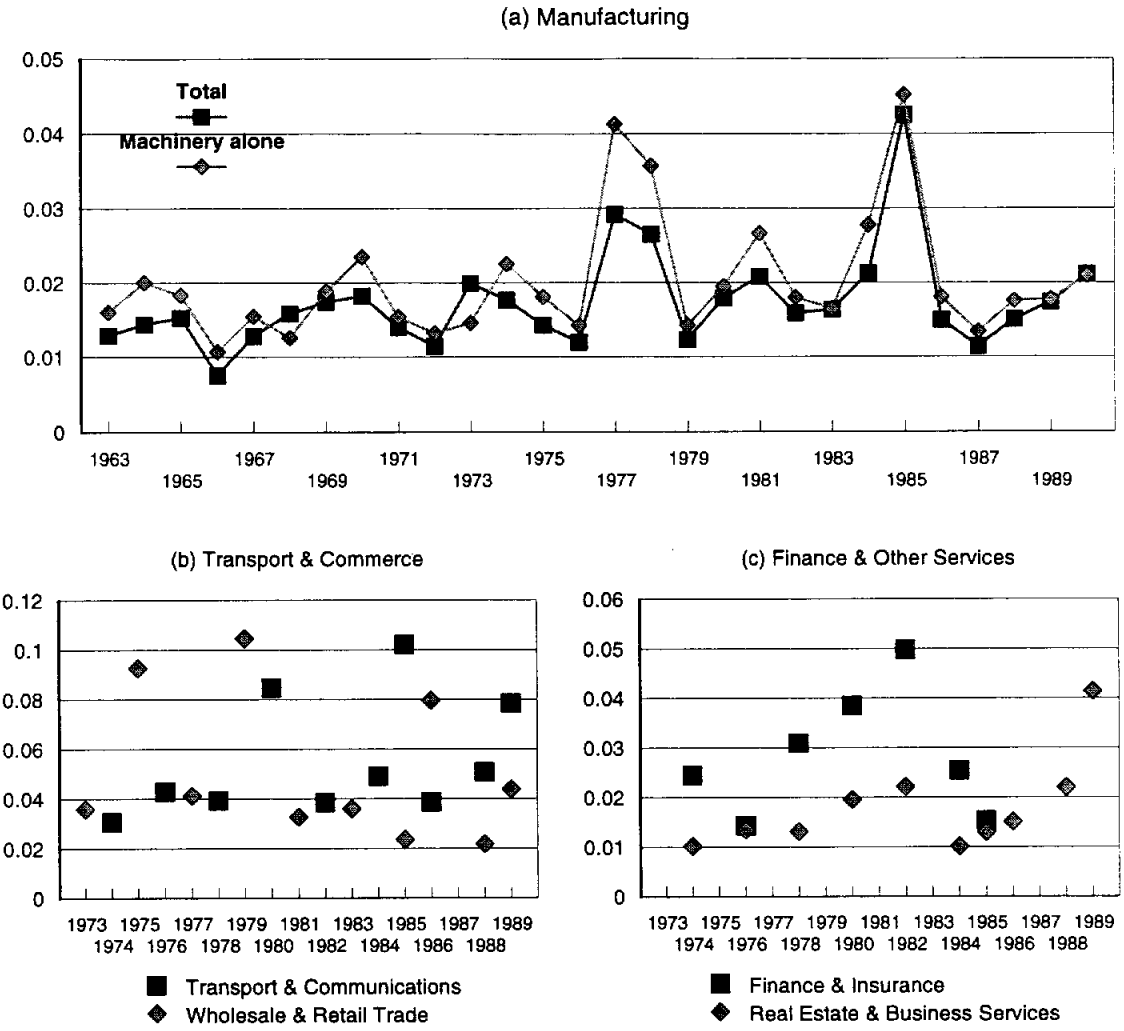
[23]I should note that when the investment figures were revised downwards in the mid-1990s, the value of exports in the national accounts was dramatically increased (something had to move in order to balance the accounts). As explained by Singapore National Accounts 1995, this was because the new goods and services tax had led to new information on the value of exports. So, if there were second-hand capital goods exports which did not appear in exports previously (i.e. Hsieh being wrong on this point), these have now been subtracted from investment and added to exports, and my revised TFP estimates incorporate the full impact of this adjustment. Interestingly, when the Singaporeans revised their national accounts, they forgot to revise upwards the quantity of exports reported in their trade statistics (Yearbook of Statistics, 1993 and 1995).

typical industrial survey collects information on the book value of fixed assets, accounting depreciation and purchases of fixed assets during the reference year. It also collects information on *sales* of fixed assets, which allows the researcher to adjust for this item. Tsao (1982, p. 58) explicitly noted that she subtracted the reported sales of fixed assets from the gross investment figures. I made a similar adjustment in my 1995 estimates (although I did not mention asset sales in my already too long paper, merely stating that I used data on fixed assets and capital formation).

From the above, the reader will realize that the data in the sectoral surveys and censuses of the Singaporean economy can actually provide some insight into the issue of increasing second hand sales of fixed assets. In Figure V below I graph the book value of annual capital sales divided by the book value of fixed assets for each sector. Although the series are highly volatile, eyeball econometrics suggest that they have positive time trends. This is confirmed in Table VI, where I regress the sales to fixed asset ratio in each sector on a time trend. In manufacturing this ratio rises .03% per annum, for a total of only .8 of one percent over the 27 years of the sample.[24] From the point of view of error in the primal estimates, only sales which leave the economy bias the estimates of productivity growth. Since land and buildings cannot move overseas, the only concern is sales of machinery & equipment. Breaking down the asset sales in manufacturing into machinery & equipment and buildings & land, one finds that, separately, neither has a significant time trend. Surveys of the other sectors of the economy show a positive time trend in aggregate sales over aggregate fixed assets, but almost none of these is significant (Table VI).

[24]The dependent variable in the regression is the sales share times 100. Consequently, one interprets the regression coefficient as percentage points. Similarly, the growth of value added, also in the Table, is the ln growth rate times 100.

Figure V: Sales of Fixed Assets/Book Value



S: Report on the Survey of Wholesale and Retail Trades, Restaurants and Hotels, Report on the Survey of Services, Report on the Census of Industrial Production, various issues. Occasionally, the surveys are titled "Census." Notes: Other than for manufacturing, fixed assets are as of the end of the year. For manufacturing, until 1986 fixed assets are as of the beginning of the year (1/1). Beginning in 1986, the manufacturing census switched to reporting fixed assets as of the end of the year (12/31). To maintain consistency, for 1986 on I use year end fixed assets reported in the previous year's census (in 1985 both beginning and year end values were reported). Prior to 1984 the data for real estate & business services included community services. Beginning in 1984 community services were separated out as a different sector. To maintain a consistent definition, I add these back to real estate & business services. The data for finance & insurance end in 1985 because beginning in 1986 all establishments within the purview of the Monetary Authority of Singapore were removed from the survey, i.e. about 80% of the value added of the sector. All of the remaining data end by 1990, because this was the last year I was able to collect when doing the background checks for my 1995 publication.

Table VI: Analysis of Sales over Fixed Assets				
	Time trend	Growth of Value Added	Time trend	N
Manufacturing	**.03** (1.86)	**-.04** (2.10)	.02 (1.16)	28
Machinery & equipment	.03 (1.41)	**-.05** (2.18)	.01 (0.69)	28
Buildings & land	.03 (1.57)	-.02 (0.86)	.02 (1.18)	28
Non-Manufacturing	.04 (0.50)	-.19 (1.70)	.00 (0.01)	37/27
Wholesale & Retail Trade	-.17 (0.92)	-.20 (1.05)	-.16 (0.90)	10
Transport & Communications	.20 (1.34)	-.24 (1.05)	.13 (0.82)	10
Finance & Insurance	.04 (0.29)	.04 (0.52)	-.00 (0.00)	7
Real Estate & Business Services	**.11** (2.05)	#	#	10
All Pooled	.03 (0.97)	**-.08** (1.92)	.01 (0.15)	65/55

Notes: Bold means significant at the 10% level in a two-tailed test. Absolute values of t-statistics in parentheses. Pooled and non-manufacturing regressions have dummies for each sector. Pooled regression uses the aggregate manufacturing sales ratio. In the national accounts, the real value added for finance and insurance is not separated from real estate & business services. Consequently, in the growth regressions I combine the sales of finance & insurance and real estate & business services and divide by their combined fixed assets. To account for the enormous change in the coverage of the financial sector, I truncate the sample for the combined sector to the 1974-1985 period. The preceeding explains why the sample size is 10 less to the right of the / marks, reflecting the smaller samples in the second specification. (#) Included under Finance.

Asset sales are likely to be high during downturns, so in the second and third columns of Table VI I modify the specification to include the growth of real value added in the reference year. The coefficient on the growth of value added is generally negative, and significant in most of the regressions with a substantial sample size. This result, which agrees with economic intuition, suggests that the data are not pure noise.[25] Once business cycle effects are taken into

[25]No doubt there is plenty of measurement error, but at least economically sensible results emerge. The reader might worry that the coefficient on the growth of value added is extremely small, e.g. -.08 of one percent in the pooled regression. The ratio of sales to capital purchases, is, however, much more sensitive to business cycles. For example, in the pooled regression the coefficient of the sales to purchases ratio on the growth of value added is -0.64 (t = -2.52), with an insignificantly positive time trend of .12 (t = 0.55). The growth of value added in the sectors varies from a high of 20% to a low of -8%. From the point of view of bias in the TFP computations, it is the ratio of sales to the stock of fixed assets (much greater than the flow of investment) that is the more direct measure, and this is what I focus on in the discussion above.

I should note that for the growth of value added I use the national accounts measure for each sector. This is because, outside of manufacturing, up until the 1980s the other surveys were biannual

account, none of the time trends is significant, and almost all of the coefficient estimates are negative or negligible. There is no evidence, either in aggregate relations or the sectoral surveys of the Singaporean economy, of a substantial upward trend in overseas capital sales as a percentage of the capital stock.[26]

(C) Accelerated Depreciation

As explained above, Hsieh argues that high rates of structural transformation might have increased the rate of scrapping in the Singaporean economy, leading me to underestimate the effective rate of depreciation in that economy. Coincidentally, this is precisely one of the explanations of Singapore's poor performance that I proposed in my 1992 paper. Image IV reproduces a scanned image of Table 9 of that paper. In my "crude" estimates I did not differentiate capital or labour input by type, and assumed

44 · YOUNG *Image IV: Increasing the Depreciation Rate*

Table 9 SENSITIVITY OF THE RESULTS TO THE DEPRECIATION RATE

	Hong Kong (1971–1990)			*Singapore (1970–1990)*		
		Contribution of TFP Growth			*Contribution of TFP Growth*	
Depreciation rate (%)	*Growth of capital*	*Absolute*	*Percentage*	*Growth of capital*	*Absolute*	*Percentage*
0	1.93	.39	.27	2.78	−.32	−.21
10	1.60	.52	.35	2.40	−.12	−.08
20	1.49	.56	.38	2.19	−.01	−.01
30	1.47	.57	.39	2.07	.06	.04
40	1.49	.56	.38	1.99	.10	.06
50	1.50	.56	.38	1.93	.13	.08
60	1.51	.55	.38	1.90	.15	.10
70	1.51	.55	.38	1.87	.16	.11
80	1.51	.55	.38	1.85	.17	.11
90	1.50	.56	.38	1.84	.18	.12
100	1.49	.56	.38	1.83	.19	.12

Notes: The analysis for Singapore makes use of figures for output growth of 1.545, labor input growth of 0.825, and an average capital share of 0.533 presented earlier in Table 5. The analysis for Hong Kong makes use of output growth of 1.472, labor input growth of 0.549, and an average capital share of 0.384.

---

rather than annual. Furthermore, the coverage of the surveys (in particular, manufacturing) changes over time, which induces "growth" in value added which has nothing to do with economic conditions. If, nevertheless, I insist on computing the growth of manufacturing value added as the nominal growth of the value added of the surveyed firms minus the growth of the sectoral national accounts deflator, the coefficient on real value added becomes -.01 (t=-.95) and the time trend is .02 (t=1.25). In other words, everything is insignificant.

[26]The reader might be worried that changing accounting depreciation rates distort the book value measures. An increase in accounting depreciation will lower both the book value of total assets and the book value of capital sales, but the effect on the latter will be stronger if the assets sold tend to be older than the average. The survey of services (transport, finance and real estate & business services) reports the gains (over book value) on the sales of fixed assets (1978-1989), while the survey of wholesale & retail trade reports the gains on the sales of all assets (1973-1989), including, presumably, financials. I take the sum of gains on sales plus the book value of sales as the measure of the sales price, and divide this by the book value of sales. Putting aside issues of time varying inflation, an upward trend in this measure could be taken as an indication that the book value of sales increasingly understates the true ratio of sales to the capital stock. The measure is extraordinarily volatile but, nevertheless, I regress it on time (with dummies for the four industries). The coefficient on time is positive (.016), but insignificant at the 10% level (t=1.56, n=31). If I take out one observation (wholesale & retail trade in 1989), the coefficient falls to .008 with a t of .80. I should note that both surveys also asked for losses on the sales of fixed assets, but these are not reported in the publications.

a benchmark depreciation rate of 10% per annum. In the Table I showed that if one cranks the Singaporean depreciation rate up to 30% per annum total factor productivity growth over the 1970-1990 period rises from -.12 to 0.06, i.e. from -0.6 to 0.3 percent per annum.

The estimates in Image IV are crude, making no adjustment for the composition of the labour force or capital stock, and do not make use of the vast improvement in the quality of my data since 1992. In Table VII below, I rerun the exercise. In my standard estimates, column (1), I assume that the depreciation rate is 1.3% for residential structures, 2.8% for non-residential structures, 3.4% for other construction, 18.3% for transport equipment, and 14.0% for machinery. Structural transformation is unlikely to have increased the depreciation rate of buildings and structures, but may have increased the depreciation rate for machinery & equipment. In columns (2) and (3) I double and then triple the depreciation rate for machinery & transport equipment. This raises the average rate of total factor productivity growth from .3 to .5 percent per annum.[27] This adjustment, similar to what I did in 1992, may not give the structural transformation hypothesis a fair run, as it assumes that the depreciation rate in the 1980s was the same as it was in the 1960s. As an alternative scenario, I double and triple the depreciation rates for machinery & equipment, but beginning in 1966 alone (columns (4) and (5)). This sudden surge in the rate of depreciation raises the average productivity growth rate yet further, but only because it raises productivity growth in early years to extraordinary levels. Finally, I consider scenarios where the rate of depreciation rises linearly from its baseline value in 1966 to double or triple that value in 1990 (columns (6) and (7)). With this path of gradually accelerating depreciation, one can, ultimately, drive the average productivity growth rate up to 1% p.a., although productivity growth since 1970 still only averages .4% percent per annum.[28] It is important to note that even

---

[27]With this Table in mind, the reader can evaluate Hsieh's statement (quoted earlier above) that:

> ...the growth rate of the real capital stock [in primal estimates] will be severely biased if the depreciation rate is incorrect, even if the gap between the available estimates of the depreciation rate and its true value remains unchanged. (1997b, p. 11)

In columns (2) and (3) of Table VII I double and then triple the depreciation rate on machinery & equipment, and the growth of the weighted capital-output ratio goes from 2.1% to 1.6%, that is, the growth of the capital stock (the item that is "severely biased") goes from 10.7% to 10.2%. To get a reasonably large effect, one generally needs a *time trend* in the depreciation rate, as in columns (6) and (7) in the Table.

[28]Of course, this is substantially better than the -.5% per annum for the same period in the baseline estimates. The point is that, with the exception of the 1966-1970 period, productivity growth in Singapore is so poor that one can heave and haul as much as one likes, and the best one can do is turn

Table VII: Impact of Modifying the Depreciation Rate							
	Baseline	2x & 3x Depreciation		2x & 3x Depreciation (beginning 1966)		2x & 3x Depreciation (linearly increasing)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
On total factor productivity growth:							
66-70	0.048	0.047	0.046	0.059	0.071	0.049	0.050
70-80	-0.012	-0.007	-0.004	-0.006	-0.004	-0.007	-0.002
80-90	-0.002	-0.000	-0.001	-0.000	-0.001	0.005	0.008
90-95	0.004	0.003	0.004	0.003	0.004	0.005	0.006
66-95	0.003	0.004	0.005	0.006	0.009	0.007	0.010
On the growth of the capital-output ratio (66-95):							
Raw	0.017	0.013	0.012	0.011	0.008	0.012	0.009
Weighted	0.021	0.018	0.016	0.014	0.009	0.012	0.006
On capital returns $\left(i-\hat{P}_K\right)$:							
1966	0.345	0.354	0.361	0.309	0.272	0.345	0.345
1970	0.339	0.347	0.349	0.340	0.343	0.335	0.331
1980	0.162	0.169	0.176	0.169	0.176	0.158	0.158
1990	0.138	0.148	0.151	0.148	0.151	0.143	0.146
1995	0.142	0.148	0.152	0.148	0.152	0.148	0.152

in this case, where, by 1990, firms are believed to be disposing of about *half* of their machinery and equipment every year, the capital-output ratio still rises by .6% per annum between 1966 and 1995. With a roughly constant capital share, the weighted real rental would be falling, not rising, as in Hsieh's estimates.

As noted earlier in Section III, the depreciation rate has an important impact on capital returns. As the depreciation rate rises, the return to capital falls (ceteris paribus). If the rate of capital depreciation has risen in Singapore, this would have had deleterious effects on the return to capital in that economy. In Table VII I report the value of the real return to capital that emerges from the procedure I use to weight asset categories, which is analogous to Hsieh's cost of capital calculations.[29] In my baseline estimates, the "real return to capital" falls from .345 to

---

regression into stagnation.

[29]As I explained in Young 1995 (pp. 655-656), without consideration of taxes, the rental on a capital good j is given by:

$$r_j(t) = P_{Kj}(t-1)\,i(t) + \delta P_{Kj}(t) - \left(P_{Kj}(t) - P_{Kj}(t-1)\right)$$

I adjust i(t) until the total payments to capital equal my estimate of the aggregate share of capital. This yields estimates of the rental price of each asset category, when then allows me to determine its share of payments to capital. I must emphasize that by no means is the formula above intended to yield an estimate of *the* real return to capital. As I explained in Young 1995 (pp. 656), I am just trying to put

.142. In the other estimates, as one doubles and triples the depreciation rate, it falls by just as much![30] In the most effective of the adjustments, where the depreciation on machinery & equipment increases linearly to three times its initial value, the weighted capital output-ratio rises only 0.6% per annum. Yet, nevertheless, the real return to capital falls by as much as it does in the baseline estimates. In other words, accelerated depreciation, while it may improve somewhat the estimated growth of total factor productivity in the Singaporean economy, has nothing to do with explaining Hsieh's estimates, which derive from the fact that, in point to point computations on highly volatile series, he finds that the return to capital in the Singaporean economy has risen through time.

In defence of Hsieh, one could argue that the computations in Table VII overstate the impact of depreciation induced by economic transformation on capital returns. Since this type of depreciation does not involve actual wear and tear, firms may recoup this value when they sell assets they no longer need. Still, to the degree that capital is clay, rather than putty, capital goods sales will involve capital losses. Further, the evidence from the censuses and surveys of the Singaporean economy (discussed above) indicates that capital goods sales constitute a minuscule share of the capital stock and show virtually no time trend. If structural transformation has resulted in accelerated depreciation, it is not, at least according to the survey records, being recouped through asset sales.

(D) Markups

To reconcile the discrepancy between his dual and primal estimates of productivity growth, Hsieh extends Hall's (1990) analysis of markups and productivity growth. Hsieh's argument proceeds as follows: Let price equal μ times marginal cost, and let output be given by

---

greater weight on assets with higher depreciation rates and declining relative prices which should, in equilibrium, command relatively higher rentals (relative to asset value). To measure the real return to capital one would have to adjust for taxation, as well as for other assets, such as inventories, which have a claim on capital income. I report the implicit i(t)'s simply to illustrate the effect of depreciation on capital returns. To report a real return (in the Table), I estimate capital goods inflation using the growth between period T-1 and T of the GFCF deflators by asset type weighted by the share of each capital good in the nominal value of the capital stock (the reader will notice that i(t) in the equation above is a period T-1 to T interest rate).

[30]The reader might notice that the return on capital in 1966 is lowest for the series where I suddenly increase the depreciation rate in that year (columns (4) and (5)). This is because, with the initial capital stock high (from the low depreciation rates early on), the sudden increase in the depreciation rate depresses the return. From 1970 on these series show much the same pattern, and proportionate decline, as the others.

the constant returns to scale production function $Y = AF(K, L)$. The economist estimates the share of labour ($\widetilde{\theta_L}$) as wage payments over total revenue which, because of the markups, understates the true share of labour by a factor of μ ($\theta_L = \mu\widetilde{\theta_L}$). Estimated and true productivity growth are then given by:

$$\hat{TFP}_{primal}\,(est.) = \hat{Y} - \widetilde{\theta_L}\hat{L} - (1-\widetilde{\theta_L})\hat{K} \qquad \hat{A} = \hat{Y} - \theta_L\hat{L} - (1-\theta_L)\hat{K}$$

and the relationship between the two is easily seen to be:

$$\hat{TFP}_{primal}\,(est.) = \hat{A} - (\mu - 1)\,\widetilde{\theta_L}(\hat{K} - \hat{L})$$

Similarly, if the dual unit cost function is given by $p = \mu A^{-1}c(w, r)$ then:

$$\hat{TFP}_{dual}\,(est.) = \widetilde{\theta_L}\hat{w} + (1-\widetilde{\theta_L})\hat{r} - \hat{p} \qquad \hat{A} = \theta_L\hat{w} + (1-\theta_L)\hat{r} - \hat{p}$$

$$\hat{TFP}_{dual}\,(est.) = \hat{A} - (\mu - 1)\,\widetilde{\theta_L}(\hat{w} - \hat{r})$$

Given knowledge of the growth of the capital-labour and wage-rental ratio, the difference between the dual and primal estimates then provides information on the size of markups in the economy:

$$(*)\; TFP_{dual}(est.) - \hat{TFP}_{primal}\,(est.) = (\mu - 1)\widetilde{\theta_L}\left[(\hat{K} - \hat{L}) - (\hat{w} - \hat{r})\right]$$

After adjusting (upward) the primal estimates of TFP growth to reflect his estimate of the overstatement of the growth rate of private capital and the understatement of the rental value of housing, Hsieh then reconciles the remaining discrepancy between the dual and primal estimates by means of an appeal to a markup of 69%. With this markup in mind, true TFP growth, after adjusting the primal and (average) dual estimates for the understatement of the share of labour, is found to be 2.34% per annum.

The problem with this argument lies in its notation. r in the equations above represents the shadow rental value of capital, not the actual capital return. To the degree that the return on capital is measured inclusive of monopoly rents, the primal and dual estimates, even when they underestimate the true share of labour, should be identical. To see this, take the identity $PY = wL + RK$, where R is the rental on capital inclusive of monopoly rents. Differentiating, one finds that:

$$\widetilde{\theta_L}\hat{w} + (1-\widetilde{\theta_L})\hat{R} - \hat{p} = \hat{Y} - \widetilde{\theta_L}\hat{L} - (1-\widetilde{\theta_L})\hat{K}$$

Only those dual estimates which make use of measures of capital returns which are *exclusive* of monopoly rents should yield higher measures of productivity growth (assuming the capital-labour

ratio is growing faster than the wage-rental ratio, as in Hsieh's primal and dual estimates). Hsieh's estimate of Singaporean productivity growth using the "average lending rate of commercial banks" is 1.63% per annum. This measure, if accurate, would be a true measure of the shadow rental of capital. Based upon the data on the return on equity, Hsieh finds productivity growth of 2.55% per annum, while using the earnings-price ratio he reports 1.89% per annum. Both of these estimates include monopoly rents in the measurement of the return to capital, but they in no way agree with the primal estimates and, furthermore, are greater than the estimate computed using a measure of the shadow rental.

Another important problem is that the expression in brackets in equation (*) above is related to the change in the share of labour. For a constant labour share and a constant markup, both of which Hsieh assumes, it is *identically equal to zero* (i.e. in this case, the growth of R and r are the same, as $R = r[1 + (\mu - 1)/\theta_K]$).

(E) Summary: Oil and Water

As Hsieh argues in his introduction:

> ...The advantage of the dual estimates is that they are based on market prices, namely wages and interest rates, paid by agents, who have every incentive to get the prices right...In contrast, the national accounts are estimated by bureaucrats in underfunded government agencies, with few incentives to provide accurate figures. (1997b, p. 3)

Hsieh does not conduct independent surveys of historical factor returns. Instead, for the most part he makes use of data (interest rates, return on equity, wage surveys, etc.) compiled by the very same government statistical agencies which produce the national accounts. Furthermore, to construct his dual estimates, Hsieh leans heavily on the national accounts, making use of the GDP and GFCF deflators to construct his real rentals, the capital formation figures to estimate capital stocks to weight the individual rentals, and my estimates of the share of labour to weight the overall growth of wages and rentals.[31] In this regard, it is worth considering a heuristic computation that illustrates the extraordinary inconsistency between Hsieh's data and the national accounts sources that he, ultimately, relies on.

---

[31]Hsieh even adjusts the GDP deflator of Taiwan in line with my estimate of the degree to which the Taiwanese national accounts overstate the growth of public sector output, estimates which I derived using purely primal data. In Young 1995 I reported that this adjustment lowers the growth of non-agricultural GDP by 0.5% per annum. Hsieh, however, uses this measure to adjust the growth of the aggregate GDP deflator (Hsieh 1997b, p. 16).

According to Hsieh's preferred measure of real rentals, i.e. that based on the return to equity, which he emphasizes exclusively in his introduction and which yields the highest estimates of productivity growth, between 1971 and 1990 the unweighted real rental on capital in Singapore rose about 2% per annum. For a constant share of capital, this implies a 2% per annum reduction in the unweighted capital-output ratio (equation (6) earlier above). The growth of the capital-output ratio is given by:

$$(7)\ \hat{K} - \hat{Y} = sY/K - \delta - g$$

where g is the growth of output and s is the savings rate that finances investment. Consequently, in steady state:

$$(8)\ \frac{K}{Y} = \frac{s}{\delta + g}$$

Imagine that the Singaporean economy was near one steady state in 1971 and near another in 1990. Taking the ln difference of equation (8) between 1971 and 1990, one sees that:

$$(9)\ \ln\left(\frac{S_{90}}{S_{71}}\right) = \ln\left(\frac{K/Y_{90}}{K/Y_{71}}\right) + \ln\left(\frac{\delta + g_{90}}{\delta + g_{71}}\right)$$

Between 1966 and 1971 real GDP grew an average of about 13% per annum, while between 1985 and 1990 it grew about 8%. Assuming that the depreciation rate is .06, and using the -2% growth implied by Hsieh's estimates, it follows that:

$$\ln\left(\frac{S_{90}}{S_{71}}\right) = -.02 * 19 - .31 = -.69$$

Between 1966 and 1971 the investment rate averaged about 27% of GDP. Between 1985 and 1990, based upon the lower investment figures of the newly revised accounts, it averaged 34%.[32] According to Hsieh's estimates of the growth of real rentals, it should have averaged .27*exp(-.69), i.e. 14% of GDP. Thus, if Hsieh is right, by 1990 the Singaporean national accounts overstated gross fixed capital formation by about 20% of GDP.[33]

[32]These figures are in constant 1990 prices. In current prices, the corresponding numbers are 26% and 34%.

[33]Say one wished to give Hsieh the benefit of the doubt and assumed that the depreciation rate almost doubled between 1966 and 1990 (specifically, increased by enough to offset the fall in GDP growth). In this case, according to Hsieh's results, the ln of the investment to GDP ratio should have fallen by -.38, i.e. should have averaged 18% between 1985 and 1990, 16 percentage points below the level recorded by the national accounts.

And how do my primal estimates fare in these crude back of the envelope calculations? According to my numbers, between 1970 and 1990 the unweighted capital/output ratio rose 2.8% per annum. Plugging this into equation (9), one finds that the ln of the investment rate should have risen by about .22 between 1971 and 1990, i.e. the investment to GDP ratio between 1985 and 1990 should have

As this crude example starkly illustrates, no amount of patching, no number of appeals to hidden sales of assets, accelerated depreciation or monopoly markups, will ever reconcile Hsieh's data with those of the Singaporean national accounts. Thus, any reader of Hsieh's paper realizes almost immediately that there are only two choices. First, one can conclude that Singapore's statisticians are colossally incompetent. If so, even dual estimates of productivity growth are problematic, as they draw upon the national accounts deflators, capital formation statistics, and labour shares, not to mention the wage and capital returns series, produced by the self-same incompetent officials. Second, one can conclude that the problem lies in Hsieh's methodology and choice of sources. I have already shown that if one corrects computational errors, adjusts for the tax code, and takes into account the fact that Hsieh ends his estimates near peak values for his series (which, otherwise, have no trend), one derives estimates that are much closer to the patterns implied by the national accounts. Further, as I show in the appendices, there exist other sources which support the picture painted by the national accounts, some of them implying even greater declines in the real rental. Although it is possible to construct series that completely contradict the national accounts, given that no compelling argument has been given as to the sources of bias in the national accounts, and given that substantial, independent, evidence can be gathered which supports these accounts, I see little reason to reject the work of a generation of Singaporean statisticians.

---

averaged about 34%, which is exactly what it did. (I did this computation *after* I had derived the theory and written the text above).

V. Conclusion: Improving on the National Accounts

To conclude, I would like to review some of the problems Hsieh faced in his computation of the growth of wages, in order to illustrate the difficulties inherent to TFP computations and the extraordinary challenge Hsieh imposed on himself when he set out to improve on the national accounts. For data on real wages in Korea, as Hsieh explains, he used the following sources:

> Wages by sex and education for 1969-1994 are complied from the annual issues of the *Report on the Occupational Wage Survey* (in Korean). Prior to 1969, a survey by the Bank of Korea in 1967 provides data on wages by sex and education in the manufacturing and mining industries. (1997b, p. 40)

Table VIII below indicates the number of workers reported by the 1980 Occupational Wage Survey (OWS), the 1980 Census and the 1980 Economically Active Population Survey of Korea. As the reader can see, according to the OWS in 1980 there were only two and a half million workers in the Korean economy, 70% of which were in manufacturing. The Census and Economically Active Population Survey disagree with this assessment. The OWS, like so many surveys, is an unbalanced and unscaled sample, in this case mainly of firms in the Korean manufacturing sector. It is, however, the principal source on wages in the Korean economy. Hsieh uses this unscaled sample to estimate the growth of aggregate wages and to make adjustments for the changing sex and educational composition of the economy's entire labour force.[34]

Table VIII: Distribution of the Korean Working Population (1980)

	Manufacturing	Other Sectors
Occupational Wage Survey	1,861,026	867,779
Population Census	4,320,605	11,430,086
Econ. Active Population Survey	2,972,000	10,734,000

In the case of Taiwan, Hsieh explains that:

> ...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 1972-1990 are thus from the published tables of the *Survey of Personal Income Distribution*. Fei, Ranis, and Kuo (1979) went back to the original tabulation sheets of the 1966 survey and estimated wages by sex and education. Unfortunately, the data from the 1966 survey is not fully comparable with the data presented after 1972 since the 1966 survey presents data on wage income of each worker and not on

[34]From this, the reader will realize that for Korea Hsieh is actually reporting substantially *lower* productivity growth than I did in Young 1995. I estimated a fairly rapid increase in output per effective worker in the Korean manufacturing sector (6.7% per annum), while Hsieh's estimate of the growth of real wages in the Korean economy (essentially, in Korean manufacturing) is only 4.38% per annum. The rapid growth of output per worker in manufacturing, combined with a minimal decline in output per unit of capital, resulted in my estimate of a robust 3.0% annual TFP growth in that sector (compare with Hsieh's estimates of 1.3% to 1.6%).

> household income. The only data on wage income for each worker by sex and education is from a survey conducted in 1972 by the Ministry of Education (Ganicott, 1972). Therefore, the estimates of the growth of real wages from 1966 to 1972 are from the 1966 household survey and from the 1972 survey by the Ministry of Education. (1997b, p. 39)

Thus, as he makes clear, Hsieh's estimate of the growth of wages from 1972 on is really the growth of aggregate household income, adjusted, presumably, by the educational attainment of the heads of households. To take these data as a proxy for the growth of wages in the Taiwanese economy, one has to put aside issues such as the rise of the nuclear family, changing female participation rates and changes in wage to non-wage income. The Survey of Personal Income Distribution actually provides data on the growth of compensation of employees per worker from 1975 on (including age & educational breakdowns), but Hsieh, apparently, did not make use of these.

Had Hsieh used the compensation of employees data presented in the Survey of Personal Income Distribution, he still would not have gotten the "correct" answer. Table IX below presents the age profile of wages in Singapore in 1980, as indicated by the Census of that year. Labour income in Singapore follows the pattern I have seen in other LDCs, with wage earnings rising up through middle age, and then falling as workers approach retirement. This inverted U-shaped pattern emerges, no doubt, because of the competing effects of experience, which rises with age, and the quantity (years) and quality (vintage) of education, which typically fall with age. Table IX also presents the age profile of wages in Taiwan, as indicated by data published in the Survey of Personal Income Distribution. As the reader can see, wages in Taiwan do not fall after middle age and, surprisingly, reach their peak value when workers pass 65 years of age.

Table IX: Relative Labour Income by Age Group (1980, Males)

	Singapore (employees)	Taiwan (publication)	Taiwan (employees)	Taiwan (wage earners)
≤ 24	1.00	1.00	1.00	1.00
25-29	1.95	1.69	1.67	1.68
30-34	2.71	2.06	2.02	2.03
35-39	3.03	2.26	2.17	2.18
40-44	2.85	2.25	2.11	2.12
45-49	2.64	2.19	2.05	2.05
50-54	2.41	2.30	2.16	2.15
55-59	2.08	2.22	2.08	2.05
60-64	1.53	2.18	2.00	1.94
≥ 65	*	2.76	1.92	1.65

(*) Included under 60-64. S: Singapore, computed using published & unpublished tabulations of 1980 Census (as explained in Young 1995, p. 653); Taiwan, publication and data tapes of the Survey of Personal Income Distribution 1980.

Image V: 1980 Survey of Personal Income Distribution (Taiwan)

Table 12. Average Primary Income & Available Agriculture, Non-Agriculture & (1980)

Income Per Income Recipient by Age Group, Sex of Income Recipients (Cont. 4)

	40 – 44 years				45 – 49 years			
	Agriculture	Non-agriculture			Agriculture			Non
	Female	Sub-total	Male	Female	Sub-total	Male	Female	Sub-total
1. Compensation of employees ($1,000)	1 458 635	55 313 729	47 006 146	8 307 583	5 463 114	4 650 487	812 627	48 696 306
No. of recipients	27 655	351 363	262 594	88 769	37 505	16 947	20 558	304 933
Average receipt per recipient ($)	52 744	157 420	178 999	93 587	145 664	274 414	39 529	159 695
2. Entrepreneurial income	1 486 628	24 916 334	21 753 277	3 163 047	10 287 392	9 104 464	1 182 928	19 713 231
No. of recipients	46 901	130 120	99 875	30 245	151 390	117 996	33 394	101 506
Average receipt per recipient	31 697	191 487	217 805	104 581	67 953	77 159	35 423	194 208
I. Net agricultural income	1 419 674	32 865	15 358	17 507	9 281 540	8 208 835	1 072 705	38 647
No. of recipients	46 157	–	–	–	146 220	113 550	32 670	–
Average receipt per recipient	30 757	–	–	–	63 477	72 293	32 835	–
II. Net forest income	12 980	55 127	53 927	1 200	88 735	77 797	10 938	1 048
No. of recipients	–	–	–	–	242	242	–	–
Average receipt per recipient	–	–						

I was confounded by this, until Christina Paxson provided me with the data tapes of the Taiwanese Survey. Image V reproduces a scanned image of Table 12 of the published 1980 Survey. The table reports "compensation of employees," which, I found out, represents the total wage earnings of *all* workers, i.e. including those who reported their employment status to be "employers", "self-employed", "students", "jobless", etc. The table also presents the "number of recipients", which only counts those who listed their status as "employee". Dividing the first term by the second, the table calculates compensation per recipient. Since the proportion of workers earning some wage compensation, but not classifying themselves as "employees", is higher in older age groups, the published data distort the age profile of wages. In Table IX I present the age distribution of wages calculated as the compensation of those calling themselves "employees", divided by the number of such persons. As the reader can see, the leap in earnings at age 65 disappears. I also compute the average wage earnings of all wage earners, including those who were not classified as formal employees, but otherwise earned labour income (excluding, however, those formally listed as employers, self-employed or unpaid family workers). The age profile is now hump-shaped, as in other LDCs.[35] In sum, due to errors in

[35]In producing my estimates of wages by age, sex and education for my 1995 publication, I automatically dropped from the sample all those listed as unemployed, producing the wage distribution labelled "employees" in Table IX. Unfortunately, the survey appears to classify those earning less than a minimum wage, those working less than a certain number of hours, housewives, the disabled, and others as "unemployed." A more appropriate wage profile would be that in the column labelled "wage earners", since those listed as unemployed (but earning income) in the Survey would, typically, be listed as

programming (which have persisted for two decades), one cannot use the published tabulations of the Survey of Personal Income Distribution to compute the growth of wages per worker in Taiwan, or to weight the changing age, sex and educational distribution of that country's working population.

In the case of Hong Kong and Singapore, the published income data are, in many cases, presented in the form of an income distribution, which must then be weighted to compute the average wage. Rather than focus on Hsieh's computations, which involve a variety of procedures and difficulties,[36] I will give an example that I encountered in my own work. In Table X below I show the distribution of the earnings of contributors to the Central Provident Fund (Singapore's

---

workers in census and labour force publications. I hope to clean this up, and make a number of other adjustments, in a later revision of my numbers for all of the NICs.

The reader might notice that wages do not fall as rapidly past age 60 in Taiwan as in Singapore. In Singapore the working elderly are considerably less educated than the working middle aged, while, according to both the Survey of Personal Income Distribution and Census sources, the opposite is actually true in Taiwan. Educational attainment has risen much more rapidly in Singapore.

[36]For Hong Kong, Hsieh states (1997b, p. 39)

> The published tables of the 1966 Hong Kong By-Census...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 estimate average wage by sex and education by assuming that the average wage for each income range was 200, 500 and 750 respectively.

The income reported in the 1966 By-Census was *household income*. About one third of those reporting income were in the "600 and above" category (for which the appropriate weight is unknown). Hsieh explains (1997b, p. 39):

> ...Data on wages by sex and education for 1981, 1986, and 1991 are from the datasets of the 1 percent sample of the Hong Kong Census 1981 and 1991 and the Hong Kong By-Census of 1986. The 1976 wage data is from the tables in the Hong Kong By-Census 1976, Basic Tables.

The income concept in 1976-1991 was "income from employment", including profit income for employers and the self-employed. The 1976 data are in the form of a distribution, although medians (but no means) were reported. Household income is also reported in the later censuses.

Regarding Singapore, for 1966 data from the Household Survey and for annual data from the Report on the Labour Force Survey, Hsieh states (1997b, p. 40):

> I assume that wages in the upper income group are log-normally distributed and average wage in the other groups is simply the midpoint between the lower and upper wage brackets.

I cannot reproduce this as I do not know how to compute the mean of a log-normal distribution with one observation (the number in the category). The 1966 income data excluded unpaid family workers (this is not always the case in later data). The Labour Force Survey's concept of income is "gross monthly income", i.e. income from employment, including profits. Hsieh states he takes estimates of wages for 1972 from the Household Expenditure Survey (includes unpaid workers and non-employment income, e.g. rents and transfers) and for 1980 and 1990 from the Population Censuses (reporting income from work alone).

Table X: Contributors to the Central Provident Fund by Wage Level (1971, S$)					
Yearbook of Statistics 1972/73		Yearbook of Statistics 1980/81		Yearbk. of Labour Statistics 1976	
< 100	62,126	< 100	62.1	< 205	241,800
100-199	164,134	100-199	164.1	205-404	105,219
200-299	80,092	200-299	80.1	405-604	33,567
300-399	37,758	300-399	37.8	605-804	13,722
400-499	21,807	400-499	21.8	805-1004	7,042
500 & over	44,495	500-599	13.0	1005-1204	3,276
		600-799	14.3	1205-1404	2,097
		800-999	6.7	1405-1504	564
		1000-1199	4.1	1505 & over	3,125
		1200-1499	3.2	Not specified	5,260
		1500 & over	3.2		
		Not stated	5.3		
Total	410,412	Total	415.7	Total	415,672
Mean Wage	295	Mean Wage	267	Mean Wage	256

social security system) as reported in three sources. These sources summarize the exact same data, but provide different breakdowns. To compute the mean wage, I use a common procedure from studies of productivity or income distribution, i.e. using a midpoint weight for each closed income category and assuming that the top two income categories follow a Pareto distribution.[37] Using this procedure on the data from the *Yearbook of Statistics 1972/73*, I find that the mean wage in 1971 was S$ 295. The *Yearbook of Statistics 1980/81* provided more detailed data on the top income categories and I now find, using the same procedure, that the mean income was S$ 267. The Pareto distribution, apparently, is not a good approximation of the income distribution in the top income categories. The *Yearbook of Labour Statistics 1976* then reported the same data again, but with a slight change in the income brackets. The mean wage is now found to be S$ 256. Apparently, the midpoint weight assumption is inaccurate, as large numbers of individuals only just fall over each of the centenary income categories. Using an identical procedure, but having simply come across three different categorizations of the same data, my estimate of the mean wage varies by 14%. The reader can only imagine the variety of results one

[37]Let X_0 and X_1 be the lower and upper bounds of the next to last income category, and N_0 and N_1 be the number of individuals in the next to last and last income categories. Then, with two observations, one "estimates" the Pareto parameter to be $\theta = \ln\left(\frac{N_1}{N_1+N_0}\right)/\ln\left(\frac{X_0}{X_1}\right)$, with the mean income of the top two income groups given by $X_0\theta/(\theta-1)$. This is the standard procedure used, for example, by Tsao (1982) and Rao & Ramakrishnan (1980).

can derive using different weighting procedures, combining data from different sources, covering different concepts of income in different years.

The statistical record of an economy is a veritable minefield. There are unbalanced and unscaled surveys, misreported and scrambled data, and data that are reported differently in different publications. Long standing surveys, giving the appearance of continuity, contain hidden changes in definitions and coverage, which make comparisons across time problematic. The reported results of occasional surveys and censuses are even more pernicious, as the values of income and wealth reported in these vary extraordinarily, with enormous amounts of income or capital reported in one survey, and disappearing in the next. In my experience, the statisticians and national income accountants of many countries try, to the degree possible, to correct for these problems. A manufacturing survey that reports extraordinary output growth (because the survey increased its sample coverage), is translated, in the national accounts, into a much more slowly growing series. A wealth or income survey that reports unusual values is quietly ignored, in favour of the data provided by more consistent surveys. Hsieh, however, wishes to cast himself loose of the national accounts. Bereft of this statistical anchor, he faces the extraordinary task of constructing a coherent and consistent statistical record for his economies. Furthermore, to do so fruitfully, he has to improve upon the knowledge embodied in the work, over a period of decades, of an army of East Asian statisticians.

The total factor productivity estimates I reported in Young 1995 are built around the twin bulwarks of the national accounts and the census, the "synthesis" and the "source", respectively, of a nation's statistical record. The national accounts are the "synthesis" because, in constructing an internally coherent set of production, expenditure and income accounts, they combine and reconcile the sectoral, expenditure and income surveys. The census is the "source" because, for better or for worse, the population values that appear in the census are usually used to scale up the labour force and income surveys (when these are scaled). I then make adjustments around these accounts, trying to avoid making additional assumptions, and minimizing the impact of unbalanced or inconsistent information. For example, wherever possible, I always try to get mean wage data, rather than weighting income groups myself.[38] When weighting labour, I ignore

[38]The only case where I weighted income groups was Hong Kong. For Singapore, I used mean income data from published and unpublished census tabulations. Even when I weight income groups, the impact is limited because, as explained above, I only focus on the relative incomes implied by the survey data. I should also note that I always use measures of personal (not household) income. Further, I use

the level of wages reported by any particular survey, which can vary enormously, and, instead, focus simply on the relative wages across educational, sex and age categories indicated by the survey data (implicitly taking the mean level as given by the national accounts). When weighting capital input, I, again, accept the level of aggregate rentals indicated by the national accounts, and use estimates of differing depreciation rates and rates of asset inflation to shift the weighting of the capital stock away from nominal value shares to hypothetical relative rentals. While there are occasions when I have moved against the national accounts and the census, e.g. ignoring the published changes in stocks series, I do so only when the evidence against these sources is overwhelming.

Total factor productivity studies, for all the clarity of their methodology, involve, in practice, the repeated exercise of judgment. My estimates represent a particular approach to data. If the question is "can one, using other sources, derive dual, *or primal*, estimates of productivity growth which are greater than, *or less than*, those reported in Young 1995?", the answer is, obviously, yes.[39]

---

iterative proportional fitting techniques (see Young 1995, pp. 653-655) and, when available, employee income tabulations to separately estimate the labour income of employees, which I then use as the implicit wage for employers, self-employed and unpaid family workers. This removes capital and other sources of personal income from my estimates of relative productivities.

[39]Which allows me, at last, to respond to the question that, no doubt, has been on the reader's mind since Section II: Perhaps Hsieh overemphasized capital deepening, when my results derive from the slow growth of output per effective worker. What then do the data on wages in Singapore have to show? In particular, do they mirror the slow growth of output per effective worker since 1980 indicated by my primal estimates. The answer is that the only annual series on mean wages, that of the Ministry of Labour (reported in the Yearbook of Statistics), indicates wage growth of about 0.4% faster per annum than the growth of output per worker between 1980 and 1995. This series does not include the employer's CPF contribution, which fell substantially between 1980 and 1995. Adjusting for this, one finds that it actually indicates about 0.5% less wage growth than my estimates. If one then incorporates the slight decline in the share of labour in my estimates, -0.4% p.a. between 1980 and 1995, the two series match exactly. The labour force survey's annual series on median gross monthly income (i.e. all employment income including profits), if taken as a proxy for mean wages, shows about half a percent greater wage growth p.a. during 1980-1994 than the mean wage series (again, without including the CPF contribution). However, the *unconditional answer* is that if I am allowed to select my sources and use the weighting procedure (on income brackets) of my choice, I can generate any pattern I like, including wage stagnation early on and extraordinary wage growth since 1980 (i.e. exactly the opposite of the pattern implied by my primal estimates). If the reader will tell me the pattern of productivity growth she wants, I can construct estimates to support that view.

Appendix A: Interest Rates

One of the measures used by Hsieh to estimate trends in the real interest rate is the prime or minimum lending rate of commercial banks,[1] taken from the *Yearbook of Statistics Singapore* (Hsieh 1997a, p. 41). In Image A1 below I reproduce the page in the 1981/82 issue of the *Yearbook* which reports domestic interest rates. The reader will notice that there is a footnote at the bottom of the page, reporting that prior to July 1975 bank interest rates were set by the Association of Banks in Singapore in consultation with the Monetary Authority of Singapore. As explained by Tan:

> Before the turn of the decade [1970], there was hardly any competition among the banks in Singapore and there was no conscious attempt in the marketing of banking services. Most banks provided the same types of services and at the same charges or interest rates. Thus, there was little need for them to engage in marketing or promotion. With relatively little competition, each bank was content to service its share of the market, and the banking industry as a whole grew at a leisurely pace (1985, p. 31).

This cartel arrangement was partly supported by the government of Singapore, which, in the belief that the Singaporean economy was "fully banked", issued only 3 new full banking licenses between 1970 and 1986 (Tan 1987, pp. 20-21). While the *Yearbook* indicates that interest rates were freed in 1975, it is interesting to note that not until September 1981 were banks "allowed to fix their own rates for large domestic transactions (S$40,000 or over), such as letters of credit, loans and overdraft, securities transactions and mail and telegraphic transfer" (Lee 1986, p. 111). In January 1983 the Association of Banks in Singapore granted its members the right to determine whether interest on savings accounts would be compounded on a monthly or daily basis, while in February 1985 banks were (finally) free to determine the commissions and fees they charged for banking transactions such as bank drafts, guarantees and the handling of trade documents.[2]

Aside from the controlled interest rates cited by Hsieh, the *Yearbook of Statistics* also reported the average lending rate of finance companies for the period 1971-1980 (see Image A1). Historically, finance companies specialized in accepting fixed term deposits (they were not allowed to take demand deposits), and in housing and hire-purchase financing. While finance

---

[1]As noted earlier, at some points Hsieh states that he used the "average lending rate" and, at others, that he used the "prime rate". These are not one and the same (see Image I). Since the average lending rate was only reported from 1968 to 1980, and Hsieh's results cover 1968-1990, in my discussion I focus on the prime rate.

[2]Singapore 1985, p. 139; MAS, Annual Report 1984/85, p. 47.

Image A1: Singaporean Interest Rates

11.13 DOMESTIC INTEREST RATES
(End of Period)

Per Cent Per Annum

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
Banks[1]											
Minimum Lending Rate	8.00	7.50	9.00	10.25	7.08	6.78	7.02	7.65	9.48	13.60	11.63
Average Lending Rate[2]	9.00	8.80	9.90	11.70	9.00	8.60	8.60	9.00	10.50	14.20	..
Deposit Rates											
3 Months	5.50	5.00	6.50	7.50	4.31	3.76	4.54	5.29	7.15	11.22	7.43
6 Months	5.75	5.25	6.75	8.00	4.96	4.34	4.98	5.55	7.40	10.92	8.40
12 Months	6.00	5.75	7.25	9.00	5.79	5.31	5.53	6.01	7.65	10.55	8.95
Savings Deposit Rate	3.50	3.50	4.00	5.50	3.50	3.52	3.66	4.20	6.38	9.52	7.90
Finance Companies											
Average Lending Rate[2]	12.60	12.40	10.40	12.60	11.50	10.80	10.20	9.80	9.90	11.80	..
Deposit Rates											
Up to 3 Months	..	..	6.70	8.30	5.00	4.90	5.30	6.40	8.10	12.20	..
Over 3 & Up to 12 Months	..	..	7.50	9.80	6.80	6.70	6.50	6.80	7.60	9.90	..
POSB Savings Deposit Rate for Amounts[3]											
Up to $100,000	4.00	4.00	4.00	6.00	5.50	5.50	5.00	5.25	6.00	8.50	9.50
Exceeding $100,000	4.00	4.00	4.00	6.00	5.50	5.50	5.00	3.50	4.25	6.00	7.00

1 Prior to October 1973, banks' interest rates were fixed by the Association of Banks in Malaysia and Singapore and thereafter by the Association of Banks in Singapore in consultation with The Monetary Authority of Singapore. After July 1975, when banks were permitted to quote their own interest rates on advances and deposits to customers, the rate refers to the average quoted by 10 leading banks.

2 These rates are weighted by outstanding loans.

3 A two-tier interest rate system was introduced in September 1978.

Source: The Monetary Authority of Singapore
Post Office Savings Bank

S: Yearbook of Statistics 1981/82, p. 183.

companies, like all financial institutions, were subject to regulation, they were free to quote their own interest rates on deposits and loans. In fact, almost half of the finance companies in the mid-1970s were owned by banks, which used the companies as a means of getting around the controls of the banking cartel (Tan 1978, pp. 99-100).

Focusing on the data in Image A1, the reader will notice that finance company lending rates were 4.6 percent higher than the bank prime (the minimum lending rate) in 1971, but 1.8 percent lower in 1980. This is extremely important, since *virtually all of the capital deepening implied by the national accounts* occurs between 1970 and 1980 (see Table II earlier). I would report the growth of the real rental using these data, except that, following Hsieh's methodology, some of the rentals in both 1971 and 1980, following rapid ex post inflation in structures, are found to be negative (a recurrent problem in his methodology). Nevertheless, the changing wedge between the prime rate and the finance company rate is a strong indication of a decline in the cost of capital in the more informal, and less regulated, segment of the capital market.

One could argue that, relative to commercial banks, the activities of finance companies are small and irrelevant. In 1975, for example, the total loans and advances of finance companies

stood at S$897.0 million, while the outstanding loans and advances of commercial banks were S$6503.1 million.[3] While correct, this argument fails to mention that since 1968 the lending activities of domestic commercial banks have steadily diminished in importance. One cannot open a statistical volume on Singaporean finance without being overwhelmed by the extraordinary growth of Asian Currency Units (ACUs). ACUs were first established in 1968 as offshore banks to promote the development of an Asian Dollar Market in Singapore and were granted a highly favourable regulatory environment.[4] While domestic banks must maintain 20% reserves, this requirement was waived (in 1972) for ACUs. Further, while domestic banks paid a 40% profit tax, ACUs were granted a preferential rate of 10% on overseas loans in 1976. This tax advantage was then extended to cover all offshore income derived from operations other than exchange profits.[5] While the number of fully licensed domestic banks went from 37 in 1970 to 35 in 1990, the number of ACUs went from 0 in 1967 to 199 by 1990. Not surprisingly, most of the domestic full license banks also operate an ACU license (as a separate accounting unit). By 1990 the total non-bank loan portfolio of ACUs stood at US$125,516.0 million (S$227,497.8 million), as compared with the S$52,744.4 million of loans and advances to non-bank customers of domestic banks.[6]

While they were initially isolated as offshore identities, ACUs gradually entered the domestic banking system. In 1973 offshore banking licenses were introduced, allowing the firm

[3]Yearbook of Statistics 1980/81, pp. 173, 177.

[4]Unless otherwise noted, all of the information in the next two paragraphs comes from the first, second, fourth, fifth and eighth editions of Chwee Huat Tan's Financial Markets and Institutions in Singapore which, together, allow one to map out, one step at a time, the changing regulatory environment.

[5]The preceeding sentences cannot even begin to do justice to the range of incentives provided to the offshore market, and the way these, like the incentives for all preferred sectors, have been extended and deepened over time. To cite a few examples, in 1976 the 1/2% ad valorem stamp duty on offshore loan agreements was limited to a maximum of S$500. In 1983 all income derived from loans syndicated in Singapore was declared tax free for a period of 5 years, subsequently extended to 10 years. The 10% concessionary profits tax was extended to area after area: e.g. fund management activities, commissions on non-Singapore dollar securities, trading in silver and platinum, etc. In 1995 it was announced that ACU activities such as the management of large funds and the underwriting and trading of foreign securities would be taxed at the concessionary rate of 5%.

[6]Including interbank funds and other assets, the total assets of ACUs stood at US$390,395.5 million (S$707,591.8 million), versus the S$134,002.0 million total assets of banks. The exchange rate I use to convert US$ to S$ is the average 1990 exchange rate of S$1.8125 per US$. Yearbook of Statistics 1991, pp. 230, 231 & 234.

to transact with resident non-bank customers and extend long term loans of S$ 1 million or more, but prohibiting the operation of deposit or other facilities. By July 1978, however, most restrictions were removed, and the offshore banks were allowed to offer a full range of credit and other services to residents. While it is true that some restrictions remain, e.g. as of the early 1990s each ACU was limited to a domestic loan portfolio of no more than S$ 50 million, the ACUs place great competitive pressure on the domestic banking system. If nothing else, given the large wedge between domestic and offshore tax rates, both borrowers and lenders have an enormous incentive to circumvent the domestic financial system and reroute loans through international sources.[7]

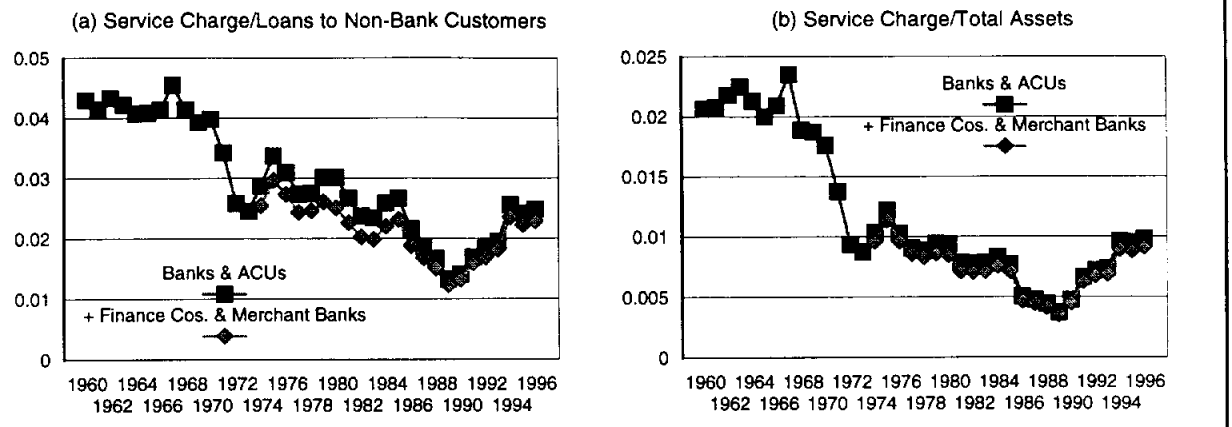
The national income accounts allow one to summarize, in one simple figure, the historical evolution of the Singaporean banking system. Under standard national income accounting precepts interest receipts and payments are not counted in favour of or against the value added of an economic sector. If this procedure were followed for the banking sector as well, its value added would be substantially negative, as formal service charges would not cover operating costs. Consequently, an additional item, the "imputed bank service charge", representing the net interest income of the banking sector (lending interest received minus deposit interest paid out), is added to value added in financial services. This item represents an intermediate input provided by the banking sector to other parts of the economy and is, consequently, subtracted from the sum of the value added of the remaining sectors. Dividing the imputed bank service charge by the total outstanding loans of all financial institutions, one arrives at a measure of the wedge between borrowing and lending rates.[8]

---

[7]Similarly, deposits received from outside of Singapore would be preferable, as they would not carry the same liquidity requirements as domestic deposits. "Roundtripping" has been a subject of some concern to the Monetary Authority of Singapore. In 1982 several banks were fined and a few bankers were investigated by the Corrupt Practices Investigation Bureau. (Tan 1996, p. 39). I asked the Monetary Authority of Singapore for precise information on the official domestic loans of ACUs, but was told that "we are unable to provide you with the information you requested as we do not publish such a breakdown." (Private communication).

[8]Of course, the potential for error in the construction of the denominator of this measure is enormous. In this regard, I have tried to be as careful as possible. Singapore National Accounts 1960-1973 quite clearly indicates that the imputed bank service charge covers the net interest earnings of commercial banks, ACUs, merchant banks, finance companies, discount houses and the Post Office Savings Bank. I have confirmed with the Singaporean statistical authorities that, with reference to the ACUs, the imputed bank service charge covers their entire loan portfolio, domestic and international (how could it not, since it is impossible to separate out the corresponding deposit charges). I then construct the denominator for the ratios shown in Figure A1 using data on commercial banks, ACUs,

Figure A1: Trends in Financial Margins



In Figure A1 (a) above I graph the ratio of the imputed bank service charge to the total non-bank loan portfolio of commercial banks and ACUs in Singapore. As the reader can see, the interest wedge collapses during the late 1960s and early 1970s, when ACUs were first introduced, recovers somewhat during the high inflation of the mid-1970s (which would raise the wedge), before reaching a minimum, at ¼ of its original value, in 1989. The loan portfolio of finance companies and merchant banks also contributes to the implicit bank service charge, but I only have data on these since 1968 and 1974, respectively. Consequently, I graph an additional series including the non-bank loans of these companies, beginning in 1974. As these are small relative to the activities of commercial banks and ACUs, this does not change the results

---

merchant banks and finance companies from Economic & Social Statistics Singapore 1960-1982 and later editions of the Yearbook of Statistics. For commercial banks, I use the total volume of non-bank loans, including bills discounting. I do not include discount houses (which ended in 1987) and the POSB, because, relative to the sum of the other financial institutions, their assets are small and, with the exception of some years for the discount houses, I do not have data on their loan portfolio. Finally, I should note that Singapore National Accounts 1987 (p. 6) could be interpreted as suggesting that by that date the coverage of the imputed bank service charge had been expanded to include the Monetary Authority of Singapore, the CPF Board and the Board of Commissioners of Currency of Singapore. It should not, since the operating surplus of public financial institutions is typically not measured as value added. Nevertheless, if the coverage of the imputed bank service charge has been expanded through time (the earlier figures were never substantially revised), then my measure *understates* the decline of the ratio (since, in the denominator, I only include the sectors that were included in the 1960s and early 1970s). The imputed bank service charge is taken from Singapore System of National Accounts 1995, the Yearbook of Statistics 1996, and checked, for earlier years, against Economic & Social Statistics Singapore 1960-1982.

substantially. One might worry that interest earnings on loans to bank customers could also contribute to the implicit service charge. The easiest way to handle this, and similar complaints, is to simply graph the ratio of the service charge to total assets, as shown in panel (b). This series has properties similar to those depicted in panel (a). The appearance of ACUs, the gradual internationalization of the Singaporean capital market, has clearly been associated with a decline in the profitability (or monopoly rents) of the Singaporean banking system.

Hsieh argues:

> it is highly unlikely that the return to capital in Singapore has fallen by the magnitude implied 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 (1997b, p. 2)

While the measure I introduce in Figure I is not without its problems,[9] it, nevertheless, provides a clear indication of the existence of capital market imperfections and imperfect international capital mobility in early Singapore.[10] Not until 1978 were all controls on the exchange of foreign currency finally removed (Tan 1981, p. 184). As explained in Doing Business in Singapore (SGV-Goh Tan 1975):

> In the past, remittances to and from non-Scheduled Territories [basically, outside the Sterling Area] had to be approved by the Foreign Exchange Control Department of the Ministry of Finance...this restriction has been relaxed...For investments in non-Scheduled Territories by Singapore residents, certain limits have been placed on remittances from the Republic. An individual can remit up to a total of S$100,000; a company...can remit up to S$ 3 million...Remittances exceeding the above stated amounts require approval from Exchange Control. (p. 23)

---

[9]Consider, for example, the case where banks require borrowers to redeposit a fraction x of loans. If loans are given out at 5% and deposits earn 3%, then the measure produces an estimated interest wedge of 2%. Now, remove the redeposit restriction, but keep loan and deposit interest rates as before. The measure would still indicate an interest wedge of 2%, even though the true cost of borrowing, and the nature of the capital market, has changed dramatically (I am indebted to Anil Kashyap for this example). I am not proposing this as *the* measure of capital market imperfections. It is simply, in my mind, the first and most natural thing to look at when thinking about trends in overall borrowing conditions.

[10]According to Lee (1986, pp. 114-115), because of the greater competition in the international market the returns on ACU lending have historically been below those earned by domestic banks. Consequently, the ACUs may have brought down the average margins in Figure I without necessarily lowering the wedge in domestic banking per se. This view would support my argument all the more, as it would imply that, as late as the 1990s, the Singaporean capital market remained heavily segmented and isolated from the international capital market.

As late as the mid-1990s, despite all of the financial reforms, domestic banks still had to consult with the Monetary Authority of Singapore (MAS) before granting a loan exceeding S$ 5 million to be used outside of Singapore because:

> The Singapore government discourages any attempt to internationalise the Singapore dollar. It believes this will lead to large destabilizing inflow and outflow of Singapore dollars and make it difficult for the authority to control money supply. Any erratic swing in the S$ exchange rate will cause undesired disruption in international trade. (Tan 1996, p. 40).

Aside from capital market imperfections, simple risk premia are likely to have kept the return on capital high in early Singapore. In the context of the stability of the 1990s, it is sometimes easy to forget that in the mid-1960s tiny Singapore was racked by internal labour & political conflict, surrounded by hostile Malay states (recall the "Confrontation" with Indonesia and the trade war with Malaysia), and, amidst all the conflict in Southeast Asia, was in the process of being abandoned militarily by the British.[11]

To conclude, I ask the reader to consider the enormous variety of financial regulations that exist in any economy, and the way these have evolved over time. Given the wide variety of statistical series produced by this evolving institutional framework, is there any doubt that one can find, in any economy, data supporting the notion of rising, falling or constant borrowing costs? As a final example, I should note that since 1975 the MAS has operated a Rediscounting Scheme under which it guarantees export financing and *pre-export* production financing at a fixed interest rate (typically 3.75%) through commercial banks, which collect commissions by rediscounting the MAS loan, but by no more than 1.5% (Tan 1987, pp. 313-314). This short-term financing is available to exporters with sales contracts, purchase orders or letters of credit. In the paper, using the prime rate in 1968 and the prime rate in 1995, I estimated, using Hsieh's methodology, that the weighted real rental fell 1.3% per annum between 1968 and 1995. If, say, I take the prime rate, i.e. banks declared minimum lending rates, in 1968 and juxtapose it against the customer cost of the MAS loans in 1995 (5.25%),[12] I compute that the weighted real

[11]As I ask my students every year, "Which is the greater evidence of disease, the fact that investment rates in East Asia went from 10 to 20 to 30 to 40 and (almost) to 50 percent of GDP, or the fact that investment rates in Africa languish at below 10 percent of GDP?" The rise of investment in East Asia begs for an interpretation based upon the role of government in overcoming capital market imperfections (either due to informational and legal enforcement problems or, in many cases, due to the regulations imposed by governments themselves) and minimizing political risk.

[12]The rate rose in the early 1990s, but MAS, Annual Report 1991-1992, p. 85, indicates that the rediscount rate was lowered back to 3.75% in September 1992, and Price Waterhouse, Doing Business in Singapore 1996, reports that it was 3.75% (with a maximum bank margin of 1.5%) in June 1996.

rental fell 2.4% per annum between 1968 and 1995. If I then adjust for the tax code (inducing a further 1 to 2 percent decline in the rental), I derive an estimate well in excess of the annual 2.1% decline implied by the national accounts. Beyond the MAS scheme, there are a variety of government supported short and long term financing arrangements, all of them introduced since the 1960s, to choose from.[13]

[13]The problem, of course, is that one needs an integrated measure of the marginal cost of capital for the representative firm. This, however, is extremely hard to construct, particularly for an evolving financial system, where old imperfections (and methods of rationing) are being removed and new sources of capital are being added. In such a situation, even if the costs associated with particular instruments are constant, the marginal cost of capital could have a trend.

Appendix B: Confirming the National Accounts

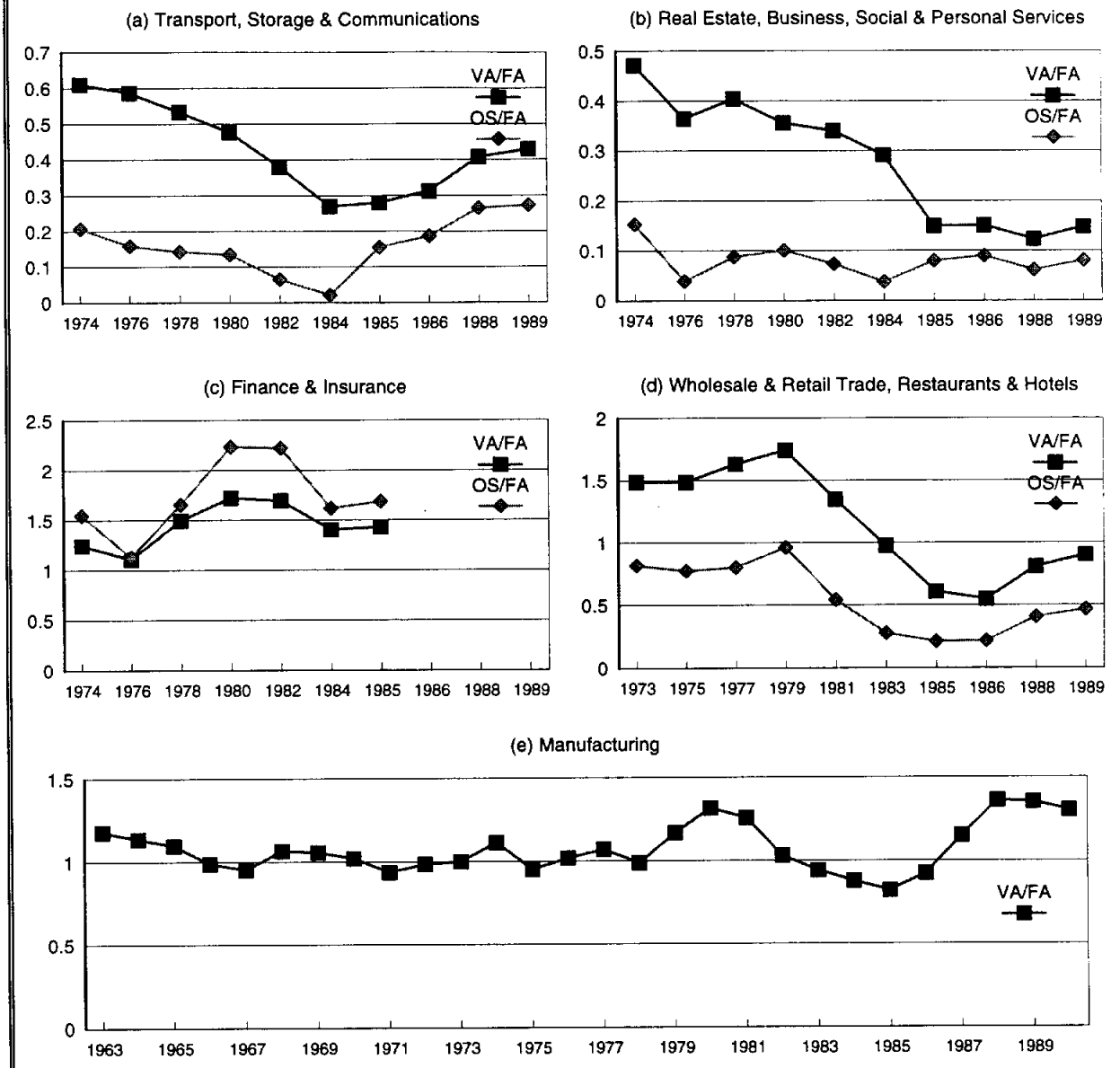
In the early 1990s I performed a variety of tests to verify the accuracy and internal consistency of the national accounts and censuses of the NICs. For the national accounts of Singapore, I drew on the sectoral surveys and censuses. Although the value added information from the surveys goes into the construction of the production side of the national accounts, the reported fixed assets, i.e. the data on the ownership of capital, are distinct and independent from the estimates of capital formation on the expenditure side of the national accounts, which are derived from data on the supply of capital goods (see Section IV above). In this appendix I use some crude back of the envelope calculations, and one careful study, to show that the information in these surveys is broadly consistent with the capital deepening depicted in the national accounts.

In Figure B1 below I graph the ratio of the value added and the operating surplus to the book value of fixed assets in the various sectors of the Singaporean economy, as reported by the sectoral surveys. At first glance, it is hard to see how these data support the Singaporean national accounts. Although the ratio of value added to fixed assets declines in transport & communications, real estate & business services and commerce, it shows no trend in finance & insurance or manufacturing. Most surprising, the ratio of operating surplus to fixed assets, a measure of profitability, appears to have a downward trend in, at best, only one sector (commerce). Once one understands the evolving statistical and accounting conventions of the Singaporean economy, however, one finds that these data support the national accounts.

To use these data, one has to make two adjustments. First, one must have consistent definitions. In 1985 the surveys changed the definition of both operating surplus and value added. In the case of operating surplus, a number of charges against operating receipts were removed (i.e. added to the surplus). These included items such as interest payments, depreciation charges, and withdrawals by proprietors or owners for their own use (previously counted as expenses under wages & salaries). In the case of value added, indirect taxes were added in, while rental payments were subtracted out. To derive a consistent series, I adjust the earlier data to conform to the statistical conventions of later years. Specifically, for the operating surplus I add back in interest payments and depreciation, and for value added I add indirect taxes and remove rental payments.[14] It is impossible to adjust for all of the items that were added to the operating

[14]For the operating surplus in financial services & insurance, I add only depreciation, as interest

Figure B1: Ratios to Book Value of Fixed Assets (sectoral surveys)



S: Same as Figure V, with the same adjustment for the change in the book value date for manufacturing. The operating surplus exceeds value added in finance & insurance because for public financial institutions value added does not include the operating surplus. The Census of Industrial Production does not report an operating surplus measure for the manufacturing sector.

surplus in the later data, but this puts the different years on a more equal footing. The resulting measure of value added is net of capital income generated by structures owned outside of the sector, while the operating surplus represents the gross rents to capital goods, ignoring capital

payments were not added to the operating surplus of this sector in later years.

financing costs. These two measures are akin to the capital-output ratio from the national accounts and the gross rental ratio from the real return to capital.[15]

Second, one must have a consistent accounting framework. In Table B1 below I report the annual accounting depreciation as a percentage of the value of the fixed assets in each of the sectors. In favoured sectors, such as manufacturing and finance & insurance, these rose rapidly over time (with little change in the composition of fixed assets).[16] It is important to emphasize that this increase in depreciation charges *cannot* be ascribed to the disposal of fixed assets due to increased structural transformation, as these are assets which are remaining on the books of the companies, i.e. have not been sold. These are pure accounting charges. A rise in the accounting depreciation charge, however, lowers the book value of fixed assets relative to its productive value in the firm. To adjust for this, I construct an index of the ratio of depreciation to fixed assets, setting it an initial value of 1 in the first year of my data series. I then multiply the book value of fixed assets in any year by this index, as a crude means of moving the book value back to the accounting conventions of the beginning of the sample period. This raises the terminal book values in manufacturing, finance and commerce, and lowers them in transport and real estate & business services, where the annual

Table B1: Trends in Depreciation Charges & Composition of Fixed Assets

	Depreciation/ Fixed Assets	Land & Buildings/ Fixed Assets	Mach. & Equip./ Fixed Assets
Manufacturing			
1963	0.066	0.438	0.562
1973	0.089	0.359	0.641
1990	0.164	0.326	0.674
Finance & Insurance			
1974	0.034	0.872	0.128
1985	0.071	0.859	0.141
Transport, Storage & Communications			
1974	0.096	0.286	0.714
1989	0.090	0.350	0.650
Real Estate, Business, Social & Personal Services			
1974	0.020	0.892	0.108
1989	0.014	0.971	0.029
Wholesale & Retail Trade, Restaurants & Hotels			
1973	0.052	0.696	0.304
1989	0.069	0.731	0.269

[15]Without, that is, consideration of taxes. See equation 2 and the equation in footnote 13 in the paper.

[16]These charges might seem low relative to the numbers for machinery & equipment quoted earlier in the paper. The depreciation charge on land is zero, and on buildings it is only a few percentage points per annum. In addition, companies are not required to take accelerated depreciation. In the case of firms enjoying tax holidays (due to other incentive programmes) there would be no cost to postponing depreciation allowances. Depreciation charges in excess of profits can be carried forward, but are lost if a significant change in ownership occurs.

depreciation charge actually fell (as the composition of the capital stock shifted to structures).[17]

The results, after these adjustments, are presented in Figure B2. Once one realizes that major elements were added to the operating surplus in the mid-1980s and once one adjusts for the fact that the book value of the capital stock is understated (relative to historical levels) because of increases in accounting depreciation charges, one finds that every sector of the Singaporean economy shows a secular downward trend in the capital-output and gross rental ratios. These estimates are crude and imprecise. With positive investment growth, the adjustment for the change in accounting depreciation is easily shown to be excessive.[18] This will impart a specious negative trend to the series for manufacturing, finance and commerce, and a positive trend to those for the other sectors. The relative price of capital goods and output changes through time, with machinery, in particular, having the lowest inflation. Consequently, the constant price output-capital ratio in sectors with large quantities of machinery (e.g. manufacturing) falls faster than indicated by the current price ratios in the Figure. Finally, with book values at historical cost, but the flows of value added and operating surplus at current values, cumulative inflation will tend to push up the ratio. This would tend to elevate the ratios during periods of abnormal inflation (i.e. the mid to late 1970s) and depress them during periods of deflation (the mid-1980s). These are, simply, back of the envelope calculations.

The correct way to proceed is to take one of the surveys and use the annual flows of capital purchases (minus reported sales of assets) to compute a capital stock, suitably deflated to constant prices. One could initialize this capital stock series with an early year's book value, but would, thereafter, ignore the depreciation charges and annual book value, as these are affected by accounting conventions. Instead, one would take standard depreciation rates for the asset types, and use these to cumulate the annual net investment series forward.[19] Finally, one would want to

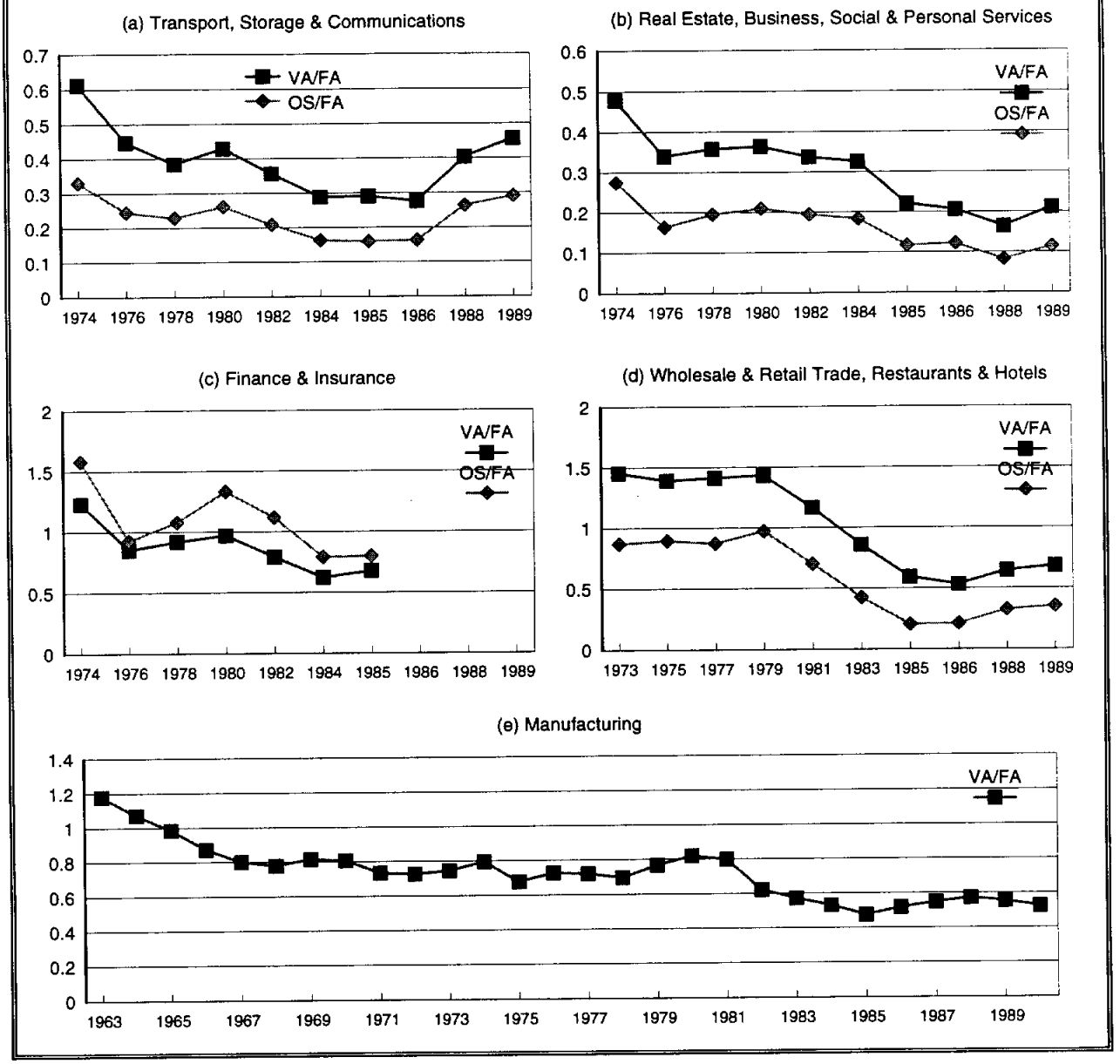
---

[17]A third adjustment would be to eliminate sub-sectors where operating surplus or value added are measured differently, e.g. public financial institutions, the representative offices of foreign airlines and shipping companies, etc.. I tried adjustments along these lines, and the results were not substantially different. To maintain transparency, I simply focus on the sectoral aggregates.

[18]Consider that, with exponential depreciation and a constant growth rate of investment g, the capital stock is given by $K = I/(\delta + g)$. If g is zero, then multiplying by the ratio of the final to initial depreciation rates recovers the capital stock using the original accounting conventions. If, however, g is positive, this adjustment is excessive.

[19]Since asset sales are accounted for one does not need to consider raising the depreciation rate through time to account for increased structural transformation. Nevertheless, if the reader wanted to consider the impact of adjustments along these lines, she could lower the growth of the capital-output

Figure B2: Ratios to Book Value of Fixed Assets (adjusted)



use an index of real output growth and compute the growth of the capital-output ratio, comparing it to the trends reported in the national accounts. It is possible to do this computation only for one sector, manufacturing, where data are available on an annual basis.

The results of a careful analysis along these lines are presented in Image B1, which simply reproduces Table VI of my 1995 paper. For the manufacturing sector, I followed Tsao's

ratio in the results which follow, pushing it toward zero. Due to the slow growth of output per worker, total factor productivity growth in manufacturing remains negligible. This simply reproduces, for the manufacturing sector, the results of my analysis in Table VII of this paper.

Image B1: Confirming the National Accounts (Young 1995)

TABLE VI

TOTAL FACTOR PRODUCTIVITY GROWTH: SINGAPORE

Time period	Annual growth of: Output	Raw capital	Weighted capital	Raw labor	Weighted labor	TFP	Labor share
Economy:							
66–70	0.130	0.119	0.134	0.054	0.033	0.046	0.503
70–80	0.088	0.122	0.140	0.050	0.058	−0.009	0.517
80–90	0.069	0.091	0.084	0.036	0.066	−0.005	0.506
66–90	**0.087**	**0.108**	**0.115**	**0.045**	**0.057**	**0.002**	**0.509**
Manufacturing:*							
70–80	0.103	0.123	0.130	0.086	0.089	−0.009	0.423
80–90	0.067	0.090	0.094	0.021	0.051	−0.011	0.385
70–90	**0.085**	**0.107**	**0.112**	**0.054**	**0.070**	**−0.010**	**0.404**

*Only covering firms recorded in the Census of Industrial Production.

(1982) method and computed total factor productivity growth using information on manufacturing output and investment drawn from the Census of Industrial Production (since the national accounts do not report capital formation by sector). While the output measures of the CIP are used in the construction of the national accounts measures of manufacturing output, the capital formation figures in the CIP are *completely independent* of the national accounts, as they are based upon ownership wihin the sector, while the national accounts estimates, for the aggregate economy, are based upon the supply of capital goods. Using these numbers, I found productivity growth of -1% per annum for the period 1970-1990. Tsao, in a more disaggregated study, found an average productivity growth rate of -1.2% across 28 industries during the period 1970-1979. Tsao also produced econometric *dual* estimates for manufacturing, finding that the first and second derivatives of productivity were not significantly different from zero in 27 of the 28 industries, with the 28th industry, footwear, showing a statistically significant negative second derivative (only).

As noted in the introduction, in 1985 Singapore's Department of Statistics informed its most influential leaders, producing the most important economic policy document of the postwar era, that the return on private capital (private, not public, not public plus private, but *private*) was in secular decline. In the various censuses and sectoral surveys of the Singaporean economy one

finds widespread evidence, completely independent of the national accounts, that supports this view.

Bibliography

Ernst & Whinney. Taxation of Companies in the Republic of Singapore. Singapore, 1987.

Fordham, Margaret. Developing Singapore - Tax Incentives for Investment & Expansion under the Economic Incentives (Relief from Income Tax) Act. Singapore: Longman publishes, 1988.

"Foreigners still welcome." The Economist. January 17th, 1998, p. 35.

Hall, Robert E. In Peter Diamond, Ed. Growth/Productivity/Unemployment. Cambridge, MA: MIT Press, 1990.

Hong, Lee Fook. Capital Allowances on Industrial Buildings and Plant & Machinery. Singapore, 1978.

Hsieh, Chang-Tai. "Measuring Technological Change." Working Paper, University of California, Berkeley, March 1997(a).

Hsieh, Chang-Tai. "What Explains the Industrial Revolution in East Asia? Evidence from Factor Markets." Working Paper, University of California, Berkeley, November 1997(b).

Jorgenson, Dale W.; Gollop, Frank M. and Fraumeni, Barbara M. Productivity and U.S. Economic Growth. Cambridge, MA: Harvard University Press, 1987.

Lee, Sheng-yi. The Monetary and Banking Development of Singapore and Malaysia. Second edition. Singapore: Singapore University Press, 1986.

Lim, Chong Yah, et al. Policy Options for the Singapore Economy. Singapore: Mcgraw-Hill Book Company, 1988.

Monetary Authority of Singapore. Annual Report. Annual issues.

Nelson, Richard and Pack, Howard. "The Asian Growth Miracle and Modern Growth Theory." Manuscript, 1995.

Peat, Marwick, Mitchell & Co. Taxation in Singapore. Singapore, 1984.

Price Waterhouse & Co. Information Guide for Doing Business in Malaysia and Singapore. USA: 1968.

Price Waterhouse. Doing Business in Singapore. USA: 1975, 1984, 1990, 1996 issues.

Rao, V.V. Bhanoji and Ramakrishnan, M. Income Inequality in Singapore. Singapore: Singapore University Press, 1980.

Republic of China. Directorate-General of Budget, Accounting & Statistics. Report on the Survey of Personal Income Distribution in Taiwan Area, Republic of China 1980.

Republic of Korea. Administration of Labour Affairs. Report on Occupational Wage Survey 1980.

Republic of Korea. National Bureau of Statistics. 1980 Population and Housing Census Report.

Republic of Korea. National Bureau of Statistics. Annual Report on the Economically Active Population Survey 1980.

Rodrik, Dani. "Getting interventions right: how South Korea and Taiwan grew rich." Economic Policy (April 1995): 55-97.

Rodrik, Dani. "TFPG Controversies, Institutions, and Economic Performance in East Asia." NBER Working Paper No. 5914, February 1997.

SGV-Goh Tan Pte. Ltd. Doing Business in Singapore. Singapore: 1975 & 1978 editions.

Singapore. Department of Statistics. Census of Population 1980 Singapore.

Singapore. Department of Statistics. Economic & Social Statistics Singapore 1960-1982. Singapore: National Printers, 1983.

Singapore. Department of Statistics. Foreign Equity Investment in Singapore, 1990-1992. Singapore: SNP Corporation Ltd.

Singapore. Department of Statistics. General Household Survey 1995. Singapore: 1996.

Singapore. Department of Statistics. Report on the Survey [Census] of Services. Singapore: National Printers, various issues.

Singapore. Department of Statistics. Report on the Survey [Census] of Wholesale and Retail Trades, Restaurants and Hotels. Singapore: National Printers, various issues.

Singapore. Department of Statistics. Singapore Census of Population 1990. Release 4. Singapore, 1993.

Singapore. Department of Statistics. Singapore National Accounts 1960-1973. Singapore, 1975.

Singapore. Department of Statistics. Singapore National Accounts 1987. Singapore: National Printers, 1988.

Singapore. Department of Statistics. Singapore System of National Accounts 1995. Singapore: 1996.

Singapore. Department of Statistics. Yearbook of Statistics Singapore. Singapore: National Printers, annual issues.

Singapore. Economic Development Board. Report on the Census of Industrial Production. Singapore: National Printers, annual issues.

Singapore. Ministry of Information and Arts. Singapore 1995.

Singapore. Ministry of Labour. Report on the Labour Force Survey of Singapore. Singapore, annual issues.

Singapore. Ministry of Labour. Yearbook of Labour Statistics. Singapore, annual issues.

Singapore. Ministry of Trade and Industry. Report of the Economic Commitee. The Singapore Economy: New Directions. Singapore, 1986

Stock Exchange of Singapore Ltd. Companies Handbook. Singapore: Stock Exchange of Singapore Ltd, annual issues.

Stock Exchange of Singapore Ltd. Fact Book. Singapore: Stock Exchange of Singapore Ltd., annual issues.

Tan, Chwee Huat. Financial Institutions in Singapore. Singapore: Singapore University Press. 1st (1978), 2nd (1981), 4th (1985), 5th (1987), and 8th (1996) editions.

Tsao, Yuan. "Growth and Productivity in Singapore: A Supply Side Analysis." Ph.D. thesis, Harvard University, 1982.

Young, Alwyn. "A Tale of Two Cities: Factor Accumulation and Technical Change in Hong Kong and Singapore." In Olivier J. Blanchard and Stanley Fischer, eds., NBER Macroeconomics Annual 1992. Cambridge, MA: MIT Press, 1992.

Young, Alwyn. "Lessons from the East Asian NICs: A Contrarian View." European Economic Review 38 (1994): 964-973.

Young, Alwyn. "The Tyranny of Numbers: Confronting the Statistical Realities of the East Asian Growth Experience." Quarterly Journal of Economics (August 1995): 641-680.

Young, Alwyn. "Paasche vs. Laspeyres: The Elasticity of Substitution & Bias in Measures of TFP Growth." Manuscript, 1998.